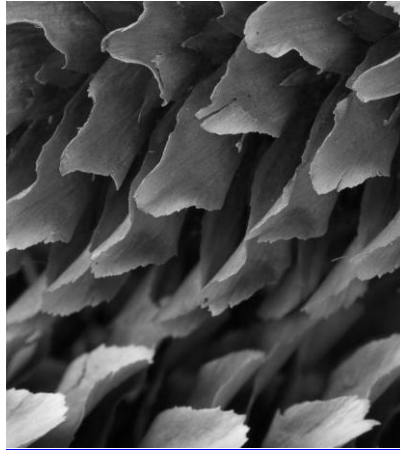


Mars for Earthlings

LESSON 4: Remote Sensing Mars***In-Class Activity 1****Scale and Context*

Purpose: Recognize the purpose and need for understanding the scale and context of various remote sensing imaging techniques.

Study the following images: What observations can you make?



(Figs 1 & 2, Image credit: Petr Kratochvil (public domain))

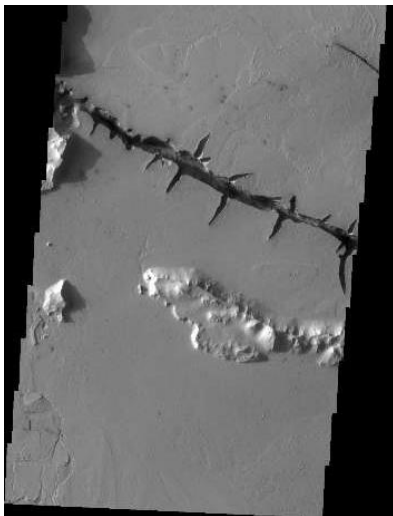


Figure 1: THEMIS Image #V13300013; Lat 7.3/Long 161.3. Image credit: NASA/JPL/ASU; Image Source: <http://themis.asu.edu/zoom-20050225a>

Mars for Earthlings

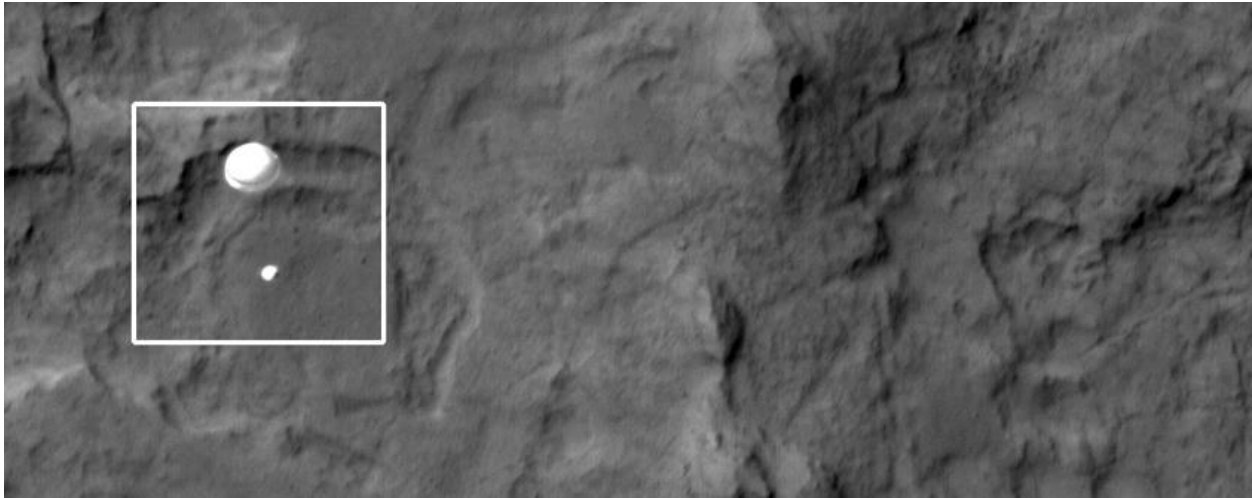


Figure 2 HiRISE image (ESP_028256_9022) of Curiosity descending to the Martian surface acquired August 5, 2012. Image Source: <http://hirise.lpl.arizona.edu/releases/msl-descent.php>

Seeing “scale” at work

Referring to Figure 1-2

1. Hypothesize what might be pictured in Figure 1 & 2.
2. Upon what evidence are you basing your hypothesis?
3. What other information could aid you in determining the identity of the image? List at least (4) ideas and explain your reasoning.

