

Human Systems Design Project Assessments/Teacher Masters/ Visuals: Table of Contents

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Rubric: Human Arm Movement

	Criterion A	Criterion B
	Joints enable movement of bones in the human arm. There are several types of joints in the arm.	Each type of joint in the human arm functions differently.
4 - Exceeds Expectations Explores content beyond the level presented in the lessons.	Understands at a secure level (see box below) and is able to identify these different types of joints in other parts of the body.	Understands at a secure level (see box below) and can extend this knowledge to other parts of the body.
3 - Secure (Meets Expectations) Understands content at the level presented in the lessons and does not exhibit misconceptions.	Can locate the various types of joints in the human arm.	Can describe how each type of joint functions.
2 - Developing (Approaches Expectations) Shows an increasing competency with lesson content.	Can locate some but not all of the types of joints in the human arm.	Knows that, in general, joints function differently, but is unable to describe how they function.
1 - Beginning Has no previous knowledge of lesson content.	Is unable to locate any of the types of joints in the human arm.	Doesn't know that the joints function differently.

Rubric: Designing a Human System

	Criterion A	Criterion B
	People design technologies that mimic the human muscular skeletal system in order to meet a need.	A variety of limitations affect the ultimate design of technologies.
4 - Exceeds Expectations Explores content beyond the level presented in the lessons.	Understands at a secure level (see box below) and describes how various technologies mimic human capabilities.	Understands at a secure level (see box below) and can point out limitations of different technologies.
3 - Secure (Meets Expectations) Understands content at the level presented in the lessons and does not exhibit misconceptions.	Can design an example of a technology that mimics a human muscular skeletal system to meet a need.	Takes into account a variety of limitations in a technological design.
2 - Developing (Approaches Expectations) Shows an increasing competency with lesson content.	Can design an example of a technology to meet a need, but is unable to describe how the technology mimics a human muscular skeletal system.	Knows that a variety of limitations affect the design of technologies, but is unable to apply that knowledge to their own design.
1 - Beginning Has no previous knowledge of lesson content.	Is unable to design an example of a technology that mimics a human muscular skeletal system.	Doesn't know that limitations affect the design of technologies.

Checklist: Planning and Sketching a Design

Teacher Assessment

Determine whether the following elements are evident in student's approach to designing a robotic arm. You might assign one point for each criterion the student demonstrates. You can add specific observations or comments in the space below each criterion.

Name _____

Date _____

Criteria:

_____ A. Considers and explains project goals and criteria while creating a design.

_____ B. Develops strong criteria for the design.

_____ C. Evaluates whether the design meets the project criteria at various stages of development.

_____ D. Redesigns or improves upon a design based on peer input, project criteria, or other factors.

Name _____ Date _____

Self-Assessment: Planning and Sketching a Design

Think about the process of designing and sketching your robotic arm and answer the following questions.

1. How would you evaluate the strength of your design criteria?

Strong

Neither weak nor strong

Weak

2. How many of the criteria did you think about in the initial sketch of your design?

All of the criteria

Some of the criteria

None of the criteria

3. Did you check whether your design met the criteria at different points in the process?

Yes

No

4. How many of the criteria did the final sketch of your design meet?

All of the criteria

Some of the criteria

None of the criteria

Remote Control

Materials:

- Pencil, 1 per pair
- Paper cup, 1 per pair
- Teacher Master “Rover Commands”, 1 per student

Preplanning:

1. Choose roles for the first trial. One partner is the rover, located on Mars. The other is the operator, located on Earth. Switch roles for the second trial.
2. Each operator, in turn, places the “sample” (the pencil) someplace in the classroom. Some suggestions are:
 - on your desk;
 - under your desk;
 - under a piece of paper (but leave part of the pencil showing);
 - on a table across the room.

Hint: Don’t make it too difficult for the rover to find and collect the sample.

Remote Control

Operator Rules:

1. Send verbal “radio” commands to the rover. (Stand close enough to speak quietly.) Relay two commands each “day.” Record the commands on the Teacher Master “Rover Commands.”
2. Relay precise commands. The following are examples of commands you might try:
 - Walk forward ____ steps
 - Stop
 - Turn around 180 degrees
 - Bend forward at waist 90 degrees
 - Extend robotic arm
 - Move robotic arm up/down/right/left
 - Grasp the sample with robotic hand, etc.
3. Send as many radio commands as you like, but remember, the rover automatically freezes and waits for new instructions whenever it gets stuck.

