Academic Rodeo
Engineering Challenge

Teacher Activity Book

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

Contents

The activities presented in this book were placed in a specific order for maximum educational benefit. We highly recommend that you ***complete the activities in the order they are presented*** so the activities will build on each other as intended.

Questions?

Call (903) 597-2501, or e-mail Deborah Newman: dnewman@tylerpoet.com

Things to Consider for Coaches

- If possible, it is recommended that you have the students build all of the various models which are outlined on the building cards included in the Lego kits. This will provide the students with the opportunity to discover how the many pieces may be used and should also help to generate ideas for their overall design.
- If you do not have the students building all of the models on the cards, you can select cards which you feel will provide a good overview of how the various components might be useful (such as how a clamping or scooping mechanism might be built with pneumatics), and use these to help the students to begin brainstorming ideas.
- Given the largely "hands-off" role of the teacher in this project, teaching through questioning the students is probably one of the most effective ways to help them. Be sure that they understand why they are doing what they do, that they can justify their design choices, and so on.
- In order to successfully complete the challenge, students will have to first learn about **gearing down**. Without the use of at least some gearing, it is virtually impossible for the supplied Lego 9-volt motors to power a Rover model.
- We strongly recommend that students construct some type of control panel to make control of the various motors and pneumatics more manageable.
- It generally takes 1½-2 weeks to receive parts from the **Lego Shop-at-Home-Service**.
- Have students carefully consider what is needed prior to ordering extra Lego parts. They will likely find the need for more gears, since considerable gearing is needed to increase the turning power of the Lego motors. Extra axles, pneumatics, or tires may also warrant strong consideration.
- When brainstorming ideas, be sure that students deliberate how the motors and pneumatics might best be used to meet all of the needs such as steering, power, and the ability to collect and store rock samples.
- Although we realize that the list of Non-LEGO Allowable Elements is rather limiting, it is designed both to inspire greater creative use of materials by the student engineers and to help keep things fair for all participants.
- The amount of rubber tubing supplied in the Lego pneumatic kit will likely prove insufficient. Many hardware stores sell rubber or plastic tubing which is small enough to connect firmly to the pneumatic pumps and pistons. Another possible source of tubing is that sold in pet stores for use in fish tanks.
- Each Lego battery box requires 6 AA batteries (not provided). Instruction sheet for opening the battery boxes is included on the green colored card #1 in the Manufacturing Systems Lego kit.

How to Utilize the Activity Books

The activities presented in these books are intended to prepare your team for the design phase of the Engineering Challenge. Although these activities are considered an **optional** component of Engineering Challenge, we ***strongly recommend*** that you complete as many activities as possible before you work with your Lego® kits. Please refer to the recommendations below and the information on pages 2-7 when choosing activities to complete with your team.

The activities have been placed in a specific order to ensure maximum educational benefit. We highly recommend that you complete the activities in the order they are presented so the activities will build upon each other as intended. They are divided into two general categories:

(1) Teambuilding Activities
These activities focus on communication, cooperation, taking on roles, and group decision-making skills. Teams with strong teamwork skills tend to progress through the Engineering Challenge well and are extremely successful at competition.

(2) Mars Exploration Activities
These activities focus on specific characteristics of Mars and the process of space exploration. The information that students will gain from these activities will help them design their Rover by introducing ideas regarding what NASA must consider when planning to explore the surface of another planet.

At the minimum, we recommend that teams complete the following activities to prepare for specific Engineering Challenge requirements:

- ★ Several teambuilding activities to strengthen teamwork skills early
- ★ ***Earthling Exploration of Mars*** to complete the timeline requirement
- ★ ***3-2-1 Pop! – An Effervescent Race*** to learn about the Engineering Design Process, as well as the Lab Notebook and Rover Display & Presentation competition events
- ★ ***Copy Cat*** to learn about the Blind Driving competition event

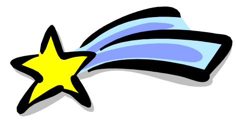
For your convenience, a copy of each student activity book activity instructions immediately follows the teacher instructions for that activity, respectfully, in order to allow teachers/parents to adequately prepare prior to engaging in each activity (refer to the pages marked "Student Version" following each activity).

Please Note

- ★ When the activity has been designed to be student-led, the full directions will be located in the Student Activity Book; and when the activity has been designed to be teacher-led, the full directions will be located in the Teacher Reference part of the Teacher Activity Book.
- ★ The Teacher Reference portion contains useful tips and suggestions for the teacher who conducts each activity with the students. Many questions have been included to stimulate post-activity discussion with the students to ensure the successful completion of activity objectives.
- ★ Most often, the Student Activity Book will contain background information, simplified directions, and, at times, worksheets for student use.

National Science Education Standards

The Engineering Challenge was created to follow the National Science Education Standards for grades 5-8 as closely as possible. Specifically, there are three standards the program adheres to – **Science as Inquiry**, **Science and Technology**, and the **History and Nature of Science.** Each component of the Engineering Challenge, including the Activity Book, contributes to the program's overall fulfillment of these standards. Below are some excerpts from the National Science Standards, brief descriptions of how the activities address the standards, and charts detailing which components of each standard are present in each activity. We have also included a chart detailing the teamwork, leadership, and science process skills targeted within each activity.



NS.5-8.1 Science as Inquiry

Students in grades 5-8 should be provided opportunities to engage in full and partial inquiries. In a full inquiry, students begin with a question, design an investigation, gather evidence, formulate an answer to the original question, and communicate the investigative process and results. In partial inquiries, they develop abilities and understanding of selected aspects of the inquiry process.

The experiments and investigations that students conduct become experiences that shape and modify their background knowledge. With an appropriate curriculum and adequate instruction, middle-school students can develop the skills of investigation and the understanding that scientific inquiry is guided by knowledge, observations, ideas, and questions.

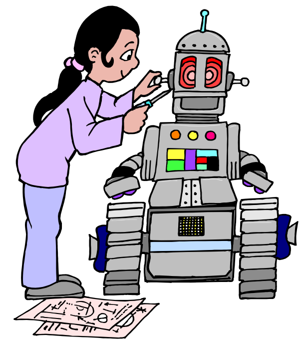
The instructional activities of a scientific inquiry should engage students in identifying and shaping an understanding of the question under inquiry. Students should know what the question is asking, what background knowledge is being used to frame the question, and what they will have to do to answer the question.

Students need opportunities to present their abilities and understanding and to use the knowledge and language of science to communicate scientific explanations and ideas. In middle school, students produce oral or written reports that present the results of their inquiries. Such reports and discussions should be a frequent occurrence in science programs. Writing, labeling drawings, completing concept maps, developing spreadsheets, and designing computer graphics should also be a part of science education.

The majority of the Activity Book activities address the **Science as Inquiry** standard. Most activities, such as "Crater Creation," are based on the power of observation, which forms the foundation of scientific inquiry. These inquiry-based activities require students to design, conduct, analyze, or communicate their own scientific investigations about Mars or space science. Most of these activities are also student-centered, allowing students to make their own observations, form their own ideas to explain their observations, and discuss these ideas with their peers.

NS.5-8.5 Science and Technology

Students in grades 5-8 can begin to differentiate between science and technology. One basis for understanding the similarities, differences, and relationships between science and technology should be experiences with design and problem solving in which students can further develop some of the abilities introduced in grades K-4. The understanding of technology can be developed by tasks in which students have to design something and also by studying technological products and systems.



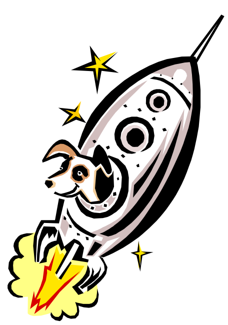
In the middle-school years, students' work with scientific investigations can be complemented by activities in which the purpose is to meet a human need, solve a human problem, or develop a product rather than to explore ideas about the natural world. Students should also, through the experience of trying to meet a need in the best possible way, begin to appreciate that technological design and problem solving involve many other factors besides the scientific issues.

Suitable design tasks for students at these grades should be well-defined, so that the purposes of the tasks are not confusing. During the middle-school years, the design tasks should cover a range of needs, materials, and aspects of science. Regardless of the product used, students need to understand the science behind it. There should be a balance over the years, with the products studied coming from the area of clothing, food, structures, and simple mechanical and electrical devices.

Certain activities, notably "3-2-1 Pop! – An Effervescent Race," address the **Science and Technology** standard. In this example, students follow the Engineering Design Process to research, design, construct, and test their own effervescent-powered rockets. The Engineering Design Process embodies the **Science and Technology** standard by requiring students to use problem-solving skills and technological design to develop a product for a real-world situation.

NS.5-8.7 History and Nature of Science

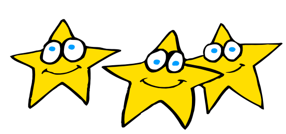
Experiences in which students actually engage in scientific investigations provide the background for developing an understanding of the nature of scientific inquiry. In general, teachers of science should not assume that students have an accurate conception of the nature of science in either contemporary or historical contexts.



To develop understanding of the history and nature of science, teachers of science can use the actual experiences of student investigations, case studies, and historical vignettes. Historical examples are used to help students understand scientific inquiry, the nature of scientific knowledge, and the interactions between science and society.

It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Although scientists may disagree about explanations of phenomena, interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communications are integral to the process of science.

Again, the majority of the activities address the **History and Nature of Science** standard by addressing issues that involve working with a diverse team, accepting alternate explanations and opinions, and examining historical perspectives of science and how ideas have changed over time.



National Science Standards Chart

	NS.5-8.1 Science as Inquiry							
Activity	Identify questions that can be answered through scientific investigations	Design and conduct a scientific investigation	Use appropriate tools and techniques to gather, analyze, and interpret data	Develop descriptions, explanations, predictions, and models using evidence	Think critically and logically to make the relationships between evidence and explanations	Recognize and analyze alternative explanations and predictions	Communicate scientific procedures and explanations	Use mathematics in all aspects of scientific inquiry
Building a Working Team								
The Spaghetti Incident								
Copy Cat							X	
Parts of the Whole						X		
3-2-1 Pop! – An Effervescent Race	X	X	X	X	X	X	X	X
Earthling Exploration of Mars								
Engineering Challenge WWW Activity			X					
Pepsi on Pluto – Weighing In & Growing Old		X	X	X	X	X	X	X
Hangin' Out on Mars!?!			X					X
Mars in Reverse				X	X	X	X	
Crater Creation	X	X	X	X	X	X	X	X
Martianscape	X	X		X	X	X	X	
The Winds of Change	X	X		X	X	X	X	
Geography & Mission Planning			X	X	X	X	X	X
Mars Mosaics	X		X	X	X	X	X	
Strange New Planet	X	X		X	X	X	X	
Mapping Unknown Surfaces		X	X	X	X	X	X	X
What on ~~Earth~~ Mars?			X	X	X	X	X	

National Science Standards Chart

Activity	NS.5-8.5 Science and Technology					NS.5-8.7 History and Nature of Science		
	Identify appropriate problems for technological design	Design a solution or product	Implement a proposed design	Evaluate completed technological designs or products	Communicate the process of technological design	Develop understanding of science as a human endeavor	Develop understanding of the nature of science	Develop understanding of the history of science
Building a Working Team						X		
The Spaghetti Incident		X	X	X	X	X		
Copy Cat						X		
Parts of the Whole						X		
3-2-1 Pop! – An Effervescent Race	X	X	X	X	X	X	X	
Earthling Exploration of Mars	X					X	X	X
Engineering Challenge WWW Activity								
Pepsi on Pluto – Weighing In & Growing Old						X	X	
Hangin' Out on Mars!?!							X	
Mars in Reverse							X	X
Crater Creation						X	X	
Martianscape						X	X	
The Winds of Change						X	X	
Geography & Mission Planning						X		
Mars Mosaics						X	X	X
Strange New Planet						X	X	X
Mapping Unknown Surfaces						X	X	
What on ~~Earth~~ Mars?						X	X	

Teamwork and Science Process Skills

Activity	Teamwork Skills								Science Process Skills									
	Verbal Communication	Non-Verbal Communication	Listening	Cooperation	Patience	Time Management	Decision Making	Taking on Roles	Predict	Measure	Observe	Record Data	Organize Data	Calculate	Summarize	Analyze	Discuss	Compare and Contrast
Building a Working Team	X	X	X	X	X	X	X	X									X	X
The Spaghetti Incident		X		X	X	X	X	X									X	X
Copy Cat	X		X	X	X	X	X	X									X	X
Parts of the Whole	X		X	X	X		X	X				X					X	X
3-2-1 Pop! – An Effervescent Race		X		X			X	X	X	X	X	X	X		X	X	X	X
Earthling Exploration of Mars		X		X		X	X	X		X		X	X		X		X	
Engineering Challenge WWW Activity												X			X		X	
Pepsi on Pluto – Weighing In & Growing Old							X		X	X	X	X		X		X	X	X
Hangin' Out on Mars!?!												X		X	X	X	X	X
Mars in Reverse											X					X	X	
Crater Creation									X	X	X	X			X	X	X	X
Martianscape									X		X				X	X	X	X
The Winds of Change									X		X				X	X	X	X
Geography & Mission Planning							X			X	X	X	X			X	X	X
Mars Mosaic					X		X			X		X		X	X	X	X	X
Strange New Planet						X	X				X	X	X		X	X	X	X
Mapping Unknown Surfaces							X			X	X	X	X			X	X	X
What on ~~Earth~~ Mars?							X				X	X				X	X	X

The Lab Notebook

The Lab Notebook is referenced often in the Activity Books. What exactly is this Notebook? The Lab Notebook is a vital part of Engineering Challenge because it teaches each team how to document the Engineering Design Process. For reference, the following is the justification from the Manual:

The team **MUST** maintain a **Lab Notebook** of the design process and expenses. The Notebook must have **DATED** entries and must **OUTLINE** your work as your team progresses through the Engineering Design Process. Your Lab Notebook is a record of the work your team does on your Rover, and must be handwritten, *not* typed. The budget pages must include both *actual* expenditures and *estimated* values of any materials used but not purchased. It may also contain drawings, brainstorming sessions, anything fun that happened at the meeting, and anything your team learned.

Encourage your team to select a notebook (spiral, binder, etc. – any form is acceptable), and start recording entries as they work through the activity process. We hope the contract created during the "Building a Working Team" activity will be included in the Notebook. Please note: None of the activities are required to be included in the notebook, but we highly encourage that your team include their notes if possible. **Remember to have the students leave the first page blank, where their timeline will be placed.**

★ The Engineering Design Process

The entire Engineering Design Process when you start designing/constructing your Rover must be reflected throughout the Lab Notebook. Every step in the process must be recorded in detailed entries that are dated and hand-written.

Recommended Activity:
"3-2-1 Pop! – An Effervescent Race"

★ Timeline

The timeline must detail when and in what order the team will complete ALL components of the Engineering Challenge, including the Engineering Design Process. **It must be the first entry in the Notebook.**

Recommended Activity:
"Earthling Exploration"

★ Budgets

Three separate, itemized budgets must be included in the Lab Notebook to document the expenditures for (1) Additional Lego® parts ($75 maximum); (2) Use of Non-Lego® Allowable Elements; and (3) Display construction ($50 maximum).