Does scale matter?

Come up with definitions for the following:

- Scale
- Context

Mars for Earthlings

In Figures 1 & 2, estimate a scale considering each image's context

1. Figure 1 Scale:

2. Figure 2 Scale:

What are you seeing on Mars?

1. What do you see in the Mars images, Figure 3-4? Anything familiar?

2. What would aid you in their interpretation?

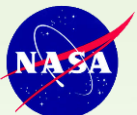
THEMIS & HiRISE Imagery

Explore one of the following websites:

(<http://themis.asu.edu>) or HiRISE (<http://hirise.lpl.arizona.edu>)

1. Choose an image that interests you. What caught your interest? What features do you see?

2. Can you find the scale and context of the image? After knowing the scale and context, does your interpretation of the image change?



Mars for Earthlings

In-Class Activity 2

Remote Sensing_MFE

*MOLA Simulation**

Purpose:

Understand how we explore the surface of Mars via remote sensing techniques by performing a ping-pong experiment.

Materials:

Ping pong balls, removable color tape, stop watch, measuring tape, and wood blocks, bricks or stone/ ceramic tiles that can sit on top of books or boxes to create different heights from the floor.

Procedure:

You must have at least 2 people in your group, but 3 is preferable.

Step 1:

1. Place 2 strips of tape on the wall, one approximately 2 meters (200 cm) high and the other 45 cm high. Both should be at least 200 cm long and parallel; you will be using these as the points to start and stop the stopwatch.
2. One partner should hold the ping-pong ball between the first finger and thumb next to the higher piece of tape approximately one inch from the wall.
3. One partner, the "timer", should have a stopwatch and have his/her eyes level with the second piece of tape. A third partner, if available, should record the results of each ball drop using the attached data sheet. *Note: Use a spreadsheet for recording and calculating the data.
4. Drop the ball. Start the stop watch as soon as the ball begins to drop.
5. The timer will stop the watch when the ball rebounds and reaches the lower line, i.e. the clock starts when the ball drops and stops when the ball reaches the second piece of tape. Record the time on the data sheet. Repeat this step four more times.
6. Calculate the velocities ($V=D/T$). The distance (D) is the combination of the height of the high tape plus the height of the low tape. After finding the velocity for each of the trials, find the average velocity of the ping-pong ball. This average will be used later in this lab as your baseline for comparing data. For each trial are you measuring an average or instantaneous velocity?
7. Many spacecraft use lasers (light) to determine topography similar to how you are using a ping pong ball. However there is a potential over-simplification in using a ping pong ball as an analog to a laser. What are the issues? (Hint: Think about velocity vs. acceleration.)



Mars for Earthlings
Data Table I (Baseline , datum)

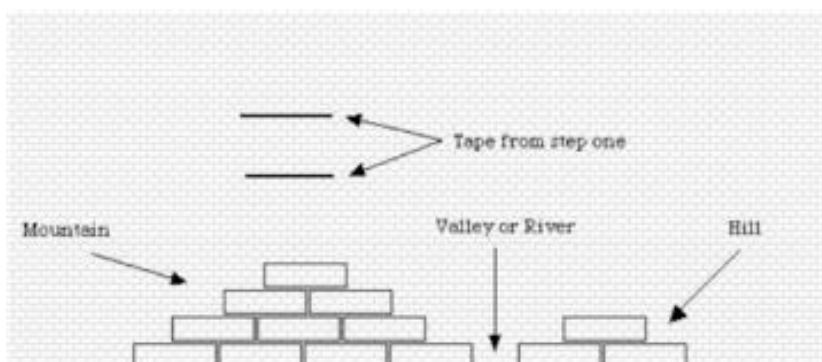
Drop	Distance Ball Traveled	Time (Seconds)	Velocity (distance/time)
1			
2			
3			
4			
5			
		Average Velocity	

Step 2:

Now that you have found the velocity of the ping-pong ball, you will use this information to plot the topography of a transect along the surface of an imaginary asteroid. You will be creating your own asteroid terrain on the floor against the wall where you just did Step 1.