Rover Rules:

1. Hold the paper cup in one hand. This is your on-board laboratory. Your other hand is your robotic arm. Your legs and feet are your propulsion system. You can bend, but not twist from the waist. You can also bend at the knees. Your “camera” head can move freely and search the Martian surface around you.
2. Receive and then follow the “radio” commands from the operator on Earth.
3. Silently count a time delay of four seconds after you receive each radio command before you begin to move. (On a real Mars mission, this time delay is several minutes long.)
4. If you hit an obstacle, freeze in place and wait for a new set of instructions.
5. Once the sample has been successfully collected, switch roles, let the new operator place the “sample” somewhere in the classroom and begin the second trial.

Name: _____ Date: _____

Rover Commands

Day	Command 1	Command 2
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Name: _____ **Date:** _____

Rover Observations and Analysis

1. How many “days” did it take to collect the sample?

Trial 1:

Trial 2:

2. How many times did the rover get stuck?

Trial 1:

Trial 2:

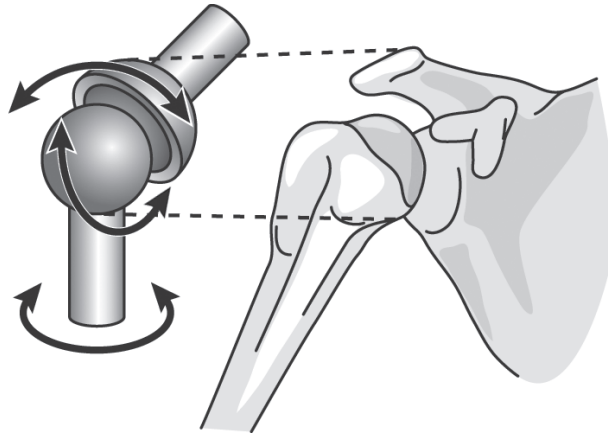
3. What are some of the reasons that the rover got stuck?

4. What are some of the challenges of controlling Mars rovers from Earth?

Setting Up the Human Arm Stations

Station	Materials
1. Ball-and-Socket Joint	<ul style="list-style-type: none"> Place two copies of the Teacher Master “Station 1: Ball-and-Socket Joint” at this station. No other materials are needed for this station.
2. Pivot Joint	<ul style="list-style-type: none"> Create two models of the pivot joint for this station. See the Teacher Master “Making a Pivot Joint Model” (pages 1 and 2, Teacher Masters 11 and 12) for directions. Place two copies of the Teacher Master “Station 2: Pivot Joint” at this station.
3. Hinge Joint	<ul style="list-style-type: none"> Create two models of the hinge joint for this station. See the Teacher Master “Making a Hinge Joint Model” (page 1, Teacher Master 14) for directions. Place two copies of the Teacher Master “Station 3: Hinge Joint” at this station.
4. Muscles Move Bones	<ul style="list-style-type: none"> Create one model of a pivot joint with muscles attached for this station. See the Teacher Master “Making a Pivot Joint Model” (page 3, Teacher Master 13) for directions to add muscles to the pivot joint. Create one model of a hinge joint with muscles attached for this station. See the Teacher Master “Making a Hinge Joint Model” (page 2, Teacher Master 15) for directions to add muscles to the hinge joint. Place two copies of the Teacher Master “Station 4: Muscles Move Bones” at this station.
5. Hands	<ul style="list-style-type: none"> For Pinching: small objects (e.g., pebbles, pieces of clay, pushpins, etc.), hand tool such as tweezers For Grabbing: large objects (e.g., a backpack, a book, etc), hand tools such as scissors and pliers For Gripping: chair Place two copies of the Teacher Master “Station 5: Hands” at this station.

Station 1: Ball-and-Socket Joint



Human example: Where the arm attaches to shoulder.

