(A) Student Instruction Sheet

Instructions:

For this activity, you will play a scientist and engineer. Have you ever wanted to travel to Mars? Have you wondered what goes into the planning the mission to Mars? You and your team will design a "mission" to Mars. Just like the NASA mission designers, you will have a "catalog" of mission hardware from which you can choose. Also, just like the NASA mission designers, you will have budgets for mass, power and cost that you must keep in balance.

Your mission will include the following 4 tasks:

1. Group current NASA mission goals for Mars;
2. Meet with your team to choose your goals for the mission using the NASA Mars Exploration Program Goals;
3. Design a mission that meets a balanced budget for mass, power, and cost but also has significant science return, and makes it safely to the planet; and,
4. Identify any engineering constraints that limited the goals of your mission.

Good luck planning your mission to Mars!

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(B) Student Worksheet. Pre-Ideas (1 of 2)

Please answer these questions as best you can.

1. What do you think would be the hardest part of planning a mission to Mars? Explain why you think these items will be so difficult.

2. Define what you think a "good" mission to Mars would be. What would be important to do during planning?

(B) Student Worksheet. Pre-Ideas (2 of 2)

3. Do scientists and engineers get everything they need and/or want when they are planning their missions? __________

4. Explain the reasons you think they do or do not get everything they request.

(C) Activity 1 Fact Sheet: Mars Exploration Science Goals

NASA Strategies and Goals for the Exploration of Mars

Thousands of questions could be asked about Mars alone, so NASA has organized its program for Mars exploration around a common strategy. This strategy is the thread that ties together all four of NASA's main goals for Mars exploration. When designing a mission to Mars, mission planners define many science objectives related to each of the four science goals. These science objectives reflect questions about the planet that they would like the mission to answer.

<table>
<tr><th colspan="3">Guiding Mars Exploration Program Strategies</th></tr>
<tr><td>Past:</td><td>"Follow the Water"</td><td>Found evidence of water, past and present</td></tr>
<tr><td>Current:</td><td>"Seeking Signs of Life"</td><td>Search for bio-signatures and return samples</td></tr>
</table>

<table>
<tr><th colspan="2">Mars Exploration Program Goals</th></tr>
<tr><td>DETERMINE IF LIFE EVER AROSE ON MARS</td><td rowspan="4">Key Mars Discoveries:
A Springboard to the Future

• Complex geological and climate history

• Diversity of ancient water-rich environments

• Environments that have potential to preserve bio-signatures

• Cold, dry planet today still changing

• Widespread subsurface ice provides resources for exploration and special environment for possible life today</td></tr>
<tr><td>CHARACTERIZE THE PAST AND PRESENT CLIMATE OF MARS</td></tr>
<tr><td>CHARACTERIZE THE GEOLOGY OF MARS</td></tr>
<tr><td>PREPARE FOR HUMAN EXPLORATION</td></tr>
</table>

(D) Activity 1: Sample Science Objectives (1 of 3)

Sample Science Objectives for Mars Missions

Here you will find a list of some of the science questions being studied by Mars scientists that can be selected as mission objectives—questions to be answered. For each science objective, place a checkmark in the box matching the Mars Exploration Program Goals that you think it matches. Keep in mind that each objective may apply to more than one of the four goals. Discuss with your team why you think each of these topics might be important. Write these reasons into the justification column of the table.

Science Objective	Mars Exploration Program Goals				Justification
	Determine if life ever arose	Characterize the climate	Characterize the geology	Prepare for human exploration	
Craters					
What kinds of craters are on Mars and how did they form?					
How old are the craters on Mars?					
How are Martian craters different from craters on the Moon?					
Have Martian craters been eroded by wind or water?					
Were some of the craters on Mars ever flooded?					
What kinds of rocks make up the ejecta from Martian craters?					
Has the amount of cratering on Mars changed over time?					

(D) Activity 1: Sample Science Objectives (2 of 3)

Science Objective	Mars Exploration Program Goals				Justification
	Determine if life ever arose	Characterize the climate	Characterize the geology	Prepare for human exploration	
Volcanoes					
What types of volcanoes are on Mars?					
Does Mars have moving continental plates?					
When/how often did the Martian volcanoes erupt?					
Have Martian volcanoes been eroded by wind or water?					
Did the lava from Martian volcanoes mix with water?					
Plains					
Were the northern plains on Mars once a huge ocean?					
Why is the northern hemisphere of Mars so smooth and flat, while the southern is so cratered?					
Polar Caps					
What are ice caps on Mars made of?					
How do the ice caps change throughout the Martian year?					
What are the dark lands/ features seen on Martian ice caps?					

