3 Propulsion

Content Area:	**Science**
Course(s):	**Aerospace Engineering**
Time Period:	**Semester 1**
Length:	**4 Weeks**
Status:	**Published**

Standards

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-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
SCI.HS-PS3	Energy
SCI.HS-PS2	Motion and Stability: Forces and Interactions
SCI.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.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.
STEM.9-12.1	Engineering & Technology
STEM.9-12.2	Science & Mathematics
STEM.9-12.9.4.12.O.(1).1	Apply the concepts, processes, guiding principles, and standards of school mathematics to solve science, technology, engineering, and mathematics problems.
STEM.9-12.9.4.12.O.(1).2	Apply and use algebraic, geometric, and trigonometric relationships, characteristics, and properties to solve problems.
STEM.9-12.9.4.12.O.(1).3	Demonstrate the ability to select, apply, and convert systems of measurement to solve problems.
STEM.9-12.9.4.12.O.(1).4	Demonstrate the ability to use Newton’s laws of motion to analyze static and dynamic systems with and without the presence of external forces.
STEM.9-12.9.4.12.O.(1).5	Explain relevant physical properties of materials used in engineering and technology.
STEM.9-12.9.4.12.O.(1).6	Explain relationships among specific scientific theories, principles, and laws that apply to technology and engineering.
STEM.9-12.9.4.12.O.(2).1	Develop an understanding of how science and mathematics function to provide results, answers, and algorithms for engineering activities to solve problems and issues in the real world.
STEM.9-12.9.4.12.O.(2).2	Apply science and mathematics when developing plans, processes, and projects to find solutions to real world problems.
	Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.
	Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.
	Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.

Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.

Enduring Understandings

1. All aerospace propulsion systems are an application of Newton's second and third laws in that they function by applying a force to accelerate a mass of air in one direction (Newton's second law), and as a result the air propels the object in the opposite direction with an equal and opposite force (Newton's third law).
2. Momentum is quantity that provides another way of visualizing and applying Newton's laws of motion.
3. The force that propels air in one direction to generate thrust is created by extracting energy from combustion, a process that is governed by the laws of thermodynamics.
4. The energy obtained through combustion is the result of a chemical reaction that breaks down the high-energy chemical bonds of an organic fossil fuel into less energic greenhouse gasses. The net energy difference provides a propulsive force but also generates pollutants that contribute to climate change.
5. All airplane propulsion systems operate by either imparting a large acceleration to a small mass of air particles (such as with a jet aircraft), or by imparting a small acceleration to a large mass of air particles (such as with a propeller driven aircraft).

Essential Questions

1. How are all aerospace propulsion systems the result of changing the velocity of a mass of gas particles?
2. How can the chemical energy stored in a gas be converted into the mechanical energy required to accelerate air particles and create thrust?
3. How is an engine a collection of sub systems working together to support the combustion of a fuel to extract the energy required to provide a force to the air to generate thrust?

Knowledge and Skills

Knowledge:

- Thrust is the force generated by an aircraft propulsion system to drive the aircraft forward and oppose the force of drag.
- Thrust is created by applying a force to the surrounding air to accelerate a mass of air to a higher velocity. By Newton's second law, the greater the mass of the air and the greater the change in its velocity, the greater the force imparted on the air. By Newton's third law, if the engine produces a force on the air to drive the air backward, the air must provide an equal and opposite force to drive the engine forward. This force is called thrust.
- A propeller driven airplane produces thrust by imparting a small acceleration to a large mass of air while a jet airplane produces the same thrust by imparting a large acceleration to a smaller mass of air.
- The force generated by an engine is the result of the work done by an expanding gas, and it is governed by the laws of thermodynamics.
- The expanding gas that does the work to drive an aircraft engine is the result of a combustion reaction where the high energy stored in the chemical bonds of a fossil fuel is extracted when greenhouse gas

products are formed.

- When an expanding gas does work to increase the volume of a machine, the area under a graph of the pressure and volume equates to the work done.
- Reciprocating engines (such as gasoline engines) use the expansion of combustion gasses to drive a piston up and down in one or more cylinders connected to a spinning driveshaft. The spinning driveshaft rotates a propeller that generates thrust.
- Reciprocating engines operate in a cyclic manner, where the cycle is defined by several repeating strokes. In the case of the four-stroke gasoline engine, the four strokes are: (1) intake, (2) compression, (3) expansion/power, and (4) exhaust.
- Many subsystems are required to support these four cycles, including a fuel system (carburetors or fuel injection), ignition system, cooling system, lubrication system, and a mechanical valvetrain.
- Turbine engines (“jet engines”) also operate on a thermodynamic cycle, but instead of having four distinct strokes that occur in order, different stages of the cycle are occurring at the same time continuously.
- Turbine engines exist in four classifications: (1) turbojet, (2) turbofan, (3) turboprop, and (4) turboshaft. A turboprop or turboshaft is a hybrid engine that makes use of the mechanical/thermodynamic efficiency of a turbine powerplant and the aerodynamic efficiency of a propeller.

Skills:

- Students will be able to take the area under a curve to quantify something that is not implicitly stated on a graph.
- Read and interpret the schematic diagram of a complex system (such as a carburetor or cooling system) and interpret the function of the system’s components based on the physical principles that govern their operation.

Transfer Goals

- Students will recognize that the area under a graph may represent an important quantity not otherwise stated on the graph, a concept that is fundamental to calculus and is applied in the physical and social sciences.
- There are no physical processes that “give something for nothing”. In terms of physics, all energy is conserved and no machine is perfectly efficient.
- The process of extracting energy from fossil fuels generates greenhouse gasses that affect society, ecosystems, and the climate of the planet.
- A reciprocating airplane engine is functionally the same as an automobile engine, and its principles of operation define and justify the maintenance procedures that every car owner will need to perform.

Assessments

https://docs.google.com/document/d/1wR7bQF-

8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing