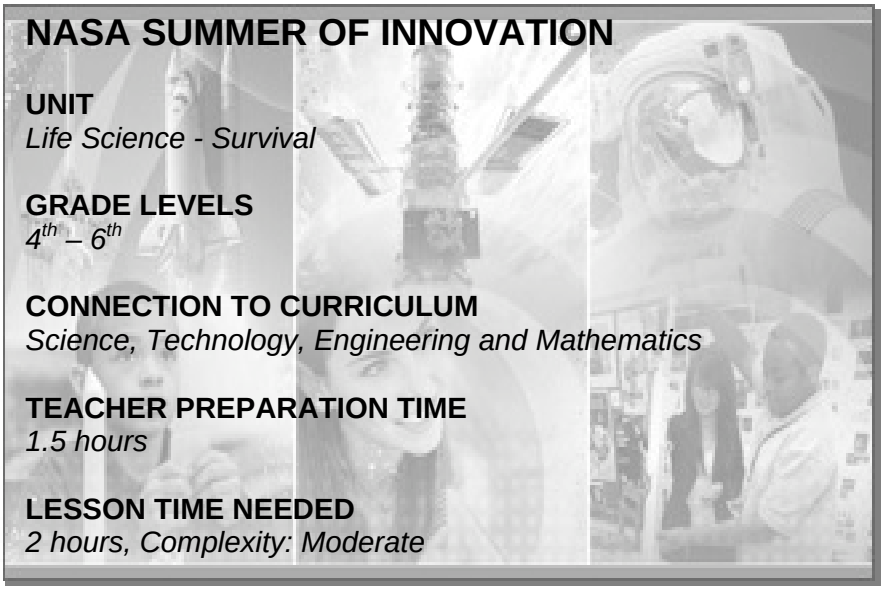
Cool Spacesuits

DESCRIPTION
This lesson will enable students to demonstrate, test and analyze materials utilized in spacesuits to keep astronauts cool in the harsh environment of space.

OBJECTIVES
Students will:
- Demonstrate the water cooling technology used in the International Space Station (ISS) Extravehicular Mobility Unit (EMU)
- Test and make an analysis of the relationship between reflection/absorption and color

NASA SUMMER OF INNOVATION



UNIT
Life Science - Survival

GRADE LEVELS
4^{th} – 6^{th}

CONNECTION TO CURRICULUM
Science, Technology, Engineering and Mathematics

TEACHER PREPARATION TIME
1.5 hours

LESSON TIME NEEDED
2 hours, Complexity: Moderate

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry
- Understanding of scientific concepts
- Understanding of the nature of science
- Skills necessary to become independent inquirers about the natural world

Physical Science Standards
- Properties of objects and materials
- Transfer of energy

Life Science
- Organisms and environments

Science and Technology
- Abilities of technological design
- Understanding about science and technology

Science in Personal and Social Perspectives
- Personal health
- Changes in environments
- Natural hazards

Common Core State Standards for Mathematics (NCTM)
Measurement and Data
- Represent and interpret data

Expressions and Equations
- Solve real-life and mathematical problems using numerical and algebraic expressions and equations

ISTE NETS and Performance Indicators for Students (ISTE)
Creativity and Innovation
- Use models and simulations to explore complex systems and issues

Research and Information Fluency
- Process data and report results

Technology Operations and Concepts
- Understand and use technology systems
- Select and use applications effectively and productively

MANAGEMENT
Review the activities and background information carefully before having the students do each activity in the lesson. You can use the Discussion Questions in this lesson to prepare the students for what they will learn from doing the activities. The students should work in groups of 2 or 3. Prepare the materials for each student group before beginning the lesson. Locate a sunny area such as a windowsill, or a sunny outside location for the "test site". If a sunny location is not available, a lamp or other low heat source may be used.

MATERIALS
- Two thermometers
- Black construction paper
- White construction paper
- Stapler
- Tape or glue
- Ruler or measuring tape
- Small boxes (shoe box size)
- Two stopwatches
- Marker
- Window, lamp or other light source
- Two clean, empty coffee cans with lids
- 7 m of aquarium tubing
- Two 1 gallon buckets
- Duct tape
- Water (solid and liquid)
- Hole punch
- Flood light and fixture
- Kitchen size plastic garbage bag

CONTENT RESEARCH
Astronauts depend upon their **spacesuits** to hold in air needed for breathing as well as pressure to keep them alive in the near vacuum of space. Spacesuits also help keep astronauts at a comfortable temperature; neither too hot nor too cold. For this reason, spacesuits are made from materials and colors that reflect large amounts of energy. By avoiding the absorption of energy, the astronauts are kept at a comfortable temperature for longer periods of time.

A common misconception about the spacesuit is that astronauts wear the suit the full time they are in space. They do not need to wear the spacesuit inside the ISS where there is an earthlike environment maintained. This is known as a "shirt sleeve" environment in which regular shirts, pants and socks can be worn. The spacesuit is only needed in the space environment outside the spacecraft.