1. Create the topography model of *your* asteroid along the wall where you did Step One. In order to do this, you need to place wooden blocks *against* the wall in a line about 6 feet long. Be sure that you build some hills, mountains, valleys, etc. (see Figure below).

Ping-pong experiment layout diagram. ©



2. Starting at the beginning of the top piece of tape, place a mark every 20cm. The bottom piece does not need to be marked. Measure and record your topography heights in the far right column of Table II as a check.

3. Again, starting at the 0 cm mark you made at the beginning of the tape, you will drop the ping-pong ball as you did in Step One, and record the time in Data Table II. Drop the ball every 20cm along the tape until you reach the end. Be sure to be as accurate as you can with the timing.

4. Find the average time for each of the intervals and record it in the data table.

5. Exchange your average time data with another student group (Table II) of just the cm interval, the average time. You will interpret each other's data to see if you can identify the topography of the other group's asteroid.

6. Next, fill in the distance traveled in Table II by multiplying the average velocity from Table I by the average time just calculated at each interval.

Mars for Earthlings

7. In Data Table III, take the original distance traveled (height of high tape plus height of low tape, which will be the same for every interval) and fill in the first column of the table.

8. In the second column, take the distance the ball traveled from the column in Table II (last column on right) and copy that information to the 2nd column of Table III. Now, for the last column, simply subtract the 1st column data from the 2nd column data (the difference between the two) to determine the altitude of your modeled topography.

9. Plot the data (with interval/distance on the x-axis and altitude on the y-axis). Connect the dots to create your transect. Does your image match the true topography? If not, explain why it is different.

Data Table II

Interval	Trial 1	Trial 2	Trial 3	Time Average	Distance Ball Traveled = (velocity*average time) (cm)	Known measured height of placed block topography (cm)
0 cm						
20 cm						
40 cm						
60 cm						
80 cm						
100 cm						
120 cm						
140 cm						
160 cm						
180 cm						
200 cm						

----- tear here to give Table III to blind student group -----

Check their altitude answers with your measured known values in far right column of your Table II.

Data Table III (share with other “blind” student group) Ave Vel. = _____

*R Interval	Time Average of 3 Trials	Original Distance Ball Traveled (Baseline From Data Table I) {D1}	Distance Ball Traveled = (velocity*average time) (cm) {D2}	Altitude (cm) {D1-D2=Altitude}
0 cm				
20 cm				
40 cm				
60 cm				
80 cm				
100 cm				
120 cm				
140 cm				
160 cm				
180 cm				
200 cm				

Mars for Earthlings

Step 3: Optional Plotting and Graphing the Data (if time, check resolution)

Step 4: Expand your thought process

The Laser Rangefinder aboard NEAR sends out a laser beam and "catches" it as it returns from being reflected by the surface of 433 Eros. The instrument records how long it takes the beam to reach the surface and bounce back. The scientists know how *fast* the beam is traveling; therefore, they can calculate how *far* it traveled. By measuring this time and multiplying by the velocity of the beam, they calculate how far the laser has traveled. They must then divide the distance the beam traveled in half.

1. Why did you not divide in half to find the distance to the object in *your* topography model?

Next, the scientist must compare this distance to a "baseline" distance we will call zero. On Earth, we might use sea level as the baseline. Another way to set the baselines is to start at the center of the planetary body being studied and draw a perfect circle as close to the surface of the body as possible. Using this baseline, the altitude compared to zero can be calculated and graphed. (Here on Earth, we often say that some point is a certain number of feet above or below sea level).