(D) Activity 1: Sample Science Objectives (3 of 3)

Science Objective	Mars Exploration Program Goals				Justification
	Determine if life ever arose	Characterize the climate	Characterize the geology	Prepare for human exploration	
Canyons					
What formed the canyon systems on Mars?					
Did water ever flow through the canyons?					
Have the canyons been eroded by wind or water?					
Were some of the craters on Mars ever flooded?					
What kinds of rocks make up the ejecta from Martian craters?					
Has the amount of cratering on Mars changed over time?					

Take a few minutes, and with your team, write 3 of your own science questions (science objectives). Which Mars Exploration Program Goal does your question fall under and why?

Question (Science Objectives)	Mars Exploration Program Goals			
	LIFE	CLIMATE	GEOLOGY	HUMAN

(E) Activity 2: Identify Your Mission Goals

In (D) Activity 1, you classified a number of science objectives according to NASA's Mars Exploration Program goals. Your task for this activity is to select the science objective that you hope to achieve with your mission.

Using the list in (D) Activity 1 (including the objectives you created yourself), choose five science objectives for your mission. When your team has agreed upon the science objectives for your mission, record them in the table below. Record your team's reasons for why each objective is important. Be sure to explain how your objectives fit into NASA's Mars Exploration Program goals.

After discussing them with your team, rank your five science objectives from 1 to 5 in order of importance to your team **(1 being the most important)**. Ignore the final column for now.

Our mission will be (Circle one)

FLY-BY	ORBITER	LANDER
Typically one of the first missions to a planet or set of moons	Typically a second mission type to collect global data, such as photos of the surface and general mineral make-up of the planet	Typically third in a mission type to collect information, such as up close photos and mineral composition in one particular spot on the planet

Rank Order (1-5)	Goal	Reason	Dropped

(F) Activity 3: Building Your Spacecraft Fact Sheet

It is now time to build the spacecraft you will use to meet your mission goals. Use the equipment cards and poster to complete this simulation. You will work with your team to design a spacecraft by choosing the cards that stand for each system involved in your mission. Read each card carefully to make sure you have all of the required systems on your spacecraft.

Remember, your goal in this activity is to design a spacecraft with your team that stays under budget, is launchable, and meets your science goals. Your teacher will decide the budget of your mission and guide you through the first steps of your mission design. You will need to record your design in the ***(I) Spacecraft Design Log*** on the next page. You may go back at any time to change your science goals and your design. In the end, you should have a good balance between meeting your science goals and satisfying your engineering constraints.

Example ***Spacecraft Design Log***:

Your teacher will give you your budget.

System	Spacecraft Component	Budget 250	Mass 125	Power 50
Launch	Medium-Lift Rocket A	-100	0	0
		150	125	50
	Rocket Nose Cone	-10	-7	0
		140	118	50
Power	Fuel Cell	-40	-25	0
		100	93	50

Mass is determined by the rocket system and Power is determined by the power system that you choose.

The systems' names have been filled in.

Fill in the name of the item chosen. Erasures and changes may be necessary along the way.

The white boxes contain the cost, mass, and power for each card to be subtracted from your remaining budget. The blue box is the remaining budget after subtraction.

Cost in millions — Mass — Power — Science Return

(G) Activity 4: Spacecraft Design Log (1 of 2)

Spacecraft Design Log					
System	**Spacecraft Component**	**Budget**	**Mass**	**Power**	**Science Return**
Launch					
Power					
Computer					
Communica-tions					
Mobility					
Entry, Descent & Landing					
Science Instruments					
Mechanical					

(G) Activity 4: Spacecraft Design Log (2 of 2)

Mission Metrics

Special Events and Launch	Budget	Mass	Power	Science Return
Final Mission Costs (Record from the last row in the Spacecraft Design Log)				
Special Event Card Selected				
Final of Totals of Mission Design Categories				

1. How did your final "Risk" card affect your mission?

2. Did your mission have a successful launch? (Circle one) Yes No

3. What are your thoughts about what you think of mission designs after this simulation?

(H) Activity 4: Engineering Constraints

Engineering constraints are limits placed on your mission by the hardware you use to accomplish the mission.

