AOPA Aviation STEM Curriculum

Career Pathways and Course Descriptions

Presented by Purdue University and the Aircraft Owners and Pilots Association
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AOPA, in partnership with Purdue University, is building high school aviation STEM curricula that will fit within career and technical education pathways. We will offer a four-year curriculum for each pathway—pilot, aerospace engineering, and unmanned aircraft systems (UAS). Each pathway will help students build career-ready skills while they learn more about opportunities in aviation and aerospace.

Following are descriptions of the three career pathways and explanations for each course. Courses will use innovative instructional strategies and offer active learning experiences—including scientifically designed, hands-on projects—to help students acquire knowledge, skills, and abilities. Each pathway will culminate in a capstone project, for which project ideas and support will be provided.

The curricula will be designed for use in high school-level career and technical educational programming and will be built to conform to Indiana's career and technical educational requirements, making it easier to obtain approval in other states.

Career Pathway Descriptions

Pilot

The Pilot pathway will teach students what it takes to fly for a living. An economic analysis of future demand estimated that the U.S. airline industry will need 95,000 new pilots over the next 20 years. This pathway will introduce students to safety, aerodynamics, aircraft systems, instrumentation, flight physiology, flight planning, flight maneuvers, and more. Other topics include aviation history, contemporary aviation issues, and postsecondary education and employment opportunities. Upper level courses in this pathway will prepare students for transition into postsecondary aviation education and careers in aviation industry. A primary objective of this career pathway is to prepare students to take the *Federal Aviation Administration Private Pilot* written examination.

Unmanned Aircraft Systems (UAS)

The Unmanned Aircraft Systems (UAS) pathway will expose students to this increasingly popular and growing technology. UAS, commonly referred to as drones, are used in operations such as security, search and rescue, disaster management, agriculture, photography, videography, and much more. Students in this pathway will learn about small aircraft operations and what it takes to fly and operate a drone. The UAS courses will cover safety, drone design and maintenance, aerodynamics, mission selection and planning, weather, airspace, regulations, systems and sensors, system automation, programming, and ethics. Upper level courses in this pathway will prepare students for transition into postsecondary aviation education and careers in the aviation industry. A primary objective of this career pathway is to prepare students to take the *Federal Aviation Administration Part 107 Remote Pilot Certificate* written examination.

Aerospace Engineering

The Aerospace Engineering pathway will allow students to extend their creativity and explore ways in which they can impact the future of aerospace. Students enrolled in this pathway will explore the evolution of flight, examine contemporary aviation issues, and identify future opportunities for innovation. Students who progress through this pathway will learn fundamental concepts such as aerodynamics, engineering design process, principles of engineering, materials and structures, aircraft design, testing, propulsion, flight systems, technical reports, sustainability, engineering drawing, and industry-standard 3D modeling software. Advanced topics in this pathway will give students foundational skills and knowledge needed to pursue postsecondary education programs and employment in the aerospace industry. A primary objective of this pathway is for students to complete a capstone project applying the engineering design process using industry-standard 3D modeling software.

Course Outline

	9th Grade		10th Grade		11th Grade		12th Grade	
	Semester 1	Semester 2	Semester 1	Semester 2	Semester 1	Semester 2	Semester 1	Semester 2
Pilot	Principles of Aviation and Aerospace	Exploring Aviation and Aerospace	Introduction to Flight	Aircraft Systems	Private Pilot Fundamentals I	Private Pilot Fundamentals II	Aviation Safety	Pilot Capstone
Unmanned Aircraft Systems					UAS Operations I	UAS Operations II	UAS Design and Applications	UAS Capstone
Aerospace Engineering			Aerodynamics for Engineers	Principles of Engineering for Aerospace Applications	Aerospace Materials	Aerospace Engineering Drawing	Advanced Aerospace Design	Aerospace Engineering Capstone

All students will begin with “Introduction to Aviation and Aerospace” and “Exploring Aviation and Aerospace” in the ninth grade.

At the culmination of the ninth grade, students can choose to enter the Aerospace Engineering pathway or continue down the Pilot/UAS pathway.

At the culmination of the tenth grade, those students who chose the Pilot/UAS pathway can then specialize in either Pilot or UAS.

