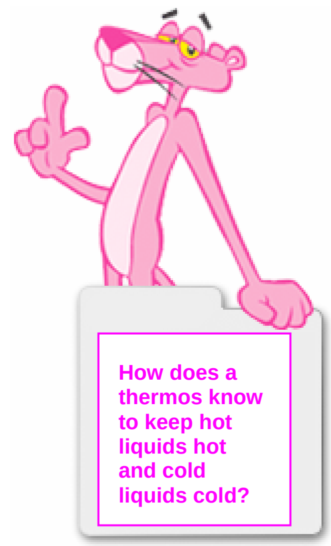
Activity Title: Build a Lunar Thermos!

Activity Objective(s): In this activity, the teams will use what they learned last week to design a Lunar Thermos that should hold the temperature of the 100 ml of water constant to within 5 degrees over 8 minutes.



Pink Panther™

Grade Levels: 6 - 8

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

Lesson Duration: One 60 min session

Materials and Tools (per group of two or four students):

- General building supplies
- Thermometers
- Timers
- Graduated cylinders
- Small plastic cups
- Larger plastic cups
- Insulating materials (e.g., bubble wrap, paper, paper towels, sand, water, aluminum foil, etc.)
- Hot and cold water from the tap
- Graph paper, if available

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

1. Imagine
2. Plan
3. Experiment (includes Data Table) - is on the back of PLAN worksheet
4. Summary
5. Fun With Engineering at Home

Club Facilitator or Teacher Notes by Stage:

Stage 1: Set the Stage: ASK (Approx 5 minutes)

- Review the concepts of energy transfer from last week.
  - The equilibrium temperature is room temperature.
  - Left alone, water in a cup will come to equilibrium; that is, cold water will warm up to room temperature, and hot water will cool down to room temperature.
  - The heat energy is transferred between the water and the surrounding air.
  - Heat energy always flows from hot to cold:
    - To cool down and come to equilibrium with the air, warm water gives up some of its heat to the air.
    - To warm up and come to equilibrium with the air, cool water takes some heat from the air.
- *ASK*: Today's engineering challenge centers on the question: *how can we minimize the transfer of heat energy?* When we go to the Moon, we will need to protect our bodies from the extreme differences in temperature. Recall from last week, 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! We want to keep our bodies at a fairly constant temperature.

Stage 2: IMAGINE (Approximately 10 minutes)

- Let's start by building a container to keep water at a constant temperature (since we are mostly water anyway!).
- Hand the Imagine worksheets out to the students. Before giving them access to building materials, ask them to draw a picture that depicts the transfer of energy, from, for example, a warm human standing on the Moon to the cold, lunar night. They should label what is warm, what is cold, and which way the heat transfers. Then ask them to draw the opposite picture: a "cool" human standing in the extreme heat of a hot lunar day. Again, they should label the components and which way the heat flows.
- Now, on the second page of the Imagine worksheet, ask them to devise a method for keeping the human not too warm, not too cool, but just right!

Stage 3: PLAN (Approximately 5 minutes)

- Hand out the Plan Worksheet. They should now be able to see what building materials they will be able to use. Ask them to devise a system to keep water at a constant temperature.

- **<u>Design Specifications:</u>** Today's challenge is to keep 100 ml of water at a relatively constant temperature. It should change by no more than 5 degrees over 8 minutes.
- Do we have to design differently for hot water than for cold water? [No.]
- Why? [Because the insulation blocks the <u>transfer of heat *from* a warm region *to* a cool region – which is what heat wants to do.</u> The system has no way of knowing which is "inside" and which is "outside" the thermos, only that heat flows from regions of higher temperatures to regions of lower temperatures.]

Stage 4: CREATE (approximately 10 minutes)

- Students use the materials to build a thermos to insulate the water in the Dixie cup. They should have access to all kinds of insulating materials. Most materials will help insulate, though aluminum foil will conduct heat fairly well. Don't tell them this; they should discover it for themselves.

Stage 5: EXPERIMENT (approximately 20 minutes)

- The students should run two experiments. One should measure the rate that cold water warms up, and the other should measure the rate at which hot water cools off. They should record a measurement in the data table every 30 seconds. The team members should take turns reading the measurements and recording the results in the data table.
- Remind the students about the design constraint: the temperature should change by no more than 5 degrees over 8 minutes.
- **Note**: the thermometers 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, they should never just stand it up in a cup and remove their hand (because it will tip over, spilling the water and possibly breaking the thermometer).

Stage 6: IMPROVE (approximately 10 minutes)

- Did the thermos meet the design constraint? If not, give the students an opportunity to improve the insulation and run one more test.

Stage 7: Challenge Closure

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

Stage 8: Pre-viewing Next Week

- This week we were trying to <u>stop the transfer</u> of heat energy using insulation. Next week we will <u>capture</u> heat energy to make a solar oven.

