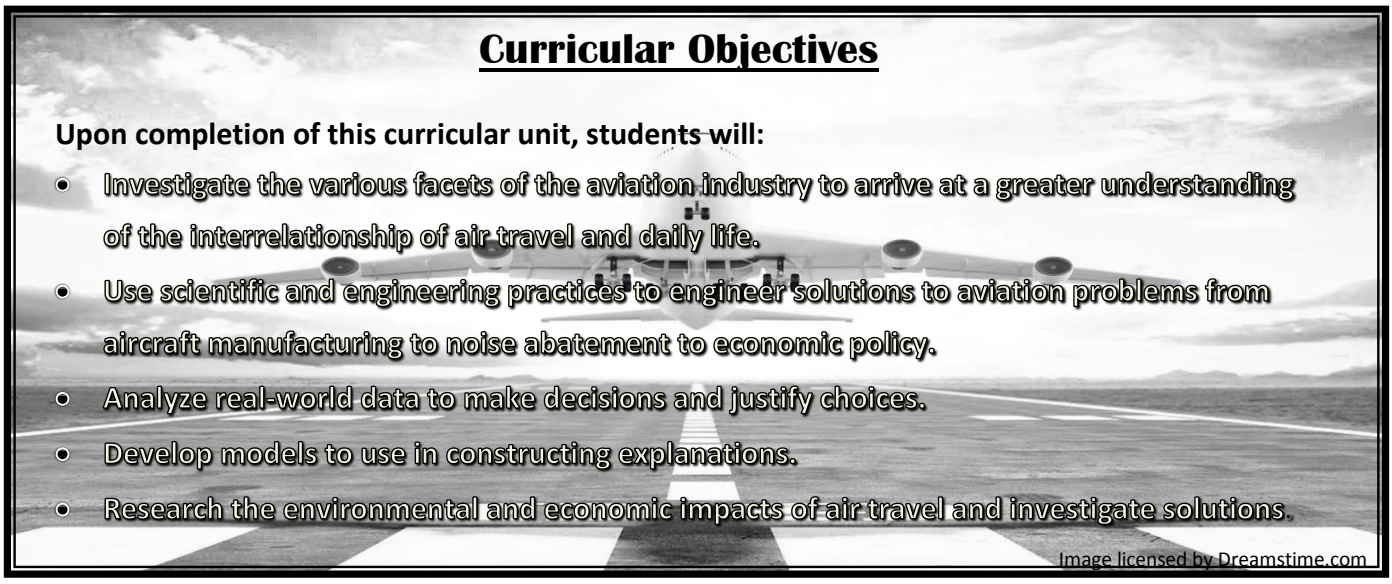
Curricular Objectives and Background Information



Curricular Objectives

Upon completion of this curricular unit, students will:

- Investigate the various facets of the aviation industry to arrive at a greater understanding of the interrelationship of air travel and daily life.
- Use scientific and engineering practices to engineer solutions to aviation problems from aircraft manufacturing to noise abatement to economic policy.
- Analyze real-world data to make decisions and justify choices.
- Develop models to use in constructing explanations.
- Research the environmental and economic impacts of air travel and investigate solutions.

Logistics

Class Size: 30 Middle Level 6 – 8 students

Location: Most activities are completed in a classroom and/or computer lab. However, several activities require outdoor space or hallway space. See specific activities for details.

Time: This curriculum is designed for 32 content hours. Unit times vary from approximately 3 – 6 hours with activities typically 1 to 2 hours. Refer to each activity for more specific time breakdowns.

Introduction

In less than 100 years, commercial aviation has evolved from a speculative novelty to a driving engine in the American economy. The world has become a smaller, more accessible place to those who can afford a ticket. Globally, the number of people who can afford air travel continues to grow at a steady rate. Aircraft manufacturers are pioneering advances in science and technology to produce increasingly sophisticated airliners that can handle the demand without producing unacceptable impacts on the environment. The infrastructure to operate these growing air fleets has also pushed the boundaries of engineering and economics.

Most air travelers take the entire experience of flying from one city to another for granted yet they have little understanding of what is happening around them. They catch cryptic snippets of conversation from the cockpit. They watch technicians scurry about ramps and runways marked with mysterious lights and coded signs. They fidget in seats which seem impossibly cramped.

They marvel at the thunderous roar of engines which push them into the sky, but are completely unaware of the science and technology which will ensure their safe arrival at the final destination.

Studying the basic principles of flight has long been a staple of middle school physical science curricula. *Take Flight* steps beyond those basics to examine the Science, Technology, Engineering, and Mathematics involved in every aspect of the modern aviation industry. At the conclusion of this curriculum, students will have a greater appreciation of how air travel works and what is going on behind the scenes. They may even want to pursue a career in the industry.

National Standards

Next Generation Science Standards:

MS ESS2-5: *Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions*

MS ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment*

MS ESS3-5: *Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century*

MS-ETS1-1 *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions*

MS-ETS1-2 *Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem*

MS-ETS1-3: *Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success*

MS-ETS1-4 *Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be reached*

MS-PS2-1 *Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects*

MS-PS2-5 *Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact*

MS-PS4-1 *Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave*

MS-PS4-2 *Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials*

Crosscutting Concepts: Cause and effect: Mechanism and explanation.

Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Crosscutting Concepts: Scale, proportion, and quantity

In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Crosscutting Concepts: Systems and system models

Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Science and Engineering Practices:

SEP1: *Asking questions and defining problems*

SEP2: *Developing and using models*

SEP3: *Planning and carrying out investigations*

SEP4: *Analyzing and interpreting data*

SEP5: *Using mathematics and computational thinking*

SEP6: *Constructing explanations and designing solutions*

SEP7: *Engaging in argument from evidence*

SEP8: *Obtaining, evaluating, and communicating information*

Next Generation Science Standards Reference:

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By State*s. Washington, DC: The National Academies Press.

Mathematics Common Core Standards

CCSS.Math.Content.5.OA.B *Analyze patterns and relationships*

CCSS.Math.Content.6.EE.A *Apply and extend previous understandings of arithmetic to algebraic expressions*

CCSS.Math.Content.6.EE.A.2 *Write, read, and evaluate expressions in which letters stand for numbers*

CCSS.Math.Content.6.EE.B *Reason about and solve one-variable equations and inequalities*

CCSS.Math.Content.6.EE.C.9 *Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time.*

CCSS.Math.Content.6.NS.C.8 *Solve real world and mathematical problems by graphing points in all four quadrants of the coordinate plane*

CCSS.Math.Content.6.RP.A *Understand ratio concepts and use ratio reasoning to solve problems*

CCSS.Math.Content.6.SP.B *Summarize and Describe Distributions*

CCSS.Math.Content.7.G.A.1 *Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale*

CCSS.Math.Content.7.EE.B *Solve real-life and mathematical problems using numerical and algebraic expressions and equations*

CCSS.Math.Content.7.NS.A.3 *Solve real-world and mathematical problems involving the four operations with rational numbers*

CCSS.Math.Content.7.G.B *Solve real-life and mathematical problems involving angle measure, area, surface area, and volume*

CCSS.Math.Content.7.RP.A *Analyze proportional relationships and use them to solve real-world and mathematical problems*

CCSS.Math.Content.7.RP.A.2 *Recognize and represent proportional relationships between quantities*

CCSS.Math.Content.7.SP.C *Investigate chance processes and develop, use, and evaluate probability models*

CCSS.Math.Content.HSN.Q.A.1 *Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays*

CCSS.Math.Content.HSN.VM.A *Represent and model with vector quantities*
CCSS.Math.Content.HSN.VM.A.1 *Recognize vector quantities as having both magnitude and direction*
CCSS.Math.Content.HSN.VM.A.3 *Solve problems involving velocity and other quantities that can be represented by vectors*

Mathematical Practices:

CCSS.Math.Practice.MP1 *Make sense of problems and persevere in solving them*
CCSS.Math.Practice.MP2 *Reason abstractly and quantitatively*
CCSS.Math.Practice.MP3 *Construct viable arguments and critique the reasoning of others*
CCSS.Math.Practice.MP4 *Model with mathematics*
CCSS.Math.Practice.MP5 *Use appropriate tools strategically*
CCSS.Math.Practice.MP6 *Attend to precision*
CCSS.Math.Practice.MP7 *Look for and make use of structure*

Common Core English Language Arts (ELA) Standards

6.RI.7 *Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue*
6-8.RH.7 *Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts*
6-8.SL.1 *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on middle school topics, texts, and issues, building on others' ideas and expressing their own clearly.*
6-8.SL.4 *Present claims and finding, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details*
SL.6-8.6 *Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate*
6-8.RST.3 *Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks*
6-8.RST.7 *Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually*
6-8.RST.9 *Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic*
6-8.W.1 *Write arguments to support claims with clear reasons and relevant evidence*
6-8.WHST.2 *Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content*
6-8.WHST.7 *Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of*
6-8.WHST.9 *Draw evidence from informational texts to support analysis, reflection, and research*

Common Core Mathematics and ELA Standards Reference:

Authors: National Governors Association Center for Best Practices, Council of Chief State School Officers Title: Common Core State Standards Publisher: National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington D.C. Copyright Date: 2010

Unit Summaries

The activities in *Take Flight: Investigating the Aviation Industry* lead students through an exploration of the world of commercial aviation.

✈ Unit 1 Design and Engineering

The design and production of commercial airliners is big business. Boeing estimates that from 2014 to 2033 there will be a demand for 36,700 new airliners, worth over five trillion dollars. Students will learn how airliners are designed and manufactured, from the raw materials to the final application of paint. Students will play the role of engineers and executives to experience some of the critical decisions necessary to bring a modern airliner from the drawing board to the flight line.

✈ Unit 2 Wind Beneath the Wings?

In this unit, students will begin to form an understanding of the conditions that are necessary in order to allow an aircraft weighing over 1.2 million pounds to get off the ground. Students will use various materials to investigate the variables that are important for lift, with special emphasis being placed on the shape of an airfoil, angle of attack, and airspeed.

