LESSON: SSME

Title: SSME
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Lesson Overview:

The Space Shuttle Main Engine (SSME) provides thrust for the Space Shuttle during the ascent phase of launch. There are three SSMEs, each of which are controlled separately. They use liquid hydrogen and liquid oxygen for propellants, which are pressurized and combusted to produce thrust. During the launch countdown, a SSME team monitors these engines, and during a KLASS-simulated launch individuals will be assigned to monitor one or more engines as well.

The SSME console has potential to offer some high-level computation activities. It introduces engineering concepts such as propellant pressurization, states of matter (liquids to gases), combustion, exit velocity, and thrust. The SSME in the KLASS software operates according to predetermined algorithms so that all the components can either be manually adjusted or calculated from existing values. There are plenty of opportunities for students to perform arithmetic computations and graphing from very simple linear forms to more complex forms involving powers and radicals. To understand the SSME console, several diagrams are provided to supplement the reading, as well as a complete mathematical description of the console.

Suggested Classroom Time: 180-600 minutes

Grade Levels: 6-10

KLASS Module: 1-Training

Topic/Console: SSME Console

Materials Needed:

Activity	Documents	Other Materials
1	RDG_ SSME.doc RDG_SSME-Math-Reference.doc RDG_SSME-Additional (Folder of documents)	
2	ACT_SSME-Console.doc (for use with console) ACT_SSME-Propellant-Flow.doc ACT_SSME-Valves-HPFTP.doc KEY_SSME-Propellant-Flow.doc KEY_SSME-Valves-HPFTP.doc	Student computers with Microsoft Excel and writing tools

National Standards/Objectives:

Discipline	Standard	Objective
Science	B. Physical Science	Students learn about properties and changes of properties in matter, transfer of energy, chemical reactions, and motions and forces.
Science	E. Science and Technology	Students develop abilities of creating technological designs.
Technology	Technology productivity tools	Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.
Math	Number and Operations	Students compute fluently and make reasonable estimates.
Math	Algebra	Students use mathematical models to represent and understand quantitative relationships.

Desired Results:

Students will be able to answer these essential questions

- How do the Shuttle's three SSMEs work?
- What will I need to know as a member of the KLASS Shuttle launch team that monitors and controls the Shuttle's three SSMEs?
- How can I contribute to a larger group within a complex operation such as the Shuttle's SSMEs?

Students will know

- The basic responsibilities of the SSME KLASS engineers.
- How to record a sequence of SSME data from the KLASS console and calculate other console variables.
- How liquid propellants are transformed into a gaseous state.
- The process of combustion.
- How the main engines produce thrust.

Students will be able to

- Record accurate observations and calculate variables while observing a variety of data feeds by the KLASS SSME consoles.
- Assimilate into the role of SSME engineer by monitoring, correcting, and communicating data to the larger launch team.

Learning Plan/Activities:

1. **Introducing the Lesson.**
   Review the appropriate documents (depending on the age/grade/level of your group) and help students understand how a SSME works. The *Understanding the Space Shuttle Main Engines (SSME)* section (RDG_ SSME.doc) provides an overview of the main engines. The *Understanding the Valves used with the HPFTP* section (RDG_SSME.doc) describes the high-pressure pumps, which are key components in the engine. The *SSME Valves* diagram (RDG_SSME.doc) points out the relevant valves the students will be working with and what they do. To help both teacher and student gain an understanding for how all the console pieces fit together, the *SSME Component Relationships* section (RDG_SSME.doc) shows which console variables affect others. A more precise formulation is presented in mathematical form in the *SSME*

Mathematical Reference handout (RDG_SSME-Math-Reference.doc). While this latter document may be overwhelming for the student, it does provide a comprehensive description of the console and may help in formulating alternative assessments and activities.

2. **Observing, Labeling, and Recording.**
   Based on the *Understanding the Space Shuttle Main Engines (SSME)* section (RDG_SSME.doc), have the students complete the *SSME Propellant Flow* activity (ACT_SSME-Propellant-Flow.doc). This will help them relate the text to the schematic they'll be working with in the Student Console. Next, based on the *Understanding the Valves used with the HPFTP* section (RDG_SSME.doc), have the students complete the *SSME Valves HPFTP* activity (ACT_SSME-Valves-HPFTP.doc). This will help them calculate propellant flow rates. Next, have the students start the SSME and, with *SSME Valves* diagram (RDG_SSME.doc), explore how they will be working with the engine valves. They may be split into groups, one observing the HPFTP and the other observing the HPOTP. Using the worksheets, have them practice recording and making the necessary flow rate calculations in ACT_SSME-Console.doc. Instructions for these worksheets are in the *Baseline Worksheet (HPFTP)* section (ACT_SSME-Console.doc) and *Baseline Worksheet (HPOTP)* section (ACT_SSME-Console.doc) activities. As the students get more comfortable with the console, they also can attempt to calculate Exit Velocity and Thrust using the equations provided in the *SSME Mathematical Reference* handout (RDG_SSME-Math-Reference.doc). Ultimately, they may be able to determine the necessary flow rates and valve positions to achieve the required thrust.

3. **Evaluating the Lesson.**
   During the above activities, students should be making the connection between the real Shuttle SSMEs and the KLASS SSME. Follow up this activity by reinforcing the key roles that will be needed for the KLASS simulation. Revisit the *KLASS Launch Team Roles* handout (RDG_KLASS-Team-Roles.doc), paying attention to the SSME description of responsibilities.

Assessment Evidence:

Performance Tasks

1. Students will be able to explain the function of each of the Shuttle's main engines components and how they all contribute to achieving the necessary thrust for lift-off. While there are some technical details they may not completely understand, they should have a basic understanding of how thrust is produced from propellants.
2. Students should begin to understand the function of the SSME KLASS module and the data that is referenced and used during the simulation.

Extensions and Going Further Resources:

- Be sure to check for student opportunities, additional educational resources and more at: http://www.nasa.gov/education