Course Descriptions

Ninth Grade Courses

All Students/All Pathways

Semester 1

Principles of Aviation and Aerospace

This core aerospace and aviation course provides the foundation for all three pathways. Students will gain historical perspective starting from the earliest flying machines to the wide variety of modern aircraft and the integral role they play in making today's world work. Students will learn about the history and impact of space exploration and have many opportunities to build and fly historical and contemporary aircraft and spacecraft designs.

Students will also begin to drill down into the various sectors of aviation, including the airlines, general aviation, military, commercial space, and unmanned aircraft. They'll discover how advances in aviation created a need for regulation, and will learn about the promulgation of civil aviation oversight.

Learning Objectives

1. Understand the historical progression of flight and the aviation system that surrounds it today
2. Identify significant aircraft and iconic individuals in aviation
3. Differentiate among general aviation, military operations, and the airlines
4. Describe the history and development of space exploration, including commercial space
5. Understand the roles of government agencies that support or oversee aviation
6. Describe milestone aviation legislation and regulation
7. Begin to explore specific aviation sectors such as airport operations, cargo aviation, unmanned aircraft systems, air traffic control, and more

Units

1. Introduction to Aerospace and Aviation
2. Aviation and Aerospace History (13th century-1903)
3. Aviation and Aerospace History (1903-Present)
4. Government Agencies, Aviation Legislation and Regulation
5. Aviation and Aerospace Sectors

Ninth Grade Courses

All Students/All Pathways (Continued)

Semester 2

Exploring Aviation and Aerospace

This core aerospace and aviation course provides the foundation for all three pathways. It is designed to give students a clear understanding of career opportunities in aviation and aerospace and the critical issues affecting the aviation system. Students will explore modern day innovations and use technology to develop their own innovative ideas to address real-world challenges facing the aviation industry. They will be exposed to a variety of career options in aviation and aerospace and take an in-depth look at the opportunities available. For schools offering multiple pathways, this course will allow students to begin to define their individual interests. Additionally, options will be provided to participate in national aviation/aerospace high school competitions.

Learning Objectives

1. Understand important issues affecting aviation and aerospace today
2. Make connections between future opportunities in aviation and the careers associated with them
3. Be able to articulate intended and unintended consequences of aviation advancement
4. Identify a current and future problem in aviation, and present a unique innovative idea to address it
5. Describe relevant careers in different sectors of aviation and aerospace

Units

1. Contemporary Aerospace and Aviation Issues
2. Future of Aviation and Aerospace, including commercial space
3. Opportunities for Aviation and Aerospace Solutions
4. Careers in All Sectors of Aviation and Aerospace

Tenth Grade Courses

Pilot/UAS Pathway

Semester 1

Introduction to Flight

This course will introduce students to basic aircraft and UAS structures and their major components, principles of flight, and the fundamental physical laws affecting flight. Students will learn about basic aerodynamics and forces that act on aircraft in flight. This course will provide students with a foundational understanding of basic physics concepts related to flight. Design characteristics will be covered, including concepts surrounding aircraft stability, controllability, and the effect of weight and balance on flight performance. Finally, the course will cover primary and secondary flight control systems.

Learning Objectives

1. Identify major components of an aircraft, including UAS
2. Articulate the fundamental physical laws governing the forces acting on an aircraft
3. Learn the basic concepts of Bernoulli's Principle and Newton's Laws
4. Identify and describe the four forces that act on an aircraft during flight
5. Identify the axes about which an aircraft rotates related to its attitude or position in flight
6. Understand the effects of weight and balance on flight
7. Articulate characteristics of primary and secondary flight controls

Units

1. Aircraft Structure (airplane and UAS)
2. Principles of Flight (including vertical flight)
3. Basic Aerodynamics
4. Weight and Balance
5. Flight Controls

Tenth Grade Courses

Pilot/UAS Pathway (Continued)

Semester 2

Aircraft Systems

This course will introduce the main systems found on large and small airplanes and UAS. It will cover the different types of power plants and how they support the operation of the aircraft. Students will learn about several different types of fuel systems and gain an understanding of the critical components of aircraft electrical systems. The lessons will include sensors, electronic components, and ground control stations, which are parts of UAS systems. Finally, students will learn about various systems that drive flight instruments and how those flight instruments operate.

