Apollo 13- Return to Earth

Grade Level:	Time Frame:
7th grade **8th grade**	50 minutes

Standards (ALCOS Math & Science):

5. Solve real-world and mathematical problems involving the four operations of rational numbers, including complex fractions. Apply properties of operations as strategies where applicable.

17. Solve multi-step real-world and mathematical problems involving rational numbers (integers, signed fractions, and decimals), converting between forms as needed. Assess the reasonableness of answers using mental computation and estimation strategies. [Grade 7, 8]

15. Analyze and interpret data from experiments to determine how various factors affect energy transfer as measured by temperature (e.g., comparing final water temperatures after different masses of ice melt in the same volume of water with the same initial temperature, observing the temperature change of samples of different materials with the same mass and the same material with different masses when adding a specific amount of energy).

16. Apply the law of conservation of energy to develop arguments supporting the claim that when the kinetic energy of an object changes, energy is transferred to or from the object (e.g., bowling ball hitting pins, brakes being applied to a car).

Objectives:

Students will use a real-world scenario to investigate energy transfer and to determine the difference between power and energy.
Students will construct an argument about the importance of energy conservation in space and the relevance of also conserving energy on earth.

Background Information:

Energy is important to humanity's survival both on Earth and in space. The use of energy in space is even more sensitive because readily available sources of energy, such as those on Earth, may not be available and everything uses up available energy to function.

Famously, Apollo 13 had an oxygen tank pressure valve fail catastrophically damaging some external equipment, causing an unexpected spin, and pushing the spacecraft slightly off course. Control jets were used to stop the spin and adjust to a new course, but its scheduled moon landing had to be called off. While returning to Earth, the crew experience numerous other failures of equipment due to damage and the change in mission activities.

This activity has the students acting in an emergency simulation as the Apollo 13 crew who must determine how best to use what little energy they have on board to finish the mission and safely arrive back on Earth.

Humanity's survival on Earth is similar to that on Apollo 13 although the example in space is easily more apparent because of its compressed timescale. On Earth, just as in space, humanity only has so many natural resources available at its disposal and is very sensitive to its external environment. While the scale is drastically larger on Earth and may hide some of our consequences, humanity is currently playing a real-life version of this simulation whereby energy is being expended without thought to our long-term survival.

Materials:

- Printed copy of "Apollo 13- Return to Earth Student Guide"

Engage (10 minutes):

Put on a show! Students will use page 1 of the student guide to role play as members of an astronaut crew.

a. Students should work in groups of 4 to assign roles and role play the information to complete their tasks for the activity.

Explore (35 minutes):

Work together! Students will work in groups of 4 complete tasks #1-4 on the student guide.

1. Students should work on Task #1 WITHOUT having information on power versus energy. Teacher should show on the board the following:

   1000 watts = 1 kilowatt

   1000 watts X 60 minutes = 1 kilowatt hour

2. Students should use their answer from Task #1 to complete the rest of the tasks. Students may have individual answers for Tasks #2-4.

Evaluate (5 minutes):

Discuss it! Students should consider the following questions:

- What is the difference between power and energy?
- What lessons about energy can you learn for use in their own lives today?
- What does the example in space tell us about our home on Earth?
- Was this role of managing energy difficult?
- Do utilities perform this function for us on Earth all the time without us thinking about it?

Additional Content and References:
Field Trip to the Moon: Educator's Guide: https://www.nasa.gov/pdf/217785main_FTM_Educator_Guide.pdf Apollo Training Course Number APC-118: https://www.hq.nasa.gov/alsj/ApolloSpacecrftSystmsFAM67.pdf Apollo Lunar Module Electrical Power System Overview: https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20090016295.pdf

Task #1 Answer:

There may be more than one way to correctly solve the problem. Below is one option.

	0:30	**1:00**	**1:30**	**2:00**	**2:30**	**3:00**	**3:30**	**4:00**	**4:30**	**5:00**	**5:30**	**6:00**
Navigation	1	1								1		1
Lighting	.5	.5								.5		.5
Heating			1.5			1.5			1.5		1.5	
Communication				.5	.5		.5	.5				
Computers/Sensors				.5	.5		.5	.5				
Remaining Battery Capacity	8.25	7.5	6.75	6.25	5.75	5.00	4.5	4.0	3.25	2.5	1.75	**1.00**

Name of Astronaut: ______________________

Date:_________ Class:____________________

"Houston, we've had a problem here."

-John "Jack" Swigert & James "Jim" Lovell, Apollo 13

<u>Instructions</u>: You and your classmates are the crew of Apollo 13. First, assign your group members a role below to play the role as one of the astronauts. Take turns reading each of the dialogues below to get the information needed for your mission and tasks.

