Academic Rodeo
Engineering Challenge

Student Activity Book

Activities Created by the NASA Idaho Space Grant Consortium
http://isgc.uidaho.edu/idahotech

Building a Working Team

Before you begin with the activities in this book, ask your teacher to show you how to build a working team.

(Your teacher has this activity in the Teacher's Edition of the Student Activity Book)

One of the biggest challenges that you will face in designing and constructing your Mars Rover is working together as a team. It is really fun to be a part of a team, but it takes a lot of work to be part of a strong team. Different people have different ideas about how to accomplish the same goal. This is normal. There are so many different ways to build a rover or to make a poster and to do it well. Developing your ideas together is definitely going to be a challenge, but the 4 C's will help guide you along the way. You are guaranteed to have loads of fun in the Mars Rover Competition if you can master the 4 C's.

★ Can you figure out the 4 C's? ★

Here is one to get you started. Ask your teacher for the 4 C's after you have thought of all the ones that you can.

? ? **Cooperation** ? ? ?

____

____

____

Here's a Challenge

You can probably think of more words than just four. First, see how many "C" words that you can think of that are important for good teamwork. Write them in the space below. Now think of any other non-"C" words that might help you to reach your goal of being a good team and write them below. Finally, after you have all written all the words that you can think of, sign your names to the bottom of the page. This is an agreement to try to follow these ideas when you are working on your Rover. You can cut this out and glue it into your Engineering Challenge Lab Notebook as a reminder. **Remember to leave the first page of your notebook blank, however - this is where your timeline will go!**

The Spaghetti Incident

Adapted from a lesson entitled "Lesson Plan 2: Developing Successful Teamwork Skills" at the LessonPlansPage.com - www.lessonplanspage.com/ScienceSSMars2DevTeamworkSkills56.htm

Why should your team do this activity?

No matter how good each individual on your team might be at building a Rover, working together as a team will greatly improve your success at the Design Competition. It takes a long time to learn how to work well together as a team, so the more practice you get, the better your team will be! This activity will help your team practice working together.

The Necessities:

- A timer or watch with a second hand
- 12 pieces of dry spaghetti noodles (plus a few extras in case some break)
- 6 gumdrops
- Small bag of miniature marshmallows
- Meterstick
- A pen or pencil
- Your Engineering Challenge Lab Notebook

Directions:

(1) Your team will try to build the tallest tower possible with only the materials listed above in ten minutes. Your team can use as many marshmallows as you wish, but only 12 pieces of spaghetti and 6 gumdrops. Here are the rules: each team member of your team has to participate ***and you cannot talk to each other at all***. If you talk, your teacher will take away one of your gumdrops, so watch out!

(2) Build away! Make sure someone keeps track of time if the teacher is not doing this for your team.

(3) Once ten minutes is up, measure how tall your tower is, and record this height in your Lab Notebook. Also, write a few notes in your Notebook about how your team went about constructing your tower. Think about how you could have worked together as a team better. **What would you do differently next time?**

(4) Clean up your tower and eat the gumdrops!

Copy Cat

Adapted from the Putnam Northern Westchester BOCES Outdoor Education Program's Challenge Course

Why should your team do this activity?

This activity is another great way to improve your team's communication skills. Not only will you have to work together while designing and constructing your Rover, but you will also have to work together during the Design Competitions. Many times, teams lose their ability to communicate well while under pressure (like during the Competition). By completing this activity, each member of your team will have a chance to practice and improve his or her skills for giving specific directions, listening, and asking questions. These skills will undoubtedly help your work together as a unit, both before the Design Competition and during the Competition.

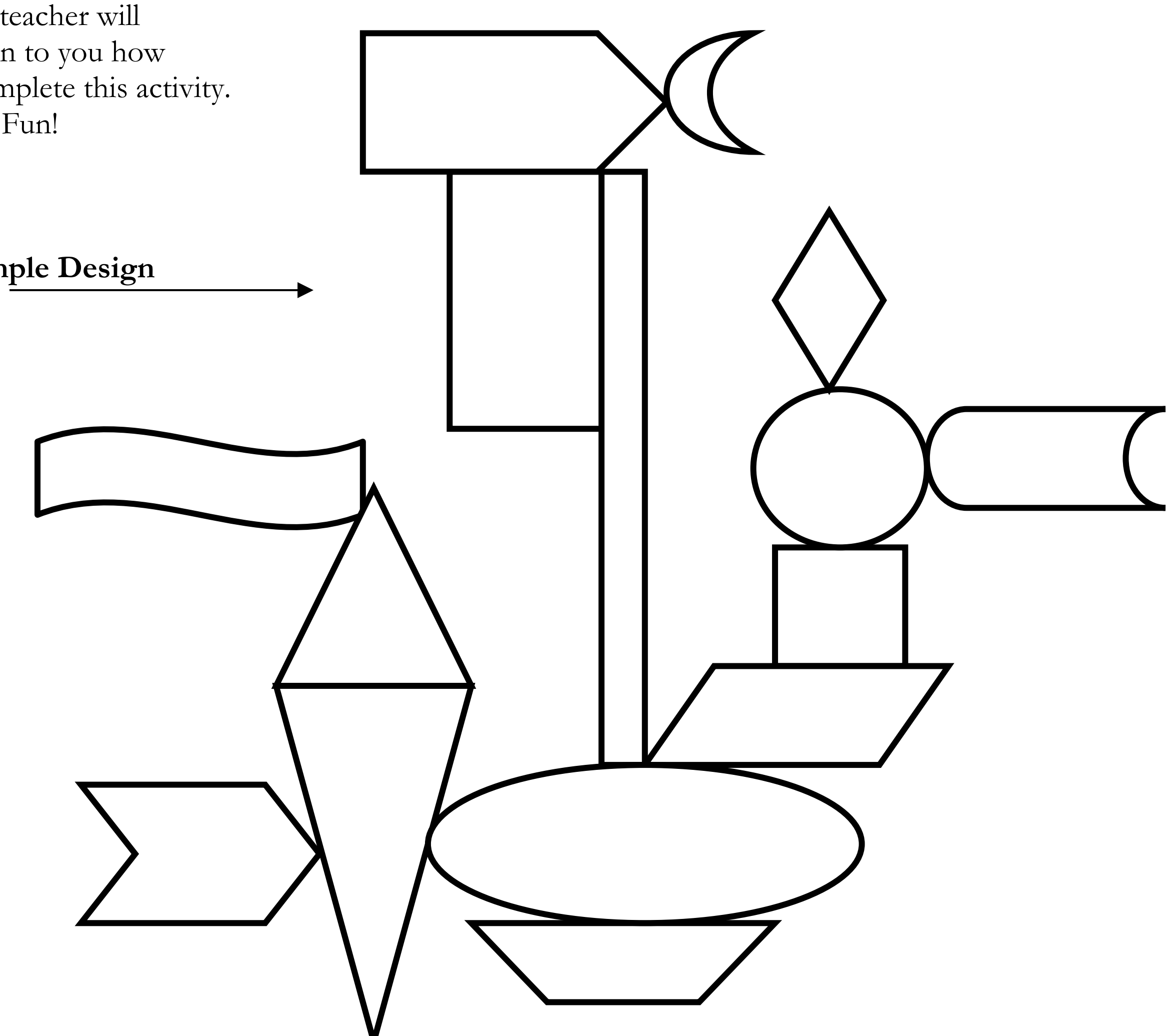
The Necessities:

- A few pairs of scissors
- One set of Copy Cat Shapes for each team member (see page 25)
- Pen or pencil
- Engineering Challenge Lab Notebook

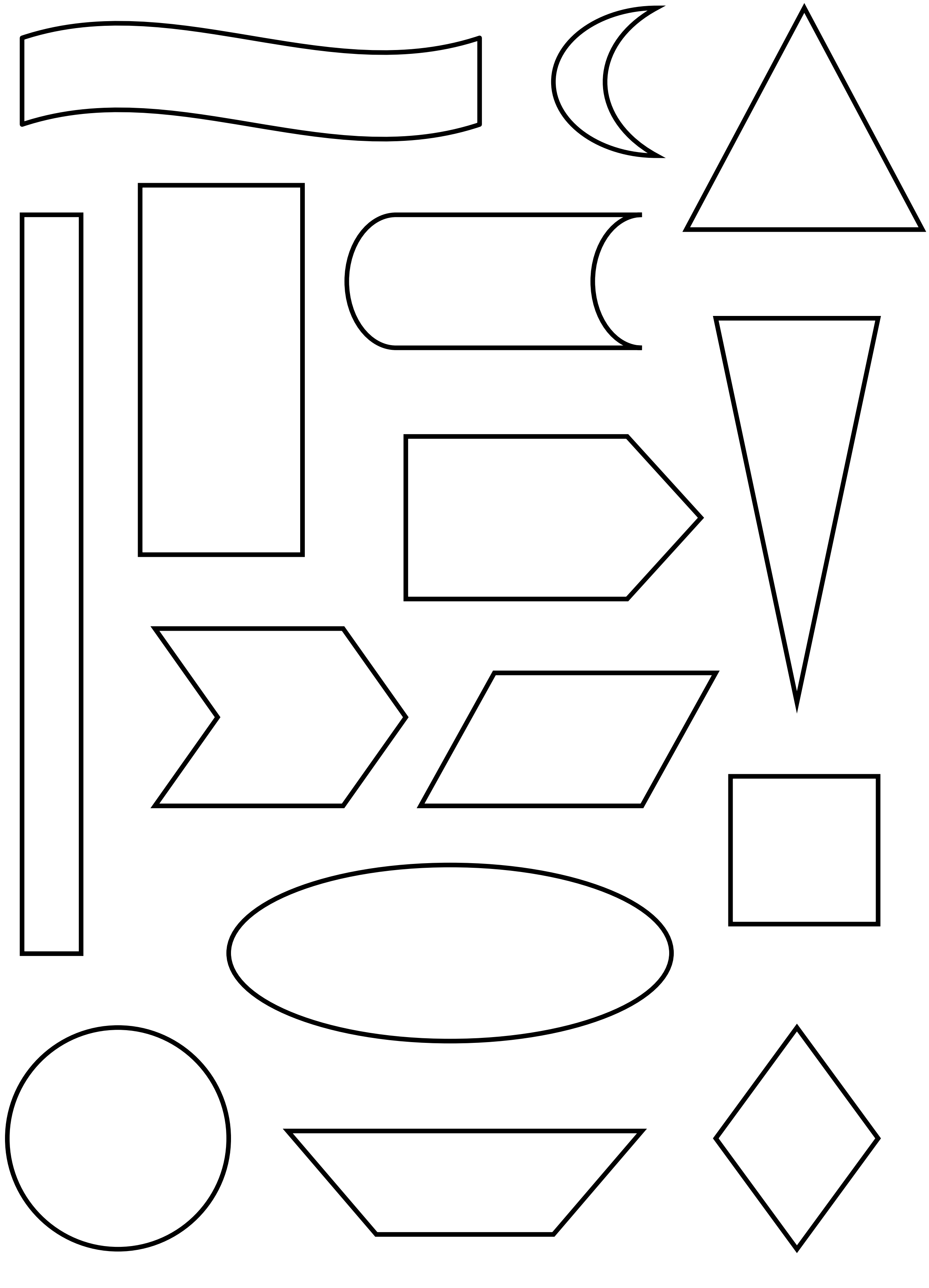
Directions:

Your teacher will explain to you how to complete this activity. Have Fun!

Example Design



One Set - Copy Cat Shapes



Parts of the Whole: Developing a Sense of Team Skills

Why should your team do this activity?

Working as a team and being aware of the different roles that individuals play on a team is one of the most important parts of solving a problem as a group. Sometimes it seems much easier to take control and to work out the problem without the help of others, but working as a team can be very rewarding. There are many ideas that team members have that you may not be able to discover on your own. As people work together as a team, they begin to discover that some of the team members are good at more than one role (what that person is supposed to do for the team), while others seem much stronger at one role over another. Discovering which role each member of the team will be best at is an important step in helping the team to work well together.

The Necessities:

- 12 wooden matches or sticks the length of wooden matches
- A pair of scissors
- 6 pencils (not sharpened)
- 8 pennies
- Pen/pencil for writing, scratch paper
- Role Question Sheet (see page 27)
- Engineering Challenge Lab Notebook

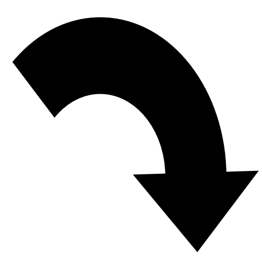
Directions: As a team, try the brain-teasers on the next three pages. For each puzzle, have individual team members select a different role each time until everyone has had a chance to participate in every role at least once. Your team can decide how to change roles each time, as long as you do it in a fair fashion. After you complete each puzzle, each team member should answer the questions (located before the puzzles in your Activity Book) for their role. There is a question sheet included for each team member. After each team member has had a chance to be in each role at least once, discuss your answers as a group. ***Write overall comments of the group in your Engineering Challenge Lab Notebook.***

★ **Remember**….it can feel frustrating to be in a role that does not fit with your skills or personality, but it is important that you try each role in order to discover what each member of your team, including yourself, will be good at. ★

Go to the next page

to find out

about your roles!



Role Descriptions

Guide: The guide leads the group in solving the problem.

- Read the problem to the whole group
- Listen to all the members of the group
- Ask questions about their suggestions
- Make the decision about what needs to be done to solve the problem, using the team's input (*the guide can have a group vote to decide on the solution or can make the final call of what solution will be attempted first)*

Organizer: The organizer is responsible for organizing all of the ideas and solutions that come about in the problem solving process.

- Keep notes of ideas or suggestions in the Lab Notebook
- Keep notes of the process in the Lab Notebook: What did the group try first? Second? What is working? What isn't working?

Brainstormers (1-2 people) : The brainstormers are the idea people.

