Lesson Plan for:
NASA Design Challenge – Thermal Protection System
Adapted For 6th - 7th Grade Comprehensive Science – Honors

Description:

This hands-on laboratory activity helps to introduce and/or reinforce thermal ideas such as conduction, convection, and radiation. In support of STEM efforts, this laboratory activity will help students develop critical thinking and problem solving skills in a group setting, nurturing teamwork and character building. By starting with a hands-on activity, students will develop a knowledge base through a real-life scenario of which curriculum material will be built upon. Students will take ownership of the learning process through active participation. The scientific process/design process will also be addressed to illustrate to students the cyclic process of design-test-redesign. This laboratory activity, created by NASA, has been adapted and added to, to align with the new generation Florida Sunshine State Science Standards for middle grades.

Objectives:

- Support district and Florida new generation sunshine state science standard "big idea 7 – Earth systems & patterns" through a hands-on approach – introduction of convection, conduction, radiation
    - See FL Standards listed below
- Support STEM efforts
- Encourage critical thinking / creative thinking / problem solving skills
    - See "Thinking Skills" on page 8 of NASA Thermal Protection Shield manual
- Increase background knowledge of NASA Ares launch vehicle project and thermal protection systems

Learning Goals:

- Define "thermal protection system"
- Understand thermal protection systems
- Understand the requirements for a thermal protection system on a reusable launch vehicle
- Recognize the need for models
- Understand the relationship between a model and the actual object being studied
- Recognize the need for a baseline measurement
- Make observations and collect data

- Record data in a table
- Understand the need for averaging
- Calculate averages
- Begin developing ideas about heat transfer

Florida Standards:

SC.6.E.7.1
SC.6.E.7.2
SC.912.P.104

Please see pages 5 – 8 of the NASA Design Challenge – Thermal Protection System PDF for correlated National Science Education Standards, Math Connections, and Thinking Skills (http://www.nasa.gov/sspdf/221638main_EDC_TPS.pdf)

504 & Other Accommodations:

Cooperative Learning
Experiment
Identify Main Ideas, Vocabulary, Concept
Problem Solving
Small Groups / Share
Use Overheads & Pictorial Presentation
Use of Child's Cultural Background & Experiences

Student Hand Outs:

- NASA Thermal Protection System Design Worksheet
- NASA Thermal Protection System Student Reflection Questions

Teacher Resources/Materials Needed:

- http://www.nasa.gov/sspdf/221638main_EDC_TPS.pdf
- Laboratory Materials Noted On Page 2 & 20 of NASA PDF (all available at Home Depot or Lowe's)
- Example Shuttle Heat Tile (optional)

Alternative Assessment Methods:

- Poster board presentation/Museum walk
- Student lab report with digital photos and data table incorporated
- Student/Teacher conversation using Learning Goals (listed above) and teacher checklist
- Structured multimedia video of student groups explaining background information, purpose, reason for group design, observations, results – rubric provided

Estimated Time Frame: 90 - 120 minutes

Class Notes/Activity Covered: Start NASA Engineering Design Challenge (Thermal Protection System)

- Discuss objective of lab
  - Using the materials available, create a thermal protection system that will be attached to the brass machine screw. The thermal protection system should be made to keep the brass machine screw attached to the dowel for as long as possible when exposed to a heat source
- Discuss supplies available for use
  - 1 – 8” wooden dowel
  - 1 – brass machine screw
  - 2 – brass hex nuts
  - 1 – brass flat washer
  - 1 – 3’’X3’’ piece of aluminum foil
  - 1 – 3”X3” piece of aluminum screening
  - 2 – pieces of copper woven wire
- Place students in groups of 4 students and assign to a workstation
- Group discussion and brainstorming of thermal protection system design
  - Student designs will vary, so please sketch and label a drawing of how the thermal protection system will be assembled on student worksheet provided.
  - Students will be asked to justify why their group decided to create the thermal protection system the way they did. Apply as much scientific knowledge and logic as possible in your reasoning.
  - Students will have their design approved by the project manager before obtaining building materials.
- Build time – upon having their design approved by the project manager (teacher), all groups will be given 15 minutes to build their thermal protection system
- Trial # 1 – groups will be called up to the testing station in order. Trial times will be recorded for data analysis and later comparison of trial # 2
  - Building background vocabulary & discussion during trial runs
    - Temperature - a measure of the average kinetic

(moving) energy of the particles in an object
- We try to not use the words hot, cold, cool, warm to avoid confusion

- Heat - the thermal energy transferred between objects that are at different temperatures
- Thermal energy – the total kinetic (moving) energy of the particles that make up a substance
- Thermal expansion – the increase in volume of a substance because of an increase in temperature
- What is the difference between a conductor and insulator?
    - Conductors – a material that transfers heat energy through a material, examples include cookie sheet, copper pipe, stove coil, iron skillet
    - Insulators – a material that reduces or prevents the transfer of heat, examples include flannel shirt, oven mitt, ceramic tiles on the space shuttle

- Group discussion and debrief of trial # 1
    - What did you observe during the trial # 1 run?
    - Did the design of the thermal protection system work the way in which the group thought?

- How would you modify the design to make it more successful?
    - Students will be asked to re-sketch and justify why their group decided to create the thermal protection system the way they did. Apply as much scientific knowledge and logic as possible in your reasoning.
    - Students will obtain building materials
- *Re-build time – all groups will be given 15 minutes to re-build their thermal protection system
- Trial # 2 – groups will be called up to the testing station in order. Trial times will be recorded and reflected against trial # 1

***To encourage higher order thinking and problem solving skills, you may increase design constraints by limiting the amount of materials available**

Start Lab Reflection Questions – Student Reflection Question Worksheet

- What will happen if two objects at different temperatures come into contact?
    - Thermal energy will pass from the warmer object to the cooler object until both have the same temperature
- What property makes thermometers work?
    - Thermal expansion, when objects increase in size (volume), causes thermometers to work
- What are two sources of heat that NASA engineers are protecting against?
    - Heat from friction between the atmosphere and the speeding spacecraft; heat from the combustion of fuel
- Name the common, lightweight material that NASA engineers are planning to use to provide thermal protection at the base of Ares V. Describe how this material provides thermal protection
    - Radiation - materials that protect by radiation radiate heat very efficiently. As soon as they start to absorb heat they release it very efficiently. They also have a high thermal capacity; they can absorb a

lot of heat without heating up very much themselves
    - Ablation – materials that protect by ablation do not absorb or conduct heat very well. Heat erodes them; their surfaces burn and fall away, carrying heat away from the spacecraft
- Name the three ways in which heat is transferred, and describe how heat is transferred in each situation.
    - Conduction – heat moving through a solid substance, substances must be in direct contact to transfer heat by conduction
    - Convection – the transfer of heat by a liquid or by gas molecules
    - Radiation – involves heat traveling as electromagnetic waves, heat can radiate through space, as does heat from the sun
- Identify a material that has low thermal conductivity and a material that has high thermal conductivity
    - Low thermal conductivity – wood, air, cork, glass, and water do not conduct heat very well
    - High thermal conductivity – copper, silver, aluminum, and steel conduct heat very well.
- Describe the term "specific heat."
    - Specific heat describes the relationship between how much heat a material absorbs and how much the temperature of that material increases.

** Technology integration can be achieved by having students document the brainstorming process using FLIP cameras. This will help document student conversation and thought process for later reflection. Students can then use the FLIP cameras to record their observations during both trials. Digital photos can also be utilized that can later be incorporated into a student lab report, if chosen as an assessment method.