For those with 90-minute clubs:

Graphical Analysis: If there is time, the students can graph the warming and cooling curves from their experiments. Put Temperature on the Y-axis and Time on the X-axis. Both cooling and warming curves could be plotted on the same graph for best comparison.

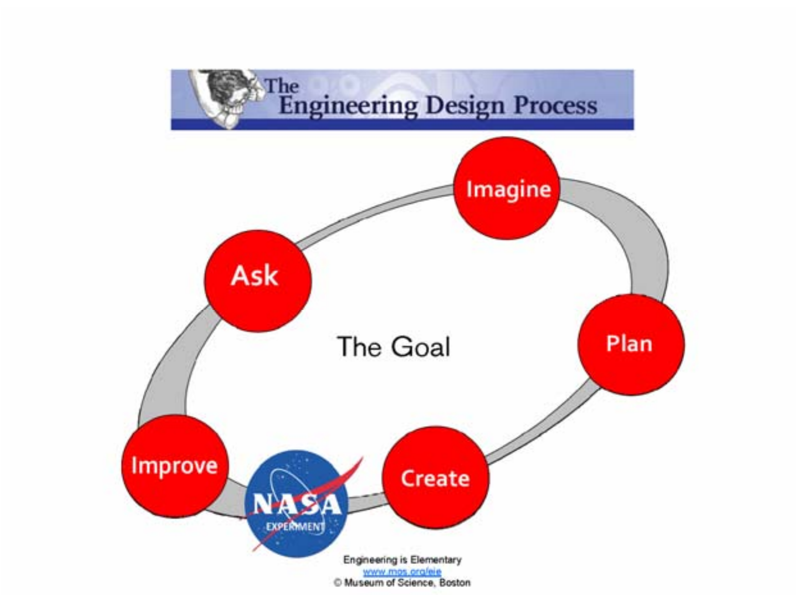
Guiding Questions:

Ask them to predict, using the graph, how long until the warm and cool samples reach room temperature. In other words, "How effective is your thermos?"

Ask them to think about how long a thermos should keep something warm (or cool) to make it a "good" thermos.

How does the application affect the answer? In other words, does it matter whether the application is keeping my soup warm until lunch time, compared to keeping my body at roughly "body temperature" when on the Moon? What is the implication for *design specifications*? Ask them to make design specifications for both examples (soup and a human body on the Moon).

Note to Educator/Facilitator:



Have you been reinforcing the Engineering Design Process? Remember, the process is the important learning objective. The students should be having fun!

1. IMAGINE

Draw a picture that depicts the transfer of energy, from a warm human standing on the Moon to the cold, lunar night. Label what is warm, what is cold, and which way the heat transfers.

Now imagine that the sun comes up, and the human is standing on the hot lunar surface. Re-draw the picture, and add the same labels: warm, cool, and which way the heat transfers.

IMAGINE (page 2)

Devise a method for keeping the human not too warm, not too cool, but just right!

2. PLAN

Design Specifications: Today's challenge is to keep 100 ml of water at a relatively constant temperature. It should change by no more than 5 degrees over 8 minutes.

Do we have to design differently for hot water than for cold water?

Why or why not?

Sketch your design. What will you use as insulation?

3. EXPERIMENT: Data Table and Results

Room Temperature = _______

COLD WATER: warm up rate		**WARM WATER: cool down rate**	
Time (sec)	Temp (deg)	Time (sec)	Temp (deg)
0 (at the start)		0 (at the start)	

RESULTS

COLD WATER: warm up rate	**WARM WATER: cool down rate**
Starting Temperature =	Starting Temperature =
Final Temperature =	Final Temperature =
Temperature Difference =	Temperature Difference =

4. Summary

How effective is your thermos?

- Did your thermos meet the design specification?
- Predict how long until the warm and cool samples reach room temperature.
- How long should a thermos keep something warm (or cool) to make it a "good" thermos?
- How does the application affect the answer? In other words, does it matter whether the application is keeping my soup warm until lunch time, compared to keeping my body at roughly "body temperature" when on the Moon?
- What is the implication for *design specifications*? Create your own design specifications for both examples (soup and a human body on the Moon).

How could you have made your thermos more effective?

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Team Name:____

Fun with Engineering at Home

Activity 10: *Build a Lunar Thermos!*

Today we designed a Lunar Thermos to control the amount of 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. Next week, we will begin to think about how to harness solar energy to do work for us on the Moon.

- **Home Challenge**: During this week talk with your parents and friends about all the ways we could use energy from the Sun to do work for us.
- List four uses of energy from the Sun that you can see around you every day. These can be uses by humans, but you may also include ways in which the energy from the Sun affects nature.
  - ____
  - ____
  - ____
  - ____

Check out this website to learn more about solar energy:

http://www1.eere.energy.gov/solar/solar_time_2000.html

Check out this website to see how NASA uses solar energy on the International Space Station

http://www1.eere.energy.gov/solar/solar_time_2000.html

HAVE FUN!!