1. Why do we not use the term "sea level" for Mars and other planets?

2. You will now calculate the altitude of the points along your model. To do this subtract the distance the ball traveled at each interval (from Data Table II) from the distance the ball traveled in Step 1 (column B, Data Table I). The number you come up with will be zero or greater. Use Data Table III to do your calculations. The number in column B in this table should be the same for every interval. Remember, it is the baseline altitude and does not change.

*This exercise was adapted from Goddard Space Flight Center:

<http://mola.gsfc.nasa.gov/pingpong.html>



Mars for Earthlings

In-Class Activity 2

Remote Sensing_ REVISED: *MOLA Simulation* (*Note: This is a shorter version of the previous activity. Instructors may choose either version depending on time constraints.)

Since we ran out of time, we're simplifying your ping pong exercise to just 3 "topographies"- 1) a base datum (floor), 2) a medium level, and 3) your highest level.

For each topography level, you should have had several timings to ensure that you have a consistent value. Just report the averages here. Transfer data in shade boxes to Data Table III for another group to calculate.

Data Table I (D1 Baseline , datum),

Level	Distance Ball Traveled	Ave. Time (Seconds)	Velocity (distance/time)
Base			

Data Table II

Level	Time Average (secs)	Calculated Distance Ball (cms) Traveled = (velocity*average time)	Your known measured height of placed block topography (cm) (keep as your "answer")
2- med			
3- high			

----- tear here to give Table III to blind student group -----
Transfer the data shown by the shade areas so they can make the calculations.

Data Table III (share with other "blind" student group)

Group _____

Give the {D1} Ave Vel. =

*R Interval	Time Average (secs) of "topographies"	Original Distance Ball Traveled (Baseline From Data Table I) {D1}	Distance Ball Traveled = (velocity*average time) (cm) {D2}	Calculated Altitude (cm) {D1-D2=Altitude}
2- med				
3- high				

After you calculate the altitude of the "unknown" topography heights 2 & 3, **check your calculated altitude answers with your measured known values the group had actually measured (their far right column of Table II).**

If the calculated doesn't match the measured values, explain why the results might be so different:

Mars for Earthlings

Part 4

The Laser Rangefinder aboard NEAR sends out a laser beam and "catches" it as it returns from being reflected by the surface of 433 Eros. The instrument records how long it takes the beam to reach the surface and bounce back. The scientists know how *fast* the beam is traveling; therefore, they can calculate how *far* it traveled. By measuring this time and multiplying by the velocity of the beam, they calculate how far the laser has traveled. They must then divide the distance the beam traveled in half.

1. Why did you not divide in half to find the distance to the object in *your* topography model?

Next, the scientist must compare this distance to a "baseline" distance we will call zero. On Earth, we might use sea level as the baseline. Another way to set the baselines is to start at the center of the planetary body being studied and draw a perfect circle as close to the surface of the body as possible. Using this baseline, the altitude compared to zero can be calculated and graphed. (Here on Earth, we often say that some point is a certain number of feet above or below sea level).

1. Why do we not use the term "sea level" for Mars and other planets?

2. You will now calculate the altitude of the points along your model. To do this subtract the distance the ball traveled at each interval (from Data Table II) from the distance the ball traveled in Step 1 (column B, Data Table I). The number you come up with will be zero or greater. Use Data Table III to do your calculations. The number in column B in this table should be the same for every interval. Remember, it is the baseline altitude and does not change.

*This exercise was adapted from NASA Goddard Space Flight Center (Education/Outreach):
<http://mola.gsfc.nasa.gov/pingpong.html>



Mars for Earthlings

Homework 1

Remote Sensing_MFE

Google Mars-Following Opportunity

Objective: The purpose of this homework set is to get you familiar with different types of Mars remote sensing imagery and programs.