- Think of suggestions for solving the problem
- Ask others in the group to contribute their ideas when the "brainstormers" have run out of ideas

★ Don't worry if you are stumped. Remember that you have a whole group of minds.
Do not be afraid to ask the other group members what they think.
Usually all people in a group are responsible for giving ideas. ★

Builder (1-2 people): The designers / builders will be the hands-on people.

- Listen carefully to team members and try to recreate what they are communicating to you
- Move the parts of the puzzle to solve it

★ The individuals who are in the designer / builder role should be
the *only* people who are touching the puzzle pieces. ★

Role Question Sheet

Name:________________________

Answer the questions about each role immediately after you have completed that role. After everyone has completed all of the roles, discuss your answers as a group. *(6 copies of this answer sheet are located in the Student Activity Book)*

Guide

1. Can you name some important qualities of the person responsible for leading the group?
2. Did you like being the guide?

Organizer

1. Why do you think it is important to have someone writing down the ideas that were discussed?
2. What are some important qualities of a recorder / organizer?

Brainstormer

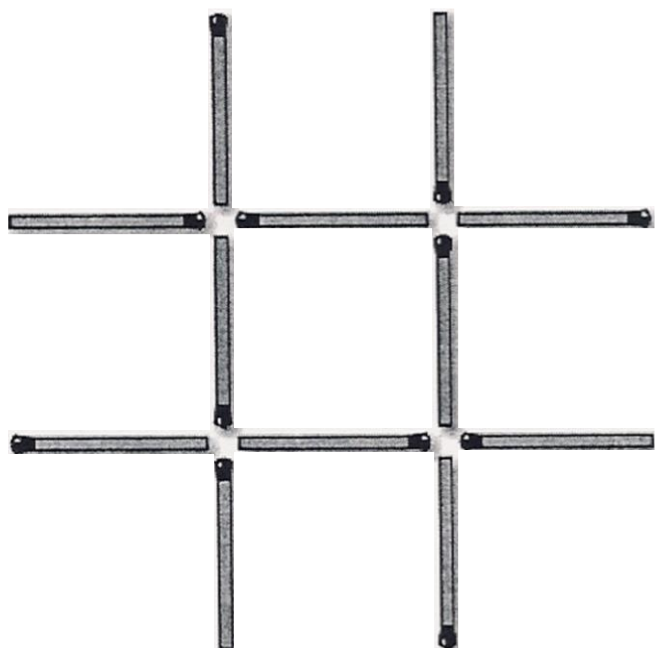
1. Did you find it easy to come up with ideas?
2. What was the most difficult thing about being the brainstormer?

Builder

1. Was it easy to follow the other team members' instructions?
2. Did you like being the builder? Why or why not?

PUZZLE # 1: THREE SQUARES

Set up instructions: Take twelve matches and arrange them into a grid shown below.
The Challenge: Move only three matches so that you get exactly three perfect squares. You can pick matches up off the table.



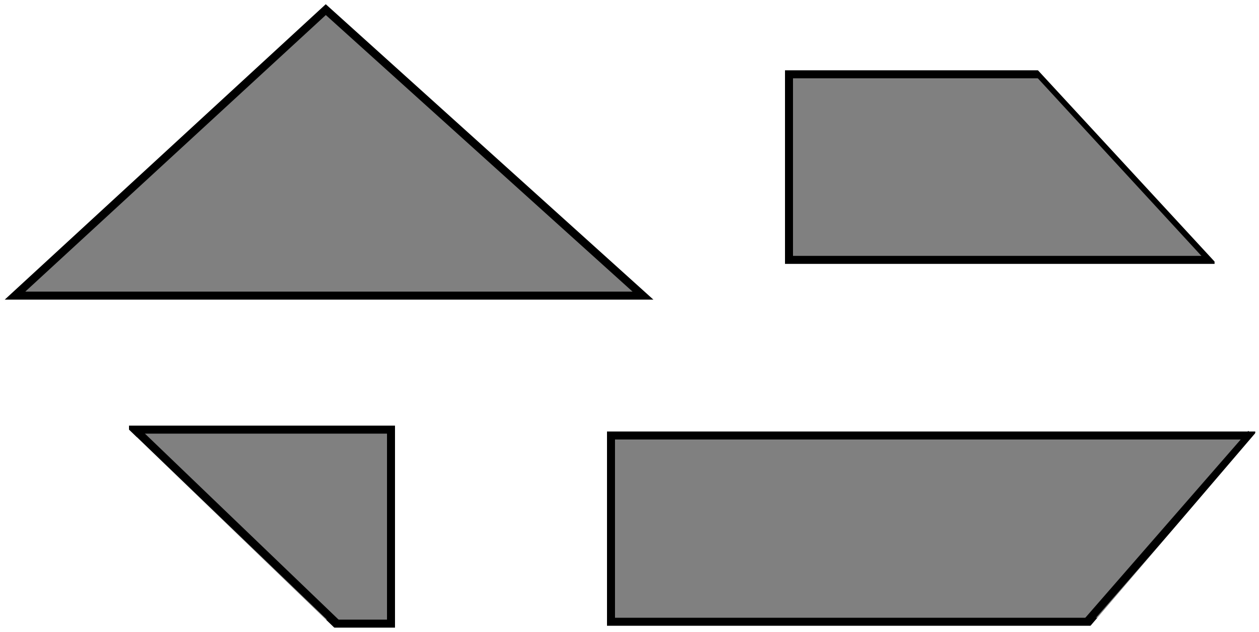
PUZZLE # 2: CORRECT EQUATION

Set up instructions: Arrange the matches into the equation that is shown below.
The Challenge: Move three matches to new positions to get a correct equation.
This puzzle can be solved in two different ways.
(Note: In Roman Numerals this says 7=1. However, one of the answers to this equation will be in all numbers, while the other answer will be in Roman Numerals.)

PUZZLE # 3: THE "M" PUZZLE

Set up instructions: Cut out the pieces below in order to complete this puzzle.

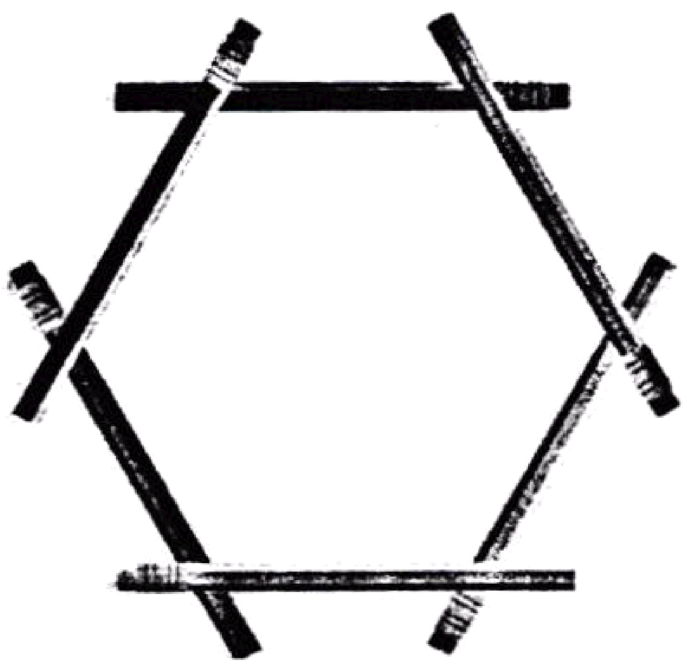
The Challenge: The objective is to make the shapes into a symmetric letter "**M**" for Mars. You are allowed to rotate the pieces as you wish and even turn them over, but they must not overlap each other in the final configuration.



PUZZLE # 4: THE SIX PENCILS

Set up instructions: Gather 6 pencils. It is as easy as that.

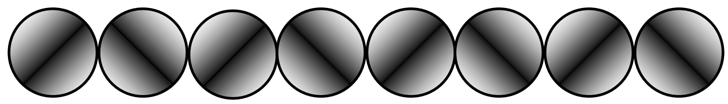
Challenge: It is possible to place six pencils on the table in such a way that every pencil touches two other pencils, as shown below. Your challenge is to figure out a way to place the pencils so that each pencil touches all five of the other pencils.



PUZZLE # 5: FOUR STACKS

Set up instructions: Place eight pennies in a row as shown below.

Challenge: The objective is to make **four** stacks of 2 coins each with only **four** moves. Every move consists of jumping a coin over two coins (*either coins in a stack or over a single coin*) in one direction and ending up on a coin after the jump (*note that spaces don't count as a coin*).



PUZZLE # 6: ADD IT UP

Set up instructions: Cut out the numbers below.

The Challenge: Place the numbers in the same formation grid that they were arranged in before you cut them out. Then, rearrange the numbers so that all the rows in every direction (vertical, horizontal and diagonal) add up to 15.

1	2	3
4	5	6
7	8	9

3-2-1 Pop! – An Effervescent Race

Adapted from NASA's "Rockets: A Teacher's Guide with Activities in Science, Mathematics, and Technology"

Why should your team do this activity?

A large part of the Mars Rover Competition, and science in general, is keeping a good lab notebook. A good lab notebook is a daily, detailed account of the design process that many scientists use in their work. If a scientist does not keep a good lab notebook, and one day makes a grand discovery, it is quite possible that the scientist will not fully understand exactly what happened. If the scientist kept really detailed, frequent records during his or her work, then a great discovery is more likely to be well understood. Your Engineering Team will want to keep good records of your Design Process too, because then you will be able to learn which designs worked and which did not, etc.

Engineering Design Process

What exactly is the Design Process, you ask? Well, the Design Process consists of the following steps: identify the problems, set the goals, brainstorm design ideas, select and construct a design, test and revise the model, and finally, present the final product. Let's go into a little detail about these steps:

(1) **Identify the problems**

You team will need to develop general statements or questions that will spell out what you need to do, and what you have to do it with. For example, a question could be - "How can we design a rocket from the given materials that can fly really high?"

(2) **Set the goals**

After you have a general idea about what your team needs to do, you will then need to break the general idea up into more specific tasks, or goals. Goals should be as specific as possible, and should address the general problems initially identified. For example, one goal could be "Our rocket will be able to fly as high as the ceiling."

(3) **Brainstorm design ideas**

The key to brainstorming is to remember that there are no bad ideas! Each idea, no matter how off-the-wall it seems, should be recorded during the brainstorming session. Try to be creative -- the more ideas generated, the more likely it is that a successful design will result! Ask your teacher for a jump start if you need help to get going.

(4) **Select and construct a design**

After the brainstorming phase, the team will need to decide which ideas it likes best, and then construct prototypes (original design) that turn these ideas into actual creations!

(5) **Test and revise the model**

After initial prototypes have been constructed, your team will need to thoroughly test them in order to see both their strengths and weaknesses. If something doesn't work the way you thought it would, you may want to look at that problem more closely, and set goals to tackle it. For example, you could ask items such as "How high does it fly?" and "Does it fly in a straight line?", and if it does not – you can look at ways of changing your design so it will. Make sure to keep using those brainstorming skills!

(6) **Present the final product!**

When your team believes it has a final product ready to go, it is time to present this product to the rest of the class and your teacher! Make sure your team includes all of the details of design and construction in your Notebook so that anyone else will be able to build the exact same rocket. You may want to draw a picture of your rocket, or even complete a verbal presentation about your rocket and how you designed it!

Okay…..so now we know about the process of doing great engineering work, so now what? This activity will walk you through the steps of the Design Process and the components of a good lab notebook, while you test how several factors affect the flight of a rocket. But before you start making rockets, you will need to read some background information about an excellent scientist named Sir Isaac Newton (he probably had a great lab notebook too!):

In a book published in 1687, Sir Isaac Newton stated three important principles that govern the motion of all objects. These principles are now known as **Newton's Laws of Motion**. Newton's Laws state:

- ★ **<u>Law 1</u>**: Objects at rest will stay at rest and objects in motion will stay in motion in a straight line unless acted upon by an unbalanced force
- ★ **<u>Law 2</u>**: Force is equal to mass multiplied by acceleration (F=ma)
- ★ **<u>Law 3</u>**: For every action there is an equal and opposite reaction

These principles are demonstrated when a rocket lifts off. To begin with, a rocket at rest is able to lift off because it is acted upon by an unbalanced force *(First Law)*. This force is produced by the thrust of the engines. The rocket then travels upward with a force that is equal and opposite to the downward force of the engines *(Third Law)*. The amount of force is directly proportional to the mass of fuel expelled from the rocket and how fast it accelerates *(Second Law)*.

Now it is time to conduct some research about your rocket's "fuel." Your rocket's base will be made of a film canister with a construction paper nose and fins attached. To make your rocket lift off, you will put some water and part of an antacid tablet in the canister, and then quickly put the lid on. Then just set it on a table and watch it go *(make sure to stand back so you don't get hit by the flying rocket)*! So exactly what is your "fuel?" The reaction that occurs between the water and antacid tablet acts as the rocket propellant, so the water and antacid tablet are your "fuel." Take a minute to read the following background information about rocket propellants:

As rocket propellants burn faster, the mass of the expelled gases increases. Also, the speed of the exhaust gases increases as they accelerate out of the rocket nozzle. Newton's Second Law of Motion states that the force or action of a rocket engine is equal to the mass expelled multiplied by its acceleration. Therefore, increasing the efficiency of rocket fuels also increases the performance of the rocket.

One method for increasing the efficiency of rocket fuels involves surface area. Expanding the burning surface increases the burning rate. This increases the amount of gas and acceleration of the gas as it leaves the rocket engine. In a liquid propellant rocket, liquid propellants spray into a combustion chamber to maximize their surface area. Smaller droplets react more quickly than do larger ones, increasing the acceleration of the escaping gases. How can you alter the surface area of your water/antacid tablet "fuel?" Another method for increasing the efficiency of rocket fuels involves temperature. In liquid propellant rocket engines, super cold fuel, such as liquid hydrogen, is preheated before being combined with liquid oxygen. This increases the reaction rate and thereby increases the rocket's thrust. How do you think this applies to your rocket's "fuel?"

