Activity Title: It's Either Very Hot or Very Cold Up There!

Activity Objective(s): In this activity, and the follow-up activity next week, teams will design and conduct experiments that will help them understand the basic principles of thermal transfer – how things warm up and cool down. They will carefully gather data and then analyze that data in order to make generalizations about the factors that affect how things get warmer and cooler.

Graphic courtesy NASA.

Grade Levels: 3 - 5

Process Skills: Experimental design, measuring, graphing, and data analysis.

Lesson Duration: One 60 min session

Materials and Tools (per group of three students):

- Thermometers
- Timers
- Graduated cylinders
- Small plastic cups
- Graph paper, if available

Club Worksheets: (Make copies for each student to put in binder)

1. Imagine
2. Data Table
3. Challenge Closure / Summary
4. Fun With Engineering at Home

Club Facilitator or Teacher Notes by Stage:

(Based on those running 60-minute Clubs)

Stage 1: Set the Stage (Approx 15 minutes)

Explain to the students that there is no atmosphere on the Moon, so temperatures fluctuate through a wide range. In the shadowed areas the temperature is –180 ^{o}C (or – 300 ^{o}F), and in the sunlit areas it is about 100 ^{o}C (or 212 ^{o}F), which is the boiling point for water! These are serious extremes for human beings!

Additionally, because of the unusual rotation of the Moon, there are surfaces permanently exposed to the Sun, and surfaces permanently in shadow. It is in the permanently shadowed areas of some craters that the possible existence of ice has been speculated by some scientists.

Anyone living on the Moon, even for a short while, will have to deal with this temperature variation, and be properly protected from damaging effects. Thus we must understand how thermal energy is transferred, and, for our concerns, how we can prevent thermal energy from being transferred (to or from our bodies): in other words, how can we insulate ourselves from the wide variations of temperature in the lunar environment?

Lead a discussion of the following vocabulary words and then complete the activity below:

- **Heat** = The energy an object has because of the movement of its atoms and molecules which are continuously jiggling and moving around, hitting each other and other objects. When we add energy to an object, its atoms and molecules move faster increasing its energy of motion or heat. Even objects which are very cold have some heat energy because their atoms are still moving.
- **Temperature** = A measure of the average heat or thermal energy of the particles in a substance. Temperature does not depend on the size or type of object.

Activity: Let students pretend to be molecules. First have them stand still and close together. Then have the students wiggle and then walk and move around to demonstrate more thermal energy entering the system. Have them move faster and jump up and down as even more thermal energy enters the system. Then have the students stop and notice where they are. They should be much farther apart and should feel much warmer than they were originally.

Stage 2: Act - The Experiment (Approx 20 min)

- Break the students into teams of three and distribute the **Challenge** worksheet.
- Explain that the students will be completing an experiment that will help us to understand how thermal energy flows, and what factors affect the rate of temperature change.
- Allow students to gather materials and begin the experiment as directed on the worksheet.
- The available materials for this activity are:
    - Thermometer (must use the Celsius scale)
    - Clock or timer for each group
    - Graduated cylinder
    - Small plastic cups
    - Hot and cold water from a tap
- Measure the room's temperature and the temperature of the water in the two cups at the start (time = 0).
- Note-1: The clearest results will occur if both samples of water (hot and cold) are the same difference from room temperature, but this isn't a big deal.
- Note-2: Clearer results will be observed if the samples begin with the temperature at the greatest difference from room temperature (in other words the hotter and colder the better).
- Note-3: Remember, the thermometers are glass. They have a small rubber "keeper" on them so that they will not roll on a table when laid down, however it is a good idea to tell the students that someone should always be holding the thermometer, and for sure never just place it in a cup and remove your hand (because it will absolutely tip over, spilling the water and possibly breaking the thermometer).

Stage 3: Graphical Analysis: If there is time the students can graph the temperature results on a line graph. They can then analyze the lines for similarities and differences in the rates of change. Put Temperature on the Y-axis and Time on the X-axis. Both sets of results could be plotted on the same graph for best comparison.

Stage 4: Challenge Closure

- Hand out the Challenge Closure / Summary Sheets (please collect one per team and save in a folder for NASA).

Stage 5: Previewing Next Week (approximately 5 minutes)

- The Moon is a very harsh environment. There is no atmosphere to protect astronauts and their equipment from solar radiation and the extreme temperature swings between night and day. Next week, we will begin to find ways to protect astronauts from those extreme temperature changes by experimenting with insulation. Please hand out "Fun with Engineering at Home."

1. ASK:

Goal: **Conduct an experiment** that enables us to understand how thermal energy flows (this is called "heating" or "cooling"), and what factors affect the rate of temperature change.

Materials:

- Thermometer (must use the Celsius scale)
- Graduated cylinder
- Timer or clock
- Small plastic cups
- Hot and cold water from a tap

2. IMAGINE:

Brainstorm some possible solutions to the questions:

What is an "experiment"?

What things will we measure?

3. TEST

Challenge Worksheet

Your group will be completing an experiment that will help you to understand how thermal energy flows, and what factors affect the rate of temperature change.

Follow the steps to complete the experiment:

- Assign each group member a job for this experiment: Timer, Recorder, and Thermometer Reader.
- Collect necessary materials for experiment and label the outsides of each plastic cup so you know which cup is the hot water and which is the cold water.
- Record the temperature of the room.
- Using a graduated cylinder, collect 50 mL of cold tap water and pour it into one plastic cup. Repeat for hot water.
- Every minute for the next 10 minutes, record the temperature for each cup of water. Record results in the chart below.

Room Temperature:	_____ ^{o}C	
	Cold Water Cup	**Hot Water Cup**
0 minutes		
1 minute		
2 minutes		
3 minutes		
4 minutes		
5 minutes		
6 minutes		
7 minutes		
8 minutes		
9 minutes		
10 minutes		

4. CHALLENGE CLOSURE

1. Were there differences between the rate that the water cooled and warmed? (Did they seem to happen at the same rate or did one happen quicker than the other?)

2. Why would it be important to record the temperature inside the room?

3. Do you think the temperatures in the cup will reach the same temperature in the room? If so, predict how long this would take.

4. Besides a table, how could we keep track of our results to best show the temperature change?

Team Name:_____

Fun with Engineering at Home

Activity 9: *It's Either Very Hot or Very Cold Up There!*

Today we designed and conducted experiments with energy flowing into or out of containers of water. We chose water to experiment with because it is such a large part of the human body, and if we try to inhabit the Moon we will have to pay close attention to keeping the human body safe from the extremes of temperature on the surface of the Moon.

- **Home Challenge**: During this week talk with your parents and friends about all the ways we keep the human body safe from extremes of temperature on the Earth (even though the range of variation is not nearly as great as that found on the Moon).
- List four ways we do something with our bodies to prevent temperature extremes from affecting them (two related heat; two related to cold):
    - _____
    - _____
    - _____
    - _____
- Now list four things we do to change the environment we live in so that the environment does not harmfully affect us because of temperature extremes (two related to heat; two related to cold):
    - _____
    - _____
    - _____
    - _____

HAVE FUN!!