Making a joint model:

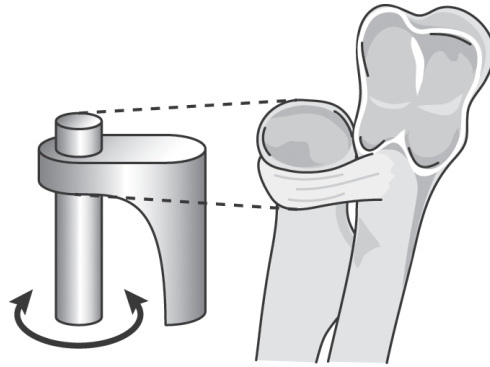
1. Make a fist with one hand.
2. Cup the fist with the other hand.
3. Rotate your fist in different directions inside the cupped hand.

Using your own arm: Move your arm from the shoulder to explore the different directions your arm can move.

1. Stand still and face the front of the classroom.
2. Extend your right arm out in front of you, with your hand facing down.
3. Rotate your arm up so your fingers point to the ceiling.
4. Rotate your arm down so your fingers point to the floor.
5. Bring your arm back to its original position.
6. Move your arm to the right as far as you can.
7. Move your arm to the left as far as you can.
8. Bring your arm back to its original position.
9. Rotate your arm in small circles.
10. Rotate your arm in large circles.
11. Explore different ways your arm can move within the shoulder joint.

Use in robots: The ball-and-socket joint allows a robot body to stay still while the arm reaches up, down, left, right, around, over, under, etc.

Station 2: Pivot Joint



Human example: Elbow (Note: the elbow is both a pivot joint and a hinge joint.)

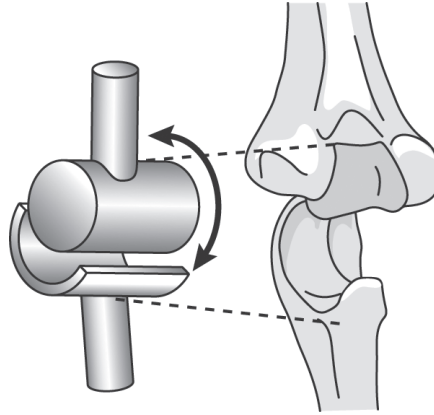
Using the joint model: Rotate the strip of cardboard partway around the pencil. Then rotate it back.

Using your own arm: Move forearm on desktop

1. Place your right forearm on your desktop.
2. Rotate your hand palm up, then palm down, then palm up, etc.
3. Use your left hand to feel how the bones are moving in your forearm while rotating your hand.
4. Think about where the rotation is happening.
5. Now pin your right forearm down with your left hand.
6. Try to rotate your hand again.

Use in robots: The pivot joint allows a robot arm to flip over or scoop sideways.

Station 3: Hinge Joint



Human example 1: The elbow and the knuckles of each finger are variations of the basic hinge joint. (Note: the elbow is both a pivot joint and a hinge joint.)

Using the joint model: Move the cardboard strips attached with brass brads back and forth.

Using your own arm:

- Bend your arm at the elbow.
- Bend a finger at the knuckle.

Use in robots: The hinge joint gives good, strong lifting power. When several are added together, like in fingers, they are good for gripping.

Human example 2: Wrist (ellipsoid joint, another kind of hinge joint)

Using your own arm:

- Move wrist up and down, then left and right.

Human example 3: Thumb (saddle joint, like a loose hinge joint)

Using your own arm:

- Move thumb back and forth and rotate it around in circles.

Use in robots: The ellipsoid joint and the saddle joint allow for greater range of motion than a simple hinge joint, but less lifting strength. They are more difficult to design, may break more easily, but may allow more precision.

Note: You don't need to memorize the names of different hinge joints. Just think about how different joints allow different movements.

Station 4: Muscles Move Bones

Human example: Every joint is held together by ligaments. The bones that meet at the joint are moved by pairs of muscles.

Using Model 1: Pivot joint model

1. Move the “bone” in one direction by pulling a “muscle” (piece of yarn).
2. Move the “bone” in the other direction by pulling the other “muscle” (yarn).
3. Note that muscles never PUSH. They only PULL. It is not possible to move the “bone” by pushing on a “muscle” (yarn).
4. Also note that muscles work in pairs to move a bone back and forth.