Now your team is ready to follow the directions below for Propellant Research. The results of this experiment will help you design your rockets. Once you are satisfied with your Propellant Research results, continue with the directions for the Design Process. Have fun, and make sure to keep a great Lab Notebook!

The Necessities:

- A timer or watch with a second hand
- 4 Alka-Seltzer or other effervescent tablets
- Tweezers
- 2 beakers
- Warm and cold water
- Thermometer
- Canisters like old 35mm film canisters with internal sealing lids (usually the clear canisters)
- Construction paper
- Tape
- Scissors
- Paper towels
- Pens or pencils
- Your Engineering Challenge Lab Notebook

Directions for Propellant Research:

(1) Using construction paper, tape, and scissors, design a rocket by wrapping the paper around the outside of a film canister. The lidded end of the canister should provide the base for the rocket (it should face down). Try to create rockets of varying lengths and make sure to include a cone-shaped nose and fins on each rocket.

(2) Turn the rocket upside down and fill the canister 1/3 full of water.

(3) Drop in half an antacid tablet and *quickly* snap the lid on tight.

(4) Quickly stand the rocket on its base (lid down) on the floor or tabletop and stand back! Your rocket should launch in a matter of seconds!

(5) Your team should then conduct further launches to help you answer the following questions:

- ★ How does the amount of water placed in the canister affect how high the rocket will fly?
- ★ How does the temperature of the rocket affect how high it will fly?
- ★ How does the amount and surface area of the antacid tablet used affect how high the rocket will fly?
- ★ How does the length or empty weight of the rocket affect how high it will fly?

Directions for Design Process:

(1) At the top of a page in your Lab Notebook, write the date. On the next line, write the names of the team members present. On the following line, write "**3-2-1 Pop! – An Effervescent Race Activity.**" Now, you are ready to get started with the first step in the Design Process - ***identifying the problems***. Your questions should be general to begin with, and as you test and revise your designs, they will probably become more specific. A good question to start with may be "How can we design a rocket out of the given materials that can fly really high?

Write your questions in your Notebook, under the heading "**Step 1: Identify the Problems**."

(2) The second step in the Design Process is ***setting the goals***, so you will need to make another heading called "**Step 2: Set the Goals**" in your Lab Notebook. Under this heading, make a goal for each problem identified. Try to be as specific as possible. For example, a goal for the question in number one above could be "Our rocket will be able to fly as high as the ceiling."

(3) The third step in the Process is ***brainstorming design ideas***. What do you think you can do in the design of your rocket that would make it fly really high? Make a list of your ideas in your Lab Notebook under a heading called "**Step 3: Brainstorm Design Ideas**." You will need to brainstorm design ideas for each goal you create. If you're having trouble thinking of ideas, ask your teacher to help you get started.

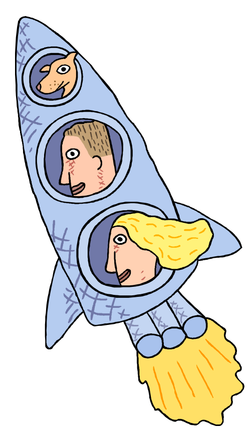
(4) Now for the fun part!! The next step is to ***select and construct a design***. Pick one of the designs you listed in your Notebook. Choose one member of your team to construct and test the design -- don't worry, everyone will get a turn! You will also need to select one team member who will take notes in the Lab Notebook about the chosen design.

(5) Using construction paper, tape and scissors, construct a rocket by wrapping the paper around the outside of a film canister. The lidded end of the canister should provide the base (bottom) of the rocket. Don't forget to include a cone-shaped nose and some fins on your rocket. Remember to follow the design idea that you chose from your list in the Lab Notebook!

(6) The team member who is taking notes should write down exactly how the rocket is being constructed. Write these under a heading called "**Step 4: Select and Construct a Design**." How long is the nose? What do the fins look like? Maybe drawing a picture would help. Remember to write neatly, so that anyone else on your team can understand exactly how to build another rocket identical to the one being built.

(7) Once the rocket has been built, it is time for the *really* fun part! Make another heading in your Lab Notebook called "**Step 5: Test and Revise the Model**." The rocket builder will test the rocket in Step 8, and the note-taker will take careful notes about how the rocket performs. How high does it fly? Does it fly in a straight line? Make sure to take good notes about the rocket launch!

(8) Now it is time to launch your rocket! Remember to have the note-taker take careful notes on this next part, too. How much of each ingredient is used? Does it fly straight? Remember to follow your design idea. The team member who built the rocket can now turn the rocket upside down, place some water and a piece of (or whole) antacid tablet into the film canister, and *quickly* snap the lid on tight (do **NOT** use more than <u>**one**</u> antacid tablet in your launch!). Then, *quickly* stand the rocket on its base (the lid side should be sitting on the floor or on a table) and make sure the whole team stands back to watch the launch!



(9) Wow – you launched! Did it go as you had planned? I bet you wish you could change a few things so it will be even better, right? That means it is time to revise your model. This process of ***testing and revising*** will probably take place many times before you reach your final goal. Think about your design and how it can be improved in order to reach your goal.

Make another list in your notebook of the new ideas that you brainstorm under a heading called "**Model #2**." Continue repeating the process *(take turns building and testing your rockets and taking notes in your Lab Notebook so it is fair to everyone on your team)* until you have reached your final goal. Your team might encounter new problems needing to be addressed. If you want, you can try to design a rocket that addresses those problems as well.

(10) Once the team feels that you have designed a rocket or rockets that accomplish your goals, it is time to ***present your final product!*** Make a heading in your Lab Notebook called "**Step 6: Present the Final Product**." Under this heading, draw (as neatly as you can) a diagram of your final rocket design. Include ALL of the details so that anyone who might pick up your Notebook can build the exact same rocket. You might even want to include a picture of your team with your creation! Be sure to share this part of your Notebook with your teacher so he/she can see how you followed the Engineering Design Process in order to create your final design. You might want to even practice giving a verbal presentation about your rocket to your teacher, since your team will also have to present about your Rover at the Engineering Challenge!

Earthling Exploration of Mars

Adapted from Thursday's Classroom activity "Red Planet Time Line" located at www.thursdaysclassroom.com/20jul01/teachtimeline.html

Why should your team do this activity?

Your Engineering Team will be taking on a challenging task in the next few months: designing and constructing a Rover that will be put through a series of demanding tests at the Design Competition. This is a big challenge, but don't feel overwhelmed! If your team divides this large task into many smaller tasks, you can easily focus on one small task at a time. Once one is complete, you can move on and tackle your next task. Before you know it, you will have an awesome Rover built! Quite an accomplishment!!

In this activity, your team will learn about the exploration of Mars. Then, the directions will help your team create a timeline that summarizes the Mars exploration you just learned about. A timeline is an organized way to list events according to when they happened or when they will happen. By looking at this timeline, you can quickly and easily see past events and current progress. Then you can use your new timeline-making skills to make your own timeline for designing and building your Rover. This timeline will help you focus on smaller tasks during the next few months, so that by the time the Design Competitions roll around, your Rover will be ready to go! Remember, a timeline is one of the requirements for your Engineering Challenge Lab Notebook, so we ***highly encourage*** you to complete this activity!

The Necessities:

- "The Earthlings Are Coming" story (see below)
- A ruler, a pencil, and some scratch paper
- Your Engineering Challenge Lab Notebook
- **Optional**: poster-sized paper or posterboard, and art supplies (paints, markers, construction paper, etc.)

Directions:

As a group, read the story called "The Earthlings Are Coming," which starts on page 30. You can either read it out loud, taking turns, or if your teacher wants to make a copy for each member of your team, you can read it individually. When everyone has finished reading the story, follow Steps 1-10 below as a group to make **A Red Planet Timeline** for your team's Lab Notebook.

(1) First, your team needs to choose roles before you begin to make a timeline. Choose one team member, the **Guide**, to read the following steps aloud to your team (start reading now ☺). Choose another team member to be the **Organizer**, who will write the timeline in your Lab Notebook. The remaining team members will be the **Timekeepers**, and will be in charge of the information that will go on your timeline.

(2) **Organizer**: Open your Lab Notebook to a blank piece of paper. Using a ruler and pencil, draw a 12-inch diagonal line on the paper. Write "**A Red Planet Timeline**" across the top of the paper.

(3) **Organizer:** Place a dot on the line you just drew at each inch mark on the ruler, starting with the 0-inch mark. When complete, you should have 13 dots.

(4) **Organizer:** Below the first dot, write the year "1890." Below the second dot, write the year "1900." Below the third dot, write "1910." Keep following this pattern until you have a year (in multiples of ten) written below each dot. Your last dot should be labeled "2010."

(5) **Timekeepers:** Get out your copy (or copies) of the story about the history of Mars exploration. Skim through and circle all the dates you can find. Also circle the dates that you can figure out (for example, where it may say, "seven months later…"). Slowly read these dates to your **Organizer.**

(6) **<u>Organizer</u>:** On scratch paper, make a list of the dates as your **Timekeepers** read them to you. Each date will have an event to go along with it on the timeline. Think about how you will fit this information on your timeline. You will have to keep your comments short since you do not have a lot of room. Will you write horizontally or vertically? Will you write near the line or write above and below the line and draw arrows to the date? The **Timekeepers** can tell you how much information goes along with each date. Brainstorm ideas with all of your team members. **<u>Plan this out before you start writing.</u>** Your timeline will have to be neat for others to read it, so you may want to practice on your scratch paper first.

(7) **<u>Organizer</u>:** Write "1892" on the time line where it belongs (on the timeline, it should be between 1890 and 1900 – closer to the 1890 mark). **<u>Timekeepers</u>:** What should the **Organizer** write there? How about "Lowell sees canals on Mars?"

(8) **<u>Organizer</u>**: Write "1907" on the time line where it belongs (between 1900 and 1910, right?). **<u>Timekeepers</u>:** What should the **Organizer** write there? Remember to keep it short so you do not run out of room!

(9) **<u>Organizer & Timekeepers</u>**: Continue working together within your roles to write all of the dates and events that were listed in the story on your timeline. Remember to be neat and brief!

(10) **<u>Guide</u>**: When the timeline is complete, slowly re-read the timeline to make sure it makes sense. Check the dates to see if they are correct and if they are in the right place on the timeline. Finished? Great! Now your whole team can make some drawings to decorate your timeline. Great work!

Now…..your team is ready to make a timeline for the Engineering Challenge: Mars Rover Challenge!

(1) First, your team needs to choose roles again, or if you want, you can stay in the same roles as before. You will need a **Guide**, who will read the following steps aloud to your team (start reading now ☺), an **Organizer**, who will write the timeline in your Lab Notebook, and several **Timekeepers**, who will be in charge of the information that will go on your timeline.

(2) **<u>Organizer</u>**: Open your Lab Notebook to **<u>the first page</u>**, and using the ruler and your pencil, draw a 12-inch diagonal line on the paper just like before. Write "**The Mars Rover Challenge 2007**" across the top of the paper.

(3) **<u>Organizer</u>:** Place a dot on your timeline at each inch mark on the ruler, starting with the 0-inch mark. When complete, you should have 13 dots.

(4) **<u>Organizer</u>:** Below the first dot, write the month "January." You should receive your Lego® kits by late January. Below the ***fourth*** dot, write "February." Below the ***seventh*** dot, write "March." Keep following this pattern until you have a month written below ***every third dot***. Your last dot should be labeled "May." This means that you will have *three inches* to write down all the information for *one month*. In other words, every inch represents about 10 days on your timeline.

(5) **<u>Timekeepers</u>:** Your job will be to lead your team during the next part in making your timeline. Your team needs to brainstorm about all of the things that you can think of that you need to do to have your Rover ready for the Design Competition. Get out some scratch paper and write down all of the ideas that your team thinks of. For example, one of the first things your team needs to do is inventory your Lego® kits! Other ideas include designing your Rover and making your Display for your Presentation. Write down all of your ideas. If you need help thinking of ideas, ask your teacher to help you get started.

(6) **<u>Organizer</u>:** Next, your team needs to choose the 12-15 most important things from your list. Read the whole list to your team, and ask your team to help you decide which are the most

important. Once you have chosen the most important things, which will be your "targets," you and your team will need to decide in what order you should complete these targets. Of course, some will overlap, and some will take a long time to finish. Just try to put your targets in a general order from start to finish. Once you have all agreed upon what order you will do your targets, make a list starting with your first target and ending with your last.

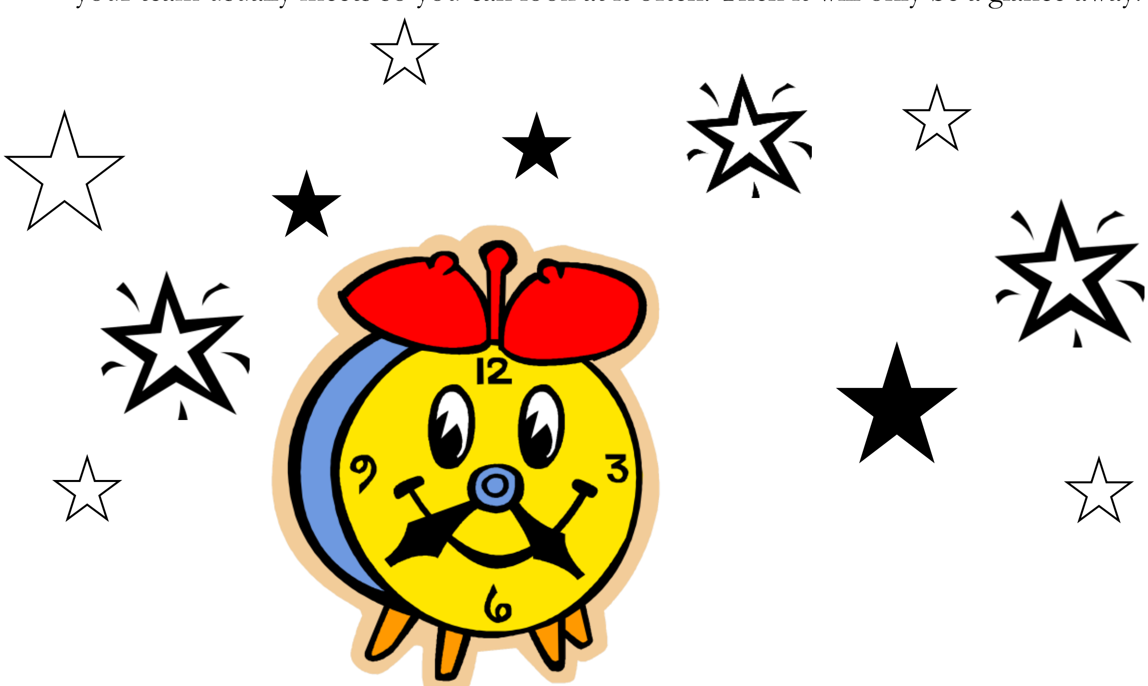
(7) **Timekeepers:** Now your team needs to set a date for when each target will be complete. For example, perhaps your team will decide that you want to inventory your Lego® kits by January 27th (the deadline is actually February 16th). Write the dates you choose next to each target on your list.

