Lesson 4: Remote Sensing Mars

Summary
This learning module and related laboratory exercise exposes students to remote sensing techniques utilized on Mars.

Learning Goals

Students will be able to:

- Apply the concepts of scale and context in remote sensing imagery.
- View THEMIS and HiRISE images and interpret major geomorphic features using Google Mars and associated homework activities.
- Understand how MOLA generates its image data by applying the fundamental equations in an experiment.

Context for Use
This learning module is meant for adaptation in an introductory earth science course and/or planetary science course. It is advised that the teacher compare Earth-based remote sensing instrumentation for context/reference such as LandSat 7.

Description and Teaching Materials
In-Class Activity

In-Class Activity 1: Scale and Context
In-Class Activity 2: MOLA simulation

Homework/Lab

Homework 1: Google Mars-Following Opportunity
Homework 2: Mars Image Analysis

Teaching Notes and Tips
1. The *In-Class Activities* can be utilized as homework as well. Students will have a lab-write up associated with the *MOLA simulation*.
2. For a large class size >20 you may either have a separate lab time/class for different sections or demonstrate the lab with the entire class and employ student participation.
3. We advise instructors to compare Earth-based remote sensing packages such as Landsat 7 for context.
4. In preparation for the MOLA simulation *In-Class Activity* instructors must gather a few materials (see the *MOLA simulation* for further clarification).

Assessment
- The *MOLA simulation* Lab write-up will assess the student's understanding of the MOLA instrument and MOLA's utility.
- The *Google Mars* homework will assess whether or not students can successfully navigate the Google Mars software and begin to interpret the data provided by Google Mars.

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References and Resources

1. THEMIS images url: http://themis.asu.edu/
2. LANDSAT 7 images url: http://landsat.gsfc.nasa.gov/images/
3. HiRISE 13 April 2011 YouTube video: http://www.youtube.com/watch?v=-U6-uYDtuSg
4. MRO/HiRISE All HiClips revisited (Feb 2012) YouTube Video: http://www.youtube.com/watch?v=YVDUQjJbjyc
5. MOLA images url: http://mola.gsfc.nasa.gov/index.html
6. Ping-Pong Lab (NASA): http://mola.gsfc.nasa.gov/pingpong.html

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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.

Preparation: This experiment requires some space (like a hallway, or space near a cleared wall in a classroom) and will take some prep time ~ 15 mins., and ~ 20-30 mins. for students to perform the exercise. Some of the data plotting can be done as homework.

Materials Needed:
Masking tape, meter sticks or measuring tape, ping pong balls, stopwatch or watch timer, bricks or blocks that allow ping pong balls to bounce (textbooks are ineffective)

Engage
How do we know what the surface of Mars is like, especially for areas that we have only seen from a distance? Think about how dolphins know the difference between a BB gun pellet and a kernel of corn from 50' (or 16 m away). Could a similar type of detection be used to decipher the surface of Mars?
Ref. http://science.howstuffworks.com/zoology/marine-life/dolphin-disarm-sea-mine1.htm

Explore
Perform a ping-pong experiment.

Procedure:
The students must have at least 2 people in their group (3 per group 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; students 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.

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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 the students' baseline for comparing data. Ask the students if for each trial are they measuring an average or instantaneous velocity?

7. Many spacecraft use lasers (light) to determine topography similar to how the students 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.)

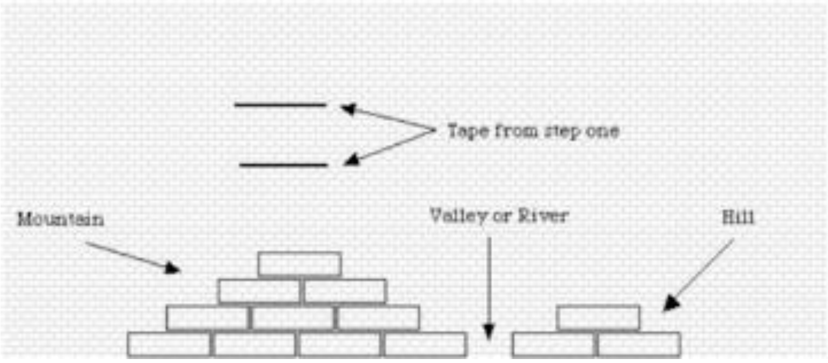
Data Table I (Baseline , datum)

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

Step 2:

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

1. Create the topography model of an asteroid along the wall where the students did Step One. In order to do this, they need to place wooden blocks *against* the wall in a line about 6 feet long. Be sure that they 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 the topography heights in the far right column of Table II as a check.

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

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

5. Have the students exchange their average time data with another student group (Table II) of just the cm interval, the average time. They will interpret each other's data to see if they 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.

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 their modeled topography.

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

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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				

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

Elaborate

Follow-Up Questions:

1. Why is it important to keep the distance between each altimeter measurement consistent?
2. How could we make the topographical profile more accurate?
3. What does the graph look like in the comparison to your model (i.e. the same, inverted etc.)?
4. Which looks more like the model, the graph you generated from the shorter or longer distance between readings (intervals)? Why is this?

Evaluate

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. Ask the students why they did not divide in half to find the distance to the object in *their* 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. The students will now calculate the altitude of the points along their 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 students come up with will be zero or greater. Use Data Table III to do the 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

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