Using Model 2: Hinge joint model

1. Move the “bone” in one direction by pulling a “muscle” (piece of yarn).
2. Move the “bone” in the other direction by pulling the other “muscle” (yarn).
3. Note that muscles never PUSH. They only PULL. It is not possible to move the “bone” by pushing on a “muscle” (yarn).
4. Also note that muscles work in pairs to move a bone back and forth.

Use in robots: For robot arms to work, they must be equipped with something like muscles that can move the robot’s “bones” back and forth as the robot works. Note that muscles never PUSH. They only PULL. Muscles work in pairs to move a bone back and forth.

Station 5: Hands

Human example: Human hands are able to pinch, grab, grip, scoop, push, lightly touch, etc. Human hands can also use different kinds of tools.

Using your own hand to pinch:

- Explore pinching by using your thumb and forefinger to pick up a variety of small objects.
- Think: What other things do you do using your thumb and finger to pinch?

Using your own hand to grab and grip:

- Explore grabbing by using all five fingers to pick up a variety of larger objects.
- Explore gripping by using your hands to hold on tightly to the legs of a chair while picking it up.
- Think: What other things do you do that use your whole hand? What tools can you use to do things your hands can't do alone?

Use in robots: Pinching, grabbing, gripping, digging, drilling, "feeling" (sensors on hands to measure temperature, pressure, etc.). Other, non-hand attachments, like hammers, crab-claws, and magnets can be used at the end of robot arms.

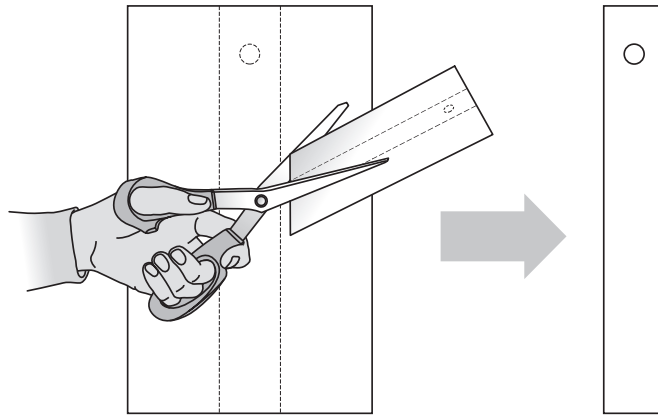
Making a Pivot Joint Model

Materials:

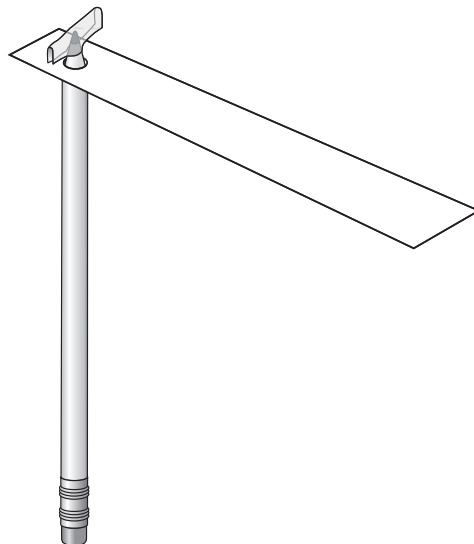
- Index card, 3 x 5
- Pencil
- Hole punch, single hole
- Scissors
- Tape, clear
- 2 pieces red yarn, 30 cm (1 ft) in length

Directions to Create Joint:

1. Cut a 1½ cm (about ¾ in) wide “bone” from the index card and punch a hole near one end of the bone.

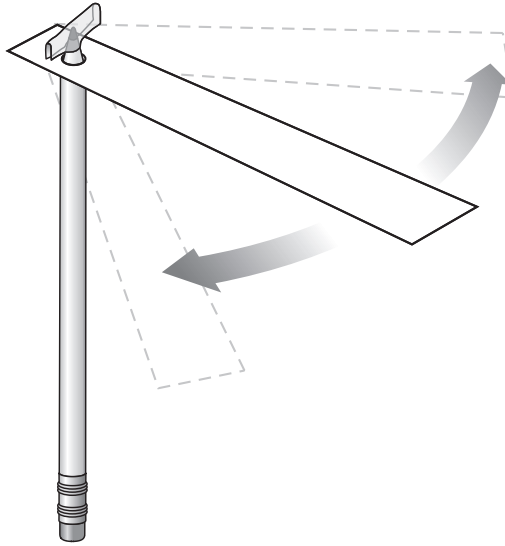


2. Place the hole of the paper “bone” on top of a sharpened pencil “bone.” Tape the sharpened end of the pencil bone so the paper bone will not fall off.