(8) **Organizer:** Now think about your list of targets. How you will fit this information on your timeline? Will you write horizontally or vertically? Will you write near the line or write above and below the line and draw arrows to the date? Brainstorm ideas with all of your team members. **Plan this out before you start writing.** Your timeline will have to be neat for others to read it, so you may want to practice on scratch paper first!

(9) **Organizer & Timekeepers**: Work together to place all of the dates and targets that are on the target list on your timeline. For example, if you want to inventory your Lego® kits by January 27, write "January 27" about halfway between the third and fourth dots on the timeline. Remember, each inch represents about 10 days. Write "Inventory Lego® kits" near January 27. Remember to be neat and brief!

(10) **Guide**: When the **Timekeepers** and **Organizer** are done with the timeline, slowly re-read the timeline to make sure it makes sense. Check the dates to see if they are correct and in the right place on the timeline. Finished? Great! Now your team has a game plan for the Engineering Challenge: Mars Rover Challenge! You know what you want to start with, and you know when you want to get that target done by! You can always refer to your timeline to see what you should be doing next. You just finished one of the requirements of your Notebook as well – Great Work!!

(11) Finally, decorate your timeline in your Lab Notebook. You may want to use the timeline in your Lab Notebook to make a bigger poster of this timeline to hang in your classroom or wherever your team usually meets so you can look at it often. Then it will only be a glance away!



The Earthlings Are Coming!

Do aliens chew gum? Are there other beings out there in the dark sky? And, as Bullwinkle would ask, "Are they friendly?" Many movies and books tell stories of bad aliens from other worlds taking over our planet. Those scary stories make you wonder: could it happen?

Mars is a hot spot when it comes to thinking about possible creatures from other planets. Since Mars is a neighbor to the Earth, scientists have been able to see it through telescopes more clearly than other planets. It is also an interesting and mysterious planet. Stories about invaders from Mars (like H.G. Wells' "*War of the Worlds*") are popular. Always looking for the truth, scientists have been studying Mars since Galileo invented the telescope in 1609.

Why Mars? Well, it is close and you can see it through a telescope. There have also been more exciting rumors spread about Mars than about other planets. These rumors started over one hundred years ago. An Italian scientist, Giovanni Schiaparelli, thought that he saw lines on the surface of Mars. That was 1877 -- and when the story was translated into English, someone translated a word wrong and said that the scientist had seen canals on Mars. At that time, we were building lots of big canals on our planet, too. Many people decided that creatures on Mars were designing and building canals of their own.

What were Martians doing with these canals? Another scientist, Percival Lowell, was very interested in Martian canals. In 1892, Lowell began a long series of observations of Mars. With his giant telescope in Arizona, he looked at Mars night after night. Watching Mars while most people sleep is not easy. Because we have so much water in our air, the view of Mars from Earth sometimes shimmers -- just like looking at something on the bottom of the pool. He would look through his telescope for hours and sometimes be rewarded with a clear view. Lowell excitedly announced to the world that there were indeed canals on Mars. Martians were probably using the canals to send water from the polar caps to the warmer areas around the equator of Mars, he said. He believed that Mars was a little like the Arizona mountains -- dry and cool, with thin but breathable air. Many people agreed with Lowell. In 1907, Alfred Wallace argued that Mars was too cold and dry for water. Wallace said that canals on Mars "would be the work of madmen rather than intelligent beings." Still, the idea that Martians were building canals was more popular.

Actually, there are no creatures building canals on Mars. We know that Lowell was wrong because scientists have continued to look for the Martians! Because it is so hard to get a good look at Mars from our planet, we Earthlings have sent spaceships to Mars for a closer look. In the 1960's, the Soviet Union, also known as Russia, sent 8 missions to Mars. Each mission had a problem and failed, but curious and determined scientists kept trying to find out more about Mars by sending more spaceships. In 1964, the United States tried to send a ship past Mars to take pictures, but the solar panels did not open; that little spacecraft is now in orbit around the Sun!

In 1965, a spaceship from the United States named Mariner 4 arrived at Mars! Mariner 4 was the first Earthling spaceship to reach Mars and send back pictures. Mariner 4 did not land on Mars, it flew close to the planet to get a good look (that's called a "flyby!"). Mariner sent 22 close-up pictures of the cratered red surface. These pictures did not show any dirt moving machinery for Martian canal building! Mariner 4 also told us that there was hardly any air pressure on Mars (air pressure is the weight of all the gases in the air pressing down on you). One really interesting part about the Mariner mission is that after the ship had left Earth, the scientists on Earth sent messages to the ship to change the program. Back then, changing the program directions in flight was a big, new idea.

Four years later, two other Mariner missions arrived at Mars. These ships also did not land, but took close pictures and measurements of Mars. Mariner 6 and Mariner 7 each took more than 200 pictures of Mars, measured the temperature of the surface, examined the atmosphere of Mars to see what was in it, and measured the air pressure. The Mariners found that there was carbon dioxide ice (like dry ice), water ice clouds, carbon monoxide, some hydrogen, and a little oxygen. There was no nitrogen or ozone. This was a lot of new information about the Red Planet, but scientists needed even more before they could send a ship to land on Mars.

In 1971, Mariner 9 made it to Mars (Mariner 8 unfortunately fell into the Atlantic Ocean), ready to orbit for 349 days. Mariner 9 sent more than 7,000 pictures back to Earth. This spacecraft took pictures of 80 percent of the planet. The pictures showed that Mars had many interesting places to explore: there were old riverbeds, craters, canyons, volcanoes and plains. The weather was also diverse, with dust storms, weather fronts, ice clouds, and even morning fogs.

None of these pictures showed canals or Martians. Scientists interested in life on Mars began to think microbiotic life on the Red Planet was more likely than little green men! Microbiotic life means living creatures that are so tiny you need a microscope to see them. For example, there are many microbes living right now in your mouth! Scientists began to study Earth microbes that could live in places as cold and dry as Mars. Some scientists have gone to Antarctica to study the microbes there. Another scientist, Carl Sagan, imitated the conditions of Mars in "Mars Jars" and threw in some Earth microbes to see if they could live. Some of them did! Even though there were no big Martians in the pictures from the Mariner spacecraft, scientists were very curious to see if there were any teeny-tiny Martian creatures living there.

The cameras on Mariner 9 taught us lots -- enough that scientists were able to design missions to land on Mars. The first mission to land on Mars was sent out by the United States in 1975. This was the Viking mission. This mission had two spacecraft: Viking 1 and Viking 2. Each of the spacecraft contained one ship to orbit the planet and another ship to land on the surface. The Viking 1 orbiter took more pictures to help find a good landing site. The Viking 1 lander separated and landed at Chryse Planitia in July 1976. Later in 1976, the Viking 2 lander touched down at Utopia Planitia. The landers took color pictures of the planet and did experiments to look for microbiotic life in the soil. The experiments were inconclusive because Mars dirt is so different from Earth dirt. But most scientists agree that the landers did not find signs of life.

Scientists kept studying the pictures and facts sent back by the Viking landers. They needed more information! But what was the best way to get it? After many years, NASA developed the Pathfinder mission. Pathfinder was designed to show that a low cost mission could land on and explore the surface of Mars. Mars Pathfinder was launched on December 4, 1996. Seven months later, it reached Mars. The experimental landing was thrilling. As Pathfinder entered the atmosphere, a parachute opened to slow the ship down to about 70 meters per second. The heat shield came out and then about 10 seconds before landing, four air bags inflated! Finally, three rockets fired to slow the fall. The lander dropped to the ground and bounced about 16 times before stopping. The lander then went to work. It opened up its solar panels and started to measure the atmosphere and take pictures.

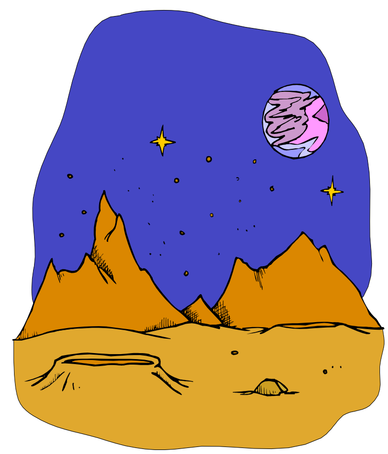
Inside the lander was a tiny remote-control jeep called Sojourner designed to explore the surface of Mars. The scientists sent the signal for this little rover to roll out and nothing happened! The rover was stuck! How could they get it out? After working on the problem for two days, the rover finally rolled out and started to explore the surface. The rover sent information back to the lander, which relayed the data to Earth. The rover and the lander continued to send information back for 5 months. On November 7, 1997, the mission was declared over.

Just as that mission ended, Mars Global Surveyor was launched to the Red Planet. The name 'Global Surveyor' describes the job of this spacecraft. It flies all around Mars taking many pictures and measurements. It has been taking pictures since 1997. Mars Global Surveyor recently took some pictures that really surprised scientists. The pictures did not show Martian-made canals, but they did show something almost as surprising. There are gullies on Mars! Gullies are ditches caused by flowing water. How could Mars have gullies if there is no water to be found on the surface of the Red Planet? This mystery is exciting! And if there is water, could there be tiny microbes living in there, as on Earth? Scientists are eager to find out.

In 1999, NASA sent two more spacecraft to Mars, but both of them crashed. Scientists figured out what happened, and in April 2001 they were ready to try again. NASA launched another orbiter, called 2001 Mars Odyssey. 2001 Mars Odyssey is carrying instruments to study what Mars is made of and what its radiation environment is like, and is still in orbit around the Red Planet.

At present, NASA is also participating in an international mission called Mars Express. In 2003, a spacecraft was sent to orbit Mars. The orbiter is exploring the planet's atmosphere and is looking for water below the planet's surface.

NASA also sent two small rovers to Mars in the year 2003, which landed on different parts of the planet. Each of these little rovers has been able to travel further in a single day than the Sojourner rover could during its whole lifetime! The rovers, called Spirit and Opportunity, landed on Mars almost the same way that Pathfinder did. They are still exploring the planet, looking for water and signs of life. Water is important because life *(as we know it)* depends on water. People who travel to Mars will need water as well.



There are several other current Mars missions, such as the Mars Reconnaissance Orbiter which launched in the summer of 2005. This orbiter is taking the best-ever pictures of the surface of Mars. Ideally, NASA would like to send a spaceship to Mars every 26 months. That's how often Earth and Mars are close together.

If our missions go well, one day human astronauts will land on Mars! Then, will we be able to look at Mars through telescopes and finally see canals? Will people who explore Mars be called Martians? Are there little microscopic bugs living on Mars? It will take years of hard work and good thinking to answer these questions. Until then, keep your eyes on the Red Planet!

Engineering Challenge Website Activity

Why should your team do this activity?

The Academic Rodeo Engineering Challenge page on the website contains all of the information your team needs to take on the Mars Rover Challenge. By knowing how to use the site, your team will be able to find answers to your questions anytime during the day. Work through this activity as a team, and then spend some time on your own to check out the site so you know how to use it!

The Necessities:

- One computer with any Internet browser
- Pen or pencil
- Engineering Challenge Lab Notebook

Directions: Gather the materials listed above and open a browser on your computer. Type the following address **http://www.etstatefair.com/p/207** in the location field at the top of the screen. Navigate through the web site by following the instructions within the activity and try to answer all of the questions. Now...go ahead and start!

Question #1: *Who serves as a Support Partner to Academic Rodeo for the Engineering Challenge?*

Question #2: *How many pie charts do you need to include?*

Question #3: *How much time is allowed for Weigh-in and the Incline Test?*

Question #4: *Who is allowed to help your engineering team design and construct your team's Rover?*

Question #5: *What is the maximum amount of money your team may spend on additional Lego® parts?*

Question #6: *How many Lego® motors and battery boxes is your team allowed to use?*

Question #7: *Where can you find information about how your team's Rover is scored at the Engineering Challenge?*

Question #8: *In what seven areas is your team's Rover scored?*

Question #9: *What information should be included in your team's display and presentation?*

Question #10: *What awards are presented at the Engineering Challenge?*

★ Tricky Description ★

Briefly describe what your **Team** needs to do in Engineering Challenge.

PSST!!! If you were not able to answer all of the questions, there are some hints on the next page!!!

Hints to Questions:

1. Engineering Challenge page
2. Contest Manual
3. Contest Rules
4. Contest Manual
5. Contest Manual
6. Contest Manual
7. Engineering Challenge Scoring
8. Engineering Challenge Scoring
9. Engineering Challenge Scoring and Contest Manual
10. Engineering Challenge page

Tricky Description: "The Challenge"

Pepsi on Pluto – Weighing In & Growing Old

Why should your team do this activity?