Google Mars-Following Opportunity

Directions/Questions:

Download Google Earth if you haven't already:

<http://www.google.com/earth/download/ge/agree.html>

In the icon list across the top of the window click on the planet with a single ring and a small dropdown arrow. You should see options for Sky, Mars, and Moon. Click on Mars.

1. Name the 5 types of spacecraft imagery available through Google Mars.

What do the 5 acronyms stand for?

- a.
- b.
- c.
- d.
- e.

Find Olympus Mons (see if you can find it without typing the name in the "fly to" box).

2. What is the highest elevation according to Google (find the appropriate *Global Map Layer* in order to determine this information)?
3. In the *Global Maps Layer*, besides the *Visible Imagery*, which imagery gives you the highest resolution of the volcano? Why is this the case?

Go to the *Rovers* and *Landers layer*

4. What are the current coordinates of these 3 lander sites?

Phoenix Lander

Viking 2 Lander

Mars 3 Lander



Mars for Earthlings

5. Where did MER Opportunity Rover land? (i.e. what crater?)

What crater did it visit next?

Look at the Burns Cliff panorama photo (camera icon, you may have to click on a couple to figure out the right one).

6. List 2 observations you can make about the photo (colors, shapes, lineations, etc.)?

Name 2 other craters the Opportunity rover explored.

7. Write down two observations about what you see in the bottom/ centers of Victoria Crater. Can you name the features?
8. Using the Traverse Path layer of the MER Opportunity Rover, locate its position on Sol 1685 (sol= Mars day). What annotated feature (labeled named) is it nearest?



Mars for Earthlings

Homework 2

Remote Sensing_MFE

Mars Image Analysis

Directions: View the following THEMIS image and answer the questions about the image. As you view the image, think about how this image might support one or more of NASA's main exploration goals:

1. Determine if life ever existed on Mars
2. Characterize the climate of Mars
3. Characterize the geology of Mars
4. Prepare for future human exploration of Mars

Go to: <http://themis.asu.edu/>

Questions:

Getting to know THEMIS imagery (click on the "about")

1. In a few sentences explain what THEMIS detects and how it works.
2. Go to THEMIS image: <http://themis.asu.edu/node/5765>
What is the title of the THEMIS image?
3. Study the THEMIS image. List at least two features you observe.
 - a.
 - b.
4. If the sun is illuminating from the left, are the features expressing positive (hill) or negative (valley) relief? If features differ from another (i.e. one has positive relief and the other negative) describe their relief separately.
5. What is the Lat/Long of the center of THEMIS image?
Lat _____ Long _____

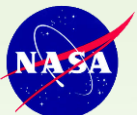


Mars for Earthlings

6. Explain how this image meets or does not meet NASA's exploration goals of Mars.
7. If you were to lead a lander mission to an area located within the image, where would you land and why?

More THEMIS Imagery

8. Go to the THEMIS image gallery by Topic: <http://themis.asu.edu/gallery>
Choose an image you like and report the following:
 - a. What is the image ID or the image url that you chose?
 - b. Why did you choose this image?
 - c. Where is the image located?
 - d. Near what major Mars geographic region is it located (South/North pole, Victoria Crater, Endurance Crater, Meridiani Planum, Hellas Basin, etc.)? Use the *View this image on Map* link at the bottom of the image data column to see a map view of Mars.
 - e. Why might this location be important to science?



Mars for Earthlings

HiRISE Imagery

9. Navigate to the HiRISE website: <http://hirise.lpl.arizona.edu/>
 - a. Scroll to the bottom of the page (gray box) and click on the link “Science Themes”. Click on the *Aeolian Processes* file of images. Under the main image click “View Images in this Theme.” Find image titled “Dunes in the Western Nereidum Montes.” If you cannot find the image type ESP_013046_1390 into the search box.
 - b. Define the term *Aeolian*. (also known as eolian)
 - c. Why might an image of *aeolian* processes on Mars be of interest to us on Earth?
 - d. Sketch what you see below. Label appropriate parts (high and low areas). Can you identify the direction of the wind if North on Mars is up? If so, what direction (cardinal direction) is it?

