M. Generating Thrust-Propellers & Piston Engines

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

Assessment

"Do Now" Activities

"Exit Ticket" Activities

Practice Problem Worksheets

Quizzes

Standards

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-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-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-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-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).
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.

Enduring Understandings

Students will come to understand:

1. Aircraft reciprocating (piston) engines operate by extracting energy from the combustion of gasoline, which does work on a piston that, through a mechanical crank system, rotates a propeller in the same manner that an automobile engine rotates a car's transmission and eventually its wheels.
2. A propeller is a specially designed airfoil that rotates and generates "lift" in a horizontal direction to

provide the thrust required to overcome or balance total airplane drag.

3. Propeller driven are more efficient than turbojet or turbofan aircraft at low altitudes and low airspeeds.
4. There are many ingenious support systems that are required to facilitate the operation of a four-cycle engine and incorporating these systems into an aircraft represents an engineering challenge.
5. Pilots set the power of a reciprocating aircraft by adjusting the intake manifold pressure using the throttle and the engine RPM using the propeller pitch control.

Essential Questions

The following questions will guide student inquiry:

- How do reciprocating and turbine engines compare with regards to both their efficiency, design limitations, and overall performance and how do these properties affect the choice of an aircraft's power plant?
- How can the chemical energy present in the bonds of a fuel be converted into the mechanical energy required to propel an aircraft?
- How do the demands of a given form of propulsion affect the subsystems that support this propulsion system?

Knowledge and Skills

Unit Content:

For most of aviation's history, the four stroke Otto engine, an internal combustion, engine drove a propeller (nothing more than a rotating wing that generates "lift" in the horizontal direction to drive an aircraft forward, opposing drag). This unit introduces the four strokes of the piston in an Otto engine (intake, compression, combustion, and exhaust) and models each of these four strokes from a thermodynamic perspective. Students will learn to compute the power produced by a multi-cylinder engine. Additionally, the unit will address the practical considerations that accompany the support systems required to run a piston engine. These systems are also common to automobiles and help explain the basic maintenance required of all cars and small engine powered tools. Finally, the basics of aircraft propellers will be explored. Modern propellers are sophisticated rotating wings whose angle of attack can be controlled by the pilot to control power output.

- Thermodynamic Cycle for the Four Stroke Piston Engine
- Computing the Power Output of a Piston Engine
- Piston Engine Power as a Function of Pressure Altitude
- Supercharging and Turbocharging Systems
- Parts of the Piston Engine
- Aircraft Propellers and Propeller Aerodynamics

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

In addition to the basic theory of the piston engine, the unit will explore the basic construction and mechanical components of a piston engine. Many of these basic components form the foundation of all other mechanical machines and are areas of study in the field of mechanical engineering. The mechanical components discussed will include bearings, bushings, pushrods, cams, gear drives, chain drives, mechanical fasteners, etc.

Piston Engine Support Systems:

- Fuel (carburetor, fuel injection)
- Induction (supercharging & turbocharging) and exhaust
- Ignition
- Cooling

Piston Engine/Propeller Combinations: Power Plant Operating Considerations

Resources

Textbook(s):

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

Cessna Aircraft Company. (1977). *Pilots operating handbook: Cessna 172*. Wichita, KS: Cessna Aircraft Company.

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

Lab Equipment:

Pasco Low Speed Wind Tunnel

Balsa gliders

Video Camera/digital camera

Computer Software:

Microsoft Excel

NASA Site