It is not sufficient for the health and well being of an astronaut just to be protected from the hazards of the environment in which he or she is trying to work. It is also necessary to consider the conditions that are created by the suit itself. One of the most important of these conditions is **temperature**. Suit insulation technologies protect the astronaut from extreme high and low temperatures of the space environment. However, the same insulation technology also works to keep heat released by the astronaut's body inside the suit. To get an idea of what this is like, imagine walking around in summer wearing a plastic bag. For this reason, an active cooling system is employed.

In Space Shuttle space suits or **Extravehicular Mobility Units** or EMUs, the cooling system consists of a network of small diameter water circulation tubes that are held close to the body by a Spandex® body suit. Heat released by the astronaut's body movements is transferred to the water where it is carried to a refrigeration unit in the suit's backpack. The water runs across a porous metal plate that is exposed to the vacuum of outer space on the other side. Small amounts of water pass through the pores where it freezes on the outside of the plate. As additional heated water runs across the plate, the heat is absorbed by the aluminum and is conducted to the exposed side. There the ice begins to **sublimate**, or turn directly into water vapor and disperses in space. Sublimation is a cooling process. Additional water passes through the pores, and freezes as before. Consequently, the water flowing across the plate has been cooled again and is used to re circulate through the suit to absorb more heat.

Supplementing the EMU cooling system is an air circulation system that draws perspiration-laden air from the suit into a water separator. The water is added to the cooling water reservoir while the drier air is returned to the suit. Both the cooling system and the air-circulation system work together to contribute to a comfortable internal working environment. The wearer of the suit controls the operating rates of the system through controls on the Display and Control Module mounted on the EMU chest.

Key Concepts
- It is not sufficient for the health and well-being of an astronaut just to be protected from the hazards of the environment in which he or she is trying to work. One of the most important of these conditions is temperature.

- Space suits are made from materials and colors that reflect large amounts of energy and preventing the absorption of energy.

Key Terms
- **absorption**: take in or soak up (energy, or a liquid or other substance) by chemical or physical action, typically gradually
- **extravehicular**: to be done outside the spacecraft (vehicle)
- **sublimate**: turn directly into water vapor and disperses in space

LESSON ACTIVITIES
The following activities are needed to complete this lesson. They can be downloaded at the following websites.

Keeping Your Cool
This activity demonstrates the principle behind the operation of the International Space Station Extravehicular Mobility Unit liquid cooling garment.
http://www.nasa.gov/pdf/188969main_Keeping_Your_Cool.pdf

Cool Suits
This activity engages students in testing and analyzing the relationship between reflection/absorption and color of the International Space Station Extravehicular Mobility Unit.
http://education.jsc.nasa.gov/explorers/pdf/p12_educator.pdf
Also for this activity, have the students observe the NASA's 21st Century Explorer 30-second newsbreak, "How will your imagination help you become an explorer?" Download the newsbreak at
http://education.jsc.nasa.gov/explorers/p12.html

ADDITIONAL RESOURCES
For additional resources and activities to enhance this lesson, refer to the following resources:
NASA curriculum guide, *Suited for Spacewalking - An Activity Guide for Technology Education, Mathematics, and Science* (EG-1998-03-112-HQ)
http://www.nasa.gov/pdf/143159main_Suited_for_Spacewalking.pdf

The *Clickable Spacesuit*
http://www.nasa.gov/audience/foreducators/spacesuits/home/clickable_suit.html

DISCUSSION QUESTIONS
The following questions can be discussed with the students as an introduction to the lesson.
- What are the important parts of our atmosphere that keep us alive and safe here on Earth? *Air, pressure, moderate temperatures, radiation protection*
- Why is the environment of space outside the International Space Station dangerous to an unprotected human body? *Contains none of what we find in our atmosphere that protects us*
- If an astronaut needs to work outside the International Space Station, what would he/she need to stay alive and be comfortable? *Extravehicular mobility unit (space suit)*
- How can a bulky and heavy spacesuit keep an astronaut cool while working outside the International Space Station? *The liquid cooling ventilation garment uses water flow to remove heat from the astronaut's body*
- Is the color of a spacesuit important? Why or why not? *yes, white reflects heat best and keeps the astronaut cooler inside the suits*

ASSESSMENT ACTIVITIES
- To prepare the students for the lesson, ask the following pre-test questions and discuss student answers without giving the correct answers. Once the lesson is complete, discuss the questions again and have the students explain their answers and how they compared to their answers before the lesson.
  1. Does the astronaut need to wear the spacesuit during the entire mission in space? *No, only outside the spacecraft.*
  2. What are the hazards the spacesuit needs to protect the astronauts from in space? *Vacuum (no air), radiation, temperature extremes, and space debris.*

3. Which color absorbs the most heat? *Black*
4. Which color reflects the most heat? *White*

- Observe and assess student performance throughout the activities. For the “Cool Suits” activity, use the provided Scientific Investigation Rubric.
- Have students design graphs to display data recorded during the activities.

ENRICHMENT

- Discuss how a liquid cooling garment could be constructed that could operate continuously without siphons and buckets of ice water that eventually run out.
- Research professions on Earth that might find liquid cooled garments useful?
- Challenge the students to design and create a “space suit” that will maintain a steady temperature in extreme hot and cold temperatures. Students will be given an empty paper towel tube and asked to design the tube so that the temperature will not vary more than 5 degrees Celsius when it is put in sunlight and then in the freezer.