★ Pie Charts

A pie chart for each team member must be included in the Lab Notebook. Each pie chart should categorize that team member's contributions to the design process.

Building a Working Team

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

Introduction & Purpose

At times, one of the biggest challenges that teachers face in supporting Mars Rover teams is team dynamics. Frustrations caused by breakdowns in communication between team members, and built up emotions that sometimes arise while working through the design and construction process can place negative strain on the team. You can prepare ahead of time to avoid or alleviate these situations by assisting your group in building a strong team ethic.

Challenges or initiatives can be an excellent tool for helping to build a strong sense of team spirit, and can give mentors a basis for leading teams through the process of assessing and improving their group dynamics. Like any lesson, without a structured format and a strong reflection and evaluation component, initiatives can be just an activity without a solid learning outcome. The following is a guide for working through initiatives with your students. This can be applied to any of the challenges on pages 12-16 that you pose to your group.

Objective:

Students will determine, develop, and assess qualities that are associated with positive teamwork behavior through guided preparatory discussion, practical challenges and debriefing discussions.

(1) **Set up the challenge.** Use clear, concise instructions. Have students restate all of the tasks of each initiative before they start. It is important that they fully understand the task before them and any information that is relevant for solving the problem.

Besides the Engineering Challenge Lab Notebook which is needed for each initiative, you will need additional materials for four of the challenges:

Pulse:	You will need a timer / watch with a second hand
Rope Knots:	You will need a 10 foot rope with one knot on the rope per team member
Probe Levitation:	You will need a tent pole
Space Walk:	You will need two blindfolds and four 1' x 1' pieces of cardboard

(2) **Prompt your students.** Before they begin, ask your students what a good plan would be for working through the challenge as a team (but don't devise the plan for them). Some examples of good leading questions that can get students off to a good start are:

Examples of Leading Questions:

* What are characteristics of a good team member?
(Listening, contributing ideas, being supportive, etc.)

* What are characteristics of a good team?
(Cooperation, everyone has a part, strong communication, etc.)

*What kind of support do you need from the other team members?
(see the four "C"s below to add to this question)

*What are you excited about today?

*What do you think will be difficult for you today?

*What is your plan for solving this problem? Are you going to try the first idea that comes to mind, or will you brainstorm many ideas before you choose one to try?

*Is there one right answer to any and/or all problems?

(3) **Introduce your group to "The 4 Cs". These are:**

- ✓ **Communication**
- ✓ **Cooperation**
- ✓ **Compromise**
- ✓ **Caring**

Included as the first exercise in the Student Activity Book is a prompt for students to brainstorm and write down the **4 C's**. They are also asked to think of other words that exemplify good team behavior and to sign the bottom portion of the page as a type of "contract" for the team to follow. ***It is highly encouraged that this contract be cut out and placed in their Lab Notebook as a daily reminder of the words that will continue to help them be a great team.***

(4) **Let them go for it!** This is a time to be watching what is going on and making notes for leading the discussion later on. Look for specific examples of strong teamwork skills. Look for the examples of poor teamwork. Try to think of something positive to comment on for every team member.

When things aren't going so well……………………

If the group is struggling and experiencing team melt down, or even "teacher melt-down" (**this does happen!** --- and it can be a good thing, depending on how you lead the discussion ☺), now is a good time to call a **time out**. This is a great opportunity to start the discussion about what is working and what is not working. You can give them a nugget of information to help get them on track.

Maybe they are exhibiting strong team skills, but are not getting anywhere with the problem. In this case, give them a little nudge in order to get them back on track. Highlight and commend them on all the things they are doing right.

(5) **Lead the students in a debrief after they have successfully completed the task.** This is the portion of the activity that lends significantly to lessons learned. Using your observations as a guide, lead the team in assessing how well they worked together. Start with asking students **"What did you learn about your team today?", "What did you or your team do today that you are particularly proud of?"** and **"What skill do you want to work on improving?"** You can usually draw out most of the issues you want to address through this discussion with the students.

Now ask them what they could do differently to improve their teamwork skills. Have them think about the task that is coming, the Mars Rover Challenge. How can they use what they have just gone through when facing challenges in building their Rover? ***Have your students write overall comments in their Engineering Challenge Lab Notebook.***

If you are wishing to address certain skills or abilities that were targeted in each initiative, the following questions adapted from the Putnam Northern Westchester BOCES Outdoor Education Program's Challenge Course Handbook may be helpful:

Communication

- ✯ Did you have effective communication within your team today?
- ✯ How did you know that your communication with the team was understood?
- ✯ What could the communicator do next time to make their message more clear?

Listening

- ✯ How did it feel to be heard when you made a suggestion?
- ✯ How did it feel *not* to be heard when you made a suggestion?
- ✯ What interfered with your ability to listen to others?

Cooperation

- ✯ Give examples of how your team cooperated during the activity.
- ✯ Give examples of how your team was uncooperative during the activity.
- ✯ How is cooperation important in other areas of your life (i.e. building a rover)?

Patience

- ✯ How does it feel when people are impatient with you?
- ✯ How can you tell when someone is being impatient?
- ✯ Why do people become impatient?

Group Decision-Making

- ✯ How were group decisions made when completing the various initiatives?
- ✯ Were you satisfied with the way decisions were made? Explain why or why not.
- ✯ Did everyone have input in making overall group decisions?
- ✯ What is the best way for a group to make a decision?

Individual Differences

- ✯ In what ways are your team members similar? In what ways are they different?
- ✯ How did the differences within your team prove to be a strength for your team?
- ✯ How did differences within the team prove to be a hindrance?
- ✯ How could the group learn and benefit from individual differences?

These initiatives can give you a reference point for talking to the group when challenges arise during Rover design and construction. They can also be a good team pickup when frustrations arise during the design and construction process.

If you have read through the steps to follow when leading an initiative, you are ready to get started. Choose from the following tasks. They are ordered according to difficulty. Most of these initiatives work better with groups of six. If you have student mentors or other team assistants, it is a acceptable to have them participate with the 5th and 6th graders, however, please remind them to hold back from dominating the process and being too quick to offer the solution.

As a final note, remember that spectators can become over-involved in the process. Ask onlookers to assist you in observing the process, and then invite them to comment during the debrief if they have something extra to contribute beyond your discussion.

Team Initiatives

#1 : COLORS

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

✯ **Teamwork Skills**: listening, verbal communication

Have each team member think of a color but not say it aloud. Once every student has a color they are thinking about (but have not stated aloud), ask all of them to shout out their color after you count to three. After the chaos, ask a few team members to tell you what color someone else said.

Why are most students not able to repeat what color another student stated aloud? What could the group do to make sure everyone knows everyone's color? Does an effective team all speak at the same time? Can you understand everyone in the group when they all speak at the same time? Why not?

#2 : BIRTHDAY LINE-UP

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

✯ **Teamwork Skills**: non-verbal communication, cooperation, patience, taking on roles

This initiative addresses a different but critical form of communication. Explain to your team that this is a nonverbal activity *(no talking ☺)*. The group is to form a single line according to their birthdays. For example, the students with January birthdays will be at the beginning of the line, earliest January birthdays first, followed in order by later dates/months. People with the same birthday share the same place in line. The students must communicate non-verbally; **no lip-reading, squeaking, or other noises are allowed**. When the line is complete, have each student state his/her birthday one at a time.

After the activity is complete, ask each team member to give you one adjective to describe what the experience was like for him or her. The usual answers will include hard, difficult, and frustrating. Then ask them to tell you, ***other than the fact that they couldn't talk***, why it was so hard, difficult, or frustrating, to complete the activity. Usually someone will state "because the other person didn't understand what I was trying to say!" This is exactly the response you are seeking. **70% of all communication results in communication breakdown.** Ask the team to suggest some strategies they can use to prevent communication breakdown *(e.g. asking questions, repeat what you heard the other person say, have the person say it a second time in a different way, etc.)*

If you wish to try variations of this activity, you can blindfold team members, or not allow them to use their hands during the activity. You can also have them line up in alphabetical order instead of birthday order, using their middle names to create the order.

#3 : PULSE

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

☆ **Teamwork Skills**: non-verbal communication, cooperation, patience, decision-making

Materials: a timer or a watch with a second hand

This is a wonderful activity to facilitate bringing a nonfunctional group back together. In this challenge, the group tries to pass a pulse as fast as possible around the circle. Have the students form a circle holding hands. Pick one student to start the pulse, and on the count of three, have them squeeze the hand of the person on their right ***or*** left. The student receiving the hand squeeze should pass the squeeze, or "pulse," on to the next student in the circle, continuing this from student to student. Warn the students not to "pulse" until they receive it, and *not to crush each other's hands*. Try and see how fast the group can move the pulse around the circle.

Ask the group what they did to move the pulse faster. How did they know when they received the pulse? When to give a pulse? Did the pulse ever slow down? Were they ever unsure if they received a pulse? Why?

Variations:
* After a couple of rounds, start the pulse in both directions so that it will have to pass itself somewhere in the circle
* Have the group close their eyes during the activity
* Have the group cross their hands and see if their time changes

#4 : ROPE KNOTS

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

☆ **Teamwork Skills**: verbal communication, listening, cooperation, patience, decision-making, taking on roles

Materials: 10 foot piece of rope with one knot per person

Set the rope on the ground in a straight line. Have the students line up along the rope. They may be on either side of the rope, but must face in the same direction. They should be spaced out evenly along the rope from beginning to end, and not grouped together. Have the students bend down and pick up the rope using either their right ***or*** left hand ***without*** touching any of the knots. **OOPS!** You forgot to mention that you put crazy glue on the rope and now they are stuck! Their challenge is to untie all of the knots without sliding or taking their "glued" hand off the rope. They may use their other hand in the process.

After the group has solved the problem, ask the group if they began by planning and working as a whole team or as smaller groups. Often, the group will unconsciously break into three groups, the two ends and the middle. What is the best way for a group to make a decision? Remind them that they will need the minds of everyone in the group to accomplish the task of building their rover.

#5 : ASTRO-KNOT

☆ **Teamwork Skills**: verbal communication, listening, cooperation, patience, decision-making, taking on roles

This is a wonderful challenge as it takes a relatively short period of time. Have the students get in a circle and extend their right hand into the middle of the circle. Then have them grasp hands with a person that is not to their immediate right or left. Next, have the students extend their left arms and grasp hands with a different individual (*not someone to their immediate left or right AND not a person with which they are already holding hands*). **The goal of this challenge is for the students to untangle themselves and to make a complete circle**. They should end up facing the middle of the circle and have all the kinks worked out so that they create a complete circle of individuals holding hands. They are not to break hands during the process.

Warning: This puzzle is not always solvable. The important thing is that the students put forth the effort towards completing the challenge as much as possible. If you see that they have exhausted their options, you can have them break and start again. You will want to give them more opportunities to try if they don't solve it right away. This will reflect the process of trial and error, and will be a good reference for working through trial and error processes encountered when building their Rover. A good idea with this challenge is to have a key word that when stated, the students freeze. You can then use this word if someone is getting pulled on, or when you need to stop them in order to discuss group dynamics issues.

#6 : LIFT-OFF

☆ **Teamwork Skills**: verbal communication, listening, cooperation, patience, taking on roles

In order to propel the team into the outer limits of space, they will need to achieve lift-off. Test runs can occur between two group members, **but the final goal is to launch all of the "crewmembers" into space via the group lift-off.** In order to practice this, have students pair off with someone who is relatively close to their size. Have the students sit back to back, with their legs out in front (knees bent with feet on the floor). They will also need to link by locking arms at the elbow. Once the students are in this position, they will need to move from this position to a standing position using good communication skills and cooperation (they need to remain back to back and linked during the process). If they can stand up, they have achieved lift-off.

After the students have practiced in pairs, have them try for group lift-off. Have the students get into the same sitting position they were in when they attempted this with only one other person. However, now they need to lock elbows with the two people on either side of them. This may mean that not everyone will have the same flat surface of someone else's back to push off of – this is okay. Instead, they must achieve a balance of force between all members of the group so that they can push themselves up into lift-off. Have them try this activity in differing group sizes, and then discuss what size was easiest, hardest, and why. This is an excellent way to discuss group dynamics.

#7 : PROBE LEVITATION

✯ **<u>Teamwork Skills</u>**: verbal communication, listening, cooperation, patience, taking on roles

Materials: A tent pole

(Do not substitute another type of pole for the tent pole. It is important to use a lightweight pole in this exercise – a heavier pole will not function properly for the goal of this exercise)

Astronauts are not only physically fit and healthy, but they are also capable of performing tasks that require control and a gentle touch. This challenge tests the teams' ability to put mind over matter, and to put the powers of concentration and teamwork to the test.

The Scenario: The team is transporting a delicate instrument to the space ship. They have done a wonderful job thus far, but the most difficult part of transporting this particular piece of equipment is setting it down. They must work as a team to gently place the equipment into a secure container on the floor (*the container is imaginary unless you have something that will work as a container*).

The Directions: Use a tent pole as the instrument that the students must set down. This is important for posing the challenge. Tent poles are very light, so they work well for this. Have the students split into two lines that are facing one another and hold only their index fingers pointing straight out. Students should line their fingers up in an alternating pattern (like a zipper). Lay the rod on top of their fingers and let them begin the challenge of trying to set the rod down. This sounds very easy, but it is not. The more people involved, the harder the process, so feel free to have mentors and others involved in this activity.

#8 : SPACE WALK

✯ **<u>Teamwork Skills</u>**: verbal communication, listening, cooperation, patience, time management, decision-making, taking on roles

Materials: Four pieces of corrugated cardboard measuring 1' x 1' (Special gravity walking space plates)**,** two blindfolds, and a clear space on the ground of about 10 feet by 10 feet.

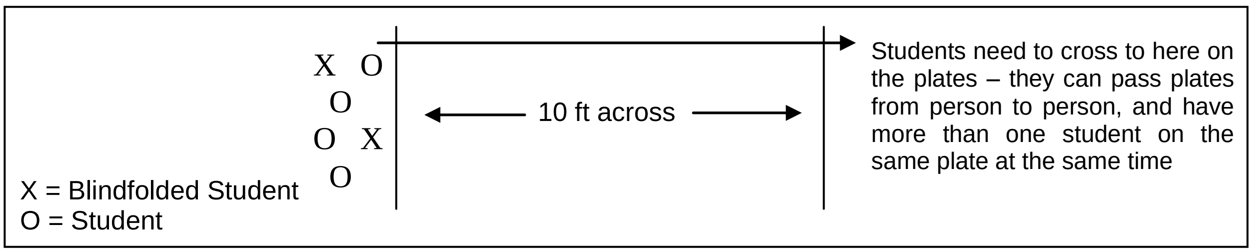
Astronauts face challenges during their time in space that we cannot even imagine here on Earth. Simple travel, such as walking, becomes an interesting experience. For example, Mars has only 1/3 the force of gravity of that of the Earth, so walking on Mars is much different than on Earth. Some planets have even less gravitational pull.

The Scenario: NASA has developed special gravity walking plates to assist astronauts in walking on planets where there is a low gravitational pull. Unfortunately, the plates must have human contact to be activated, and the people using them cannot let go of the plates while using them, or they become deactivated. Once deactivated, a plate cannot be reactivated. This is a design flaw that is currently being worked on.