Making a Pivot Joint Model

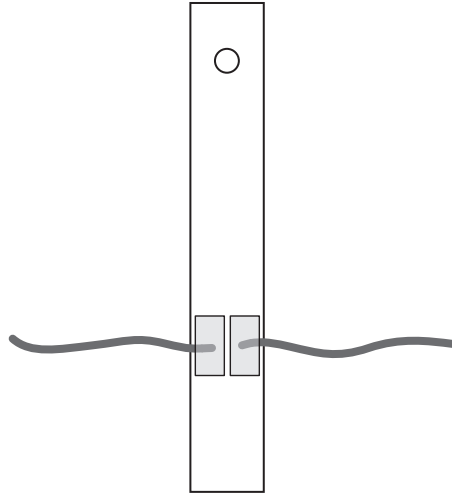
3. Rotate the paper bone back and forth around the pencil bone to simulate a pivot joint.



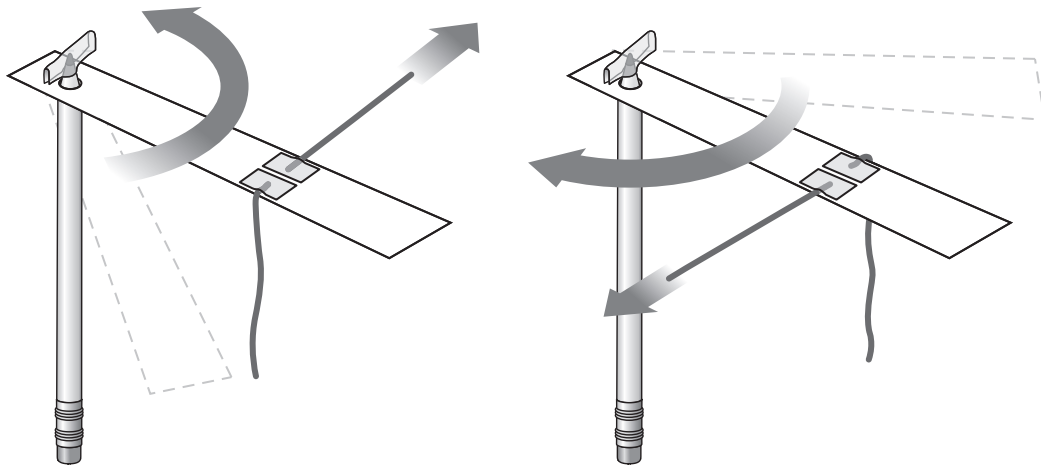
Making a Pivot Joint Model

Directions to Add and Use Muscles:

1. Tape the “muscles” (pieces of yarn) near the middle of the bone so the unattached ends trail in opposite directions.



2. Pull one “muscle” (yarn) to make the pencil bone pivot in one direction. Pull the other “muscle” (yarn) to make the bone pivot back in the other direction.



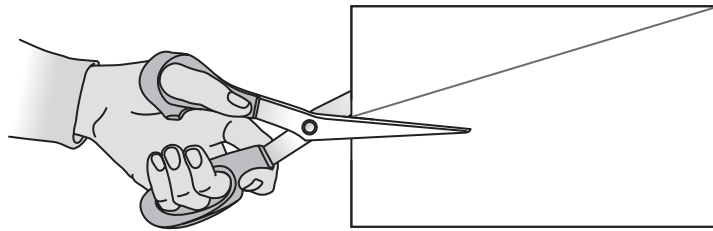
Making a Hinge Joint Model

Materials:

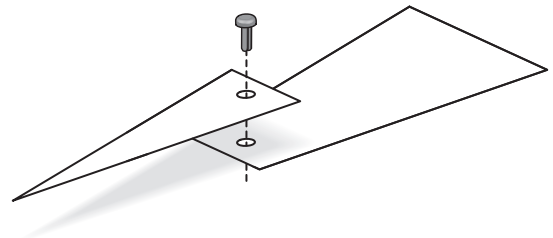
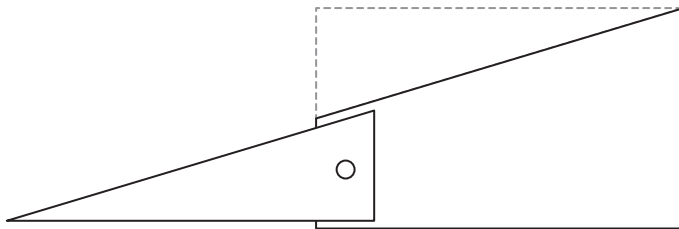
- Index card, 3 x 5
- Pencil
- Ruler
- Brad
- Scissors
- Tape, clear
- 2 pieces red yarn, 30 cm (1 ft) in length

Directions to Create Joint:

1. Use a ruler to draw a line from one corner of the index card to a point about $4\frac{1}{2}$ cm ($1\frac{3}{4}$ in) from the opposite corner. Then cut the index card along the line.



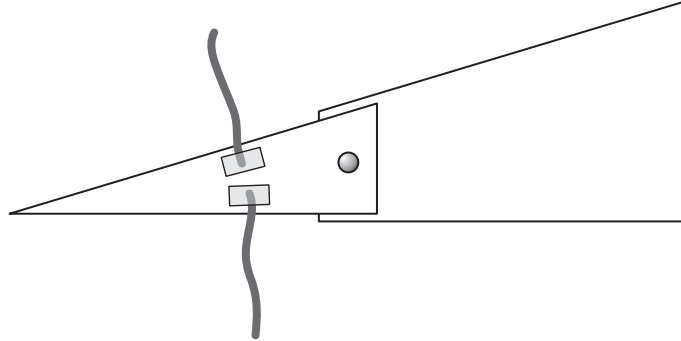
2. Arrange the “upper arm bone” (trapezoid piece) and the “forearm bone” (triangular piece) into a large triangle. Then poke a hole through the pieces and attach them with the brad.



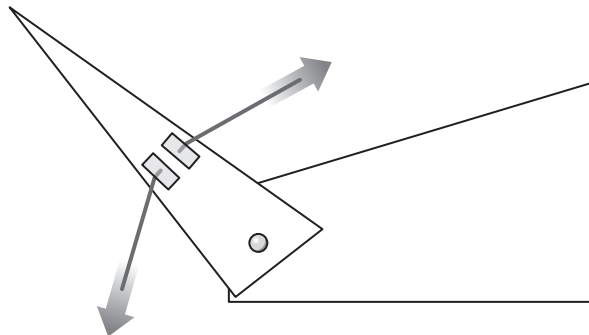
Making a Hinge Joint Model

Directions to Add and Use Muscles:

1. Tape the “muscles” (pieces of yarn) near the middle of the forearm so the trailing ends are in opposite directions.



2. Alternately bend and straighten the hinge joint model at the “elbow” by pulling on one “muscle” (yarn) and pulling back with the other “muscle” (yarn).



Name: _____ **Date:** _____

Robotic Arm Primary Criteria

Create the primary criteria for your robotic arm by answering the following questions:

1. What are you trying to find out about Mars?

2. What is the task of the robotic arm?

3. How does the robotic arm do this task?

Example Primary Criteria

Question	Weak Criteria	Strong Criteria
What are you trying to find out about Mars?	We want to find out where the rocks are.	We want to search in 10 different places to see if there are any rocks at least 1 m below the surface.
What is the task of the robotic arm?	To dig.	To dig holes in the sand at least 1 m deep.
How does the robotic arm do this task?	With a shovel.	With a shovel attached to a hinge joint on the robot's arm.