This activity will help you understand the differences in gravitational fields among the planets of our Solar System. Scientists must take into consideration the effects of gravity while designing spacecraft such as a rover destined for Mars. How will gravitational fields different than that of the Earth affect the rover's mobility? How will the difference in gravity affect the rover's ability to sample Martian rocks?

Additionally, you will learn about how the length of the year, or a single revolution of a planet around the Sun, varies for different planets. Scientists must consider the length of planets' orbits while planning missions.

Background Information:

An object or person's weight on a planet is based on the strength of that planet's gravitational force pulling on it. The amount of matter that makes up the planet and the planet's size (diameter) determines how much gravitational force it has. As future astronauts venture to the other bodies in our Solar System, they will experience different "pulls" of gravity. This change in the pull of gravity will result in a change in an astronaut's weight. For instance, an astronaut who weighs 180 pounds on the Earth will weigh only about 29 pounds on the Moon. On Mars, the same astronaut will weigh approximately 68 pounds.

Your age is determined by the length of an Earth year (the time it takes for Earth to complete one revolution around the sun). Your age on another planet would be determined in a similar manner. Therefore, if you were on a planet that required less time to travel around the Sun, a year would be shorter relative to Earth. If you were on a planet that required a greater amount of time for a single revolution around the Sun, a year would be longer.

The Necessities:

- Pepsi cans filled with different amounts of pennies
  (your teacher will prepare these for you)
- *Planetary Data* table (on page 60)
- *Multiplication Factors* table (on page 60)
- Computer with Netscape Navigator or Explorer (or any Internet browser)
- Pen or pencil and paper
- Calculator
- Your Engineering Challenge Lab Notebook

Directions:

Your teacher will guide you through this activity – directions for the activity are in your teacher's edition of the Student Activity Book.

Planetary Data Table

Planet	Diameter	Length of One Revolution (Earth Time)
Mercury	3,025 miles	88 days
Venus	7,502 miles	224.7 days
Earth	7,909 miles	365 days
Mars	4,212 miles	687 days
Jupiter	88,784 miles	11.86 years
Saturn	74,400 miles	29.48 years
Uranus	32,116 miles	84.01 years
Neptune	30,690 miles	164.1 years
Pluto	2,170 miles	247.7 years
Moon	2,155 miles	n/a

Multiplication Factors Table

Planet	Weight Factor	My Weight on Planet:	Age Factor	My Age on Planet:
Mercury	0.38 X my weight	=	4.200 X my age	=
Venus	0.91	=	1.600	=
Earth	1.00	=	1.000	=
Mars	0.38	=	0.530	=
Jupiter	2.53	=	0.080	=
Saturn	1.07	=	0.030	=
Uranus	0.92	=	0.010	=
Neptune	1.18	=	0.006	=
Pluto	0.03	=	0.004	=
Sun	27.8	=	n/a	n/a
Moon	0.16	=	n/a	n/a

You may want to record everyone's answers in your Engineering Challenge Lab Notebook!

Hangin' out on Mars!?!

Why should you complete this activity?

How much do you know about Mars? How similar and/or different is it in comparison to the Earth? Scientists believe that people will live on Mars by the year 2036. Using what scientists know about Mars, **what do you think Mars is like?** Hopefully, this activity will help you create an image of Mars using the data that scientists have collected in order to understand the physical properties of Mars.

The Necessities:

- Calculator
- Scratch paper
- Road atlas
- Pen or pencil
- Your Engineering Challenge Lab Notebook

Directions: Check out the data tables that list the physical properties of both Earth and Mars. Work together to answer the questions that are located after the data tables. Have fun!

Physical Properties:

Measurement	Earth	Mars	Convert both Earth & Mars data to:
Average Distance from the Sun	149,597,890 km	227,936,640 km	Earth =__________miles Mars =__________miles
Equator Diameter	12,756 km	6,974 km	Earth =__________miles Mars =__________miles
Polar Diameter	12,718 km	6,744 km	Earth =__________miles Mars =__________miles
Mass	5.97×10^{27} g	6.4×10^{26} g	Earth =_________pounds Mars =_________pounds
Maximum Surface Temperature	331 K	293 K	Earth =______degrees C Earth =______degrees F Mars =_______degrees C Mars =_______degrees F
Minimum Surface Temperature	184 K	133 K	Earth =______degrees C Earth =______degrees F Mars =_______degrees C Mars =_______degrees F

Other Physical Properties to Note:

Measurement	Earth	Mars	Convert both Earth & Mars data to:
Rotational Period *(planet spins on its axis)*	1.0 day	1.02 days	How many hours for Earth?___ For Mars?___
Orbital Period *(planet revolves around sun)*	365.26 days	686.98 days	How many years for Earth?___ For Mars?___
Density	5.52 g/cm^3	3.94 g/cm^3	Earth = 0.197 lbs./in^3 Mars = 0.141 lbs./in^3
Escape Velocity at Equator *(speed at which you can "escape" from a planet's atmosphere)*	11.2 km/sec^2	5.02 km/sec^2	Earth = 6.94 miles/sec^2 Mars = 3.11 miles/sec^2
Gravity *(how fast objects fall to ground when dropped)*	980 cm/sec^2	371 cm/sec^2	Earth = 0.0061 miles/sec^2 Mars = 0.0023 miles/sec^2

Atmospheric Components:

Element/Compound	Earth	Mars
Nitrogen	78%	3%
Oxygen	21%	0.1%
Carbon Dioxide	less than 1%	95%
Water Vapor	less than 1%	0.03%

Conversion Factors:

Metric Unit	Conversion
1 kilometer (km)	0.62 miles (m)
1 gram (g)	0.035 ounces (oz.) -- How many ounces in a pound (lbs.)?
1 centimeter (cm)	0.394 inches (in)
1 Kelvin (K)	Celsius (C) -- subtract 273 from Kelvin
1 Kelvin (K)	Fahrenheit (F) – Convert to C, then multiply by 9/5 and add 32
1 day (d)	24 hours (hr.) – how many seconds (sec) in an hour?
1 year (yr.)	365 days (d)

Questions: Remember there are ***not*** always correct answers to questions. Please use the information in the data tables <u>and</u> your imagination to create logical and creative responses to the questions. Place the responses in your Engineering Challenge Lab Notebook. Remember -- scientists do not always have ***answers***; rather, they carefully examine the data (or information) and develop ***ideas*** based on that information.

(1) What do the letters mean that are listed after the numbers in each column? *(The letters are called metric units)*

(2) Using the information in the Physical Properties and Conversion Factors tables, convert each number from Metric units to English units.

For example:
10 kilometers = 6.2 miles. This means that for every 1 kilometer, there are 0.62 miles in that kilometer. Therefore, you must multiply the number of kilometers by 0.62 to convert the kilometers to miles.

Here is the math:
1 km x 0.62 miles = 0.62 miles
10 km x 0.62 miles = 6.2 miles

(3) Why do you think scientists use the Metric system? Is this system easier to use than inches, feet, and miles? *(Look at a ruler and observe how millimeters and centimeters relate to one another)*

(4) Astronomers use the radius of the Earth's orbit (149,597,890 kilometers) as a handy "yardstick" to measure other distances in the solar system. They call it 1 Astronomical Unit (abbreviated 1 AU). On the average, Mars is 227,936,640 kilometers from the Sun. How many Astronomical units is that?

HINT: Divide 227,936,640 kilometers by 149,597,890 kilometers.

(5) Pluto is the farthest known planet. Its average distance from the Sun is about 5,920,000,000 kilometers. How many Astronomical Units is that?

HINT: Divide 5,920,000,000 kilometers by 149,597,890 kilometers. The first number may be too big for your calculator. No problem! Just think of it as 5,920 million kilometers, and divide by 149 million kilometers. That's the same as dividing 5,920 by 149.

(6) If you plan to travel 240 kilometers at an average speed of 80 kilometers per hour, how long will your trip last? Use the fact that **the time anything travels is equal to the distance it travels divided by the speed.**

HINT: Divide distance (240 kilometers) by speed (80 kilometers per hour)

(7) On Mars, the Sojourner Rover only went about 24.4 meters per hour (Why so slow? To keep out of trouble, and because Sojourner only has about 60 watts of solar power). How long would it take the rover to move 48.8 meters?

HINT: Divide distance (48.8 meters) by speed (24.4 meters per hour).

(8) Now, let's go a little faster! Pathfinder traveled just over 499,000,000 kilometers along its curved orbit to get to Mars. How long would it take to fly that far at the average speed of a passenger jet, about 960 kilometers per hour?

HINT: Divide distance (499,000,000 kilometers) by speed (960 kilometers per hour). This will give you how long it will take in hours. Divide the length of time in hours by 24 hours per day to get the number of days it will take. Then divide the number of days it will take by 365 days per year to get the number of years it will take. Now you have your final answer!

(9) Now let's try the fastest speed in the universe! When Pathfinder landed on Mars, it was 194,000,000 kilometers from Earth. The spacecraft communicated using radio waves, which travel at the speed of light – 300,000 kilometers per second. How long did it take Pathfinder's first message from Mars to reach the Earth?

HINT: Divide the distance to Mars (194,000,000 kilometers) by the speed of light (300,000 kilometers per second). Divide your answer by 60 seconds per minute to get your answer in minutes.

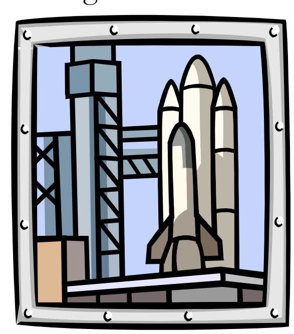
(10) What do the numbers reveal about the differences between Earth and Mars? – Earth and Mars have different values for gravity. Do you think you would be able to stand on the Martian surface? How many times can you travel to Disneyland to cover the same distance around Mars?

HINT: Use an atlas to measure the distance from your school to Disneyland, then compare it to the equator diameter of Mars.

(11) Using the tables on the previous pages, how do the physical properties of Earth compare with those of Mars?

(12) Pretend your Engineering Team is traveling to Mars. What do you think it will be like according to the information listed above? What will you bring? What would you wear? Could you breathe on Mars? What other information would you like to know before you left for the trip?

(13) Your Engineering Team will be designing a Mars Rover for the Engineering Challenge: Mars Rover Challenge. If you were really going to send your Rover to Mars, what types of things would you have to consider while designing and building your team's Rover?



(14) How could you test the Rover on Earth before it is sent to Mars?

★ **Remember to write down the answers and your ideas in your team's Engineering Challenge Lab Notebook!**

Mars in Reverse

Adapted from the Athena Mars Exploration Rovers web site located at athena.cornell.edu/kids/home_03.html

Why should your team do this activity?

Early astronomers believed that as Mars moved through its orbit, it would stop, go in reverse, and then go forward again. Today, that sounds like a crazy way for a planet to move, but that's still the way it looks from Earth despite the fact that we now know Mars travels in an elliptical orbit around the Sun without backing up. Why does Mars appear to go backwards? Try this simple activity, and you'll soon find out!

The Necessities:

- Your Engineering Challenge Team split into groups of two (pairs)
- A bike, pair of inline skates, or skateboard
- A helmet for the person riding the bike, inline skates, or skateboard
- Your Engineering Challenge Lab Notebook

Directions:

(1) Go to your school's playground or a park and find a long, clear straightaway with few pedestrians.

(2) Have one person in each pair put on inline skates, or get your bike or skateboard ready. The other person in each pair will remain on foot.

(3) Pick a starting point and ending point on the straightaway, and then find a stationary object in the middle of the straightaway to focus on.

(4) Both members of each pair should begin at the starting point, and the person on foot should then begin walking forward at a steady pace towards the ending point. While walking, this person should focus on the middle point. After the person on foot has walked a bit (but NOT past the middle point) the person on wheels should begin moving forward, slightly slower than the person walking, while focusing on the middle point.

(5) The person on wheels should keep their eyes on the middle focus point, and then speed up and pass their walking partner. What do you think they will see?

What did you see?

Your walking partner never stopped moving forward, but from your point of view, he or she appeared to back up! The same thing happens when Earth moves faster and passes Mars on its way around the Sun – Mars only *appears* to go in reverse. This type of apparent motion is called retrograde motion. The odd retrograde motion of Mars helped to clue some astronomers into the flaws inherent in some early models of the Solar System – why would this one planet go backwards for such a short period when the others move steadily in one direction? Mars going in reverse may have put astronomy in fast-forward!

Crater Creation

Adapted from "Exploring Space & Cyberspace: Live From Mars" Resource Book and NASA's "Mars Activities: Teacher Resources and Classroom Activities – Mud Splat Craters" located at mars.jpl.nasa.gov/classroom/pdfs/MSIP-MarsActivities.pdf

Why should your team do this activity?

What does a crater look like? What happens to a planet's surface during an impact? What are the features created during an impact? How do mass, velocity, size of the projectile, angle of approach, and type of surface material at impact affect how the crater looks? This activity will help you find out the answers to these questions and more.

Background Information

Almost all objects in the Solar System that have solid surfaces (including planets, satellites, and asteroids) have craters. While a few are of volcanic origin, most are the result of impacts from space. Much of the cratering we see dates back to a "period of bombardment;" in the early days of the Solar System, the gravitational pull of larger bodies attracted smaller objects causing the small objects to crash into these bodies. This process has been important in the evolution of the planets. Cratering caused early melting of the planets' crusts and excavated fresh sub-surface material. Impacts from space continue, but at a slower rate. A recent example is the collision of Comet Shoemaker-Levy 9 with Jupiter in July 1994.

Impacts are caused when meteoroids strike a planet or other object in space. A meteoroid is a particle of rock traveling through space. Size can range from microscopic to several meters across. The average size of the meteors we see at night (shooting stars) are probably no larger than a grain of sand. Speeds of meteoroids can exceed 50,000 miles per hour.

