Heat: An Agent of Change

Protecting the Genesis Spacecraft from Heat

TEACHER GUIDE

BACKGROUND INFORMATION

Spacecraft designers encounter many heat-related problems. Heat transfer via conduction, for example, is a major concern when a spacecraft enters or reenters an atmosphere. The Genesis spacecraft designers also face another heat transfer problem: how to prevent heat transfer from external features that will be constantly exposed to the Sun's radiant energy to the internal electronic components. Both situations require engineers to come up with a way to insulate the spacecraft.

In this activity, students will build a model of the Genesis spacecraft to illustrate how to insulate components from heat. They will then perform an investigation, comparing data from a control model to data from an experimental model.

STANDARDS ADDRESSED

Grades 5-8

Abilities necessary to do scientific inquiry
Understandings about scientific inquiry
Physical Science:
- Properties and Changes of Properties in Matter
- Transfer of Energy

Abilities of technological design
Understandings about science and technology

Grades 9-12

Abilities necessary to do scientific inquiry
Understandings about scientific inquiry
Physical Science:
- Conservation of energy and the increase in disorder
- Interactions of energy and matter

Abilities of technological design
Understandings about science and technology

MATERIALS NEEDED

Each lab group will need the following set of materials. If you choose to have students build only one model, supply only the materials for that model. (All these materials can be inexpensively purchased from a general all-purpose store, such as WalMart, Target, or K-Mart. Hardware stores are often particularly good places to find design-related building materials.)

To build one control model:

Metal electric switch box and cover
Metal octagonal box cover
Scissors
5 m of wound copper wire
Masking tape
Flat head screw driver (this can be shared among lab groups)
2 Celsius thermometers
1/2 m length of aluminum foil

To build one experimental model:

Metal electric switch box and cover
Metal octagonal box cover
Scissors
5 m of wound copper wire
Masking tape
Flat head screw driver (this can be shared among lab groups)
2 Celsius thermometers
Styrofoam plate
Glue suitable for bonding metals
1 m length of polyester batting (blanket fill)

To test the models:

Lamp that can function on its side
Material for props, e.g., washcloths.

The following substitutions may be used for materials in the model design:

Recommended Materials	Material Substitutions
• Metal electric switch box	• Any similar metal box with a cover/lid
• Copper wire	• Any good conducting wire
• Styrofoam plate	• Paper plate
• Lamp	• Any safe heat source
• Polyester batting	• Cotton ball or any other insulator
• Metal octagonal box cover	• Any similar metal disk or section of aluminum pie plate

PROCEDURE

In this activity, students will experiment with insulating spacecraft components from heat conduction. The activity requires the construction of a control model and an experimental model. There are four ways to conduct this activity, depending on how much building you want to do and how much building you want students to do. Choose the way that suits your class.

1. Each lab group builds a control model and an experimental model, and then collects data in class.
   Day 1: Build control model
   Day 2: Collect control data while building experimental model
   Day 3: Collect experimental data; begin data analysis
   Day 4: Complete data analysis

2. Teacher builds the control model in advance; students build the experimental model and then collect data in class.
   Day 1: Teacher demonstrates control model and do data collection: class builds experimental model
   Day 2: Class collects experimental data; teacher hands out control data
   Day 3: Complete data analysis

3. Teacher builds the control model in advance; students build the experimental model and then collect data at home.
   Day 1: Teacher demonstrates control model and data collection; class builds experimental model; lab group selects member to take equipment home overnight and perform data collection on experiment model.
   Overnight (NOTE: Stress safety in the home experiment. Make sure students realize that an adult must help and supervise.)
   Day 2: Teacher hands out control data; students who collected data at home shares data with his/her laboratory group; complete data analysis.

4. Teacher builds the control model and the experimental model in advance, and then demonstrates data collection to students in class.
   Day 1: Show control and experimental models (built by teacher); collect data from both
   Day 2: Complete data analysis

Divide your students into lab groups and carry out the experiment, using the method you selected above. The instructions given in the Student Activity should guide students through each step of the process.

After all of the data has been gathered, find the class average, where appropriate, and conduct a class discussion about data accuracy issues. Then instruct students to write their conclusions.

Students may need a review of graphing skills before they can analyze the data.

Alternate Strategy Tips

During the model construction process, review the guidelines in the Design Assessment Checklist scoring guide given in the ”Survival!” activity. Begin to accustom students to its use in assessing their performance in an activity.

Some students may need either more or less direction than is given in the Student Activity. It may be helpful to reconstruct the schematics at a couple of different levels of complexity, so the amount of prompting needed for student success can easily be provided, but *only* that amount.

To enhance learning about data organization and representation, do not supply the students with the data table or the pre-scaled graph. Creating tables and graphs is a skill that students should master if they have not by now shown proficiency.

If questions arise about the accuracy of some of the data, have the students switch models between groups randomly and repeat the experiment.

Creating class sets of items such as screwdrivers, scissors, glue, etc., is advisable. A system needs to be maintained that keeps a stock of these materials organized for each group of students. Containers of some type, such as shoe boxes, can be used for this purpose, allowing one shoe box per group. You may wish to number the groups in each class, as this will allow you to keep track of which group from each class is using a certain stock of materials. For example, group 1 from each class through the day will use box 1, group 2 from each class will use box 2, and so on.