The team has been asked to test the gravity walking plates for an emergency mission to Mars, which has a low gravitational force field. An additional task has been added in order to test your crews' teamwork ability. If you have 6 team members, two of your team members will be blindfolded. If you have only 4-5 team members, only one member will be blindfolded.

The Directions: To test the plates, the entire team must use the plates to walk on the surface of Mars for a total distance of 10 feet. Place markers on the ground so that the students can see the space they need to cross. Choose the member(s) that will be blindfolded. Now they are ready to put the plates to work. **Remember, they cannot let go of the plates at any time or the plates will not work**. They can be holding a plate, standing on one, or just touching one in order to maintain this human contact and keep the plate active. However, note they cannot step anywhere on the ground off of the plates at any time, or they will be subjected to Mars' true gravitational force, and thus fail the mission. More than one student can be standing on / touching / holding a plate at the same time.

During the crossing process, if the students fail to keep contact with a plate, even for a second, confiscate the deactivated plate. **The goal is to get all of team members across the area, and to hold onto as many plates as they can**. Below is a drawing to help you visualize the process. Discuss the teamwork involved to complete this activity.



The Spaghetti Incident

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

Introduction & Purpose

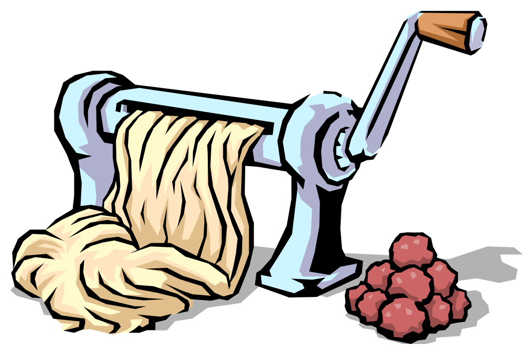
This activity will demonstrate how well your students work together as a team, especially in terms of communication. The students will work as a team to build as tall a tower as possible with only the materials listed below, without speaking to each other. This exercise will demonstrate to your students that good communication is essential in order to function together as a team successfully. They should also realize that they could work more efficiently if team members each take on a separate role (although these roles certainly do not need to be permanent). This activity can be repeated several times, so students have the opportunity to improve upon their tower height and their teamwork skills.

Objective:

Students will work as a team, but without speaking, to build the tallest possible tower out of a limited supply of common materials. Students will discuss the importance of communication within a team and analyze their strengths and weaknesses as a team.

Materials Needed:

- 12 pieces of dry spaghetti noodles
  (have a few extra in case some break)
- 6 gumdrops
- Small bag of miniature marshmallows
- A meter stick
- A pen or pencil
- Engineering Challenge Lab Notebook



Procedure:

Complete directions for this activity are included in the student copy of the Activity Book. Before allowing your team to begin tower construction, have them read over the directions. Do not allow them to discuss any aspects of how they will build the tower. **Remember that the students <u>cannot talk</u> while building the spaghetti / gumdrop / marshmallow tower.** Warn them that each time someone breaks the no-talking rule, you will confiscate one of their gumdrops. Set a time limit for tower construction – most often, ten minutes is sufficient.

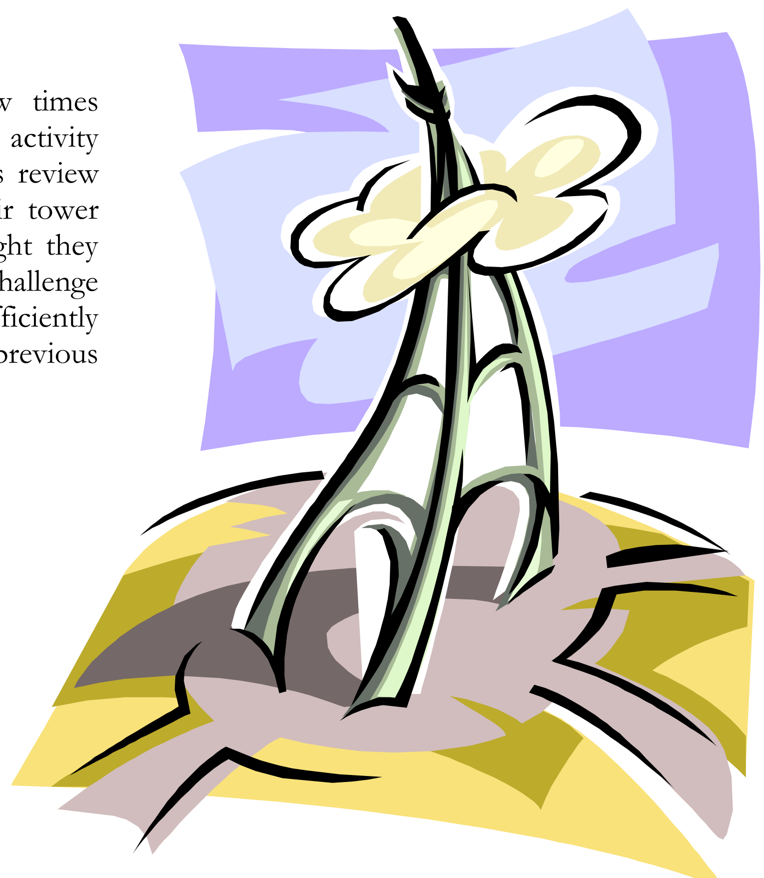
Once everyone understands the rules, let them begin to build. Make sure to start timing the event once the students start to build. Once time is up, have the students measure the height of their tower and record it in their Lab Notebook.

Now lead the team in a group discussion about how they went about building their tower. Ask questions such as, **"What was most difficult about building the tower?", "What impact did not being able to speak have on your success?", "Did all team members participate equally?"** and **"Did everyone do the same sort of thing?"** Try to direct the group discussion toward recognizing non-verbal communication skills, and assignment of members to specific tasks, or "roles." Have the students write some ideas about how they built their tower, especially in terms of teamwork skills, in their Engineering Challenge Lab Notebook.

After the students have recorded their ideas, lead another discussion about how they could have worked as a team more effectively. "**What could your team have done differently?" and "How do you think these different ideas would have affected the height of the tower?"** Have them write some ideas regarding these questions in their Engineering Challenge Lab Notebook as well.

Hints / Suggestions: You can allow students to break up the spaghetti, gumdrops, or marshmallows to enable the team to have more building pieces. Remember, there is **NO TALKING during the ENTIRE building section of the activity** -- if this rule is not followed, take away one entire gumdrop each time a student speaks.

This activity can be repeated a few times during the year. If you complete this activity again, make sure to have the students review their notes about how they built their tower the time before, and what they thought they could do better after they built it. Challenge them to work together even more efficiently than the last time, and to break their previous tower height record.



Copy Cat

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

Introduction & Purpose

This activity focuses on the role of communication in working as a team. We all know how difficult it is to communicate clear and concise directions to another person. The person who is listening to the directions often needs to ask questions to clarify a point. Other times, long after you have completed giving the directions, you think of a forgotten detail or may discover a better way to explain a component of the directions. This activity will provide your team practice in giving clear, concise directions, listening carefully, and asking directive questions while receiving directions.

Objective:

Students will instruct each other on how to arrange a variety of paper cut-out shapes into an original design. Students will also practice listening and asking questions about the given instructions.

Materials Needed:

- 1 set of Copy Cat Shapes for each team member
  (6 sets are included in the student workbook)
- A few pairs of scissors, ideally one pair for each student
- Engineering Challenge Lab Notebook

Procedure:

The students do not have information about this activity in their booklet, other than the Copy Cat Shapes and an example of a design, so you will need to provide directions for this exercise. First, have the students cut the shapes out. Make sure they understand that each student should keep his/her shapes separate from other students' shapes (each student should have a complete set of shapes – do not mix sets!). Have the students pair off and sit back to back with a table/desk in front of each of them. Have each pair decide who will be the **"Builder"** and who will be the **"Explainer"** for the first part of the round. Each student will have a chance to play both roles. You may want to set a time limit for each puzzle *(there will be a total of four)* -- five minutes per puzzle construction has been found to be sufficient for this activity. Once the pairs begin Round 1 of this exercise, walk around and listen to the directions being given, and use what you hear as examples of clear communication and poor communication.

Round 1: One-Way Communication

Have the "Explainer" arrange their set of shapes into a single design of some sort, ***using every shape in their design***. The design must be built so that each piece is touching another piece, but none of the pieces should be overlapping *(refer to the example provided in the Student Activity Book)*. The "Explainer" must then explain to the "Builder" how to build the design with their set of shapes ***without looking at each other*** (No peeking! ☺). The "Builder" must construct what they hear described ***without speaking or asking questions***. Once the allotted time has passed (e.g., five minutes), the partners can compare designs to see how close the "Builder" came to replicating the "Explainer's" design.

For the second part of the round, have the members of each pair switch roles while still remaining back to back. Have the "Explainer" arrange the shapes into a new design, then have the "Explainer" explain how to build the design to the "Builder." After the allotted time has passed, again allow the partners to compare designs.

Debriefing

Once round one is completed, you will want to start a discussion with your students about clear and concise communication. **How can one person assure that what they are saying makes sense to the other person?** Other questions to ask include **"Did you have good success in building what the Explainers described? Why or why not?," "What was difficult in the process?,"** and **"How could it have been easier?"** Most often, students will state that not being able to talk or ask questions was the most difficult component of the process, and that asking questions would have made it much easier.

Round 2: Two-Way Communication

In round two, have each pair from round one change roles again, still sitting back to back. Together, each pair must try to improve their results from round one. Have the "Explainer" build a new design to explain to the "Builder." This time, however, the "Builder" is allowed to speak and ask questions *(but there is still no peeking allowed!)*. Once the allotted time has passed (five minutes), partners should compare results. Then, have the partners switch roles for a last time, and complete the exercise again, comparing their results after time has expired.

Debriefing

After round two, bring the group back together and ask them if they had better success using two-way communication. **Were they able to complete the design? Why or why not? Did two-way communication provide better accuracy between designs, but slow down the process?** Most often, once questions and answers enter the exercise, the students are not able to complete the design entirely, but what they do complete contains higher accuracy than the one-way communication design process. **What makes a good Explainer?** Answers might include slow, specific, and clear instructions. **What makes a good Builder?** Answers might include good listening skills, asking good questions, and patience. These are all qualities that are necessary to work together towards the end result of producing a Mars Rover. Have the students record their thoughts and answers in their Lab Notebook.

Now, if you would like a real challenge……

Round 3: Team Communication

For the third round, select (or have the team select) one student to be the "Explainer," and have the rest of the team act as the "Builders." Arrange the "Explainer" and "Builders" as stated in previous rounds, with the "Builders" using only **ONE** complete set of shapes. Depending on how much time you have available and what your team needs to practice the most, you can either start with one-way communication (builders cannot speak or ask questions) or skip to two-way communication (builders may speak and ask questions). Have the "Explainer" create a design, and then follow the procedures outlined in round one and two to complete round three. A suggested time limit for this round is ten minutes. Once the allotted time has passed, let the team compare the designs. If you wish, you may allow all team members to act as the "Explainer," or complete the round only once or twice.

Debriefing

After round three, ask the group what they learned after completing all of the rounds. Was it more difficult to have several builders (Round 3), or more difficult to have only one builder (Rounds 1 and 2)? Why or why not? How did the building group deal with having several ideas at one time? Did anyone in the building group fall into a leadership role? Did builders take turns being leaders, or did only one person play that role? How well did the building group communicate with each other? Listen to each other? Did it take longer to build this design than it did with only one builder? Why or why not? Was the design constructed by the building group more accurate than the design made by a single builder? Why or why not? Often, it is found that differences in individuals create problems in teams, especially in respect to communication. Have the team recognize that effective communication is essential to the teamwork process if they want to succeed in the Mars Rover Challenge. Have them record their thoughts and ideas in their Lab Notebook.

Parts of the Whole: Developing a Sense of Team Skills

The brainteasers are in the Student Workbook. If you do not want them to cut the puzzle pieces out of the book, you may want to make a copy for them to use.

Introduction & Purpose

The teambuilding activities up to this point have been a wonderful way to help build team spirit and to have students practice and discuss behaviors that are conducive to working together. The activities may also bring certain individual strengths to the surface. An example of this would be a student who automatically assumes the role of the guide in each initiative during the "Building a Working Team" exercise. The following activities are designed to bring these strengths and weaknesses to light even more, and to have students think about the roles they enjoy being responsible for in a group. There are a series of brainteasers that students will work through as a group to assist with bringing these strengths, weaknesses and roles to the forefront.

Objective:
To expose students to the multiple skill sets beneficial to working as a cooperative team unit. Students will assume specific roles that are essential when problem solving in a group setting, and will rotate through the roles using various practical brain-teaser problems as the foundation for working together in their specific roles.

Materials Needed:

- 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 (**included** in Student Activity Book)
- Engineering Challenge Lab Notebook

Procedure:

Assist the group with choosing a beginning role for each team member. Also devise a system for alternating roles as the group moves through the various puzzles (the students may wish to devise the plan, but make sure you are aware of it). If they are struggling to solve a puzzle, you may want to give them a *slight* nudge in the right direction. If they are totally stumped, have them move on to another puzzle and come back to the puzzle that they are stuck on later. When they revisit this puzzle, have them assume the same roles, or assume different roles if they feel they need to in order to solve the puzzle on the second attempt. After the group completes a puzzle, have the students answer the questions on the role question sheet for the role they just completed. After each student has had the opportunity to participate in all four roles, have the students discuss their answers as a group. **What role(s) worked best for each student? How did student strengths and weaknesses become involved when the students were required to take on specific roles?**

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?

