1 Flight Mechanics

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

Standards

CCSS.Math.Content.HSA-CED	Creating Equations
CCSS.Math.Content.HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
CCSS.Math.Content.HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
CCSS.Math.Content.HSA-REI.A.1	Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.
CCSS.Math.Content.HSA-REI.A.2	Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.
CCSS.Math.Content.HSA-REI.B	Solve equations and inequalities in one variable
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-PS3-5.2	Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
SCI.9-12.HS-PS3-1.4.1	Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
SCI.9-12.HS-PS3-1.5	Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
SCI.9-12.HS-PS3-1.5.1	Create a computational model or simulation of a phenomenon, designed device, process, or system.
SCI.9-12.HS-PS1-2.6.1	Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
SCI.9-12.HS-PS2-6.8.1	Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Enduring Understandings

1. The principles of physics are universally applicable to all objects. For example, the vector analysis of a mass on an incline is physically analogous to vector analysis of the forces acting on an airplane in a steady climb or descent, and while the object's in question and their respective situations are different,

the analysis is exactly the same and yields the same conclusions.

2. While the quantity of mass alone determines the magnitude of a linear acceleration due to a net force, the mass and its distribution determines the magnitude of a rotational acceleration due to a net torque.
3. An aerodynamic force is a force generated on an object as a result of the motion of air over an object. The component of this aerodynamic force parallel to the motion of the oncoming air is referred to as drag, while the component perpendicular to this oncoming air is referred to as lift.
4. The motion of all airplanes is the result of the magnitude and direction of four fundamental forces: lift, drag, thrust, and weight.
5. Control surfaces (referred to as the ailerons, elevators, and rudder) control rotations (respectively known as roll, pitch, and yaw), around the three axes about which an aircraft rotates (the longitudinal, lateral, and vertical axes, respectively).

Essential Questions

1. How can a system of classification organize flying machines by structure and function to facilitate their analysis in much the same way that binomial nomenclature classifies organisms to facilitate their study?
2. In what way are forces, which interact with an object's mass to cause translational motion along three axes, analogous to torques, which interact with an object's moment of inertia to cause rotation about the same three axes?
3. How are basic problems in physics (such as a mass on an incline, or a bucket swinging in horizontal circles on a rope) exactly the same as seemingly different situations in aeronautics, such as an airplane in a steady climb/descent or in a turn?

Knowledge and Skills

Knowledge:

- The Federal Aviation Administration classifies aircraft into different categories (airplane, rotorcraft, powered lift, lighter-than-air, etc.), and each of these categories into different classes (single-engine landplane, multi-engine seaplane, etc.), to facilitate certification of both the aircraft and the crew's the operate them.
- Different airplanes, though wildly different in design, all share common components, each of which must be familiar when studying the overall design and operation of aircraft.
- Forces are the "pushes" and "pulls" that act on a mass, and according to Newton's Second Law, when they are unbalanced they cause the mass to accelerate.
- There are four forces that act on all airplanes, lift, drag, thrust, and weight.
- Trigonometry can be used to break forces acting at angles into components, and these components can be used to predict the net result of these forces' action.
- When the forces acting on an airplane in a climb are analyzed using trigonometry, it is found that the angle of the climb depends upon the difference between the thrust and drag and not the difference between lift and drag.
- Airplanes turn due to their bank angle, which directs the wing's lift diagonally. While the vertical

component of this lift supports the airplane's weight, the horizontal component acts perpendicular to velocity to make the airplane change direction in uniform circular motion.
- The basic net force equations in the horizontal and vertical directions for an aircraft in a turn can be manipulated to find the commonly used equations for the radius of a turn and the rate of turn.
- Rotational acceleration is caused by a net torque, just as linear acceleration is caused by a net mass. The ailerons, rudder, and elevator of an airplane aerodynamically generate net torques about their respective axes that rotate the aircraft in flight.

Skills:

- Students will be able to design and create spreadsheets that perform engineering calculations, including the use of trigonometry, to solve problems.
- Students will be able to read basic three-view drawings (orthographic drawings) and assembly drawings in order to build functional model airplanes.
- Students will be able to carry out an investigation of the behavior of a model airplane when its control surfaces are manipulated and recognize the importance of repeating steps until repeatable results are obtained.
- Students will be able to objectively document the results of an investigation.

Transfer Goals

- Establishing the results of a measurement or observation by repeating the observation or measurement until the results converge on a single repeatable value or distinct trend.
- Creating and using force diagrams as the foundation for a mathematical model of a physical problem.
- Recognizing accelerations, be they linear or rotational, as the result of an imbalance of forces or torques.

Assessments

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

Modifications

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

Textbook Resources

Anderson, J. D. (1989). *Introduction to flight* (3rd ed.). McGraw-Hill Book Company.

Anderson, D. F., & Eberhardt, S. (2010). *Understanding flight* (2nd ed.). The McGraw-Hill Companies, Inc.

Dusenbury, M., Ullrich, G., & Balogh, S. (2016). *Aerodynamics for aviators* (2nd ed.). Aviation Supplies and Academics, Inc.

Federal Aviation Administration. (2016). *Pilot's handbook of aeronautical knowledge* (Manual H-8083-25B). Federal Aviation Administration.

Hurt, H. H. (1965). *Aerodynamics for Naval aviators*. Aviation Supplies and Academics, Inc.

Jeppesen Sanderson. (1986). *Aviation fundamentals*. Jeppesen Sanderson, Inc.

Jeppesen. (2018). *Guided flight school discovery: Private pilot*. Jeppesen Sanderson, Inc.

Jeppesen Sanderson. (1990). *Private pilot manual*. Jeppesen Sanderson, Inc.

Serway, R. A., & Faughn, J. S. (2006). *Physics*. Holt, Rinehart, and Winston.

Smith, H. C. (1992). *The illustrated guide to aerodynamics* (2nd ed.). TAB Books Division of McGraw-Hill, Inc.

Zitzewitz, P. W., Guitry, N. D., Kramer, G. W., Davids, M., Hainen, N. O., Nelson, J. B., & Nelson, J. (2002). *Physics: Principles and problems*. Glencoe McGraw-Hill.