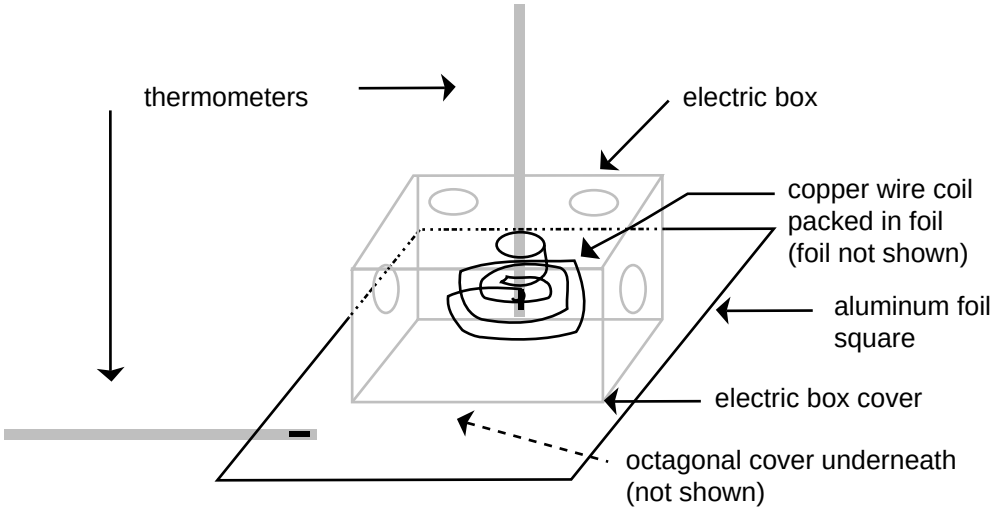
ADDITIONAL LEARNING OPPORTUNITIES

Students may wish to proceed beyond the mock-up stage in design to investigate a potential "faster, cheaper, better" model. Encourage them to find out about other materials, costs, and design features.

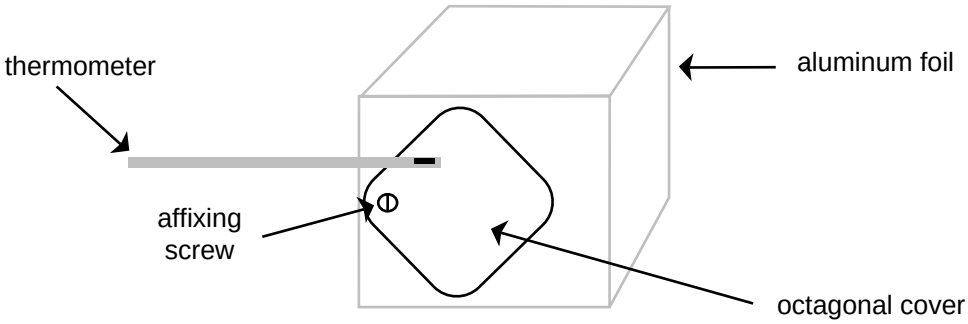
Students can conduct research on the various aspects of design used in the heat shield, including the materials used and the process of their development.

An interesting modification of the experimental model would be to compare varied insulators such a s rubber, wood, and glass.

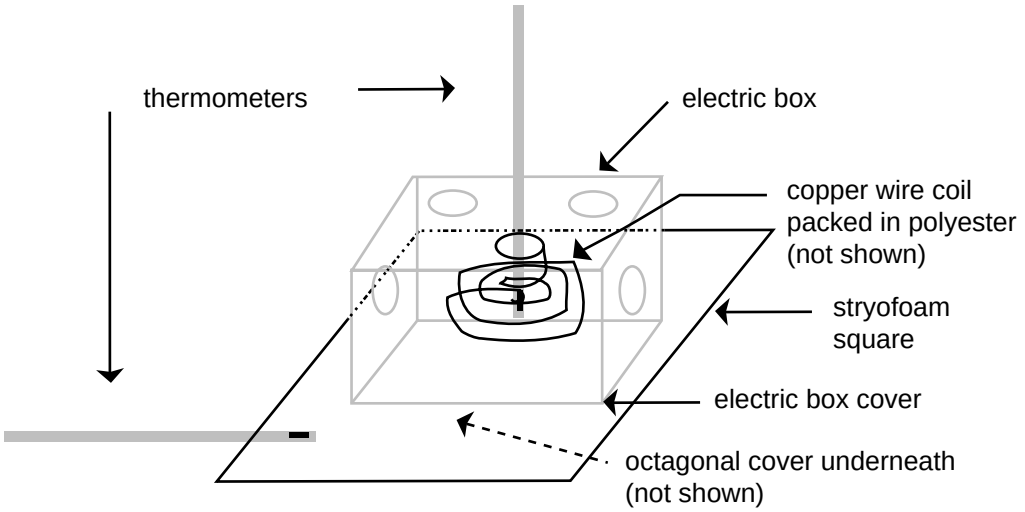
Control Model
(Figure 1)



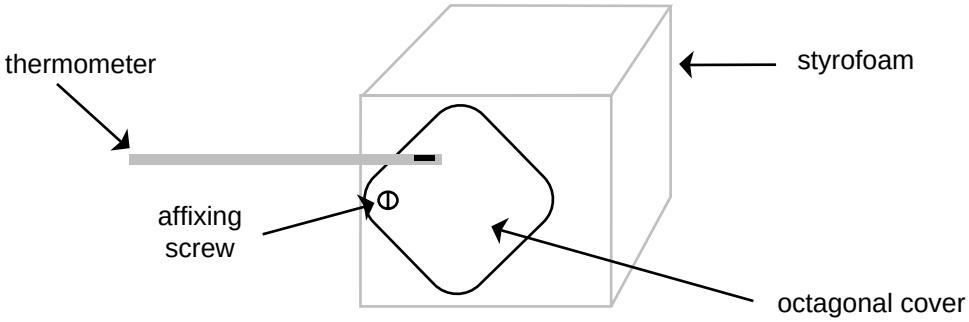
Front View of Control Model
(Figure 2)



Experimental Model
(Figure 3)



Front View of Experimental Model
(Figure 4)



Experimental Model Data Collection Setup
(Figure 5)