Engineering Design Challenge: Thermal Protection System

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Engineering Design Challenge: Thermal Protection Systems
Thermal Protection System

• Have you had a chance to look at this lesson?

✅ Yes
❌ No
Syllabus

- Lesson overview
- NASA connection
- Lesson in detail
- Extensions
Introduction

• Design and build a thermal protection system on a “rocket.”
• Test the system using a propane torch.
National Standards

• Grade Level: 8 - 12
• Transfer of heat energy
• Development of technology design
• Measurements, rounding, & graphing
• Calculating averages
Value to students

• National standards in science, math & critical thinking skills
• Student get excited about this challenge
• Opportunity to solve real-world problems
• Use of creativity and scientific knowledge
• Learn about heat and heat transfer
• Develop presentation and communication skills
Do students know?

Conduction - Convection - Radiation

Conduction vs. Insulation
Do students know?

1. Insulation

a. Energy that is transmitted in the form of rays, waves or particles
b. The process by which heat or electricity is directly transmitted through a substance
c. The movement caused within a fluid by the tendency of hotter and therefore less dense material to rise, and colder, denser material to sink
d. a material that reduces or prevents the transmission of heat or electricity
Do students know?

1. Insulation - d
2. Radiation

- Energy that is transmitted in the form of rays, waves or particles
- The process by which heat or electricity is directly transmitted through a substance
- The movement caused within a fluid by the tendency of hotter and therefore less dense material to rise, and colder, denser material to sink
- a material that reduces or prevents the transmission of heat or electricity
Do students know?

1. Insulation - d
2. Radiation – a
3. Conduction - b
4. Convection - c

a. Energy that is transmitted in the form of rays, waves or particles
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Do students know?

Conduction - Convection - Radiation

Conduction vs. Insulation
• **Thermal Conductivity** - the ability of a solid object to transmit heat within itself as well as into an object touching it

• **Heat Capacity** – amount of heat energy an object can absorb without changing its overall temperature
Let’s pause for questions from the audience
NASA Connection
Thermal Protection Systems
Examples

- Argon Gas
- Insulation
- Cooling System
- Protective Gear
Ablative Thermal Protection

- Neither absorb nor radiate much heat.
- When the surface becomes very hot, the material starts to burn and erodes away.
Radiant Thermal Protection

• Designed for the Orbiter, so they must be reusable.
• Dissipate heat quickly.
• Four different kinds of thermal protective materials on the Orbiter.
Which has Radiant Thermal Protection?

A

Thermal Images of Discovery

B

Apollo Command Module

C

Orion Heat Shield
The Challenge

• Using the materials provided, build a thermal protection system that protects your “rocket” from severe heat for the longest possible time.
Lesson in Detail
Thermal Protection Systems
The Lesson

• Students will take on the role of engineers for this lesson.

• They will attempt to solve a problem that NASA engineers are working on as they develop rockets.
Engineering Design Process

Design

Build

Test

Record Data

Analyze Results
Prep Time

- 4 - 8 hours
  - Read the guide
  - Gather materials
  - Construct the test stand
  - Test your own design
  - Set-up the classroom
Baseline Protection Time

• Students will first test several unprotected assemblies to establish a baseline.

• Conduct at least three separate tests and calculate the average time for the baseline.
TPS Design Specifications and Test Results Sheet

Date: __________________________ Class: __________________________ Team: __________________________

Designers' Names: __________________________

Sketch your design below. Check that you have drawn and labeled the following:

- Dowel
- Screw
- Glue joint
- Hex nuts
- Washers
- Other materials

Describe the key features of your design:

Describe what happened during the test:

NASA Engineering Design Challenge
Design Constraints

• Use only the materials specified to construct the thermal protection system (TPS).
• No glue in the TPS itself.
• TPS may not touch the dowel.
• TPS may not touch the glue.
Testing Designs

• Have a stop watch ready.
• Add mass as an extension activity.
• Caution: Anyone near the testing area should wear safety goggles.
• Caution: Allow design to cool before touching it with bare hands.
Student Discussion

• Allow students to share group results.
• What worked?
• What needs re-designed?
• What would you do differently next time?
What works?

• The idea is to use air as an insulator in the system to protect the screw from getting hot.

• Watch this video for some ideas.
Extensions and Resources
Thermal Protection Systems
Extensions

• Turn up the Heat
• Limit Designs by Mass
• Limit Designs by Size
• Design on a Budget
• Design with additional materials
• Real World: Hubble Thermal Blanket
Culminating Activity

• Create a “storyboard” poster that documents the evolution of the TPS designs from initial to intermediate to final stage.
Any other extension ideas?

• Type responses into the chat box.
• Are you part of the NASA Explorer Schools program?

✔ Yes

✖ No
Finding the guide
Finding the guide

NASA Explorer Schools provides access to a growing list of some of NASA's top education products designed to excite and inspire students in grades 4-12 by involving them in authentic NASA problems. NES has designed targeted support for each product to support teacher's efforts to use the materials in their classrooms. NES product modules consist of featured lessons, professional development support (live webinars and on-demand videos), classroom implementation ideas, lesson plans, and supplemental tools and activities.

Follow these steps to find NASA Education Products that fit your classroom needs:

1. Find product modules using the search below. You can filter the results by grade, subject, and/or keyword. Select "Show all Modules" to see the entire list of offerings.

2. Access the professional development opportunities to get ideas for classroom implementation.

3. Use the module in your classroom.

4. Get credit for your participation in the professional development activities and your use of the product module by taking the two surveys found on each of the product module pages.

The links found within the following modules may take you off the NASA Explorer Schools Virtual Campus website. NASA Explorer Schools takes no responsibility for, and exercises no control over, the organizations, views, or accuracy of the information contained on these websites.
Thermal Protection System

NASA Guide

Live Seminars

Video Collection
Video Collection

Video 1 of 4: Introduction

This video gives an overview of the lesson, which explores the design of thermal protection systems that are used to protect vehicles during re-entry from space into a planet’s atmosphere. The overview includes national standards addressed by this activity, instructional objectives, location of the activity and classroom resources.
Let’s pause for questions from the audience
Collaboration
Making teaching Easy

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