Learning Objectives

1. Describe the different types of aircraft power plants (turbine, reciprocating engine, and UAS propulsion) and their critical components
2. Explain the process of fuel combustion and its relationship to power production
3. Understand differences between basic and advanced fuel systems
4. Know the primary components of an aircraft electrical system, including UAS
5. Describe the aspects of a pitot-static system and its associated instruments
6. Describe the aspects of a vacuum-driven system and its associated instruments
7. Understand the basics of a magnetic compass and how it works

Units

1. Power plant (turbine, reciprocating, UAS propulsion)
2. Fuel Systems
3. Electrical Systems
4. Flight Instruments (including vacuum and pitot-static)

Tenth Grade Courses

Aerospace Engineering Pathway

Semester 1

Aerodynamics for Engineers

Aerodynamics for Engineers is a foundational course that will introduce the principles of flight and aerodynamics and lay the ground work for applying engineering principles. This aerodynamics course focuses on the study of the flow of air about an airfoil. Students will interact with technology which simulates various airfoil designs and determines airflow around various shapes. Students completing this aerodynamics course will gain a fundamental understanding of mathematical and physical concepts and models used to aerodynamically analyze and design subsonic, transonic, and supersonic aircraft.

Learning Objectives

1. Calculate associated forces and conditions of flight
2. Evaluate the four major forces that act on an aircraft flying in the Earth's atmosphere
3. Identify the control surfaces of an aircraft and the impact of each on the axis of rotation and motion
4. Hypothesize the flight characteristics of an airfoil
5. Compare and contrast the various methods by which different aerospace technologies achieve and maintain stable flight

Units

1. Four forces of flight
2. Flight controls and axes
3. Atmospheric conditions and effects of aerodynamics
4. Aerodynamics of subsonic, transonic, and supersonic flight

Tenth Grade Courses

Aerospace Engineering Pathway (Continued)

Semester 2

Principles of Engineering for Aerospace Applications

This course introduces aerospace engineering as an interdisciplinary profession, including other areas of engineering. Students will learn the engineering design process, which includes defining the need or problem, researching related principles and solutions, creating designs, testing prototypes, evaluating, and redesigning. Relationships between aircraft performance and other aspects of engineering (i.e designing runways) will also be explored. Students will learn to analyze and interpret data to improve performance. While working alone and in groups on aerospace solutions, they will learn how to document progress and present results. Additionally, options will be provided to participate in national aviation/aerospace high school competitions.

Learning Objectives

1. Describe the important components of the engineering design process
2. Be able to collect, analyze, and interpret data
3. Identify sources of aerospace engineering analysis that consistently present valid data, principles, and conclusions
4. Conduct, document, and present aerospace engineering design studies

Units

1. Engineering Design
2. Scholarly Studies of Aerospace Engineering Principles
3. Maximizing the Forces of Flight
4. Reporting Results
5. Aerospace Engineering Exploration
6. Safety and Risk Management Concepts

Eleventh Grade Courses*

Pilot Pathway

Semester 1
Private Pilot Fundamentals I

This course is the first in a sequence of two in which students will prepare to take the *Federal Aviation Administration's Private Pilot* written exam. Topics include: pilot and aircraft qualifications, principles of flight, aerodynamics, spin awareness, flight maneuvers, pre- and post-flight procedures, airport operations, regulations, safety, weather, aircraft systems, weight and balance, human factors, cockpit management, emergency procedures, night operations, and aeronautical decision-making.

Semester 2
Private Pilot Fundamentals II

Successful completion of Private Pilot Fundamentals I is a prerequisite to taking Private Pilot Fundamentals II. This course will cover remaining topics necessary for students to take the *Federal Aviation Administration's Private Pilot* written exam. Students will learn cross-country flight planning, performance and limitations, airspace, chart use, aviation phraseology, radio communications, and navigation systems. Students will be provided the opportunity to participate in multiple practice examinations. At the end of this course, a school may choose to arrange for students to be signed off to take the *Federal Aviation Administration's Private Pilot* written exam.

* Learning objectives and units will be added to the eleventh and twelfth course descriptions as the curriculum nears development in 2018 and 2019

Eleventh Grade Courses*

UAS Pathway

Semester 1

UAS Operations I

This course is the first in a sequence of two in which students will prepare to take the *Federal Aviation Administration's Part 107 Remote Pilot* written exam. This course is an introduction to the fundamental concepts of unmanned aircraft systems. Topics include: small unmanned aircraft systems regulations, airspace classification and operating requirements, flight restrictions affecting small unmanned aircraft operation, safety protocols, weight and balance, operating environments, aviation weather sources and effects of weather (micro-meteorology) on small unmanned aircraft performance, small unmanned aircraft loading and performance, emergency procedures, and crew resource management.

