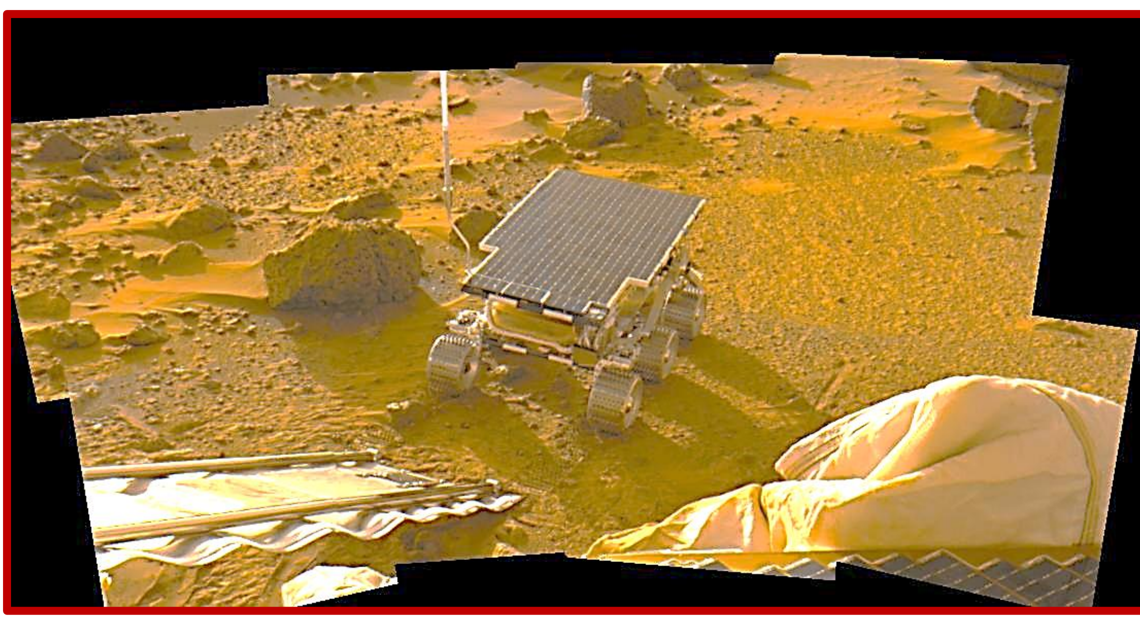
Project - Building & Testing Mars Rovers:

Introduction

A **Mars rover** is a remotely operated vehicle that propels itself across the surface of the planet Mars. Rovers have several advantages over stationary landers. They can study more territory, examine interesting features, and place themselves in sunny positions to weather winter months. The goals of the rovers are to determine whether there was ever life on Mars, characterize the climate of Mars, characterize the geology of Mars, and prepare for human exploration of Mars. More specifically, the rovers were designed and developed to study a variety of rocks and soils that hold clues to past water activity on the planet of Mars. NASA uses the rover to obtain samples of rock and soil that have minerals deposited by water-related processes such as precipitation, evaporation, or hydrothermal activity. There have been four successfully operated Mars rovers: Sojourner, Spirit, Opportunity, and Curiosity.

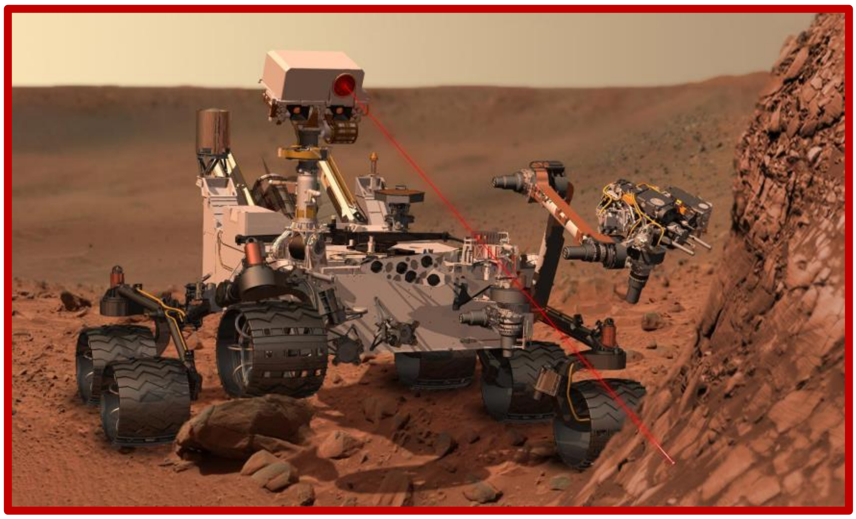


Sojourner disembarks Mars Pathfinder base station lander onto the surface of planet Mars

