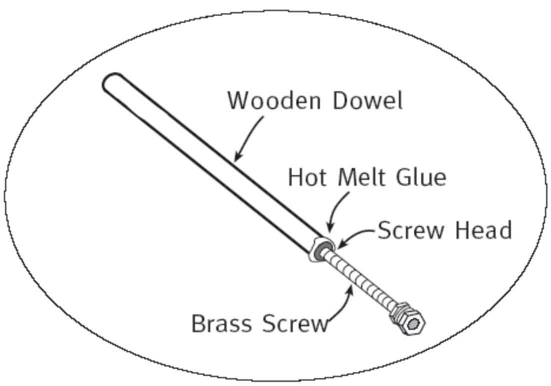
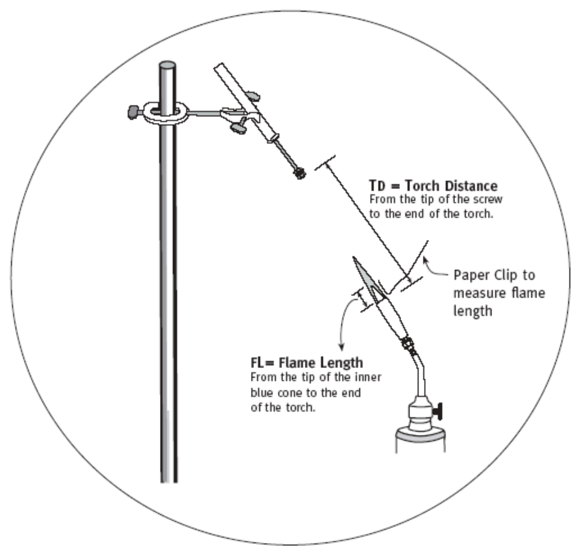
Engineering Design Challenge:
Thermal Protection Systems

Kit Certification: <u>2 hour workshop</u>
Suggested Grade Level: 5-12

In this challenge, students learn how NASA engineers design lightweight but effective, reusable thermal protection systems. Space vehicles must have thermal protection systems to maintain acceptable temperatures. When designing the Thermal Protection System (TPS), aerospace engineers must consider the heat from atmospheric friction on a spacecraft during launch and re-entry and the extreme heat generated from the exhaust plumes of the engine. Students work in teams to design, build and test a thermal protection system of their own.





<u>Kits Available: 2</u>

Kit contains:

- Ring stand
- Propane torch with holder
- Materials to design a heat shield (aluminum foil, mesh, wire)
- Safety goggles
- Infrared thermometer
- Spacecraft heat shield for demo
- Hot glue melting tray and extra glue
- Teacher guide with background information, instructions, and handouts

WV NxGen Science Standards

S.3-5.ETS.1 define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
S.3-5.ETS.2 generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
S.3-5.ETS.3 plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

S.6-8.ETS.1 define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
S.6-8.ETS.2 evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
S.6-8.ETS.3 analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
S.6-8.ETS.4 develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

S.7.PS.2 develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
S.7.PS.5 construct, use and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
S.7.PS.7 plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

S.8.PS.3 develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

S.HS.ETS.1 analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
S.HS.ETS.2 design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
S.HS.ETS.3 evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

S.HS.P.15 plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).