✈ Unit 3 What Goes Up … Must Come Down: Runway Math

Airliners are useless without properly engineered runways. In this unit students will study the basic math behind the winds which constrain the design and naming of runways around the world. A special emphasis is placed on the airports in Illinois, with which students are most likely to become familiar.

✈ Unit 4 Take to the Skies: Navigation by Air

Now students take the controls and experience what pilots must do to find their way from one airport to another. Maps, charts, software, and other navigational tools are placed in their hands for simulated flights. Students learn why pilots follow the paths they do and why the most efficient path may be far more sensible in the air than it appears on paper.

✈ Unit 5 Air Traffic Control

Large commercial airliners are guided along highways-in-the-sky by a dedicated team of professionals on the ground. From the moment it pushes back from the gate to the moment it is parked at the final destination, an airliner is guided by instructions from a succession of air

traffic controllers. Students will learn how the process works and then assume the role of a controller in computer simulations. After learning how to safely guide airliners on a computer screen, students will demonstrate their skills by guiding blind-folded classmates in a kinesthetic activity that emphasizes the importance of communication skills. Students who might consider a career as an air traffic controller will be given a battery of game-like tests to see if they have the necessary skills.

✈ Unit 6 Environmental Concerns

As with every mode of travel based on fossil fuels, commercial aviation has a significant impact on the environment. Pollution from aircraft exhaust can impair human health by reducing air quality. CO_2 and contrails can contribute to global climate change. On the local level, noise can degrade the quality of life for those living near an airport. Students will learn about each of these phenomena and end the unit with an engineering design activity that models the work being done to reduce the noise from commercial jet engines.

✈ Unit 7 Economic Issues

Airlines operate in a fiercely competitive business climate. They face huge operating expenses, thin profit margins, and the uncertainties of weather, labor relations, and the fluctuating budgets of potential air travelers. Making sound forecasts and shrewd business decisions calls for a highly analytical approach to problem solving. The laws of probability and statistics rule. Students will examine the practice of overbooking to see why airlines rely on this controversial technique. They will also consider the economic impacts of organizing air-routes and establishing geographic hubs for their fleets of airliners.

✈ Unit 8 Take Flight: Culminating Activity

Now that students understand how many different professionals are involved in the aviation industry, they may examine the possibility of a career in the industry with the optional *Careers in the Aviation Industry* activity. Anyone with an interest in math or science would find many rewarding possibilities. Finally, students will end their year with an engineering design challenge to build gliders and compete with their classmates to produce an aircraft with superior flight characteristics.

In this curriculum, middle-school students will be immersed in the various facets of the aviation industry ranging from aircraft design and assembly, airport structure and runway design, navigation, and air traffic control, to the economic and environmental impact aviation has on their lives.

Unit Objectives

Design and Engineering

The students will:

- Design a custom livery for a fictional commercial airliner and research the importance of a recognizable brand.
- Investigate the properties of composite materials and learn about their use in commercial aircraft.
- Learn about the various systems that must be managed to manufacture a commercial aircraft from design and ordering through final assembly and testing.

Wind Beneath the Wings?

The students will:

- Investigate the lift force of flight.
- Compare Bernoulli's and Newton's theories of lift.
- Design and test an airplane's wing using an online computer simulation inspired by the Wright Brothers.

What Goes Up...Must Come Down: Runway Math

The students will:

- Investigate the role that air and wind play in the takeoff and landing of aircraft.
- Use real-world wind data to construct a wind rose diagram and use the diagram to determine runway placement.
- Understand how runways are named and investigate the impact of earth's changing magnetic field on runway designations.
- Interpret FAA airport diagrams.

Take to the Skies: Navigation by Air

The students will:

- Understand basic air navigation techniques such as pilotage and dead reckoning.
- Explore why two-dimensional flight paths look curved at higher latitudes.
- Read aeronautical charts to determine headings to fly to a destination and plan a short trip by air using online software.
- Investigate sectional maps and use navigational tools to deduce locations.

Take Flight:
Investigating the Aviation Industry

Air Traffic Control

The students will:

- Learn about the United States' air traffic control system as a model to safely direct aircraft through controlled airspace.
- Investigate the skills and habits of mind that air traffic controllers utilize.
- Understand the importance of aircraft separation and use mathematics and a simulation model to explore the idea of separation.
- Use teamwork and communication to model and navigate a simulated controlled air route.

Environmental Concerns

The students will:

- Design and build structures to minimize noise pollution from jet engines.
- Use models to predict when aircraft will produce contrails.
- Learn the impact contrails and exhaust have on global climate.

Economic Issues

The students will:

- Use polyhedra dice to simulate airport delay probabilities for a four-leg aviation itinerary.
- Mathematically determine the likelihood of being bumped from a flight based upon the aviation industry practice of overbooking and determine if the practice of overbooking is economically advantageous to airlines.

Take Flight: Culminating Activity

The students will:

- Design, build, and test a balsa glider to maximize lift and glide time.
- Conduct trials during a "competition" and analyze data to determine what necessary modifications would be made in future product iterations.