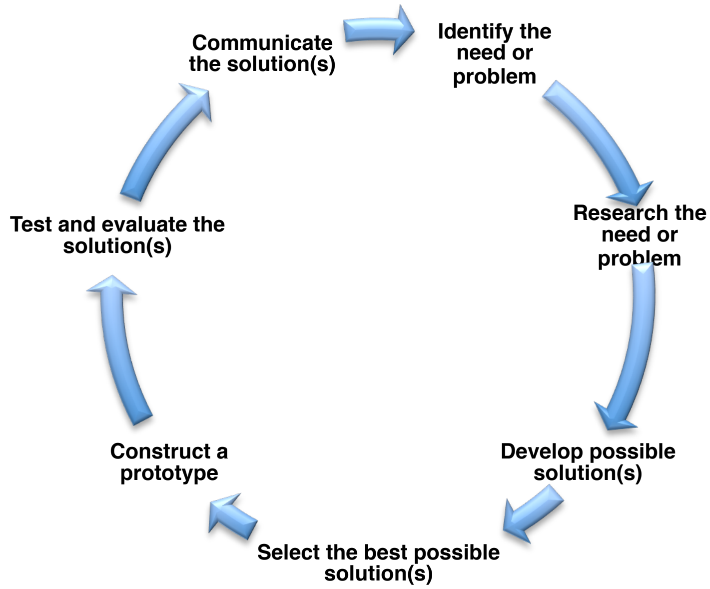
With your team, recall the MARSBOUND! Simulation and brainstorm at least 3 hardware constraints you ran into during your mission planning. For each of these run ins with constraints, describe how your team reworked your mission to adjust to these limitations.

Engineering Constraints and Accommodation List

	Hardware #1	Hardware #2	Hardware #3
Hardware			
Constraint			
Accommodation			

(I) Activity 4: Engineering Design Cycle (1 of 2)

This diagram of the engineering cycle is a simple version of what really happens when engineers work on a task. The process is much longer, often going from later steps in the cycle and circling back to earlier steps as new information is gathered.



Identify the need or problem
- Specify and prioritize requirements and constraints to better define the need or problem

Research the need or problem
- Examine current state of the issue and current solutions
- Explore other options through resources (Ex: Internet, interviews, periodicals, etc.)
- Identify the constraints

Develop possible solution(s)
- Brainstorm possible solutions
- Draw on mathematics and science
- Explain or describe the possible solutions on paper, computer simulation, or 3D model
- Refine the possible solutions

Select the best possible solution(s)
- Determine, using simple analysis, which solution(s) best meet(s) the original requirements

Construct a prototype
- Model the selected solution(s) on paper, computer simulation, or 3D model

Test and evaluate the solution(s)
- Does it work?
- Does it meet the original design constraints?

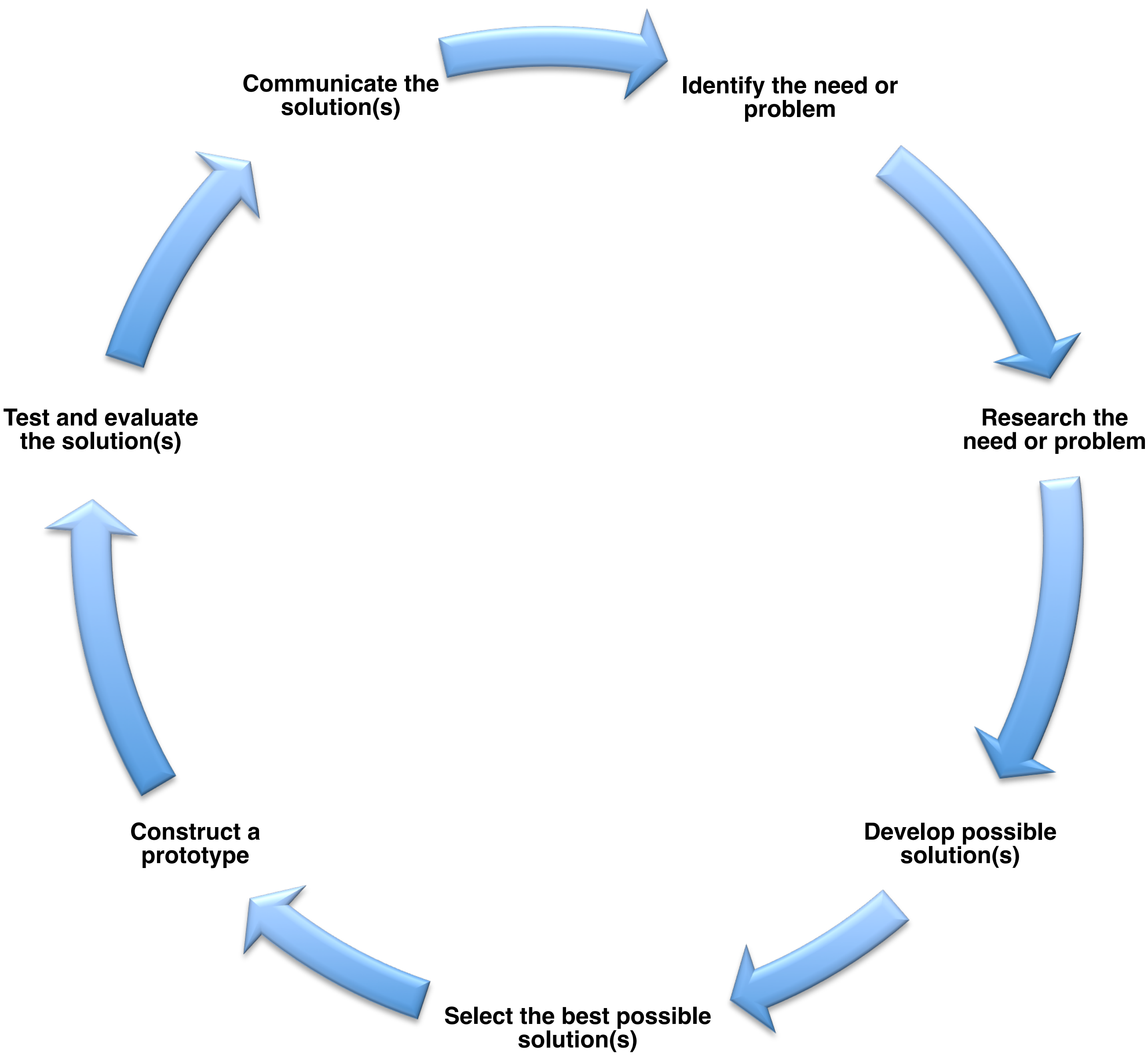
Communicate the solution(s)
- Make an engineering presentation that includes a discussion of how the solution(s) best meet(s) the needs of the initial problem, opportunity, or need
- Discuss societal impact and tradeoffs of the solution(s)