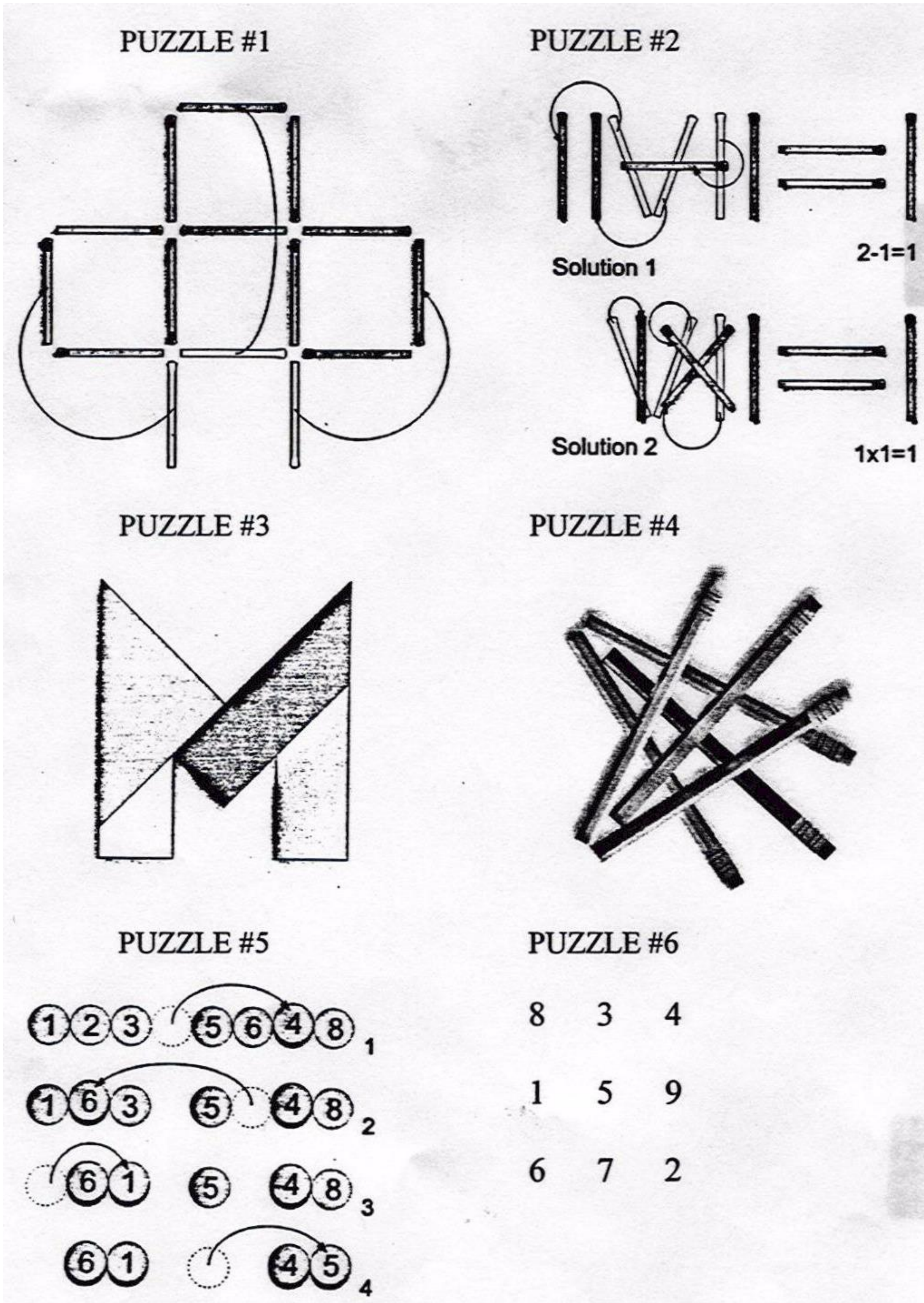
2. What was the most difficult thing about being the brainstormer?

Builder

1. Was it easy to follow the other team members' instructions?

2. Did you like being the builder? Why or why not?

Answers to the Puzzles



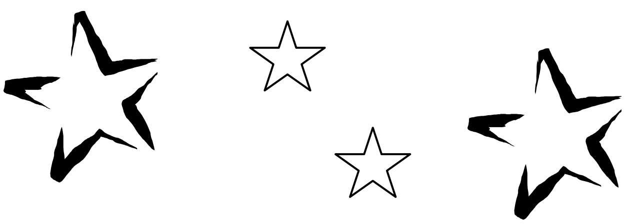
3-2-1 Pop! - An Effervescent Race

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

Introduction & Purpose

Many Engineering Challenge teams in the past have lost points during the Engineering Challenge in the Lab Notebook / Budget event, which is ***20%*** of the overall composite score. The only event worth more in competition is the Rover Presentation & Display (25% of the overall composite score). A complete description of the requirements and scoring for each event will be included in this Competition Manual. Before using kits, it is important that the students have a working knowledge of how to keep this Lab Notebook, and how to approach this project using the Engineering Design Process. This activity is designed to introduce your team to the Engineering Design Process and the elements of a good lab notebook in order to improve their science skills and performance at the Engineering Challenge. You can also use this activity to reinforce the idea of assigning roles to team members. The following is a description of the Engineering Design Process for the Engineering Challenge.

Objective:
Students will research the effects of surface area and temperature on the efficiency of rocket fuels. Students will follow the Engineering Design Process while constructing a series of rocket designs, and will record the steps of the Engineering Design Process in their Engineering Challenge Lab Notebook.



Materials Needed:

- Timer or a watch with a second hand
- 4 Alka-Seltzer or other effervescent tablets
- Tweezers
- 2 beakers
- Warm and cold water
- Thermometer
- 35mm film canisters with internal sealing lids (usually the clear canisters) - *these can typically be obtained from a film developing shop, which recycles these containers*
- Construction paper
- Tape
- Scissors
- Paper towels
- Pens or pencils
- Engineering Challenge Lab Notebook

Engineering Design Process:

Engineering Challenge teams are responsible for observing the Engineering Design Process during the creation of their Rover. This process must be reflected in the Display and Presentation created by each team and in the required Lab Notebook maintained by each team, which will be evaluated at the Engineering Challenge. The six steps of the Engineering Design Process are detailed in the student instructions for this activity.

Procedure:

The Student Activity Book contains all the directions for this activity. Your role will be to provide guidance, supervision, and act as a resource for the students. The students will compare the reaction rates of effervescent antacid tablets under varying conditions of surface area and temperature in a rocket design.

A Word About Safety:

Be **<u>VERY CAREFUL</u>** with these rockets. Depending on how much water and antacid is placed into the canister, these rockets can take off with impressive acceleration. Make sure your students observe the following procedures during this activity:

- ★ To ***stand several feet back*** from the rocket before take off
- ★ To alert everyone in the room about the launch before allowing the rocket to take off
- ★ To ***NOT*** use more than ***ONE*** whole antacid tablet per canister

In the first part of this activity, the students will investigate the effects of surface area and temperature on rocket fuels (i.e., the water and antacid tablets). In the second part of the activity, the students will use the information gathered to ascertain the efficiency of homemade rockets. Their homemade rocket's base will be made of a film canister with a construction paper nose and fins attached. To make the rocket lift off, a small amount of water (maybe 1/3 full) and part of an antacid tablet ***(no more than one whole tablet)*** is placed in the canister, and the lid is quickly snapped into place. The pressure created by the carbon dioxide released from the tablet will make the canister lift off in a matter of seconds (depending on how much water, tablet, temperature, etc.).

The students have specific directions in their Activity Book for how they should design their rockets following the Engineering Design Process. Be sure the students take good notes about each step in their Lab Notebook. This is the process they will need to follow when designing their Rover, and the notes taken in this activity reflect how notes should be taken in their Lab Notebook when designing their Mars Rover.

If they need ideas during brainstorming, help them get started, but do not give them too many ideas. They should have a few ideas from conducting the research on how surface area and temperature affect the rocket "fuel." Other ideas include:

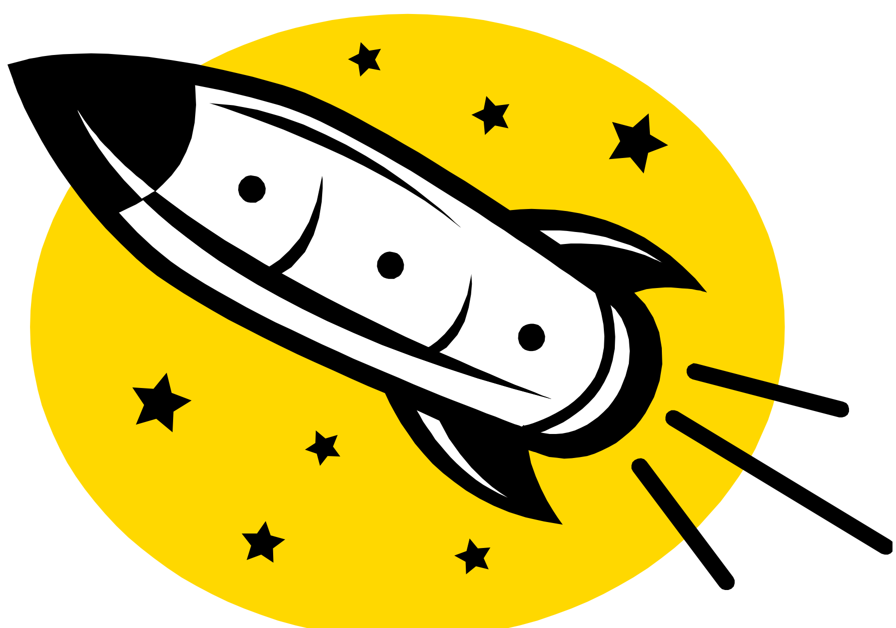
- ★ How does the amount of water placed in the canister affect how high the rocket flies?
- ★ How does the amount of the antacid tablet used affect how high the rocket flies? ***(Remember – do NOT use more than ONE per canister!)***
- ★ How does the length or empty weight of the rocket affect how high it flies?
- ★ How do the number, shape, and orientation of fins affect how the rocket flies?

<u>Debriefing</u>

Once your students have completed their design, be sure they present their final product in their Lab Notebook to you. You might want to give them some suggestions about how they can improve their

Lab Notebook for the future (i.e., Rover Engineering Design Process). **Be sure to give them lots of positive feedback and support!** If your team is willing, have them give a verbal presentation to you or the class as well *(this is a component of the Engineering Challenge)*. Presenting their rocket design is great practice for the real thing!

Also, lead the team in a discussion about the Engineering Design Process and the Lab Notebook in general. Start by asking if they have any questions about either topic. Then have them consider how much time it took to complete each step in the Design Process. **Which steps took the longest?** The same steps will probably take the most time when building the Rover as well, so they should remember this when planning for their Rover Engineering Design Process. **Which steps were the most and least difficult? Does every team member agree, or did some people find one step difficult, while other people found that step easy?** This is another consideration for the team's future Rover construction. **Did everyone do all steps? Why or why not? Did some team members naturally fall into certain roles? If so, how does the rest of the team feel about this?** Continue to lead the discussion until you think you have touched upon everything that could be helpful for the students to think about in terms of their Rover Engineering Design Process and Lab Notebook. This activity should serve as a very useful learning experience for your team, and great preparation for the Presentation and Lab Notebook components of Engineering Challenge.



Earthling Exploration of Mars

Adapted from Thursday's Classroom Activity "Red Planet Time Line" – located on the web at www.thursdaysclassroom.com/20jul01/teachtimeline.html

Introduction & Purpose

This activity will not only introduce your students to the historical exploration of Mars, but it will also teach them how to make timelines and set goals! Creation of a timeline is a **required** activity for each team in Engineering Challenge because it is important for teams to think about what designing and constructing a Rover for competition entails ***early on*** in the process. Often, teams wait until the last minute to start testing designs, or underestimate the amount of time it takes to complete one of the tasks of the program. If the team understands ***early on*** the level of involvement necessary for the Engineering Challenge, perhaps these and similar situations can be avoided, thus allowing the team the best opportunity to achieve success.

Objective:

Students will read an article about the past exploration of Mars and construct a timeline with information from the article. Students will then develop goals and construct a timeline for the design, construction, and presentation of their Rover.

Materials Needed:

- "The Earthlings Are Coming" story *(in the Student Activity Book)*
- Engineering Challenge Lab Notebook
- A ruler, pencils, and some scratch paper
- **Optional:** poster-sized paper or poster board and art supplies (like paints, markers, construction paper, etc.)

Procedure:

There are detailed instructions for this activity in the Student Activity Book. Your role during this activity is that of a facilitator.

First, the students will read an article about the exploration of Mars included in their Activity Book. A timeline that outlines the events described in the article will then be created. During this part of the activity, be sure your students understand the suggested structure of the timeline. Encourage them to think ahead about how they will organize the information on the page, and what information they will use from the story. For example, they should not include long descriptions for every event, but short, specific titles.

The next part of the activity will most likely be more difficult for your students. They will have to think ahead through the next few months, and brainstorm all the things they will have to do to prepare for the Rover Design Competition. Goals for each of these target areas then need to be created, and a timeline for accomplishing these goals constructed in the Lab Notebook. We suggest that the team include the following items ***at the minimum*** on their timeline:

- Inventory Lego® kits (by February 10th)
- Practice gearing designs (for mobility, speed, climbing, etc.)
- Practice steering designs (for mobility, speed, etc.)
- Practice rock collection designs
- Brainstorm ideas for final design, based on practice designs
- Select final design

- Build final design
- Test & revise final design as necessary
- Prepare poster & verbal presentation
- Attend local Engineering Challenge
- Kit return

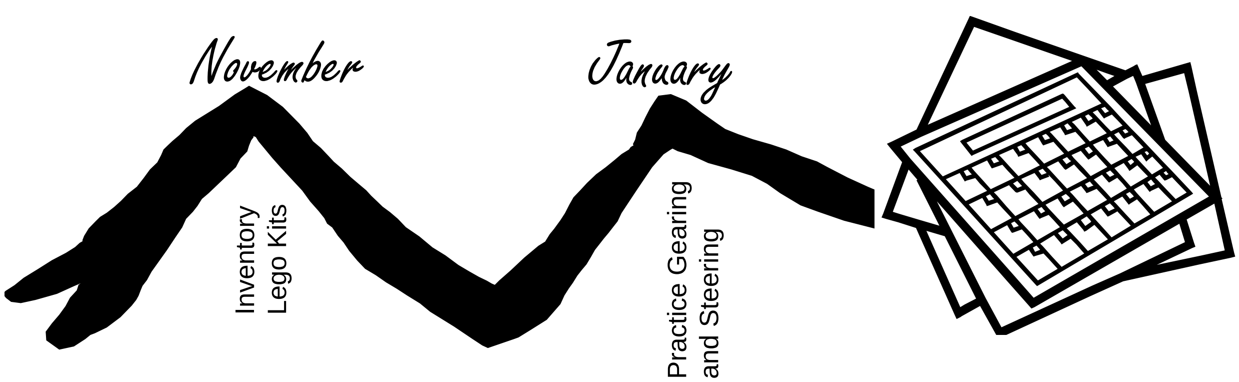
In order for the team to establish a reasonable timeline for the items they identify, it will be necessary to have them refer back to the "3-2-1 Pop! – An Effervescent Race" activity for information about the engineering design process. Additionally, you will need to advise them about the following information. This information was gathered from a survey of former teacher sponsors in order to help teams determine the level of involvement necessary for success in Mars Rover activities.

General Logistics of Engineering Challenge:

- Most Engineering Challenge teams meet after school at a regularly scheduled meeting time at the school
- On average, most teams meet for 2-4 hours at a minimum each week, and 1-2 times overall each week
- The total preparation time for students in the Engineering Challenge on average is 50-60 hours. Many teams increase the hours they meet each week to 5-6 during the two weeks prior to competition
- Teacher sponsors, on average, spend 10-20 hours preparing activities and participating in personal learning about concepts of the program in order to assist the team in the Engineering Challenge
- Most teams approach the tasks of the program by assigning tasks to certain team members, or by having the team focus on one task at a time

Lastly, explain to the team that if they do not meet a goal by the original date on the timeline, this is not a sign that the team is going to fail. Sometimes things take longer than expected, and this is okay. *Goals can be flexible.* **The point of this exercise is not to overwhelm the team, but to help the team begin to create an overall picture of the Engineering Challenge**.

We also recommend that the team create a poster of their timeline so it can be hung where the team will meet as a frequent reminder of their goals and of what is still to come. Let them be creative, and most of all, **HAVE FUN**!