Introduction (cont.):

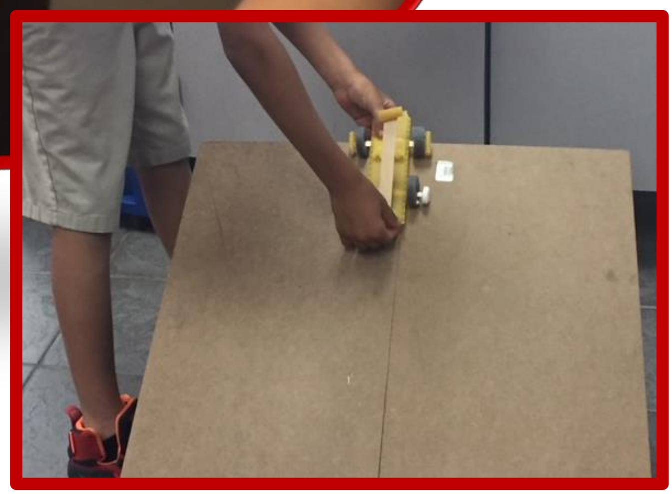
The Mars rovers Spirit, Curiosity and Opportunity have collectively driven over 37 miles on Mars. Opportunity has driven more miles than any other Mars rover at over 26 miles. Both the Opportunity and Curiosity rovers are still operational and exploring the planet Mars. Opportunity launched in 2003 and landed successfully in 2004. Curiosity was launched in 2011 and landed in 2012.

Artist's conception of the *Curiosity*



Some days a rover may drive less than one meter, or not at all. Other days the rover may drive over 100 meters. The engineers who plan the drives, called Rover Planners, must define their criteria for success–what the rover must do for the drive to be considered a success. They must also take into consideration the constraints that may limit the rover's ability to successfully complete a drive. What obstacles are in the way? Is there a slope along the way? Is it too steep for the rover to safely drive? Does the terrain change part way through the drive? Some of these things depend on which part of Mars the rover is exploring. Some are based on how the rover was built. Like Rover Planners, students in this activity will have to define what a successful drive will look like and identify the limiting factors they will face on their drive.

BUILDING MARS ROVERS INSTRUCTIONS



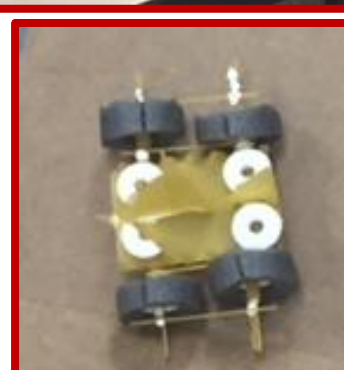
MATERIALS:

- Various types of pasta, including pasta wheels (rotelle) and spaghetti strands (Note: If pasta wheels are not available, substitute round disk-shaped candy mints or circular foam pieces.)
- White glue or cold-melt glue guns
- Scraps of cardboard for glue gun residue
- Paper and pencils for sketching
- 4-6 ramps - will use science fair boards
- Textbooks to elevate one end of the ramp 1-2 feet
- Linear measuring device - ruler, meter stick, measuring tape
- Masking tape to mark distance rover traveled
- Copies of pasta budget sheet
- iphone with Stopwatch function - 1 per group (for extension)
- Copies of data sheet (for extension)

Building & Testing Mars Rover Instructions: (60 minutes)