When we do see a streak of light in the night sky, which we call a meteor, it is caused by a meteoroid entering the Earth's atmosphere and vaporizing in a flash of light. The heat of friction between the meteoroid and the Earth's atmosphere produces the light. When a meteoroid actually strikes the Earth, it is known as a meteorite. On impact, large meteorites leave craters and may bury themselves deep in the ground.

The Earth, our Moon, and the planet Mars all bear the scars of impacts from space, but the Moon and Mars have many more craters than Earth. This is partly because water covers almost three-fourths of our planet, and partly because geologic processes like crustal movements and wind and weather have eroded most of the Earth's craters over time. There is no atmosphere or plate tectonics on the Moon, where many craters are visible. Many lunar craters still have steep walls and are very rugged in appearance--evidence of the lack of weathering.

Mars occupies a middle ground between the Earth and the Moon in terms of craters. Widespread cratering is visible, but more craters are seen in Mars' southern hemisphere than in the north. Since the bombardment was presumably uniform across the planet, the relative lack of craters in the north correlates well with the evidence of geological activity we can see in the region (faulting, uplifting, volcanism and flooding). Also, Martian craters show the effects of weathering. They are shallower, have lower rims, and look much less rugged than most lunar craters.

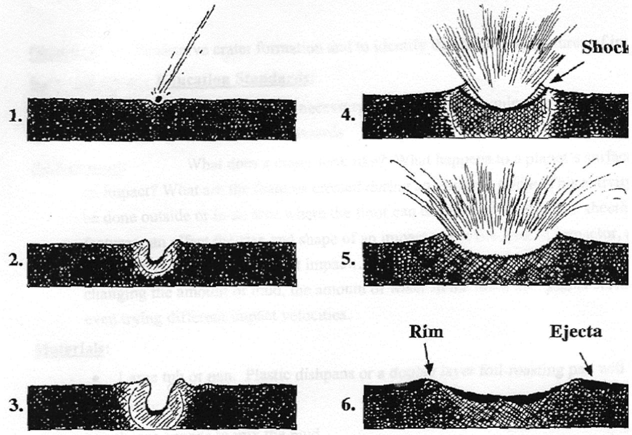


Illustration 1: This diagram shows the stages of an impact of a crater. Used by permission *CRATERS!* by William K. Hartman with Joe Cain.

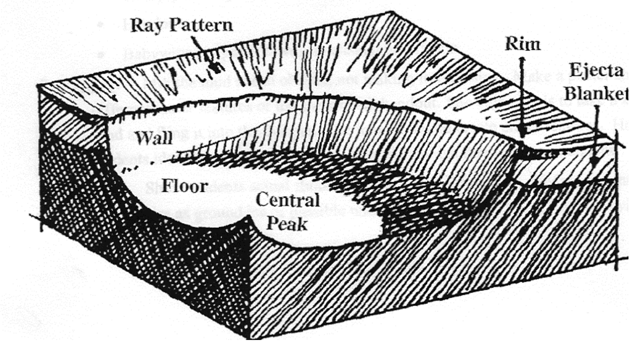


Illustration 2: This diagram shows the features created by an impact crater. Used by permission of *CRATERS!* by William K. Hartman with Joe Cain.

It is time to make some craters!

The following activity will allow your team to explore how numerous variables influence crater formation: the size of the meteoroid, the speed of the meteoroid, the mass of the meteoroid, and the angle of impact.

Make sure to look at the parts of a crater in this picture – it will be important later in the activity!

- Flour and Cocoa
- Fairly clean dirt
- 3 balls the same size (approx. 1" across) but of differing weights / masses
- 3 marbles/balls of different sizes
- Large tub or pan *(plastic dishpans or double layer foil roasting pans work best)*
- Plastic sheeting *(to keep the floor clean if you're inside)*
- Aprons or old front button shirts *(to protect clothes)*
- Water pitcher filled with water *(to create mud)*
- Large spoons to mix the mud and sturdy plastic spoons
- Ruler and meter stick
- Baby wipes or paper towels to clean mud off skin
- Broom and dustpan
- Crater Creation Answer Sheet (on page 46)
- Pens, Pencils and Engineering Challenge Lab Notebook

Directions:

(1) Fill the large tub or pan with flour approximately 3" deep, sprinkling a little cocoa on the surface to help make the changes more visible.

(2) Form a hypothesis about each cratering test prior to conducting the tests described in Step #3 and Step #5 (there are a total of 5 tests).

(3) With your teacher or parent's help, conduct the four cratering tests described below. Choose one team member to record measurements and observations. Choose another team member to drop the balls / marbles / mud into the tub. One to two team members can describe the resulting crater to the recorder. Finally, one to two team members can measure the crater diameters. You may want to switch roles between each experiment. After each crater test, smooth out the flour and sprinkle additional cocoa on the surface before you conduct another test.

Experiment #1: How mass affects impact craters

- ★ Using the 3 balls that have the same size but differing masses, drop the first ball into the flour from a height of 2 meters. Record the diameter of the crater created.
- ★ Repeat the process with the remaining 2 balls. Be sure that each ball is dropped from the same height above the box.

Experiment #2: How velocity affects impact craters

- ★ Using the largest marble, drop it into the flour from a height of 10cm. Record the diameter of the crater created.
- ★ Repeat the process with the same marble dropped from 1 meter above the box and 2 meters above the box.
- ★ From a height of 2 meters above the box, *throw* the marble into the box and record the diameter of the crater created.

Experiment #3: How size of projectiles affects impact craters

- ★ Using the 3 different sized marbles, drop the smallest marble into the flour from a height of 2 meters. Record the diameter of the crater created.
- ★ Repeat the process with the remaining 2 marbles. Be sure that each marble is dropped from the same height above the box.

Experiment #4: How angle of approach affects impact craters

- ★ Using the largest marble, throw it into the flour with a moderate amount of force. Record the shape and diameter of the crater created.
- ★ Using the same marble and the same amount of throwing force, repeat the process while varying the angle of the marble's approach. Be sure that the height from which the marble is thrown remains constant.

(4) Now you will try making craters in a different medium - mud! Be sure you do this part of the activity outside or in an area where the floor can be covered with plastic sheeting. Also, wear aprons or old shirts over your clothes to keep them clean!

(5) Empty your tub or pan of flour. Mix the dirt with some water in the tub or pan to create mud. Be careful not to add too much water – you don't want the mud to be soupy! Then conduct the fifth experiment below.

Experiment #5: How the type of surface material affects impact craters

- ★ Scoop a spoonful of mud out of the pan.
- ★ Carefully fling the mud back into the box.
- ★ Record the diameter of the crater created. Repeat this several times.
- ★ How do these craters compare to the craters you created in the flour?

(6) When you are done with all five tests, compare your results with your five original hypotheses. Form a statement for each test that explains your results, and record this information in your Lab Notebook. Ask your teacher for help with this if you get stuck.

Crater Creations Answer Sheet

Experiment # 1: How Mass Affects Impact Craters

How do you determine an object's mass?

State your hypothesis (What do you think will happen?):

Record the following:

Mass of Ball 1:_________________ Diameter of Crater 1:__________________

Mass of Ball 2:_________________ Diameter of Crater 2:__________________

Mass of Ball 3:_________________ Diameter of Crater 3:__________________

Experiment # 2: How Velocity Affects Impact Craters

What does velocity mean?

State your hypothesis:

Record the following:

Diameter of crater 1 when ball is dropped from 10 cm: ___________________________

Diameter of crater 2 when ball is dropped from 1 meter: ___________________________

Diameter of crater 3 when ball is dropped from 2 meters: ___________________________

Diameter of crater 4 when ball is thrown from 2 meters: ___________________________

Experiment # 3: How Size of Projectiles Affects Impact Craters

State your hypothesis:

Diameter of crater created by smallest ball: ___________________________

Diameter of crater created by medium sized ball: ___________________________

Diameter of crater created by largest ball: ___________________________

Experiment # 4: How Angle Affects Impact Craters

State your hypothesis:

Diameter of crater when ball is thrown from above: ___________________________

Diameter of crater when ball is thrown from ____angle: ___________________________

Diameter of crater when ball is thrown from ____angle: ___________________________

Experiment # 5: How the type of surface material affects impact craters:

State your hypothesis:

Diameter of crater(s) when mud is flung with spoon: ___________________________

General Observations about craters in mud versus craters in dry sand/dirt:

The Winds of Change

Adapted from the Athena Mars Exploration Rovers web site located at athena.cornell.edu/kids/home_07.html

Why should your team do this activity?
The Martian surface can be very windy and often experiences huge dust storms. These Martian winds and dust storms alter how Mars appears to observers here on Earth. This experiment will show you how the weather affects the way Mars appears, and how wind and weather can change the surface of the planet.

The Necessities:

- Red, brown, or orange modeling clay
- A tray or cookie sheet
- Sugar
- Pen or pencil
- Engineering Challenge Lab Notebook

Directions:

(1) Use a spoon to spread a thin layer of modeling clay over the surface of the tray, making bumps to represent the surface of Mars.

(2) Evenly sprinkle some sugar over the clay.

(3) In the next step, you will blow across the landscape. What do you think will happen? How much sugar will move? What will it look like while it's in the air, and after it has settled? Write down some of your ideas in your Lab Notebook.

(4) Experiment with blowing across your Martian landscape and watching the effect of the moving sugar and the patterns that are formed when the sugar is allowed to settle.

What did you find?

The winds on Mars are fast and furious enough to keep the dusty sand forever suspended in the air – turning the sky a pinkish-peach color. All that wind not only moves the sand and soil from place to place, but also reveals and hides features on the surface of the planet that astronomers try to spot. How do you think Martian winds might affect the exploration of Mars?

Martianscape

Adapted from the Athena Mars Exploration Rovers web site at athena.cornell.edu/kids/home_02.html

Why should your team do this activity?

There was once water on Mars – that much is certain. How do scientists know that? They have seen channels on the Martian surface that are believed to have been created when water was in abundance sometime in Mars' past. Here's a way to create your own Martian channels and discover how after the water is gone, the effects of erosion (the slow wearing away of soil) are long-lasting.

The Necessities:

- Aluminum cookie sheet
- Plaster of Paris
- Paper cups
- Popsicle sticks
- Pitcher filled with water
- Sand
- Pencil or pen
- Engineering Challenge Lab Notebook

Directions:

(1) Fill the aluminum cookie sheet with plaster and use a Popsicle stick to smooth it.

(2) Poke several holes in the bottom of a paper cup (have your teacher help you).

(3) In the next step, you will put water in the cup to simulate rainfall and watch how the water washes the plaster away. But first, your team should make some predictions. Think of a few different types of rainfall you can do with your paper cups. Will more plaster be washed away with bigger "raindrops" *(you might want to poke different types of holes in several paper cups)*? Will more plaster be washed away if it "rains" at different angles to the surface (by tilting the tray)? Write these predictions down in your Lab Notebook.

(4) While positioning the tray at an angle, pour water from the pitcher into the cup, allowing it to "rain" down on your Martian landscape. Experiment with the different types of precipitation that you made predictions about. Mark the cookie sheet near where you "rained" a certain type of raindrop so you do not forget later.

(5) In the corner, make a small channel with your Popsicle stick.

(6) Sprinkle sand over the surface when you're done and allow the plaster to dry for a few days. Compare and observe the different channels. Make notes in your Lab Notebook about the different structures formed by the "rain."

(7) For a final touch, paint your Martianscape!

What did you find?

The channels you created with water look smoother and rounder than the one you made with the stick. These same types of observations clue scientists in on how the channels on Mars were formed. Close and thorough examination of all evidence and samples from Mars can determine many more details of Mars' past, completing the picture of the planet's geological history.

Further Explorations:

Try making ridges and valleys in the plaster before it dries and then "rain" on them. How do the ridges and valleys affect the patterns of erosion caused by the rain? Is the erosion similar to erosion observed before? Are "river" channels created?

Adapted from "The Exploration of Mars: NASA Educational Brief"

Why should your team do this activity?
If you were planning a mission that would land a spacecraft on the surface of Mars, where would you choose to land? Why? What kinds of factors would be most important to you in making this decision? NASA scientists must consider these same questions every time they send a mission to Mars. This activity will help your team understand how missions are planned and landing sites chosen.

Background Information:

Although a number of U.S. spacecraft flew past Mars in the 1960's and in the early 1970's, it was not until 1975 that the United States launched two orbiters / landers to explore the red planet in greater detail. Arriving at Mars in the summer of 1976, Viking 1 and Viking 2 began sending back a wide variety of data to scientists, including information about Martian weather, soil, and terrain.

The chart below includes the Martian latitudes and longitudes of locations that were considered as possible landing sites for the Viking spacecraft. The actual landing sites chosen are also indicated.

Latitude	Longitude
22 N	48 W (Viking 1 landed near here)
20 N	108 E
44 N	10 W
46 N	110 W
46 N	150 E (Viking 2 landed near here)
7 S	43 W
5 S	5 W

The Necessities:

- Large world map with latitude and longitude markings
- Engineering Challenge Lab Notebook
- Pen or pencil
- **Optional**: an atlas

Directions:

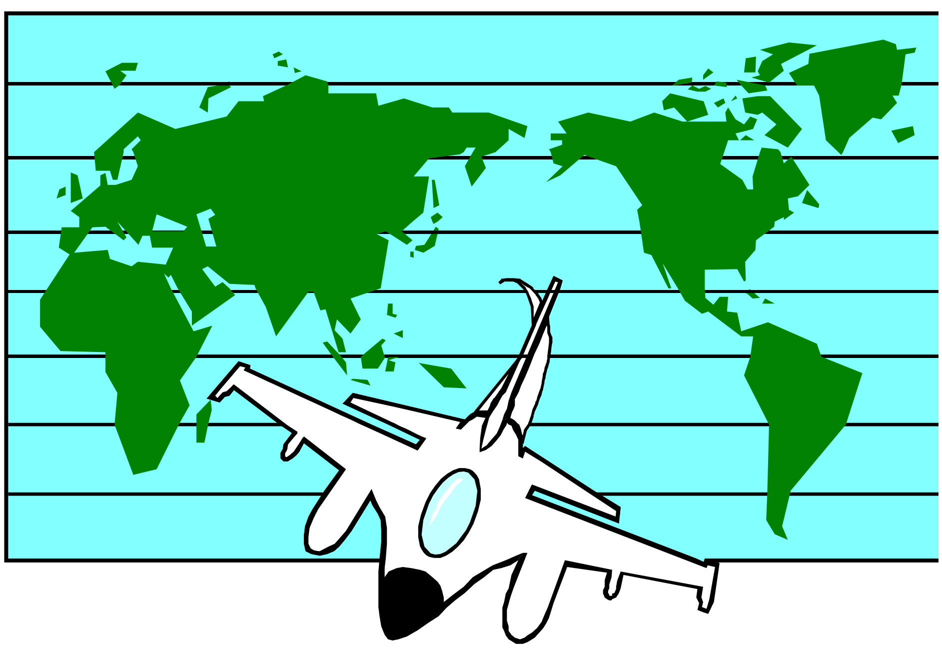
Using your world map and your brainpower (and atlas if you have one available), work together as a team to answer the following questions:

(1) If MASA (Martian Aeronautics and Space Administration) sent spacecraft to land on Earth at each of the same latitudes and longitudes as NASA considered for Mars, where would each spacecraft land?