Academic Rodeo Website Activity

Introduction & Purpose

This activity is intended to familiarize the team with the Engineering Challenge rules and other information about the contest on the Academic Rodeo Engineering Challenge page on the website. Often, a member of the team, an advisor, parent, or even a teacher will have questions about the Mars Rover Challenge. The Academic Rodeo website is an excellent resource for everyone involved, and will likely provide the answers to many of your questions. We highly recommend that your entire group, not just the Engineering Team, become familiar with this website, so please take time to explore it! **http://www.etstatefair.com/p/207**

Objective:
Students will explore the Academic Rodeo website in search of the answers to ten questions and a tricky description.

Materials Needed:

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

Procedure:

The Student Activity Book contains all of the information necessary for the students to perform this activity. You will need to provide assistance as necessary if the students encounter difficulties. This activity guides the students to the Academic Rodeo Engineering Challenge page on the website, located at **http://www.etstatefair.com/p/207**, and has the team respond to ten questions using the information on the site. Encourage your team to answer the questions in their Lab Notebook. There is a hint for where to find the answer to each question in the Students' Activity Book, and the answers to the questions are provided below. Finally, the students should provide a response to the Tricky Description called for in their Lab Notebook.

Answers to Questions

(1) The University of Texas at Tyler Ingenuity Center

(2) One for each individual on the team - 4

(3) 15 minutes

(4) Only the Engineering Team is allowed to design and construct the Rover.

(5) A team can spend up to $75 on additional Lego® parts.

(6) A team is allowed to use no more than three Lego® motors **OR** three battery boxes (*NOT three motors AND three battery boxes).*

(7) Click on "Rover Scoring" in the list of links at the bottom of the main site. The scoring for each component of Engineering Challenge is outlined there.

(8) Each Rover is scored in the following seven areas: Speed Test, Rock Collection Test, Hill Climb Test, "Blind Driving" Test, Rover Weight, Display & Presentation, and Lab Notebook & Budget.

(9) The team's spokesperson should convince the panel of judges that his or her team's vehicle is the best-constructed, most thoughtfully designed Rover available for the purported mission to Mars.

(10) The awards presented at the Engineering Challenge include: 1st, 2nd, and 3rd places in each level. Additionally, special awards may be award and may include: Fastest Rover, Most Rocks Collected, Best Climbing Rover, Best "Blind Driving" Teamwork, Lightest Rover, Most Creative Rover, Best Rover Display, Best Rover Presentation, Best Lab Notebook, Best Team Name, Best Team Spirit, and Best Understanding of the Design Process.

Answer to Tricky Description: Using any or all of the Supplied Elements and Other Non-Lego® Allowable Elements, design and construct a Rover which will be able to navigate Martian terrain, be as lightweight as possible, and be able to collect rock samples. Each Engineering Team must also maintain a Lab Notebook that includes notes on the Design Process, a timeline, pie charts, and three budgets.

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: Click on The Challenge

Pepsi on Pluto – Weighing In & Growing Old

Introduction & Purpose

This activity will introduce your students to how gravity and age varies on the different planets due to differences in planetary mass, size, and orbit. Most students are surprised at how their own weight and age would differ on each planet, which makes this a fun activity. This activity is also relevant to Rover construction because the Martian gravitational field is different than that of the Earth, so the performance of a Rover tested on the Earth's surface will perform differently on Mars. The Rover's ability to collect and/or sample rocks on the Martian surface may be affected by this difference in gravity.

Objective: Students will form a hypothesis about the weights of the planets in our solar system. Students will also calculate their own weights and ages on each of the planets. They will use their weight information to revise their initial hypothesis. Finally, students will check their weight and age calculations on the Internet.

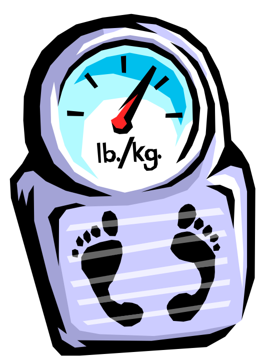
Materials Needed:

- 8 empty Pepsi cans and one unopened Pepsi can
- 824 pennies
- *Planetary Data* table (in Student Activity Book)
- *Multiplication Factors* table (in Student Activity Book)
- Calculator
- Computer with Netscape Navigator or Explorer (any Internet browser will work)
- Pens or pencils
- Engineering Challenge Lab Notebook

Procedure:

To set up this activity, fill empty Pepsi cans with the number of pennies indicated in the following list:

- Mercury - 38
- Venus - 101
- Earth - (use an unopened can of Pepsi)
- Mars - 38
- Jupiter - 293
- Saturn - 119
- Uranus - 102
- Neptune - 133
- Pluto - none



Randomly label each can with a number, and record which number represents which planet. ***Do not share this information with your students.***

Have the team compare the weights of the different cans by picking them up one by one. Then have the students form a hypothesis in their Lab Notebook about the proper order of the cans according to the order of the planets in our solar system based upon how much each can weighs. Have the team line up the cans in the order they hypothesized.

Next, have the students review the background information that demonstrates how mass and size determine the gravitational pull of a planet. Be sure they understand the relationship between gravity and weight. Also, review how the length of a planet's orbit affects the length of that planet's year. Be sure they understand the relationship between the length of a planet's orbit and an individual's age. Have the students use their calculators and the multiplication factor table included in the Student Activity Book to calculate their weights and ages on the various planets.

Now that the team has thought about their weights on the different planets, they should be able to revise their hypothesis about the Pepsi cans with this new knowledge. Let them change the order of the cans if they wish. Once they are satisfied with the order, reveal to them which planet is represented by each Pepsi can.

Finally, have the students check their answers for their weight on each planet by using the following web site:

To check weight:: http://www.exploratorium.edu/ronh/weight/

If time allows, encourage the students to explore these web sites further. Make sure the team records its thoughts and ideas in their Lab Notebook!

Debriefing

Lead the team in a discussion about why being aware of your weight and age on another planet may be important. Have them reconsider some of the questions posed at the beginning of this activity in their Activity Book -- **How will gravitational fields different than that of Earth affect the Rover's mobility? How will the difference in gravity affect the Rover's ability to sample Martian rocks? What other aspects of a Mars Rover mission might be affected by differences in weight? How could differences in age affect a mission to Mars in which astronauts spend time on the surface? What about if humans ever colonize Mars**? Encourage the team to use their imaginations, and to record their thoughts and ideas in their Engineering Challenge Lab Notebook.

(Included in 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!?!

Some questions are adapted from an activity from the American Museum of Natural History, entitled "Martian (and Other Extraterrestrial) Math" located at www.amnh.org/rose/mars/mathact.html

Introduction & Purpose

An excellent way to introduce your students to Mars is through comparison. Since the students are most likely familiar with some of the basic characteristics of the Earth and know what it's like to be on the Earth's surface, your students can learn a lot about Mars by comparing its characteristics to those on Earth. Your students should then be able to begin to imagine what it is like to be on the surface of Mars. Their ideas about the Martian surface may be useful as they begin to design and construct their Rover, so have them write down their ideas in their Lab Notebook. This activity will also exercise the students' mathematical abilities by prompting and guiding them to convert various units of measure into others. Your primary role during this activity will involve assisting with mathematical conversions and encouraging creativity while brainstorming.

Objective:

Students will work as a group to answer a series of questions about basic Martian characteristics by performing mathematical conversions. Students will compare these characteristics to those of Earth, and imagine what it is like to be on the surface of Mars. Finally, students will brainstorm ideas as to how these characteristics of the Martian surface may impact their Rover design.

Materials Needed:

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

Procedure:

The Student Activity Book contains all the information necessary for the students to perform this activity. The students will perform mathematical conversions and answer twelve questions about Mars and the Earth. Provide assistance as necessary, and check that your students are correctly calculating the conversions *(the answers are included below)*. If the students are having trouble with the conversions, gather them as a group and walk them through the first couple of conversions, thinking out loud. They should be able to pick up how to perform the conversions from your modeling. You may need to encourage creativity on questions 12 and 13. Have them write down their ideas in their Lab Notebook, especially the answers to questions 12 and 13!

Answers to Questions

(1) The letters indicate what standard unit of measure the number was measured with

(2)

Measurement	Convert both Earth & Mars data to:
Average Distance from the Sun	Earth = 92,750,692 miles Mars = 141,320,717 miles
Equator Diameter	Earth = 7909 miles Mars = 4324 miles
Polar Diameter	Earth = 7885 miles Mars = 4181 miles
Mass	Earth = 1.31 x 10^{25} pounds Mars = 1.4 x 10^{24} pounds
Maximum Surface Temperature	Earth = 58 degrees C Earth = 136 degrees F
	Mars = 20 degrees C Mars = 68 degrees F
Minimum Surface Temperature	Earth = -89 degrees C Earth = -128 degrees F
	Mars = -140 degrees C Mars = -220 degrees F
Rotational Period (in next table)	How many hours for Earth? 24 hours For Mars? 24.5 hours
Orbital Period	How many years for Earth? 1 year For Mars? 1.88 years

(3) Scientists use the metric system because it is based on units in sets of ten, which makes converting between units simple

(4) 1.5 AU - the orbit of Mars is one and a half times larger than the orbit of Earth

(5) 40 AU - Pluto's orbit is 40 times larger than the orbit of Earth

(6) 3 hours - the answer is in hours because the speed was in kilometers per hour

(7) 2 hours

(8) About 22,000 days or 60 years -- of course, no airplane can fly through empty space….but rockets do, and they are also much faster!

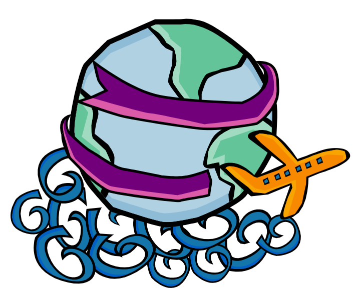
(9) 647 seconds, or about 11 minutes -- so you are not able to have a quick "conversation" between Mission Control and the Pathfinder!

(10) Student responses will vary

(11) Student responses will vary

(12) Student responses will vary

(13) Student responses will vary



Mars in Reverse

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

Introduction & Purpose

This brief demonstration is a good way to get your students thinking about how people discovered how celestial bodies in the solar system move. One of the larger clues was the retrograde motion of Mars, as viewed from Earth. As Earth passes Mars in its orbit, Mars appears to stop, briefly back up, and then move in the original direction again. This retrograde motion is only possible because the planets move in elliptical orbits around the Sun, instead of in circular orbits as originally anticipated.

Objective:

Students will demonstrate the retrograde motion of Mars that is apparent when its orbit is viewed from Earth.

Materials Needed:

- Students in pairs
- One student in each pair is to be on wheels (bicycle, skates, skateboard, etc.)
- A helmet for the student on wheels
- A place with a clear, long straightaway with few pedestrians and ***no cars!*** (a park, playground, gym, etc.)
- Pen or pencil
- Engineering Challenge Lab Notebook

Procedure:

The students have a little background information in their Activity Book regarding this activity, as well as an explanation of how the demonstration relates to the retrograde motion of Mars. Every student should get a chance to be on wheels, because it is from this perspective that you can see the retrograde motion. Also, to demonstrate student understanding of the connection to the orbit of Mars, have each pair explain the phenomenon to you after the activity is complete, and comment in their Lab Notebook.

To complete the activity, each pair will establish a start point, end point, and a stationary midpoint along the long straightaway. Both students in each pair will begin at the starting point at the same time. Have the student on foot begin to walk forward in a straight line first, and then have the student on wheels **(*make sure they wear a helmet!*)** begin moving forward a little more slowly than the other, having both students focus on the middle point as they progress forward (this is why it is important that the path be ***clear*** and ***free of pedestrians and cars***). As both students approach the middle point, the student on wheels should speed up and pass their partner, still watching the middle point as long as it is safe. The student on wheels should see their partner go in retrograde motion. Specifically, the student on foot should appear to stop, back up slightly, and then continue forward -- similar to that of Martian orbit as seen from Earth.

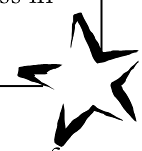
Crater Creation

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

Introduction & Purpose

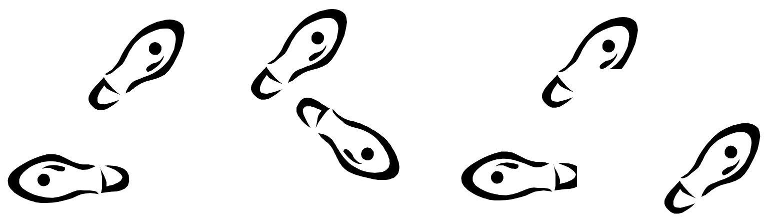
This activity explores the formation of impact craters on a planet's surface. By understanding the processes involved in cratering, and how several variables such as mass, velocity, size of projectile, angle of approach, and surface material at impact affect the features of craters, scientists have been able to learn much about the history and surface of the Earth and other planets. In the five experiments of this activity, students will vary each of the variables listed above to determine how they affect crater features.

Note: The fifth part of this experiment involves mud, making it potentially messy. Secure a good location in order to perform the fifth component, such as outside or somewhere you can lay out plastic sheeting. Use old shirts to keep students' clothes as clean as possible, or request the students dress in clothing that can get dirty.



Objective:

Students will determine through experimentation how five variables affect the features of an impact crater.



Materials Needed:

- Flour
- 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
- Sturdy plastic spoons
- Baby wipes or paper towels to clean mud off skin
- Broom and dustpan
- Ruler and meter stick
- Pens or pencils
- Crater Creation Answer Sheet (in Student Activity Book)
- Engineering Challenge Lab Notebook

Procedure:

The Student Activity book contains detailed directions for the students to use, which have been reproduced below so you may plan accordingly.

(1) Have the team read through the background material and look at the illustrations provided in their Activity Book. Fill the large tub or pan with flour approximately 3" deep, sprinkling a little cocoa on the surface to help make changes more visible.

(2) Have the team collaborate to form a hypothesis about each cratering test prior to conducting the tests described in steps #3 and #5 *(this activity contains a total of 5 cratering tests)*.

(3) **Closely supervise** *(to prevent messes)* while the students conduct the four cratering tests described below. We suggest that you assign or have the team members choose roles for the experiments, and have the members rotate to different roles so each member can obtain experience in each role. One team member can record measurements and observations, one member can drop the balls / marbles / mud into the tub, one or two members can describe the resulting crater to the recorder, and the final one or two members can measure the crater diameters. The team has a list of questions in their Student Activity Book for use in recording observations and measurements in their Lab Notebook. When making observations, have them refer to the illustrations included in their Activity Book, and encourage the use of the feature terminology (i.e., rim, ejecta blanket, ray pattern, wall, floor, central peak). Have the students smooth out the flour and sprinkle additional cocoa on the surface before each crater attempt.

Experiment #1: How mass affects impact craters

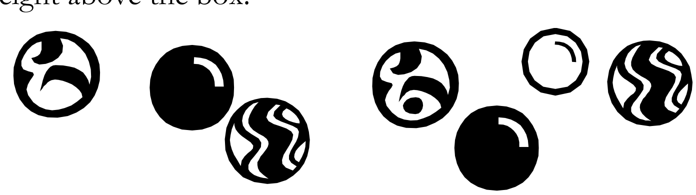
- ★ Using the 3 balls that are the same size but differing masses, drop the first ball into the flour from a height of 2 meters. Record the diameter of the crater created.
- ★ Repeat the process with the remaining 2 balls. Be sure that each ball is dropped from the same height above the box.