Mission Specialist:

"An oxygen tank pressure valve has blown off and damaged most of the batteries we have outside the spacecraft. We do not have enough energy left in the batteries to run all systems at the same time and make it safely back to earth. We must determine how we will use what little energy we have left in order to save ourselves and our crew!"

Flight Engineer:

"At this time, we only have 9 kilowatt hours (kWh) of energy stored in our batteries and we have 6 hours before we will reach Earth. During these final hours, we need each of the systems running to make it back. Can you give us the rate of energy use?"

Payload Commander:

"Here's the system's rate of energy use, or system power:

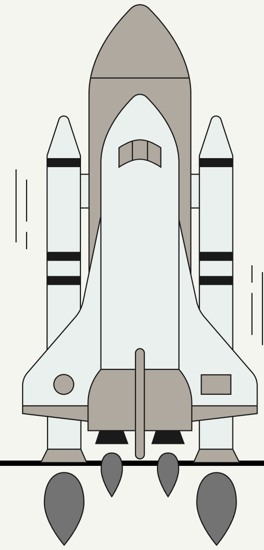
- Navigation system – 1 kilowatt (kW)
- Lighting – 0.5 kilowatt (kW)
- Heating – 1.5 kilowatt (kW)
- Communications – 0.5 kilowatt (kW)
- Computers and Sensors – 0.5 kilowatt (kW)."

Science Pilot:

"We must energize each system for at least 2 hours but our battery cannot handle more than 1.5 kilowatt (kW) of demand at a time. If we draw more than 1.5 kilowatt (kW) at a time, our battery will fail completely and we will not make it back to Earth. REMEMBER, we cannot go more than 2 hours without heat or we will become too cold to function effectively enough to do our jobs."

Name of Astronaut: ____________________

Date:________ Class:__________________



- You have 9 kWh of total battery capacity
- You must run each system for at least 2:00 hours
- Your battery can only provide 1.5 kW of demand at a time
- You cannot go more than 2 hours without heat or you will get too cold to do your jobs

Task #1: Save the Ship

As a team, discuss which systems you will turn on and at what time you would turn them on in order to make it back to Earth safely.

	0:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	5:30	6:00
Navigation												
Lighting												
Heating												
Communication												
Computers/Sensors												
Remaining Battery Capacity												

Task #2: Report Back to Houston

You've developed your plan to make it back to Earth safely...but there are few questions that mission control has for you.

1. Why did you choose those systems and those times to turn them on?

2. Are your choices realistic?

3. How will you deal with any unexpected events?

Name of Astronaut: ______________________

Date:_________ Class:____________________

Task #3: The Power Is In Your Hands

Your plan was accepted by mission control but now your need to motivate your crew members by reminding them what it means to "have the power" to make it back to Earth.

Energy is what allows us to do things whereas **power** is the rate (how fast) at which energy is used or supplied.

- More power results in more energy available at a given time, but uses the available energy up faster
- More power an engine has means faster the race car but needs a bigger gas tank
- More watts in a light bulb means more light
- More calories used to run means a faster run for a shorter time

Power is **total energy** per **unit of time**.

- **Power** is often measured in units called **Watts**.
- <u>Power multiplied by time gives us energy</u> used:
  - One watt of electrical power, maintained for one hour, equals one watt-hour of energy because one watt X one hour equals one watt-hour.
    - Example: A 100 watt solar panel generates electricity at its full capacity for 10 hours.
    - 100 watts X 10 hours = 1000 watt-hours
    - 1000 watt-hours = 1 kilowatt hour (usually represented as 1 kWh)

1. Explain below how you will use **power** to make it back to earth. Use drawings to support your argument.

Name of Astronaut: ____________________

Date:_________ Class:__________________

Task #4: Saving Energy On Earth

Your motivated crew made it back to Earth safely. You are all thankful you had enough power for the space craft to make it back to earth. Now, you feel that its your role to help the people on Earth understand the importance of saving energy.

Energy makes it possible to do work such as pushing things around. It comes in many forms and can be switched from one form to another.

- Energy is used by an engine to move a car down the road.
- Energy is used to push a sofa across the floor.
- Energy is converted from electricity to light in a light bulb.

If we know the amount of the force we need in order to move an object, and the distance we're going to move it, we can calculate the amount of energy, or work, we'll need to perform the task. Energy cannot be created from nothing. To do work, we must change the energy already present to a useful form. We need enough energy to do a task, but we also don't want to waste energy.

1. Explain to the public what your experience managing and conserving energy on the space craft was like.

2. What examples would you give to the public about managing and conserving energy in their everyday lives on Earth?