(2) What hazards would be encountered at each landing site? What would happen to the spacecraft? Would it detect water? Life? Human life?

(3) If you were working for MASA, which two sites would you select for a landing on Earth? Why? For each site you select, identify the hazards that your spacecraft lander would have to survive.

(4) What would you expect to find at each landing site that you selected?



Mars Mosaic

Why Should Your Team Do This Activity?

When a satellite is sent to orbit Mars, one of its missions involves taking thousands of pictures of the planet's surface. Instead of keeping the pictures separate, scientists at NASA will put the pictures together like puzzle pieces to create what we call a **mosaic** – a larger image, or picture, made from combining several smaller images. This allows the scientists to view a larger area of the surface using one picture mosaic, rather than by flipping through hundreds of smaller images. The only problem in creating a mosaic is that the pictures they take and put together are flat, or two-dimensional, and we know that Mars is round, or three-dimensional! In order to find the best landing spots for the Rovers and better describe the landscape, scientists need to be able to construct a three-dimensional "globe" using the two-dimensional mosaics they create. This is exactly what you will be doing today!

In this activity, you will learn how scientists at NASA take two-dimensional mosaics and use them to create a globe of Mars. You will also be comparing distances across a flat wall map to help you see how flat maps and globes show the same places in slightly different ways. When you are done, your team will have your very own Mars globe!

The Necessities:

- Wall map of the Earth
- Globe of Earth
- Mars mosaic *(see pages 67-68)*
- 5" Styrofoam© ball
- Yardstick
- Glue
- Scissors
- String *(at a minimum, string should be the width of the wall map)*
- Engineering Challenge Lab Notebook

Directions:

(1) Using your wall map of Earth and the piece of string, estimate the distances between the following places by comparing how much string it takes to get from one place to the other and then measuring that distance using your yard stick. Use the map's mileage legend to estimate the mileage between locations in order to complete the table below.

Locations	Ft / Inches	Est. Mileage
Boise, Idaho, USA and Orlando, Florida, USA		
Paris, France, and Honolulu, Hawaii, USA		
Tokyo, Japan and Seattle, Washington, USA		
Anchorage, Alaska, USA and Seattle, Washington, USA		
Anchorage, Alaska, USA and Moscow, Russia		

(2) Now, rank the distances from 1-5, with 1 being the shortest distance, and 5 being the longest distance.

_______ Boise, Idaho, USA and Orlando, Florida, USA
_______ Paris, France, and Honolulu, Hawaii, USA
_______ Tokyo, Japan and Seattle, Washington, USA
_______ Anchorage, Alaska, USA and Seattle, Washington, USA
_______ Anchorage, Alaska, USA and Moscow, Russia

(3) Now, using your globe of the Earth, estimate the distances between the same places and rank them again based on your measurements from the globe. Enter mileage in the table below if your globe has a mileage legend for you to use.

Locations	Inches	Est. Mileage
Boise, Idaho, USA and Orlando, Florida, USA		
Paris, France, and Honolulu, Hawaii, USA		
Tokyo, Japan and Seattle, Washington, USA		
Anchorage, Alaska, USA and Seattle, Washington, USA		
Anchorage, Alaska, USA and Moscow, Russia		

_______ Boise, Idaho, USA and Orlando, Florida, USA
_______ Paris, France, and Honolulu, Hawaii, USA
_______ Tokyo, Japan and Seattle, Washington, USA
_______ Anchorage, Alaska, USA and Seattle, Washington, USA
_______ Anchorage, Alaska, USA and Moscow, Russia

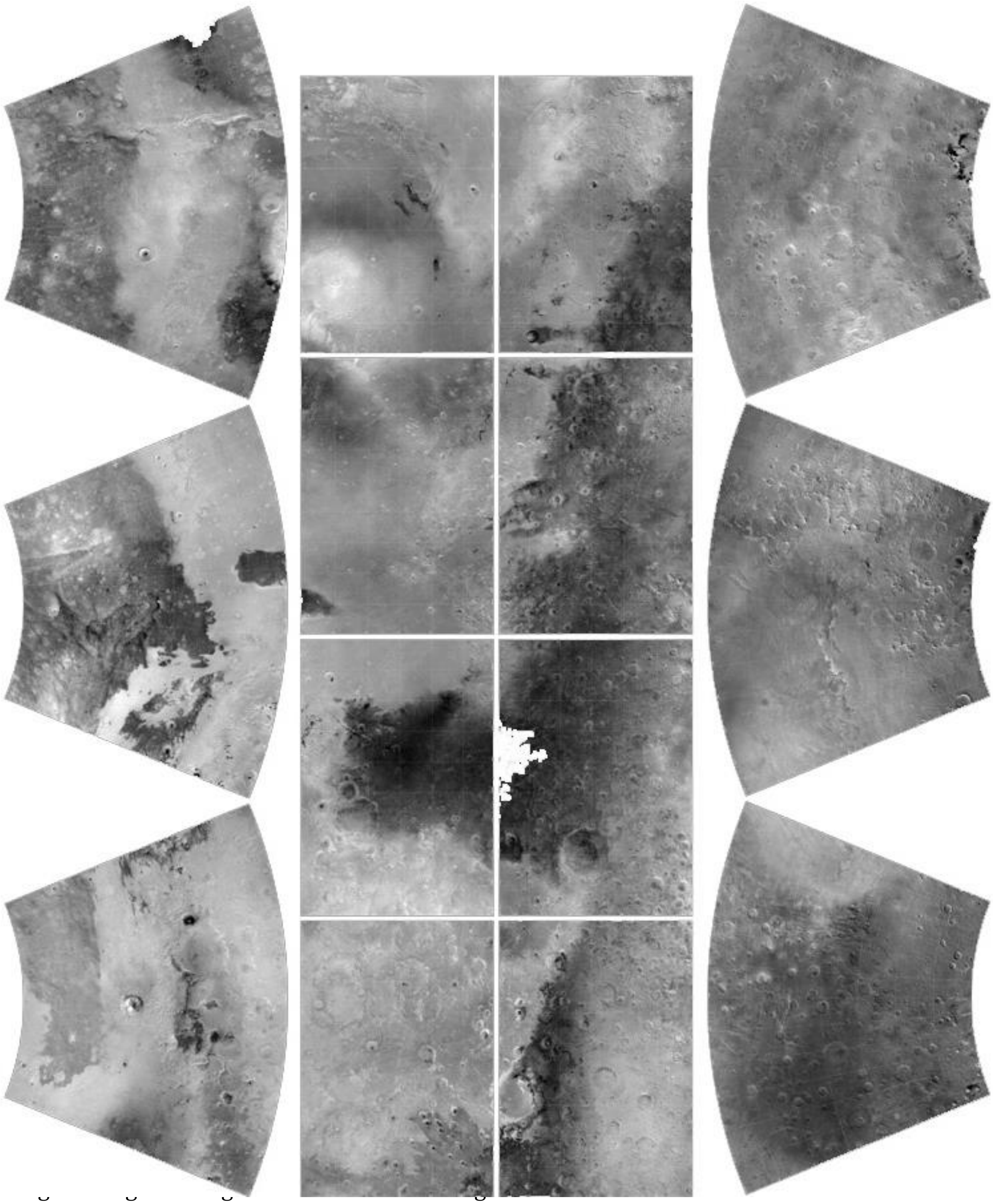
What Did You Find?

Did you rank the locations in the same way when you used the wall map and then the globe? If you take the two ends of your wall map and bring them together to form a cylinder, does it look like globe? Why or why not? Do Anchorage and Moscow look closer together, further apart or the same on the wall map or the globe? How are these two ways of representing the same places different?

On to Mars!

Using the picture mosaic of Mars taken by NASA satellites below, cut out the mosaic pieces, and glue the pieces to your Styrofoam© ball to make a three-dimensional Mars globe "mosaic" of your own. As you do this, think about why the pieces are shaped the way they are. **Why can't NASA scientists create their own globe by gluing a large, continuous image around the ball? Do the images line up perfectly, or do they overlap some? Why do you think that is?**

To better understand what types of pictures NASA combines to create mosaics, your team should complete the "What on ~~Earth~~ Mars?" activity that starts on page 97. Once images are taken, scientists also look for mountains and valleys using radar in order to determine more about the landscape – much like your team can do in the "Mapping Unknown Surfaces" activity on page 93. If you want to create another Mars globe, your team can use a slightly different NASA image located at **photojournal.jpl.nasa.gov/catalog/pia02992**. The image below was obtained from **www.msss.com/mars_images/moc/moc_atlas/**.



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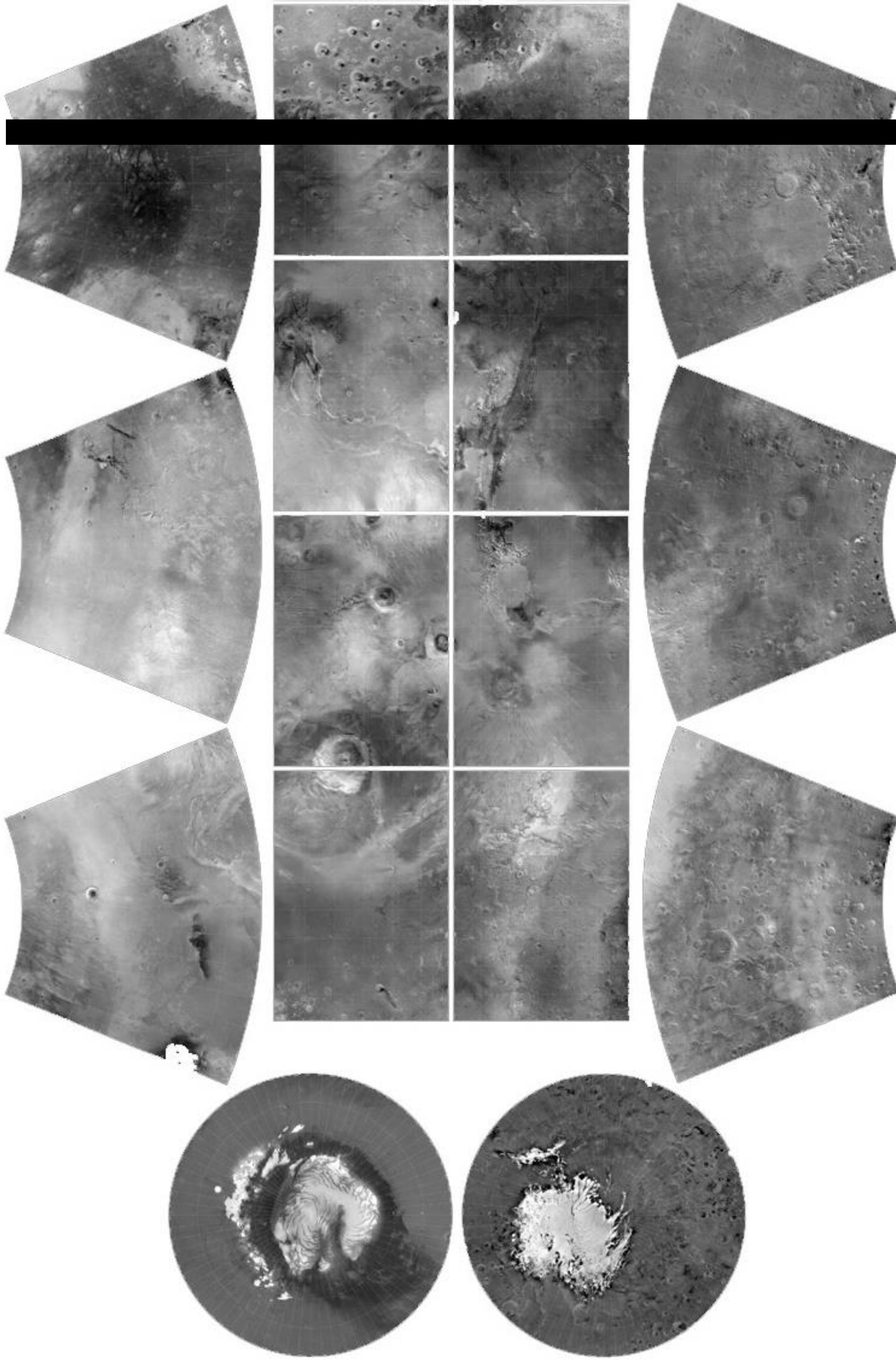


Adapted from NASA's "Mars Activities: Teacher Resources and Classroom Activities – Strange New Planet" located at mars.jpl.nasa.gov/classroom/pdfs/MSIP-MarsActivities.pdf

Why should your team do this activity?
Your team should now be somewhat familiar with Mars, the planet your Rover will be designed to navigate and explore. Why do we send rovers to planets in the first place? Well, different kinds of spacecraft are able to make different kinds of observations. Think about how different the information gathered by looking at a planet from Earth is from the information that a rover might collect. The information that a rover can gather about rock materials on the surface of Mars is much more specific than what an astronomer can collect simply by looking through a telescope. Yet the astronomer's information is necessary to successfully land and operate a rover on the surface of another planet, right? As you will see, each kind of mission has its advantages and drawbacks.