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

(4) Using the largest marble, throw it into the flour with a moderate amount of force. Record the shape and diameter of the crater created.

(5) 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) The next experiment involves making craters in mud, so it is encouraged to do this part of the activity outside or in an area where the floor can be covered with plastic sheeting. Have the students wear aprons or old shirts over their clothes to keep them clean. We recommend that you **closely supervise** your students during this experiment –*do not allow them to fling mud at each other!*

(5) Have the students empty the tub or pan of flour and then mix the dirt with some water in the tub or pan to create mud. Use only a little water so the mud will not become soupy. Then have the students complete the fifth experiment.

Experiment #5: How the type of surface material at impact 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 the students have completed all five experiments, have the students compare their results with their original hypotheses and form a statement for each test that explains their results (i.e., the larger the mass of a meteorite, the larger the diameter of the crater formed). You may wish to help them get started on forming these explanations by giving them an example for the first experiment. Encourage the team to write their explanations in the Lab Notebook.

Note: The results of this activity are often surprising to students. Most expect the craters to have an oblong shape on extremely wide angles of impact. In fact, all craters seen on the Moon or on Earth are basically circular. This is because on impact an explosion occurs, and the forces associated with the explosion are always spherically symmetrical. The explosion is caused by the fact that the ground does not stop a large meteorite instantly upon its moment of impact. As it descends below the surface, frictional heating increases the temperature of a meteorite much more than the frictional heating of the atmosphere had done previously. Heating is so rapid that an explosion can occur. Imagine trying to change quickly all of the energy of a room-sized meteorite traveling at 30,000 mph into heat!

Further Explorations:

(1) Have students go on-line and check out Malin Space Science Systems' page on Martian Craters (www.msss.com/http/ps/crater.html). There are great pictures of different kinds of craters on this web site!

(2) Have students download images of craters from different planets. Ask them to explain how these craters may have formed, pointing out examples of new and older craters.

(3) Have the students research the theory about the giant impact which many people believe led to the extinction of the dinosaurs.

Martianscape

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

Introduction & Purpose

Scientists now believe there was once water on Mars. Several images from the Mars Global Surveyor mission have shown channels in the planet's surface that appear to have been formed by water erosion. This activity will demonstrate to your team how scientists can interpret landforms in order to draw conclusions about a planet's geological history.

Objective: Students will compare the different types of channels that can form on a planet's surface due to water erosion.

Materials Needed:

- Aluminum cookie sheet
- Plaster of Paris
- Paper cups
- Popsicle stick
- Pitcher of water
- Sand
- Pencil or pen
- Engineering Challenge Lab Notebook
- **Optional**: water-based paints and paintbrushes

Procedure:

Complete directions for this activity are included in the Student Activity Book. Part of this activity involves predicting how different types of precipitation *(amounts or patterns)* cause different kinds of erosion. The students will have to think of a few aspects of rain that they can vary. If they have trouble, help get them started (ideas can include varying the angle of the tray, quantity, height, size of raindrops, etc.). Be sure the students make predictions and write them down in their Lab Notebook before starting the rainfall simulation. Have the students try a few different types of precipitation when creating their landscape (label different types on the cookie sheet), so they will be able to compare the landforms created. Compare the effects while the plaster is wet, and again when the plaster dries (it may take a day or two to completely dry). If the students would like, you can have them paint their Martianscape when dry to approximate the surface of Mars.

Debriefing

First, have the students compare and contrast the channels formed by the Popsicle stick and the "rain." **How are they similar? How are they different? Why do they think they are different?** Have your students compare the different kinds of erosion caused by the different types of precipitation. **Can they distinguish between them?** Often, by looking at certain kinds of erosion, scientists can identify the type of precipitation that caused them. **Can your students make any generalizations about different types of precipitation that could help predict what kind of erosion they create?**

If the team has completed the "Crater Creation" activity, have the students compare and contrast the landforms created by impact craters and water erosion. **How are they different? If they were standing on the surface of Mars looking at two landforms, one caused by an impact crater and the other by water erosion, could they distinguish between which processes created which landform?**

The Winds of Change

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

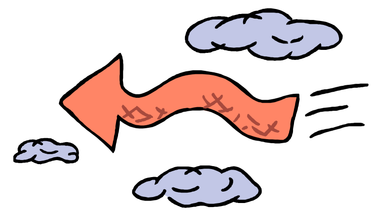
Introduction & Purpose

The Martian surface frequently experiences high winds and massive dust storms that can envelop a large portion of the planet. This unique climate affects how human observers on Earth perceive the planet. This activity will show your students how wind can alter perceptions from a distance, and how wind forms a variety of surface features.

Objective:

Students will demonstrate how the wind on Mars affects how the Martian surface appears from a distance.

Materials Needed:



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

Procedure:

Complete directions for this activity are included in the Student Activity Book. Have the students make some predictions about what will happen when they blow across their landscape before they attempt the activity. Have them write their thoughts down in their Lab Notebook. Also, have them try a few different "types" of wind by altering the wind angle, wind speed, amount of time spent blowing, and the amount of sugar blown across the landscape. Encourage the students to be creative and to have fun, *but be careful that they do **NOT** blow sugar in each other's faces*!

Debriefing

Once your students have spent ample time experimenting with blowing the sugar, lead them in a debriefing session. **How does the force of wind create changes in the Martian surface and atmosphere? How has this impacted human perception of the Martian surface?** Lead them to the answer that sand in the atmosphere and/or moving sand on the surface can obscure (or reveal) geographical features on the planet. **What do the patterns that are formed on the surface look like, once the sand has settled? How can wind affect the exploration of Mars?** Think about how large dust storms on Mars may affect landing site choices, mapping of the surface, navigating a rover on the surface, etc.

Encourage the students to think about other activities they completed that involve how the topography of Mars is formed and altered (e.g., Crater Creation or Martianscape). **How does the force of wind cause topographical features to be formed? How are these features similar to and different from impact craters and channels caused by water erosion? How are the creative forces** (i.e., meteorites, moving water, and wind) **similar and different? How can knowledge of these processes and their results help scientists understand more about Mars and its history?**

Geography & Mission Planning

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

Introduction & Purpose

The purpose of this activity is to get the team thinking about mission planning and selecting landing sites. Many factors must be considered when planning a mission to another planet, and these decisions are often difficult but very critical because space missions are so expensive. Spacecraft must avoid hazards in order to land safely and continue the mission, and must also land in the vicinity of planetary features of interest. During this activity, your students will make some decisions about landing on a planet with which they are familiar: Earth.

Objective:

Students will find particular latitude and longitude coordinates on a world map. Students will choose landing sites on Earth based on potential hazards and potential findings.

Materials Needed:

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

Procedure:

There is a list of questions regarding mission planning and choosing a landing site in the Student Activity Book. Students are directed to answer the questions as a team, using their map (and atlas, if available). Please encourage them to be creative, but also practical as well. Have the team record the activity in their Lab Notebook.

If the team has also completed one or more of the activities entitled "Crater Creation," "Martianscape," or "The Winds of Change," guide them in connecting concepts from those activities with this activity. **How might the features explored in these three activities -- craters, channels created by water erosion, and features affected by wind -- be related to choosing a landing site? Would scientists want to avoid or explore these features? Or both?** Have students explain their thoughts, and record them in their Lab Notebook. **Remember, there is not necessarily a correct answer to any of these questions.**

If the students enjoy this activity or enjoy being creative, have them continue to explore the topic of landing missions by encouraging them to compose creative writing stories from the perspective of a Martian who has landed on Earth at one of the landing sites they have selected.

Mars Mosaic

Introduction & Purpose

When a satellite is sent to orbit Mars, one of its missions involves taking thousands of pictures of the planet's surface. When NASA receives the pictures back, the pictures are used to create an image mosaic – a larger image, or picture, made from combining several smaller images. This activity will help your students take two-dimensional mosaics and use them to create a three-dimensional globe of Mars, allowing them to understand distance transfer from a two-dimensional wall map and/or image to a three-dimensional object.

Objective:

Students will discover how a two-dimensional map/image translates into a three-dimensional object, and how distances are appropriately measured in each venue. Students will be engaged in viewing and interpreting satellite imagery in order to create a three-dimensional globe of Mars.

Materials Needed:

- Wall map of the Earth
- Globe of Earth
- Mars mosaic *(see pages 85-86)*
- 5" Styrofoam© ball
- Yardstick
- Glue
- Scissors
- String *(at a minimum, string should be the width of the wall map)*
- Engineering Challenge Lab Notebook

Procedure:

The Student Activity Book contains the directions for this activity. As students are working through the wall map/globe component of this activity, step back and allow students to make errors – for example, students may likely measure across the entire wall map to determine the distance between Seattle and Tokyo, or Honolulu and Paris (depending on your wall map layout), not realizing that they should measure to the edge of the map, and then from the edge to the location due to the "flattening" of the globe. Students most likely will realize this error when they measure the distance between the same locations on the globe. After the students complete the measurements, discuss why students ranked distances the way they did, leading into a discussion on how two-dimensional images representing three dimensional objects, such as spheres (or planets), can be deceiving. Encourage the students to determine how the wall map would turn back into a globe. **Has the map been distorted at all, or would this be an easy task (depends on your map, but most likely, the map has been distorted in order to "fit" into a two-dimensional format)?** Discuss the benefits of using a two-dimensional image versus a three-dimensional globe (for example - ease of use, able to view the entire surface of a planet at the same time, etc.).

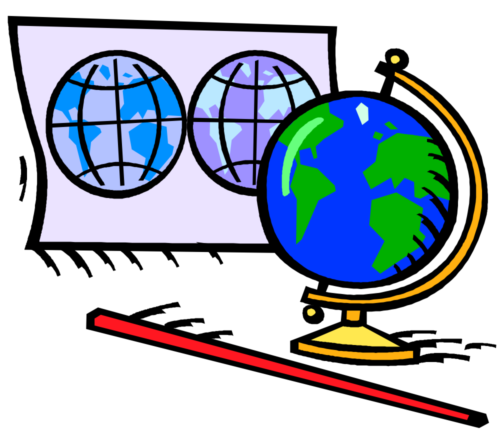
As the student team is constructing the Mars globe, make note to have them cut out all of the trapezoid-like pieces separately, **<u>but to cut out the square strip as one piece</u>**. The globe will fit together better if the slight space in-between each square image remains. Use the circle "poles" to "best fit" the trapezoid pieces – in other words, the trapezoid pieces will need to be slightly overlapped on each side in order to fit the pole correctly. Once they are positioned to fit each pole, the square images will wrap around the center of the globe with slight overlap. Overlap is okay and very expected when trying to "merge" several mosaics.

After the team creates their globe, speak with them about why the images did not fit together "perfectly." Point out that Mars is not a perfect sphere like the Styrofoam© ball they used to create the globe, and that the images are mosaics – a combination of pictures that make a "best fit" and are designed to tell a "story" about a particular area, rather than provide every single detail as a regular photograph would do. NASA often works in a "best fit" mode in regards to imagery, hence the high use of image mosaics. Mosaics are used to help NASA mission teams learn more about an area for landing purposes, exploration, etc. It is quite common that mosaics contain several overlapping components, "not perfect" seams, and appear slightly "pieced" together. It is important that the student teams note that while mosaics are not perfect, they are very valuable in planning, and can be quite useful and convenient. Being able to understand how "piecing" together several satellite images into one master image is important, and will assist the team in discovering terrain they may have to traverse in Engineering Challenge(the manual will contain several "satellite" images that when used to create a mosaic, will form a picture of possible competition courses).

Answers:

Locations	Ft / Inches	Est. Mileage
Boise, Idaho, USA and Orlando, Florida, USA	*Depends on type and size of map used*	2182 miles
Paris, France, and Honolulu, Hawaii, USA		7432 miles
Tokyo, Japan and Seattle, Washington, USA		4778 miles
Anchorage, Alaska, USA and Seattle, Washington, USA		1434 miles
Anchorage, Alaska, USA and Moscow, Russia		4345 miles

___2___ Boise, Idaho, USA and Orlando, Florida, USA
___5___ Paris, France, and Honolulu, Hawaii, USA
___4___ Tokyo, Japan and Seattle, Washington, USA
___1___ Anchorage, Alaska, USA and Seattle, Washington, USA
___3___ Anchorage, Alaska, USA and Moscow, Russia



Strange New Planet

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

Introduction & Purpose

This activity will help your students further understand the processes involved in planetary exploration by demonstrating how planetary features are discovered through the use of remote sensing techniques.

Objective:
Students will be engaged in making multi-sensory observations, gathering data, and simulating spacecraft missions.

Materials Needed:

- A "Planet," which can be created from any one or more of the following materials:
  - Plastic balls
  - Modeling clay and/or Playdoh©
  - Inflated balloons
  - Styrofoam© balls
  - Round fruit – such as a cantaloupe, pumpkin, orange, grapes, etc.
- Vinegar, perfume, or other scents
- Small stickers, sequins, candy, marbles, or other small, interesting items
- Cotton balls
- Toothpicks
- Objects that can be pierced with a toothpick to make a moon
- Glue *(if needed)*
- Towel (*to drape over planet)*
- Pins or tacks
- A "Viewer" per student, such as empty paper towel or toilet paper rolls
- A 5" x 5" blue cellophane square per student
- One rubber band per student
- Masking tape to mark the observation distances
- Student data collection questions (in the Student Activity Book)
- Pens or pencils
- Engineering Challenge Lab Notebook

Procedure:

Selecting a planet – Create a planet in the absence of the students. Choose an object such as a plastic ball or fruit (cantaloupe, etc.) that allows for multi-sensory observations. Decorate the object with stickers, scents, etc. to make the object interesting to observe. Some of the materials should be placed discretely so they are not obvious upon brief or distant inspection. Some suggestions for features are:

- Create clouds by using cotton and glue
- Carve channels in the ball (if possible)
- Attach a grape using a toothpick (to make moons or orbiting satellites)
- Affix small stickers or embed other objects into the planet
- Apply scent sparingly to a small area

Set-up - Place the planet on a desk in the back of the room, and cover the planet before allowing the students into the classroom. Brief the students on their task: To explore a strange new planet. Explain that their exploration will occur in a series of phases, just like space exploration. There will be four phases: (1) pre-launch reconnaissance; (2) a fly-by mission; (3) an orbiter mission; and (4) a lander mission. Have the students construct viewers by using empty paper towel or toilet paper rolls, or by rolling loose-leaf paper into a tube. These viewers should be used at all times when observing the planet. Sometimes, the students will be limited as to how close or for how long they can make observations. Explain that this is how the various phases of space exploration will be simulated. Also, make sure students have their student data collection questions, which are located in the Student Activity Book – one set for each phase of the exploration. Encourage use of all senses during observation, except taste unless specifically called for.

Space Exploration Phases

Pre-launch Reconnaissance

The first phase simulates Earth-bound observations. Arrange students against the side of the room, far away from where the planet sits (it should still be covered at this time). This area where the students are standing will be referred to as **Mission Control**. A blue cellophane sheet should be placed on the end of the viewers, taped or held in place by a rubber band. The cellophane helps simulate how objects appear when viewed through Earth's atmosphere. Once the students have fitted their viewers with the cellophane paper, remove the towel and expose the planet. Have the students observe the planet for one minute. Replace the towel after time expires. Let the team then discuss and record their observations of the planet in their Lab Notebook. At this point, most of the observations will be visual and will include color, shape, texture, and position. The team should also compose questions to be explored in the future fly-by, orbiter, and lander missions.

