# L. Intro to Thermal Science & Thermodynamics

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| 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

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| 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-ETS1-1 | Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. |
| 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-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-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-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.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. Aerospace propulsion systems rely on changing the momentum of a mass of atmospheric air, thus generating a net force via Newton's Second Law; equal thurst can be created by changing the velocity of a small mass of air by a large amount (as in a turbojet) or changing the velocity of a large mass of air by a small amount (as in a propeller driven aircraft).
2. While heat is a measure of the net internal energy possessed by some body as a result of molecular motion, temperature is a measure of the average kinetic energy of some object's molecular motion.
3. The first law of thermodynamics states that the total internal energy of some system can be changed by adding heat to the system or by doing work on the system.
4. The mechanical work done by a thermodynamic processes can be found by taking the area under the curve of pressure vs. volume.

## Essential Questions

**The following questions will guide student inquiry:**

- How can an object at a lower temperature have more thermal energy than an object at a higher temperature?
- What is the relationship between the various disciplines in the field of thermal science?
- How can cyclic thermodynamic cycles be employed to drive machines, such as aircraft?

## Knowledge and Skills

**Unit Content:**

All of the previous units explained how different flight surfaces produced the aerodynamic forces required to produce the lift and balance the moments required for steady flight. This study culminated in the ability to characterize the total drag of an aircraft. The remainder of the course is designed to introduce student to the various means of producing the propulsion required to counter this total aircraft drag. Since all aircraft engines are examples of heat engines, the remainder of the course provides an opportunity for students to learn about heat, thermodynamics, and heat transfer. This first unit regarding propulsion introduces fundamental concepts of thermodynamics. The two units that follow will apply these notions of thermodynamics to piston engine and jet engines, respectively. The course will close with a brief survey of high-speed aerodynamics. High speed aerodynamics, defined as aerodynamic conditions that exist when aircraft are traveling so fast that the compressible nature of air must be taken into account, is a combination of the fluid mechanics and thermodynamics presented throughout the whole course.

- Principles of Propulsion: Application of Newton’s Laws or Conservation of Momentum (1 day)
- Review of Heat vs. Temperature & the Zeroth Law of Thermodynamics
- Conservation of Energy and the 1$^{st}$ Law of Thermodynamics

- Thermal Processes and PV diagrams
- Isothermal and Adiabatic Changes of an Ideal Gas
- Cyclic Processes and the Carnot Cycle

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

This entire unit is composed of fundamental physics content that forms the foundation further study regarding aerospace propulsion.

## Resources

**Textbook(s):**

Hurt, H. H. (1965). *Aerodynamics for Naval aviators*. Washington, DC: Federal Aviation Administration.

**Lab Equipment:**

Vernier Thermal Science Lab equipment

**Computer Software:**

Microsoft Excel

Hyper Physics Site

NASA Site