N. Generating Thrust-Jet & Rocket Engines

Content Area: **Science**
Course(s): **CAD Architect**
Time Period: **Marking Period 1**
Length: **1**
Status: **Published**

Standards

SCI.9-12.HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
SCI.9-12.HS-ETS1-4	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
SCI.9-12.HS-ETS1-3	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.
SCI.9-12.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
SCI.9-12.HS-PS2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
SCI.9-12.HS-PS2-1	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
SCI.9-12.HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
SCI.9-12.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects).

Enduring Understandings

Students will come to understand:

1. Jet propulsion is more efficient than reciprocating engines and propellers for high speed, high altitude flight.
2. Jet engines are turbine engines that convert chemical energy in fuel to thrust via a continuous thermodynamic cycle.
3. The design of a jet powered aircraft relies on proper design of the jet air intake duck and jet exhaust nozzle.
4. Rocket engines carry their own source of oxygen to support combustion and thus can operate outside of the atmosphere.
5. The severe mechanical, thermal, and sonic stresses that act on the turbine blades of a jet engine are a significant metallurgical challenge to overcome when designing and building jet engines.

Essential Questions

The following questions will guide student inquiry:

- How can a machine extract chemcial energy from fuel using a continuous thermodynamic cycle?
- How can a metal alloy be manipulated to withstand the stresses associated with the turbine section of a jet engine?
- How does a rocket engine support combustion outside of the atmosphere?

Knowledge and Skills

Unit Content:

Jet engines propel an aircraft by drastically changing the velocity of a small mass of air molecules as a result of a continuous thermodynamic cycle. Exactly the opposite of the case of the reciprocating engine, a jet engine becomes more efficient at high speeds and high altitudes. This unit will introduce the jet engine and motivate the incredible engineering challenges associated with designing a jet engine. Rocket engines will also be briefly considered due their importance in space flight.

- Thermodynamic Cycle for the Gas Turbine Engines
- Parts of the Jet Engine
- Jet Engine Types (turbojet, turbofan, turboprop, turboshaft)
- Jet Engine operating considerations
- Airliner Auxiliary Power Units (APUs)
- Air Intake Ducts for supersonic aircraft
- Introduction to Rocket Engines
- Solid vs. Liquid Fuel Rocket Engines
- Jet Engine Support Systems:
    - Fuel
    - Air Induction and exhaust

Science, Technology, Engineering, Mathematics, and/or Aerospace Skill(s):

In addition to the basic theory of the jet engine, the unit will explore the basic metallurgic principles that contribute to the challenge of designing jet engine turbine blades. Students will be exposed to the solid phase diagrams for metal alloys and how these different phases contribute to the mechanical (and thermal) properties of a given alloy.

Resources

Textbook(s):

Smith, H. C. (1992). *The illustrated guide to aerodynamics* (2nd ed.). Blue Ridge Summit, PA: McGraw-

Hill, Inc.

Federal Aviation Administration. (2013). *The pilots handbook of aeronautical knowledge*. Washington, DC: Author.

Lab Equipment:

Estes Model Rockets and Rocket Thrust Measurement Tool

Computer Software:

Microsoft Excel

NASA Site