1. Act as a facilitator in the Activity. Ask questions, provide guidance regarding materials and the task. Don't lead them towards a specific rover design.
2. Introduce the activity by showing images of NASA rovers. (Appendix A: Rover Main Parts and Functions).
3. Ask students to examine rover images and identify the main parts of a rover (e.g., wheels, body, science instruments, axles, suspension, cameras, etc.).
4. Tell students that rovers are expensive to build and require careful engineering, often incorporating new technologies. Discuss the Design Process with the girls. (Appendix B: Engineering Design Process Chart).
5. After discussing the types of pasta available, challenge students in <u>groups of two</u> to brainstorm ideas and sketch concepts for their pasta rovers on paper.   A picture of the types of pasta and any other materials are provided in your supplies.
6. The rovers are required to have the following parts:
    1. Mars Rover Body
    2. Robotic Arm
    3. Solar Panels
    4. Batteries
    5. Wheels
    6. Antenna

    They can have other parts (such as robotic arm or camera), but those are optional.



7. The rover needs to travel down the ramp and then travel a full meter from the ramp on a flat surface to successfully complete it's mission.

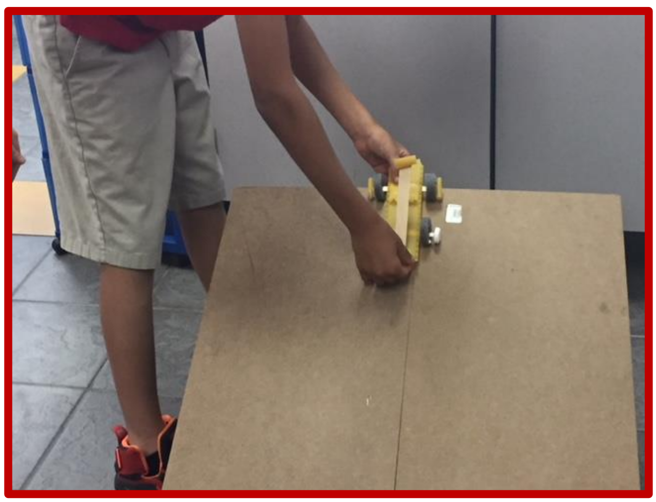
Building & Testing Mars Rover Instructions:

8. The rover must be built within a budget of $80,000,000. The costs of the different types of pasta are on their data sheet (Appendix C: Mars Rover Data Sheet). Note: Some pasta will break or not work out as students expect. Their rover cost will be based on total pasta (used and wasted) in the final product. If they have pasta that they didn't use and it is not broken, they can return it to the store and it doesn't count against them.

9. After they design their rover and discuss what pasta they will use for the different parts of their rover, they will go to the store (one set up in each room) to get their supplies. They will record on their data sheet (Appendix C: Mars Rover Data Sheet) the quantity and cost of their supplies to ensure they stay within their budget. Fortunately, glue is considered an incidental expense and will not be billed.
10. After students have workable concepts and have collected their pasta from the store, allow building to ensue. Have them track how much they are spending on their rover on the data sheet provided.

Building & Testing Mars Rover Instructions:

10. Have them name their rover and mark it on the rover with marker if possible.
11. Before the team runs their rover, have them explain their design to the rest of the table.
12. Run one rover at a time by having the team place their rover at the top of the ramp and letting it go without pushing it. We will have two ramps in each room so 2 or 3 tables will share one ramp.



13. Mark distance traveled by each rover on the flat surface with masking tape and the team's rover name. Rovers that travel the full meter on a flat surface have achieved the full goal of the assignment.

Building & Testing Mars Rover Instructions:
(15 minutes)

Extensions if the boys finish early – 15 minutes

1. Hand out the pasta rover data sheet to each team.
2. Using stop watch function on iphones, have students measure the time (t) a rover is in transit and measure the distance (d) the rover travels.
3. Repeat step 2 at least three times per rover and record the results on the data sheet.
4. Compute the rover's rate (r) of travel for each trial and its average rate of travel: d=rt, so r=d/t.
5. If distance is measured in centimeters and time in seconds, rate will be in cm/sec, which is a bit abstract to some students. Have them compute their rate in miles per hour. Depending on their math level, they may use dimensional analysis to do this or use the conversion 1 cm/s = 0.0223693629 mph.

APPENDIX A: Rover Main Parts & Functions
Can you identify the parts?