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

Have the students remove the cellophane from their viewers. Now the team will have one chance to quickly walk past one side of the planet and observe it through their viewers (the other side should remain draped under the towel). A distance of five feet from the planet must be maintained during this "fly-by." Once the fly-by is complete, replace the towel over the entire planet, and have the team reconvene at Mission Control. Have the team record their observations in their Lab Notebook and discuss what they will look for on their next mission (inform the students that the next mission will be an orbiter 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 Orbiter in 2003-present)*

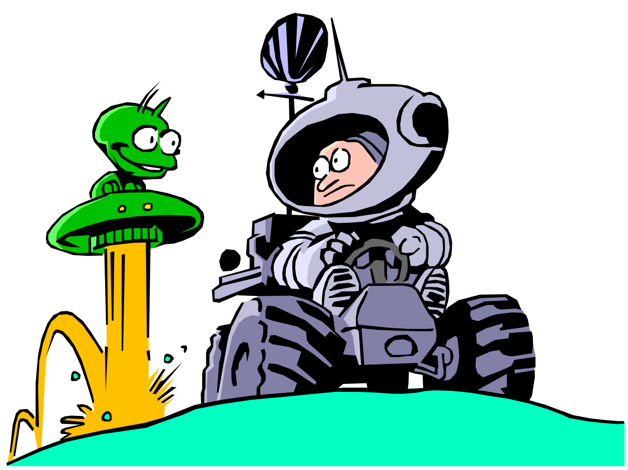
During this mission, the team has a total of two minutes to orbit (circle) the planet, one person at a time, at a distance of two feet. You might want to help them determine how long each member has to orbit, so everyone has the same amount of time for observation. While orbiting, have the students observe distinguishing features through their viewer and record this data back at Mission Control. The team will need to develop a plan for their landing mission using this data and previously collected information. The plans should include the landing site and features to be examined once on the planet. Have the students record these plans in their Lab Notebook.

Mission 3: The Lander *(Viking 1 & 2 Landers in 1976-82, Mars Pathfinder in 1997, 2003 Mars Exploration Rovers in 2003-present)*

On this mission, the team will approach their landing site and mark it with a pin or tack, or masking tape if the planet will pop by using a pin. Team members will then take turns observing the landing site with their viewers. The team has a total of five minutes to make these observations. Again, you may want to help them determine how long each member has to view the landing site. Field of view is kept constant by the team members aligning their viewers so the pin is on the inside and top of their viewers. Within this field of view, students should enact their mission plan. After five minutes, have the team return to Mission Control to discuss and record their findings in their Lab Notebook.

Debriefing

Now that the team has simulated planetary exploration through several different missions, have them think about which phases were more conducive to making different kinds of observations. Which planetary features were easiest to observe at each phase? Which features were more difficult to observe? Did different team members notice different features than other members? Was it necessary to complete all phases of the mission before being able to accurately describe the planet? Is further exploration necessary? What would they like to explore on this planet with a rover mission? What kinds of tests would they like to perform on the surface? How did they formulate their plans for exploration? How did they choose their landing site? What factors did they consider? Was it difficult to come to consensus while making such decisions? Tie this activity to any activities the team has already completed that addresses topography, mission planning, or landing site choice.



Mapping Unknown Surfaces

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

Introduction & Purpose

Most people do not often think about how scientists arrive at data about other planets. Much of this information is gathered indirectly. One example is the creation of three-dimensional maps. Scientists use radar and photographs to compile three-dimensional maps of far away planets using techniques similar to those used in this activity. This activity should get your students thinking about how difficult it is to take meaningful measurements of other planets, and just how amazing it is that we know so much about other planets without ever having been there ourselves.

Objective:
Students will simulate radar data collection to determine if a safe landing site exists on a landscape. They will also use this data to create a topographical map of the landscape.

Materials Needed:

- Shoebox or similar cardboard box with a lid
- Modeling clay, Playdoh©, stucco, or rocks
- Awl or similar long, narrow, sharp pointed tool - **be careful!**
- Data sheet (in Student Activity Book)
- A few wooden skewers
- Pencil
- Marker
- Engineering Challenge Lab Notebook

Procedure:

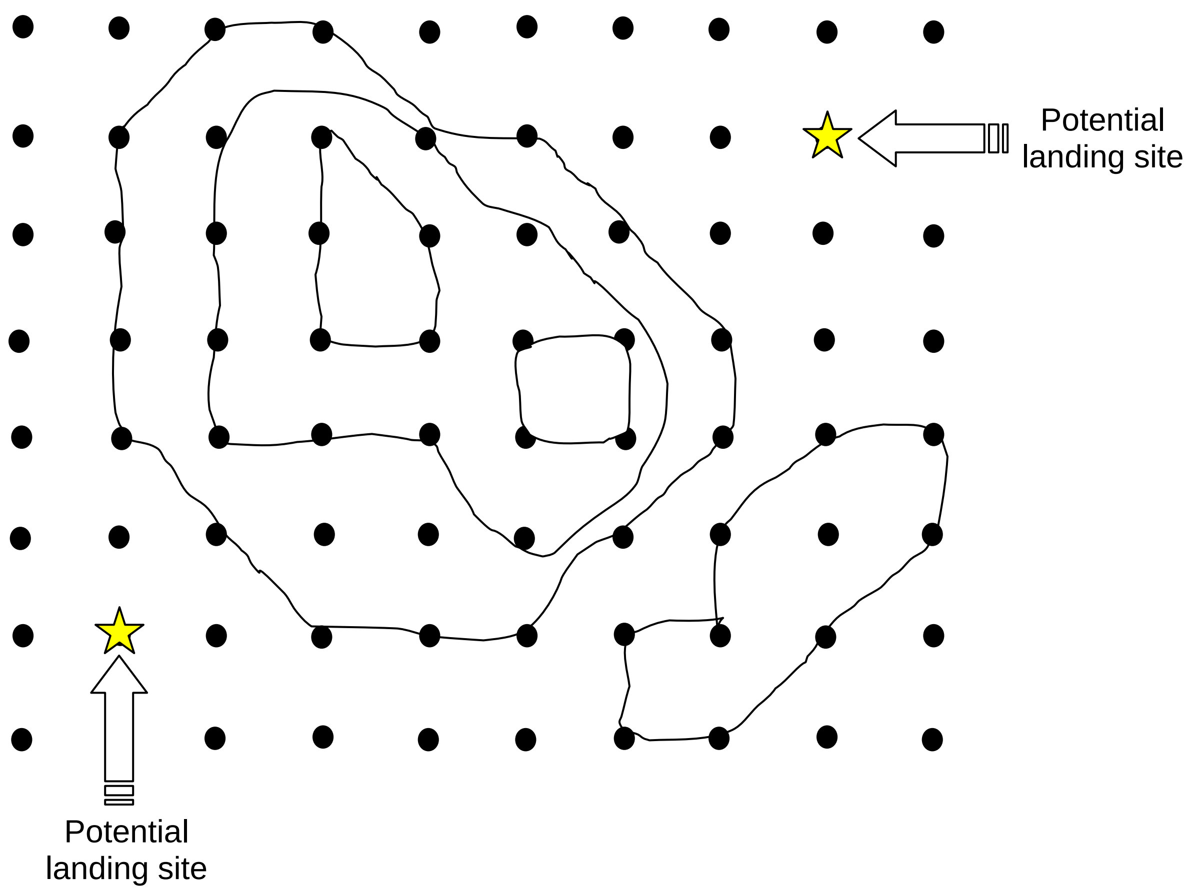
This activity requires the following preparation:

Create a landscape box - Create an uneven landscape in a box, including craters, mountains, and valleys, using modeling clay, Playdoh©, or similar materials. Leave at least one 4 centimeter by 4 centimeter square area relatively flat within the box, with less than a one centimeter change in elevation, which will serve as a landing site for spacecraft (you can leave more than one if you wish). Use an awl or similar tool to punch holes in the box lid approximately 2 cm apart in a grid-like pattern (use the data sheet in the Student Activity Book as a guide). Finally, label the grid -- letters across the top, and numbers down the side.

Make data collection instruments - On the wooden skewers, measure out and draw centimeter markings with a marker so the students can use them as measurement tools.

After this preparation is complete, have the students refer to the directions in the Student Activity Book to complete the activity. Each student will take several measurements through each hole with a skewer, and then record each measurement on their data sheet next to the corresponding dot. Have the students record their data consistently - for example, always above the dot, always to the right of the dot, etc. for data accuracy. The students will have to try to determine if there is a safe landing site for a spacecraft using their collected data. Have the students hypothesize where a safe landing site may be from the initial measurements taken. Finally, have the students connect an area of dots that contain equal measurements on the data sheet to make a topographical map (see example below). This may be a difficult concept for them to grasp, so be sure to provide plenty of explanation before the students begin to make the map. It may help to draw an example on the board, explaining your thought process as you make the topographic map, to help your students understand the concept.

Once the students have created their topographic map, have them review their hypothesis, changing it if necessary. Then allow them to open the box and look at the real landscape. **Are all of the features of the landscape represented on the map? Which ones did they miss? Why? How accurate is the radar method they used? How could they improve the accuracy?** One idea is to take measurements closer together by using a finer-scale grid. **Is the selected landing site in the box really a safe place for a spacecraft to land? Why or why not?** Have the team record their observations, ideas and thoughts in their Lab Notebook.



NS.5-8.1 Science as Inquiry
NS.5-8.7 History and Nature of Science

What on ~~Earth~~ Mars?

Adapted from Hawai'i Space Grant's "Mars Landform Identification" activity at www.spacegrant.hawaii.edu/class_acts/MarsQuizTe.html

Introduction & Purpose
This is an excellent culminating activity for students who have completed the activities involving how the surface features of Mars were created (primarily meteorites, water, or wind). If your students have not yet completed the "Crater Creation," "Martianscape," or "The Winds of Change" activities, it is recommended that they do so before attempting this activity. They will gain knowledge and experience about Martian landforms in those activities that is crucial to their success in this activity.

This activity uses ten photographs, most of which were taken by Viking Orbiter cameras, to demonstrate nine different features on the surface of Mars -- impact craters, volcanoes / volcanic craters, river valleys, river beds, dry lake beds, polygonal ground, lava flows, sand dunes, and fractures. Each of these features is defined and described in the Student Activity Book. The students will examine these photographs, and then identify landforms, interpret what they see, and answer questions about each photograph.

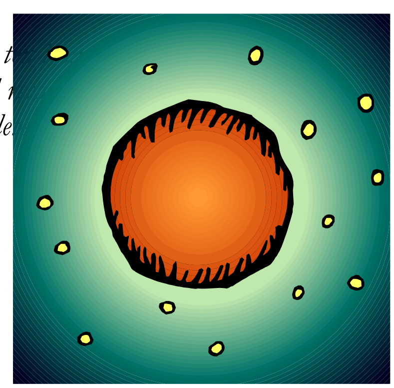
Objective:
Students will use their knowledge about Martian landforms to interpret several photographs of Mars.

Materials Needed:

- 10 photographs of Mars (in Student Activity Book)
- Pens and/or pencils
- Scratch paper
- Engineering Challenge Lab Notebook
- **Optional:** colored pencils, markers, or other coloring implements

Procedure:
Have the team read through the background information located in the Student Activity Book. Understanding the definitions of the boldface terms is crucial to completing this activity. To verify that the students fully comprehend the terms, have them take turns explaining what each landform looks like and how it is created. You may want to take time to review the "Crater Creation," "Martianscape," or "The Winds of Change" activities to remind the team of features about which they have already learned.

Once the team is comfortable with the terminology, have them examine the t
Activity Book. They should respond to the questions next to each image and r
Lab Notebook. The table located before the images should also be comple
landforms, as they are identified.



A Quick Note…….

- ★ Remember -- NASA does not know everything about Mars, so do not let the team become frustrated – instead, encourage creativity!
- ★ If the team wishes, they can code the landforms by coloring each feature a different color. For example, the team could color all impact craters orange and all volcanoes / volcanic craters blue.

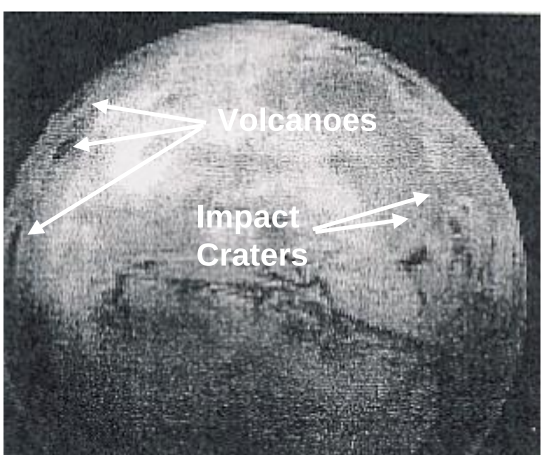
Image Answers

Below is the completed version of the chart the students will complete for this activity:

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

For reference and debriefing purposes, the images and questions the students are asked to respond to in this activity are included below. Please note that the students' images are larger, clearer, and include a scale.

Image 1 – Mars Hemisphere



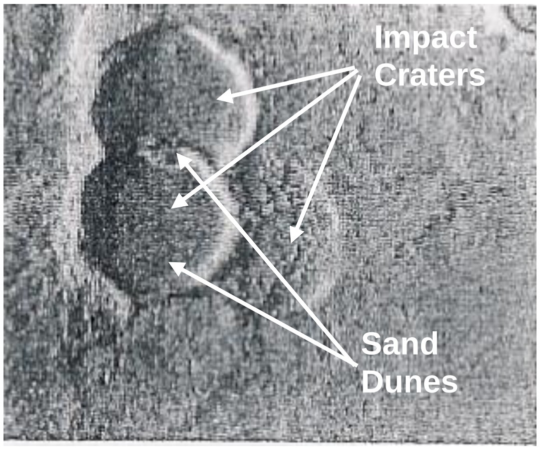
This photograph shows Mars from 2,500 km above the surface. It is a mosaic of 102 images taken by the Viking I spacecraft in 1976. This view shows some large impact craters and volcanoes. Each volcano is 25 km tall and about 350 km in diameter. *Valles Marineris*, a huge 4,800 km canyon, can be seen across the middle.

Student Questions:

(1) What do you think the feature across the middle of this picture of Mars is? How do you think it was formed?

(2) What do you think the circles on the left side are? Why?

