4 Performance

Content Area: **Science**
Course(s): **Aerospace Engineering**
Time Period: **Semester 1**
Length: **2 Weeks**
Status: **Published**

Standards

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).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.
STEM.9-12.9.4.12.O.(2).4	Use scientific and mathematical problem-solving skills and abilities to develop realistic solutions to assigned projects, and illustrate how science and mathematics impact problem-solving in modern society.
STEM.9-12.9.4.12.O.(2).6	Demonstrate the knowledge and technical skills needed to obtain and succeed in a chosen scientific and mathematical field.

Enduring Understandings

1. Since the performance of an airplane is largely based on the density of the surrounding air, the performance of an airplane (its speeds, climb rates, takeoff and landing distance, etc.) vary tremendously based on the weather and the location where the airplane is flying.

2. The weight of an aircraft affects its performance, and since pilots and engineers cannot change the density of the air, the weight must be varied to obtain critical performance measures.

3. The safety of all flights are checked by ensuring that the aircraft performance meets or exceeds what is required to takeoff, climb, cruise, and land in the given conditions.

4. Aircraft performance differs from design to design and a large part of the test flight program is to obtain the performance data that will be used to construct the performance charts/tables used by pilots and dispatchers to ensure the safety of planned flights.

5. “Density altitude” is a way of representing the current density of the atmosphere at some location in terms of an equivalent altitude in a standard atmosphere, and it is a convenient way to represent air density for performance calculations.

Essential Questions

1. How can aircraft operators be sure their aircraft will be able to takeoff, climb out, fly to a distant destination, and safely land within the weather and logistical constraints surrounding the flight?

2. How can graphs and tables be created to depict values based on many related quantities or variables?

3. How do internationally recognized standards, such as the standard atmosphere, simplify the communication of design specifications and product performance despite the varying conditions in which a machine will operate?

Knowledge and Skills

Knowledge:

- In the absence of intermolecular attractive forces, the relationship between the temperature, pressure, and density of a gas can be given state equation, or the ideal gas law. The law states that the density of a gas increases as pressure increases, or as the temperature decreases. This is a combination of Charles's Law and Boyle's Law.
- The performance of any aircraft is based on the density of the air passing over it, however there is no "density meter" which can directly measure density. As a result, engineers and pilots indirectly measure density by taking direct measurements of temperature and pressure (which are measurable with thermometers and barometers, respectively).
- Aircraft performance is a general term for measurements that quantify the aircraft's required takeoff distance, its rate of climb after takeoff, its cruising range/speed/endurance, and its required landing distance (among many others). Each of these performance quantities is based on primarily on two factors: (1) the density of the air, and (2) the weight of the airplane.
- The more dense the air, the more air molecules present to contribute to the production of lift and thrust, and the greater the aircraft's performance. Since density is not directly measurable, the higher the barometric pressure and cooler the air the greater a given aircraft's performance.
- The greater the weight of the aircraft, the less able the aircraft is to take off in a given distance, climb at a given rate, etc. Thus, if temperatures are high and/or pressures are low, it is imperative that the weight of the aircraft be lowered to obtain required performance values.
- Rather than depict the density of the air in kilograms of mass per unit volume, aerospace engineers and pilots state the density of the air in terms of "density altitude". The density altitude at some location is the altitude in a standard atmosphere where the air has the equivalent density to the air at that location.
- Other factors may affect specific aircraft performance measures. For example, the type of runway surface and the upslope/downslope of a runway will, in addition to air density and aircraft weight, affect takeoff performance.
- Engineers represent how performance values change with the various factors (weight, air temperature, air pressure, etc.) using either tables or graphs. These tables and graphs are complex because they represent how a single performance characteristic varies across multiple variable.

Skills:

- Students will have the ability to read tables and graphs that represent how a dependent variable changes with respect to multiple independent variables.
- Students will be able to interpolate to find values between individual data points on data tables.
- Students will be able to make technical decisions by assessing multiple factors based on physical principles.

Transfer Goals

- Students will have the ability to interpret both charts and graphs where a single dependent variable varies with multiple independent variables.
- Students will be able to use linear interpolation to find values between given values on a table, and understand that a linear interpolation is based on the assumption of linearity between points.
- Students will be able to make comparisons between charted values by converting units (include units of time) from one system to another.

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

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