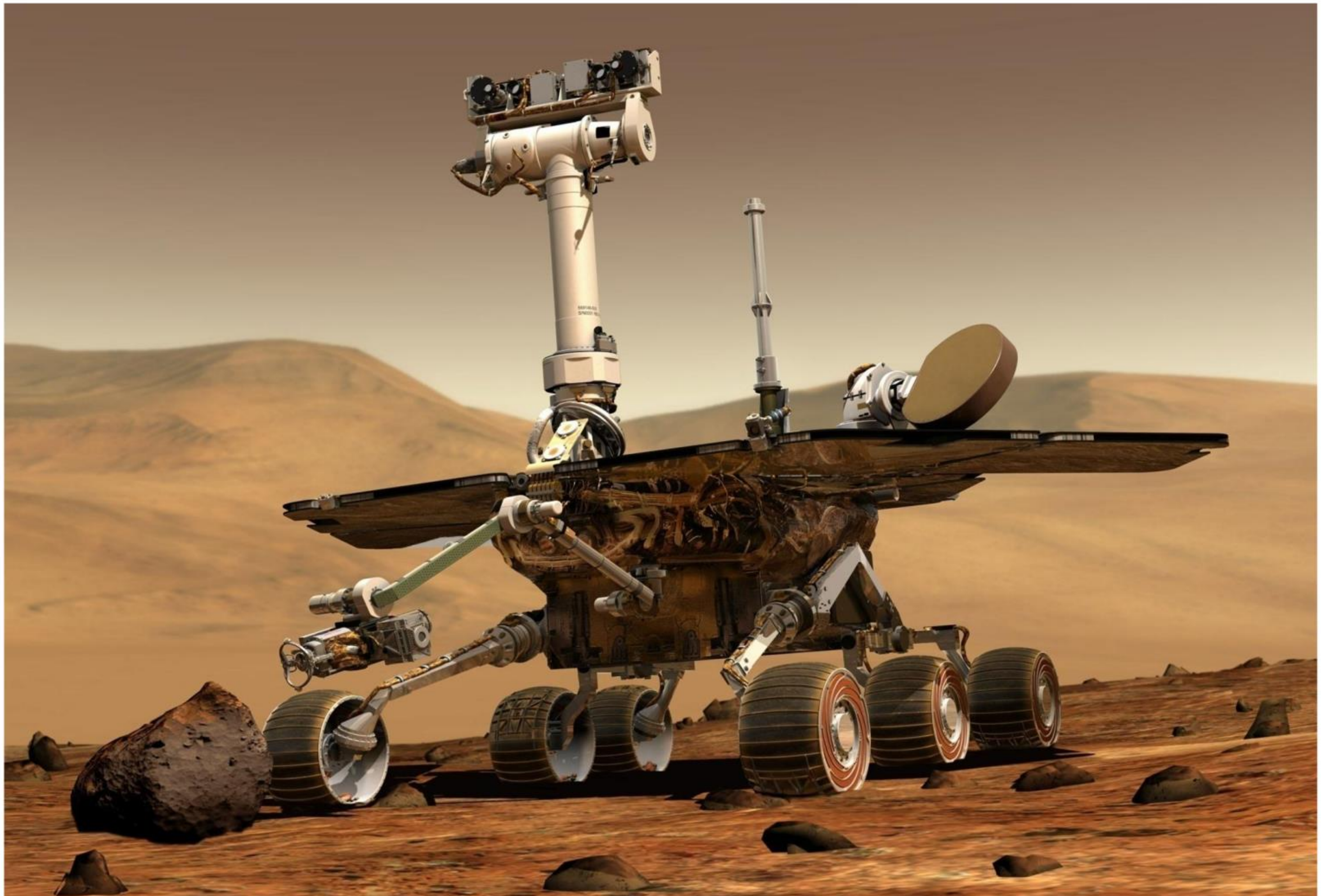


Image source: Courtesy NASA/JPL-Caltech, http://marsrover.nasa.gov/gallery/artwork/hires/rover3.jpg