Name: _____ **Date:** _____

Robotic Arm Secondary Criteria

Create the secondary criteria for your robotic arm by answering the following questions:

1. How is the robot controlled from Earth?
2. How will the robotic arm cope with unexpected problems on Mars?

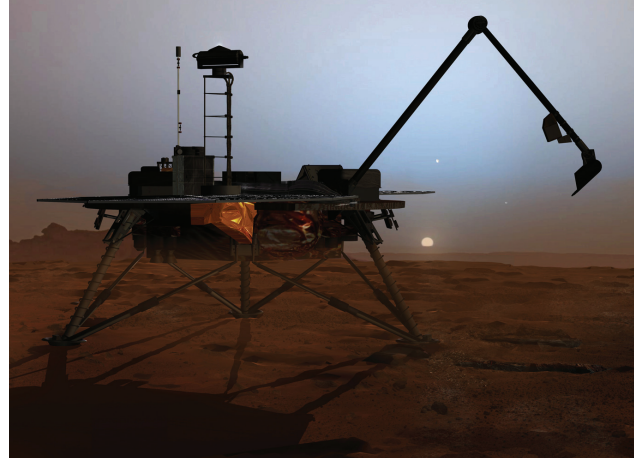
Example Secondary Criteria

Question	Weak Criteria	Strong Criteria
How is the robot controlled from Earth?	By scientists.	Scientists send radio signals to the robot to tell it what to do. When the robot receives a signal it carries out that command.
How will your robot cope with unexpected problems on Mars?	We don't expect any problems.	We have designed special joints that work well in high and low temperature. The joints are also protected from dust and sand. We have extra joints available in case any of them break. If the power system breaks down, we have another one available to use.

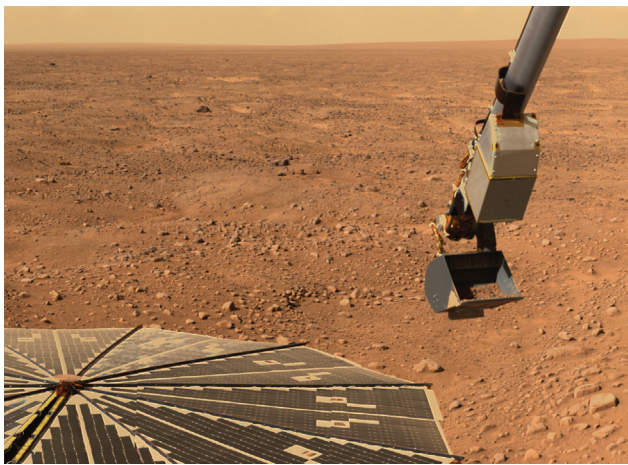
Phoenix Mars Lander Images



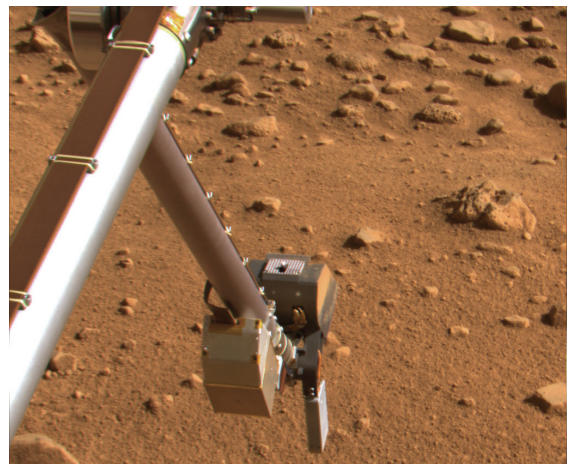
Courtesy: NASA/JPL—Caltech/University of Arizona



Courtesy: NASA/JPL—Caltech/University of Arizona



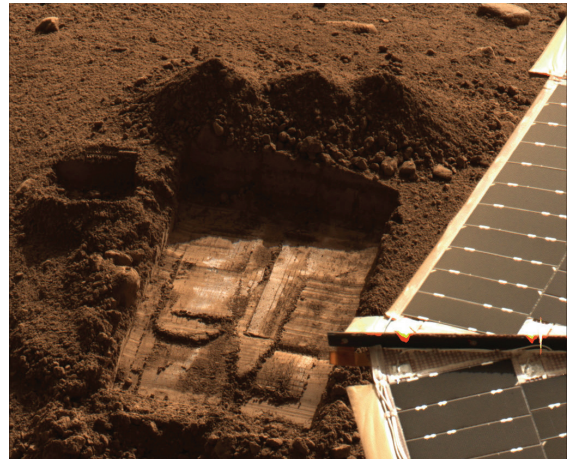
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