(I) Activity 4: Engineering Design Cycle (2 of 2)

Name: ______________________________

Working with your group, discuss your Marsbound mission and identify when you experience each step of the Engineering Design Cycle. Write the event, problem, need, solution, test, etc. your team ran into next to the correct section of the cycle. Add arrows between steps if your team needed to go back (iteration) during the mission planning to test a new option. There should be at least one example next to each step in the cycle.

Engineering Design Cycle



(J) Student Worksheet. Post-Ideas (1 of 2)

Based on the MARSBOUND! simulation, please answer the following questions as best you can.

1. What do you think would be the hardest part or parts of planning a mission to Mars? Explain why you think these will be so difficult.

2. Refer back to your response to #1 in the Pre-Survey. Was your prediction correct? _______ What reasons do you think allowed the prediction to be correct or incorrect?

(J) Student Worksheet. Post-Ideas (2 of 2)

3. Define what you think a "good" mission to Mars would be? Why?

4. Do scientists and engineers get everything they need and/or want when they are planning their missions? __________.

5. Explain why you think they do or do not get everything they request.

(K) Comparing Two Mars Rover Projects

Comparing Two Mars Rover Projects

	Mars Science Laboratory	Mars Exploration Rovers
Rovers	1 (Curiosity)	2 (Spirit and Opportunity)
Launch vehicle	Atlas V	Delta II
Heat shield diameter	14.8 feet (4.5 meters)	8.7 feet (2.65 meters)
Design mission life on Mars	1 Mars year (98 weeks)	90 Mars sols (13 weeks)
Science Payload	10 instruments, 165 pounds (75 kilograms)	5 instruments, 11 pounds (5 kilograms)
Rover mass	1,982 pounds (899 kilograms)	374 pounds (170 kilograms)
Rover size (excluding arm)	Length 10 feet (3 meters); width 9 feet (2.7 meters); height 7 feet (2.2 meters)	Length 5.2 feet (1.6 meters); width 7.5 feet (2.3 meters); height 4.9 feet (1.5 meters)
Robotic arm	7 feet (2.1 meters) long, deploys two instruments, collects powdered samples from rocks, scoops soil, prepares and delivers samples for analytic instruments, brushes surfaces	2.5 feet (0.8 meter) long, deploys three instruments, removes surfaces of rocks, brushes surfaces
Entry, descent and landing	Guided entry, sky crane	Ballistic entry, air bags
Landing ellipse (99-percent confidence area)	15.5 miles (25 kilometers) long	50 miles (80 kilometers) long
Power supply on Mars	Multi-mission radioisotope thermoelectric generator (about 2,700 watt hours per sol)	Solar photovoltaic panels (less than 1,000 watt hours per sol)
Computer	Redundant pair, 200 megahertz, 250 MB of RAM, 2 GB of flash memory	Single, 20 megahertz, 128 MB of RAM, 256 MB of flash memory

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