During this activity, your team will explore a strange new planet, one that your teacher has made especially for you. You will explore this planet just like NASA explores Mars. As you make observations, you will make decisions about what your team would like to explore further. Your observations will continually refine the goals of your exploration. During the last phase of exploration, you will land on the surface and carry out your investigations. Happy exploring!

The Necessities:

- A planet (your teacher will provide this)
- Planetary viewers, one for each team member (your teacher will help you with this)
- One 5 inch by 5 inch blue piece of cellophane paper and rubber band per member
- Pen or pencil
- Engineering Challenge Lab Notebook

Directions:

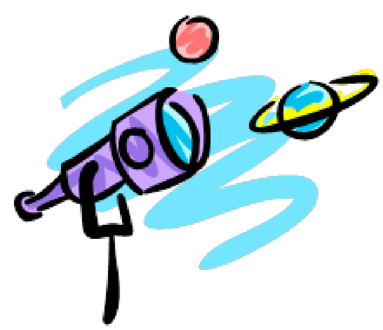
Your teacher will guide your team through this activity. Be sure you read through each mission *before* you perform it. Respond to the questions in your Lab Notebook.

Pre-Launch Reconnaissance – Earth-bound observations

(1) Estimate your distance from the planet in meters.

(2) Using your viewers (with blue cellophane attached to simulate Earth's atmosphere), observe the planet for one minute. What types of things does your team observe? Record any observations (shape of planet, color, size, etc.) in your Notebook.

(3) As a team, write questions to be explored in future missions to the planet. What else do you wish to know and how will you find out that information (special features of the planet, life of any kind, etc.)?



Mission 1: The Fly-By *(Mariner 4 in 1965, Mariner 6 & 7 in 1969)*

Using your viewers with the cellophane removed, your team will quickly walk past one side of the planet. A distance of five feet needs to be maintained from the planet. Your team will then meet back at Mission Control.

(1) Record your observations of the planet. What did you see that was the same as your Earth observations? What did you see that was different? Can you hypothesize (make a science guess) as to why there were any differences?

(2) List the team ideas of what you want to observe on your orbiting mission.

Mission 2: The Orbiter *(Mariner 9 in 1971-72, Viking 1 & 2 Orbiters in 1976-80, Mars Global Surveyor in 1996-present, 2001 Mars Odyssey in 2001-present, Mars Express in 2003-present)*

Using your viewers, your team will take a total of two minutes to orbit (circle) the planet at a distance of two feet. Divide the two minutes by the number of team members to get the time each person has to orbit the planet. After your orbit, return to Mission Control.

(1) Record your observations of the planet. What did you see that was the same as in your reconnaissance or fly-by missions? What did you see that was different? Can you hypothesize as to why there were any differences?

(2) As a team, develop a plan for your landing expedition onto the planet's surface.
- ★ Where will you go and why? How did your team decide where to land?
- ★ What are the risks or benefits of landing there?
- ★ What specifically do you want to explore at this site?
- ★ What type of special equipment or instruments would you need in order to accomplish your exploration goals? (Remember, anything you bring has to be small and light enough to bring on a spacecraft!)

Mission 3: The Lander *(Viking 1 & 2 Landers in 1976-82, Mars Pathfinder Rover ["Sojourner"] in 1997, 2003 Mars Exploration Rovers ["Spirit" & "Opportunity"] in 2003-present)*

Your team will approach your landing site and mark it with a pin, tack or masking tape. Each team member will take a turn observing the landing site through the viewer. Field of view (the area that you can see through your viewer) is kept constant by aligning the viewer so the pin is located inside and at the top of the viewer. Your team has a total of five minutes to view the landing site, so make sure everyone has time to view the site. After each member views the landing site, return to Mission Control.

(1) Now that you have landed, what do you think you can accomplish at this site?

(2) How long (in days) will it take you to get the job accomplished?

(3) Was your mission successful? Why or why not?

(4) What were the greatest challenges of this mission (personally and as a team)? What would you change for the next mission?

Mapping Unknown Surfaces

Adapted from "Mapping Unknown Surfaces" from the American Museum of Natural History web site located at www.amnh.org/rose/mars/mapping.html

Why should your team do this activity?

We always want to know what the surface of a planet is like. Sometimes we can't see it, like in the case of Venus. On Venus, a thick cloud layer covers the surface of the planet. Sometimes on Mars, massive dust storms can obscure the surface in the same way. Other times, we can see the surface and take a picture of it. But these images are two-dimensional. We have no definite information on depth. To find out the high and low points of a planet's surface, scientists use radar to map the landscape. A spacecraft orbiting the planet beams radar down to the surface and then measures how long it takes for the reflection to come back. A shorter time means a higher surface; a longer time means a lower surface. In this way, we can create a three-dimensional picture of the landscape.

In this activity, you will be given a hidden landscape. You will take "radar" measurements to create a three-dimensional map of a planet's surface. Using this data, you will then determine if there is a safe landing site for a spacecraft and construct a topographical map.

The Necessities:

- Hidden Landscape *(your teacher will provide the landscape)*
- Thin wooden skewers with centimeter markings *(your teacher will provide these)*
- Data sheet *(see page 58)*
- Pencil
- Engineering Challenge Lab Notebook

Directions:

(1) Insert a skewer straight down into a hole until it will not go down any further.

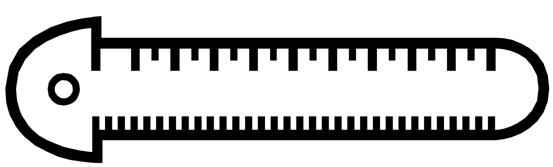
(2) Read the measurement for how far down the skewer went.

(3) Write each measurement on the data sheet near the dot that corresponds to the hole you measured. Be consistent about where you write your data – always below the dot, or always to the right of the dot, etc. Let each member of the team take several measurements.

(4) After you take measurements for all the holes, examine your data. Is there a square area that is 2 holes by 2 holes where all the measurements are the same or differ by no more than 1 centimeter? Would this be a safe landing spot for a spacecraft?

(5) Now draw lines connecting equal measurements to create a topographic map of your surface (have your teacher show you an example).

(6) Remove the top of the landscape box. Are all of the features of the landscape represented on your map? Which did you miss? Why? Record your thoughts in your Lab Notebook.



Data Sheet

What on ~~Earth~~ Mars?

Why should your team do this activity?

Photographs taken from orbit give us a closer look at the surface of Mars. Much of our knowledge about Mars was obtained by looking at and interpreting pictures, just like your team will do in this activity. If your team has completed the activities "Crater Creation," "Martianscape," or "The Winds of Change," you probably already know about some of the features that scientists use to interpret pictures of Mars. In this activity, your Engineering Team will learn a little more about such features before looking at pictures. Then your team will work together to examine pictures of Mars, discuss the features in each image, and hypothesize about what may have caused each feature.

The Necessities :

- 10 Martian photographs *(on following pages)*
- Data Table *(on page 105)*
- Pen or pencil
- Scratch paper
- Engineering Challenge Lab Notebook
- **Optional:** colored pencils or markers

Background Information:

Your team will need to know the following terms:

- **impact crater -** a roughly circular hole created when something hits the surface. The floor of the crater is below the surrounding landscape. You may see a raised rim or deposits of debris ringing the crater.
- **volcano -** a mountain formed by lava and/or erupted materials. A **volcanic crater** is a depression at the summit of a volcano. In contrast to craters made by impact, volcanic craters are above the surrounding plain.
- **river valley -** a winding channel carved by water; may have multiple branches that make a pattern resembling a branching tree.
- **river bed -** a type of river valley with a wider, flatter floor; may contain streamlined islands.
- **dry lake bed -** an irregularly shaped depression.
- **polygonal ground -** a surface pattern (wedges of polygonal shapes) generally attributed to the alternate freezing and thawing of soil layers containing water or ice. The size of the polygons is believed to be directly related to the thickness of the soil layer (i.e., thicker soils produce larger polygons). The implication for Mars: presence of liquid water at some time in the past.
- **lava flow -** a place where magma broke out from underground onto the surface.
- **sand dune -** a hill or ridge of wind-deposited sand.
- **fracture -** a straight groove or line on the surface where rock has been broken.
- **wind streak -** a dark streak; they have been interpreted as deposits of salt and coarse-grained particles from craters, but it seems the most widely accepted idea is that they are wind erosion features. This means the dark streaks are erosional zones - surfaces that have had fine-grained particles stripped away. The difference in brightness is probably due to a difference in the particles themselves. Generally, fine-grained materials are lighter-colored because they are weathered more rapidly than the larger particles. Alternatively, dark streaks are probably dark-colored, silt- and clay-

sized particles deflated from the adjacent crater floor. Deflation is defined as the sorting out, lifting, and removal of loose, dry, fine-grained material by wind action. The orientation of the streaks indicates the direction of the wind at the time they formed. So differences in orientation may be due to local topographic influences on wind direction or to changes in wind patterns.

Directions :

First, make sure your team has read through the background information. Understanding the boldface terms is crucial to completing this activity, so if you have any questions at all, ask your teacher for help. Remember that the Internet is a good source of information too.

Look through the ten images on the following pages. These images were taken during the Viking Orbiter missions to Mars (except Image 10). Try to answer the questions next to each image. **Remember that even NASA does not know everything about Mars, so be creative! Your ideas may be even better than what NASA has!** Record your answers in your Engineering Challenge Lab Notebook. Also, record which features you see in each photograph in the table below *(the first image is already done for you!)*:

➔ *If your team wants to, color code the pictures by coloring each feature a different color. For example, color all impact craters orange and all volcanoes/volcanic craters blue.*

	Image #1	**Image #2**	**Image #3**	**Image #4**	**Image #5**	**Image #6**	**Image #7**	**Image #8**	**Image #9**	**Image #10**
# of different features in photo	2	2	2	3	2	3	2	3	2	
Impact craters	X									
Volcanoes/ volcanic craters	X									
River valley										
River bed										
Dry lake bed										
Polygonal ground										
Lava flows										
Sand dunes										
Fractures										

Web

The following web sites are resources for more activities and fun with space exploration – Enjoy!

Program Information:

Engineering Challenge:
The official Engineering Challenge page on the website:

http://www.etstatefair.com/p/About/Academic-Rodeo/207

ETXSC: The official web site for the Ingenuity Center

http://www.ingenuitycenter.org/

NASA Homepage: The official web site of the National Aeronautics and Space Administration

http://www.nasa.gov/

Information & Activities Related to Mars:

Mars Map-A-Planet: Allows you to get an image map of any area on Mars.

astrogeology.usgs.gov/Projects/MarsPDSExplorer/

Mars Exploration Program: Learn about all the different missions that NASA currently has at Mars, or planned for future Mars exploration.

mars.jpl.nasa.gov

NASA Quest – Mars Team Online: Extensive information about the Mars Pathfinder & Mars Global Surveyor missions.

quest.arc.nasa.gov/mars/

Mars Exploration - Just for Kids: Information about Mars missions, the science and technology of exploring Mars, and a Fun Zone for kids with lots of great activities.

http://mars.jpl.nasa.gov/participate/funzone/

2001 Mars Odyssey Fun Zone!: Click on **Odyssey Home** on the left side of the blue bar at the top of the page on this web site to find cool stuff about the Odyssey mission.

mars.jpl.nasa.gov/odyssey/funzone.html

Imagine Mars: Interact with scientists, engineers, artists, architects, and community leaders to learn about Mars.

imaginemars.jpl.nasa.gov/index4.html

2003 Mars Exploration Rovers: Learn about the progress of Spirit and Opportunity, the Rovers currently on Mars, and see awesome photos and facts!

marsrovers.jpl.nasa.gov/home/index.html

Information About Astronauts:

So You Want to be an Astronaut?:
Learn about the benefits and challenges of being an astronaut.

http://astronauts.nasa.gov/

Cool Sites About Space:

Spaceday 2007 – Return to the Moon: Become scientists, engineers, and explorers working on the space frontier to design a totally unique solution to some "out-of-this-world" challenges, including going to Mars using the Moon as a launching point.

www.spaceday.org

The ~~Nine~~ 8 Planets: A multimedia tour of the Solar System by Bill Arnett.

www.nineplanets.org

The Space Place: Information and cool interactive activities related to space science. There are even pages to do and make "spacey things!"

spaceplace.nasa.gov/en/kids/

NASA Kids: A site with activities, games, projects, and more!

www.nasakids.com

Mars Map-A-Planet: Allows you to get an image map of any area on Mars.

http://pdsmaps.wr.usgs.gov/maps.html

StarChild – A Learning Center for Young Astronomers: Visit this site to learn more about the Solar System, the Universe, or other Space Stuff!

starchild.gsfc.nasa.gov/docs/StarChild/StarChild.html

Astronomy Picture of the Day: Check out a new astronomy picture every day!

antwrp.gsfc.nasa.gov/apod/astropix.html

Window to the Universe Kids' Space: Fun activities and games for kids.

www.windows.ucar.edu/tour/link=/kids_space/kids_space.html

Welcome to the Planets: A complete collection of information about and images of the bodies of our Solar System.

pds.jpl.nasa.gov/planets/

The NASA Science Files: Join the Tree House Detectives as they solve problems using their math, science, and technology skills!

http://www.knowitall.org/nasa/scifiles/

Astro-Venture: Astro-Ferrett will help you build your own planet!

http://astroventure.arc.nasa.gov/DAP/index.html

See your team at competition! Have fun creating and designing your Rover!