Image 2 - *(34.79N, 309.14W)*



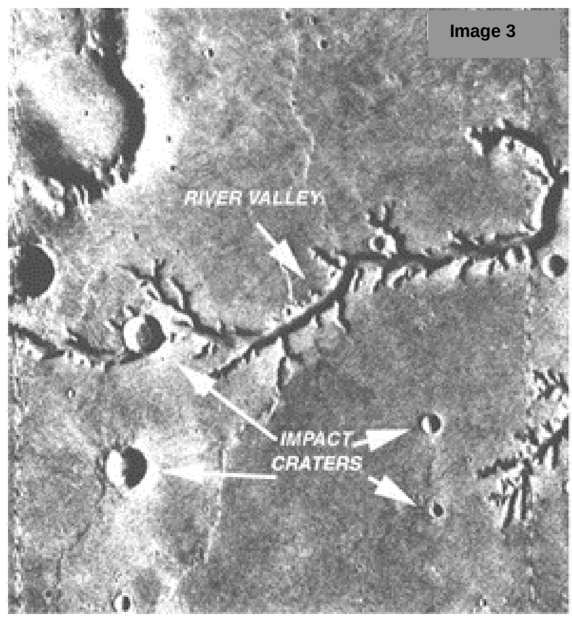
Craters, formed when meteors strike a surface, cover much of Mars. These craters are located in the heavily cratered uplands about 5,500 km east of *Ares Vallis* (the Ares Valley). When one impact happens near another, the resulting craters overlap. The squiggles in the bottom of the two upper craters are dune fields; wind is a significant factor in this area. The craters have two ejecta patterns-lobed (to the left) and striated (below). Lobed patterns suggest that water-rich material, such as mud, flowed upon impact. Striated patterns are caused when an impact propels material across the surface at high speeds.

Student Questions:

(1) In what order were these circular features formed? How can you tell?

(2) What do you think formed these circular features – wind, water, or a meteorite? Why do you think so?

Image 3 - *(27.4°S, 44.2°W)*



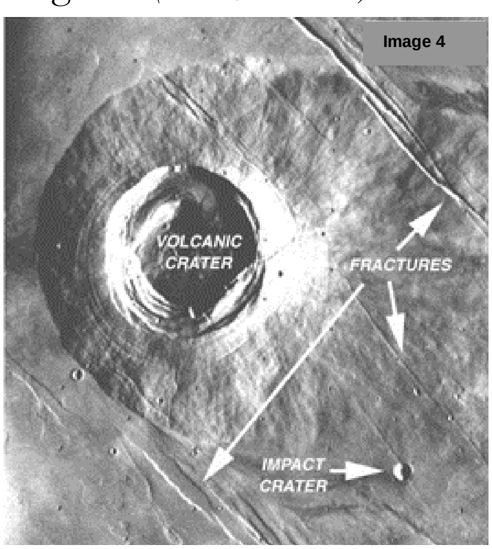
Student Questions:

(1) What do you think created the feature across the middle of this picture? Have you ever seen anything like it on Earth?

(2) Does anything in this picture look interesting to investigate on a rover mission? Do you see any places where a spacecraft could land to deploy a rover?

(3) Do you think a rover could navigate from the top of the picture to the bottom?

Image 4 - *(2.0°N, 124.0°W)*

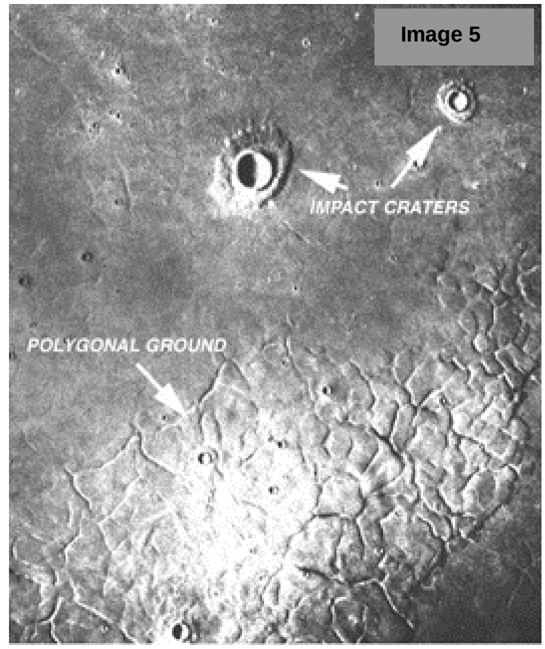


Student Questions:

(1) Describe some characteristics of what you think made this circular feature – was it large or small? At what kind of angle did it form these features? Write down any ideas you have in your Lab Notebook.

(2) What can you tell about the nature of the surface at this site from the linear patterns formed in the surface? From the circular feature?

Image 5 - *(31.5°N, 245.0°W)*

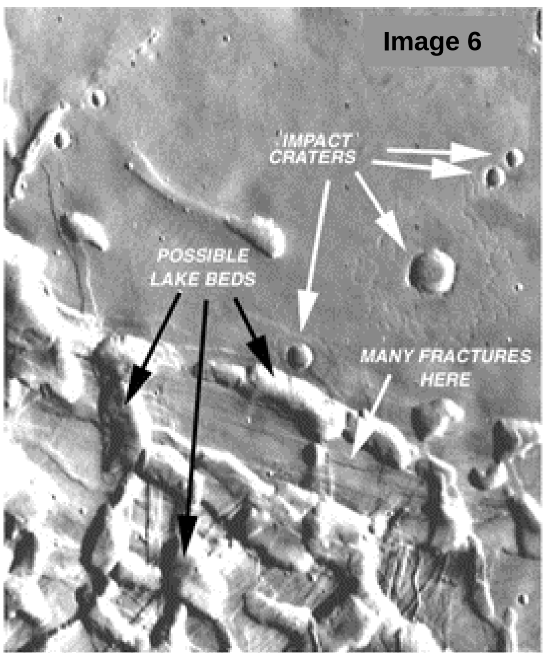


Student Questions:

(1) How do these circular features look different than those that you have examined in Images 2 and 4? What does this difference tell you about the surface in this area?

(2) Do the geometric patterns in the lower half of the picture support your ideas about the surface from the previous question? Why or why not?

Image 6 - *(7.5°N, 101.7°W)*

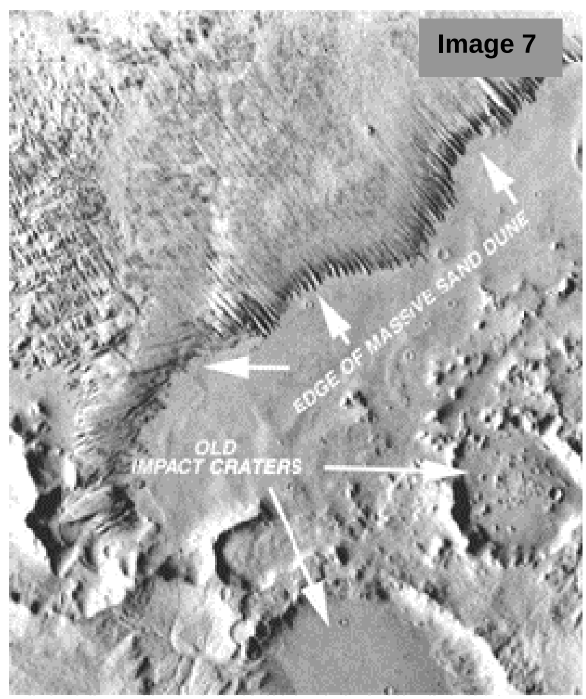


Student Questions:

(1) What do you think created the features in the lower half of this picture? Why?

(2) How big are these features? How can you tell?

Image 7 - *(13.0°S, 183.0°W)*



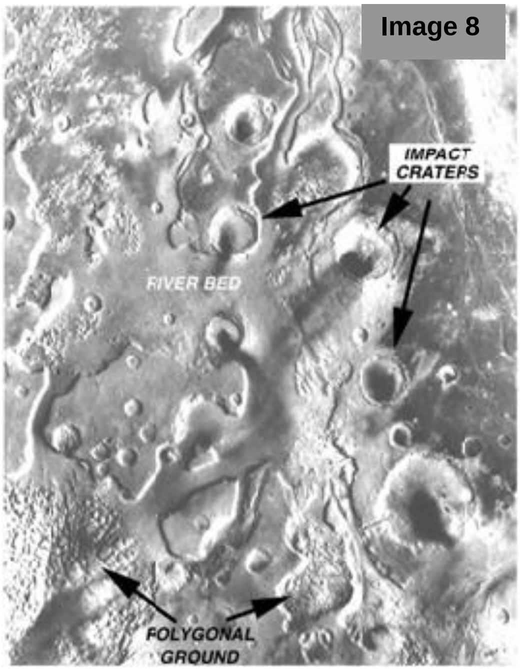
Student Questions:

(1) What do you think formed the streaky lines that run diagonally across the middle of this picture – water, wind, or meteorites? Why do you think so?

(2) What do you think created the circular features?

(3) Which were formed first, the streaky lines or the circular features? Why do you think so?

Image 8 - *(7.3°N, 30.5°W)*



Student Questions:

(1) How many different sizes of impact craters do you see in this picture?

(2) What could have made these craters be so different in size?

Student Questions:

(1) Does this look like an interesting place to investigate with a rover? What would you like to explore? Why?

(2) Would this be a good place to land a spacecraft to deploy a rover? Why or why not?

(3) Would this be a safe place to navigate a rover? Why or why not?

Image 9 - *(22.0°S, 140.0°W)*

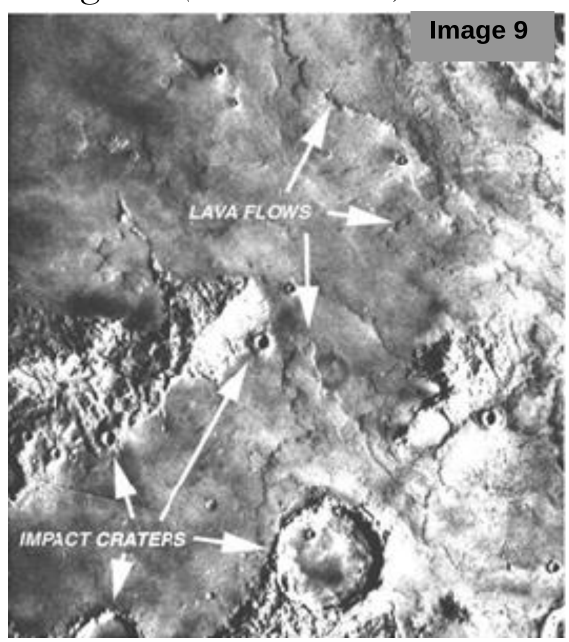
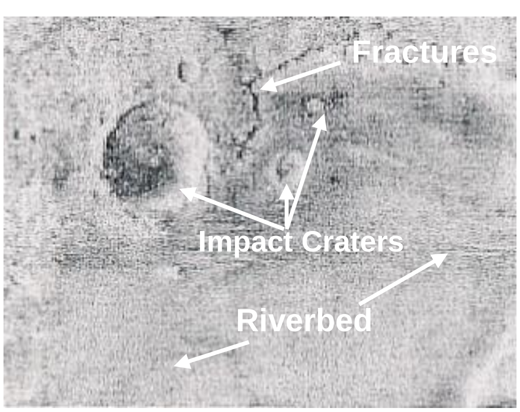


Image 10 - *(27.0°N, 58.0°W)*

This image shows a rich diversity of geological processes. There are fractured ridged plains (top center), craters as big as 100 km, lobed ejecta blankets, an enormous channel, and wide streaks (going in the opposite direction of the former water flow).



Student Questions:

(1) How many different kinds of landforms do you see in this picture (this was left blank in your table on purpose!)?

(2) How do you think each of these landforms was created? Why?

(3) In what order were these landforms created? What clues in the picture led you to this decision?

(4) What are the streaks in the middle and bottom center parts of the picture? What do these streaks tell you about the history of the Martian surface?

Debriefing

Compare student charts with the answer chart and discuss any discrepancies. Were some landforms easier to identify than others were? Did shadows (sun angle) help make some features easier to see? Which landforms would you like to explore the most? Which areas look like they would be the safest landing sites? Why?

If the team completed the "Crater Creation" activity prior to this one, challenge the students to identify and name the parts of an impact crater (e.g., ejecta blanket, rim, wall, etc.) in each photo.

Also, take the time to review the questions about each photo. Student answers to the questions will vary. Instead of judging their responses as right or wrong, look for sound, supporting evidence for their conclusions. Remember that even NASA does not know everything, so your students' responses may be better than what NASA has! Reward the students for solid justifications and creativity. If they are interested in what NASA thinks about these areas, have them do the "Further Explorations" section of this activity.

Finally, as a group, review the team's responses to the last set of questions that link this exercise with the Mars Rover Challenge *(included below)*. Encourage them to brainstorm and think ahead to their Rover design. Have students write their responses in their Lab Notebook:

(1) Your Engineering ChallengeEngineering Team will be designing and constructing a model Mars Rover. What types of terrain must your Rover be able to navigate over and through if it were to travel on Mars?

(2) What do you think Mars' surface is like to touch, to walk on, and to drive on?

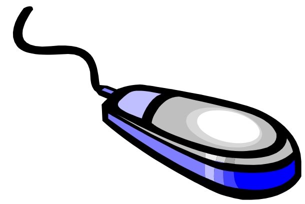
(3) Refer to the Engineering Challenge page on the website to determine what your Rover must be able to do at the Engineering Challenge. Do you have any questions about the Competition yet?

Further Explorations:

Use the latitude & longitude coordinates on each photo to locate the areas on a map or globe of Mars. Then conduct some research online about each of these areas on Mars. What does NASA think about these landforms?

More Fun on the Web

Introduction & Purpose
This page is a list of web site resources specifically designed for teacher use. Refer to the Student Activity Book for additional web site resources that will link your Engineering Challenge team to more activities and research opportunities!



Activities and Information About Mars & Space Exploration:

NASA Quest: NASA Quest is a rich resource for educators, kids and space enthusiasts who are interested in meeting and learning about NASA people and the national space program. **quest.arc.nasa.gov/index.html**

NASA Explores: This NASA web site provides weekly lesson plans for grades K-4, 5-8, and 9-12. Topics will be selected from current NASA Aerospace Technology and Human Exploration of Space topics. **www.nasaexplores.com**

Science@NASA: Science stories and involvement projects that bring the cutting edge to adults interested in science. **http://science1.nasa.gov/educators/**

NASA's Mars Exploration Program: NASA's official Mars exploration site. Use this site as a reference or click on the "Mars for Educators" link for workshops, classroom resources, and education programs about Mars. **mars.jpl.nasa.gov**

Amazing Space: This site uses the Hubble Telescope's discoveries to inspire and educate about the wonders of the universe. Includes online space explorations for the classroom, teaching tools such as readings and graphic organizers, etc. **amazing-space.stsci.edu**

Live From Earth and Mars: This site includes information about Pacific Northwest weather, online workshop materials, project ideas, and activities for a mission to Mars. Click on the "Teaching Tools" link for interactive educational modules, which are the heart of "Live from Earth and Mars." **www-k12.atmos.Washington.edu/k12/index.html**

More Fun on the 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 UT Tyler Ingenuity Center

http://www.ingenuitycenter.org/

NASA Homepage: The official web site of the National Aeonautics 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

<u>2003 Mars Exploration Rovers</u>: 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:

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

http://astronauts.nasa.gov/

Cool Sites About Space:

<u>Spaceday 2007 – Return to the Moon</u>: 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

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

www.nineplanets.org

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

spaceplace.nasa.gov/en/kids/

<u>NASA Kids</u>: 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

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

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

<u>Astronomy Picture of the Day</u>: 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!