APPENDIX A: Rover Main Parts & Functions

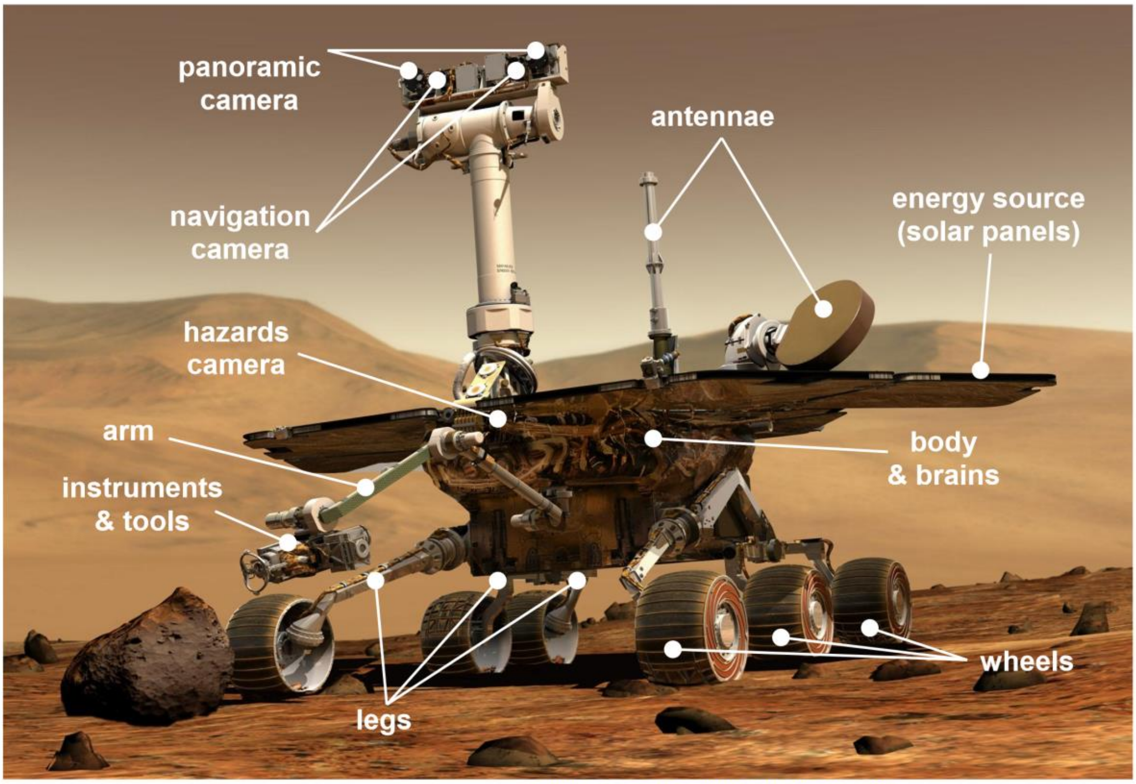
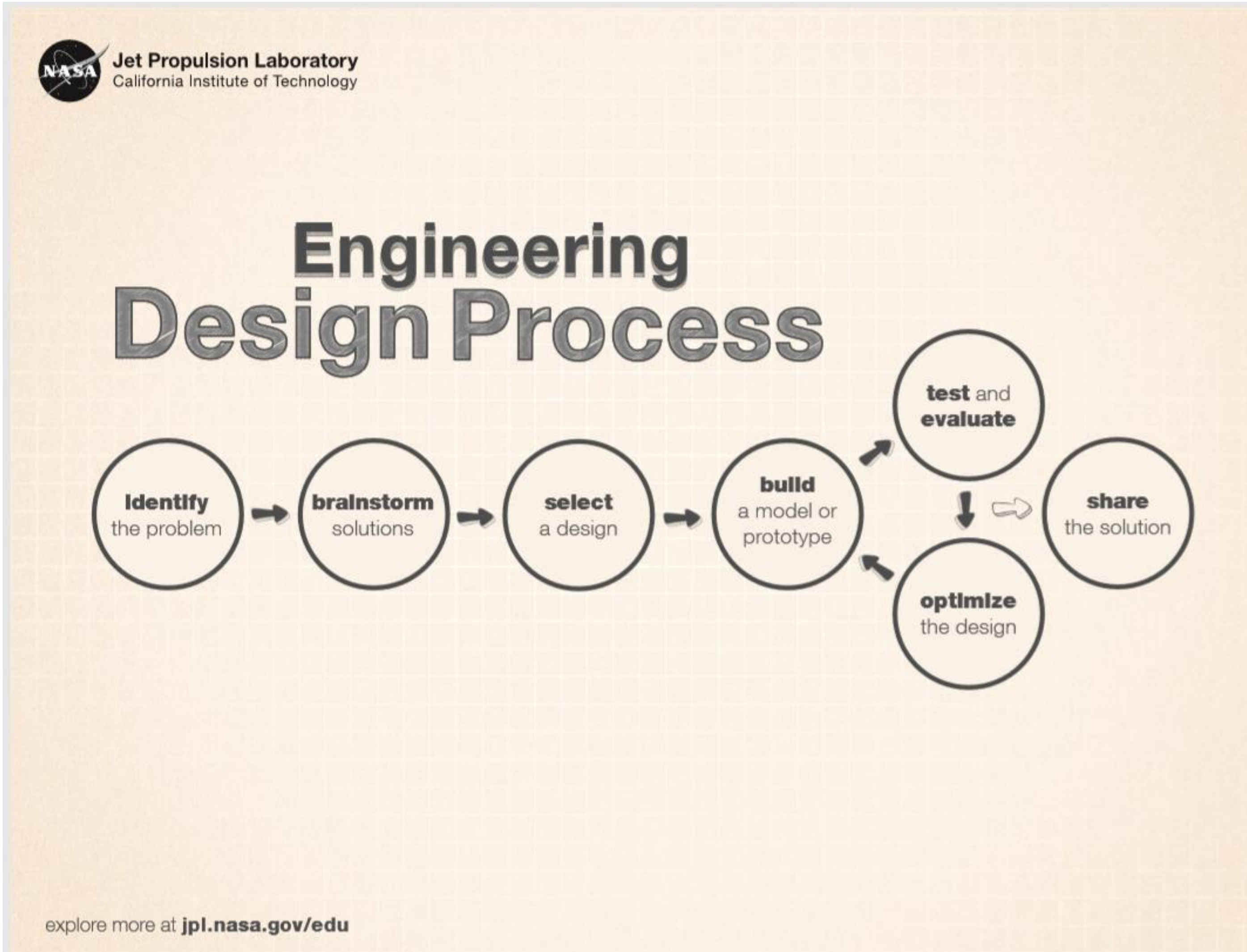


Image source: Courtesy NASA/JPL-Caltech, http://marsrover.nasa.gov/gallery/artwork/hires/rover3.jpg

Rover Main Parts and Functions:

- **Body:** protects the rover's "organs"
- **Brains:** computers to process the rover's information
- **Wheels:** allows rover movement
- **Robotic Arm:** extends and moves tools and instruments
- **Energy Source:** solar panels and batteries provide power
- **Cameras:** cameras mounted on the head, front and back of the rover to "see" and take pictures
- **Communications**: antennae for communication with NASA and Earth
- **Temperature Controls:** heaters and insulation to protect the rover instruments
- **Tools**: such as:
    - **Abrasion tool:** scrapes rock to bring back samples
    - **Spectrometer:** identifies any minerals that contain iron
    - **X-ray Spectrometer:** takes x-rays of rocks and soil so NASA can identify elements in the rocks
    - **Microscopic imager:** shows very small details of rocks and soil

APPENDIX B: Engineering Design Process



Appendix C: Mars Rover Data Sheet

Like all NASA projects, the Pasta Rover must stay within a budget. Your Pasta Rover budget is $80,000,000. You may use as much pasta, candy, or other parts as you can afford. Glue is no charge.

ITEM	Cost per each	Qty	Iteration 1 Qty x Cost	Qty	Iteration 2 Qty x Cost	Qty	Iteration 3 Qty x Cost	Qty	Iteration 4 Qty x Cost
Lasagna	$15,000,000								
Lasagna w/o ridges	$12,000,000								
Spaghetti	$ 4,000,000								
Rigatoni	$ 5,000,000								
Bow Ties	$ 1,000,000								
Fettuccine	$ 6,000,000								
Elbows	$ 500,000								
Mostaccioli	$ 3,000,000								
Ditalini	$ 800,000								
Manicotti	$6,000,000								
Rotini	$1,000,000								
Mint Candy	$ 2,000,000								
Foam Circles	$ 4,000,000								
Popsicle Sticks	$ 2,000,000								
TOTAL COST		Itn 1		Itn 2		Itn 3		Itn 4	
RESERVE									