Semester 2

UAS Operations II

Successful completion of UAS Operations I is a prerequisite to taking UAS Operations II. Topics will include: radio communications, small unmanned aircraft performance, flight physiology, ethics, human factors, aeronautical decision-making and judgment, airport operations, maintenance and preflight inspection procedures. Students will be provided the opportunity to participate in multiple practice examinations. Students will be prepared to complete the *Federal Aviation Administration's Part 107 Remote Pilot* written exam upon completion of this course.

* Learning objectives and units will be added to the eleventh and twelfth course descriptions as the curriculum nears development in 2018 and 2019

Eleventh Grade Courses*

Aerospace Engineering Pathway

Semester 1

Aerospace Materials

This course emphasizes the study of structural analysis, structural dynamics, structural design, and behavior of aerospace materials while considering basic aerospace physiological concepts. This includes topics that deal with the principles of mechanics and the theoretical, computational, and experimental techniques necessary to ensure the structural integrity of aerospace vehicles. Students will have an opportunity to explore various materials and structures that will impact the future of aviation and aerospace.

Semester 2

Aerospace Engineering Drawing

This course will serve as an introduction to computer-aided design (CAD) with aerospace applications. Through this course, students will learn the basics of drafting and computer-aided drawing techniques in both two- and three-dimensions. This course will introduce students to precision measuring tools, industry-standard design software, drawing mechanical parts of aircraft or spacecraft, isometric views, engineering diagrams and more.

* Learning objectives and units will be added to the eleventh and twelfth course descriptions as the curriculum nears development in 2018 and 2019

Twelfth Grade Courses*

Pilot Pathway

Semester 1
Aviation Safety

This course will help students develop an attitude and philosophy for safety of flight and accident prevention. Topics of study will include flight physiology, human factors, aeronautical decision making, preventative maintenance, cockpit and crew resource management, and an introduction to accident investigation. Students will analyze case studies of aviation accidents to identify common causes and prevention strategies.

Semester 2
Pilot Capstone

The Pilot capstone course is the culmination of the student's learning experience throughout this pathway. The students will work as individuals or in small groups to study and report on an approved aviation topic of their choosing. The goal of this capstone course is to allow students to demonstrate an understanding of a contemporary topic in aviation as it relates to flying. The curriculum will include suggestions for research topics or projects that can be adapted to match available resources.

* Learning objectives and units will be added to the eleventh and twelfth course descriptions as the curriculum nears development in 2018 and 2019

Twelfth Grade Courses*

UAS Pathway

Semester 1

UAS Design and Applications

This course will cover UAS design concepts, sensor capabilities, communication and data links, ground control station, and sense-and-avoid systems. Practical applications of UAS operations including agriculture, public safety, photography, ethics, preventative maintenance, commerce, environmental studies, and other contemporary uses will be explored. Current limitations and future capabilities will be addressed through a review of unmanned aircraft systems case studies.

Semester 2

UAS Capstone

The UAS capstone course is the culmination of the student's learning experience. Students will work as individuals or in small groups to study and report on an approved aviation topic of their choosing. The goal of this capstone course is to allow students to demonstrate an understanding of a contemporary topic in aviation related to unmanned aircraft operations. The curriculum will include suggestions for research topics or projects that can be adapted to match available resources.

* Learning objectives and units will be added to the eleventh and twelfth course descriptions as the curriculum nears development in 2018 and 2019

Twelfth Grade Courses*

Aerospace Engineering Pathway

Semester 1

Advanced Aerospace Design

This course will provide students the opportunity to participate in designing a prototype aircraft component, an aircraft, or a spacecraft, such as a rocket or unmanned device. Students may further explore aircraft materials and design, propulsion, aerodynamics, and thermodynamics. Students will use industry-standard 3D modeling software to experience the product development process in aerospace engineering.

Semester 2

Aerospace Engineering Capstone

The Aerospace Engineering capstone course is the culmination of the student's learning experience. The students will work as individuals or in small groups to design, create, test, and report on an approved aerospace engineering prototype of their choosing. The goal of this capstone course is to allow students to demonstrate an understanding of a contemporary challenge in aviation related to aerospace engineering. The curriculum will include suggestions for design projects that can be adapted to match available resources. Students will be prepared to complete an industrial certification exam in 3D modeling software upon completion of this course.

* Learning objectives and units will be added to the eleventh and twelfth course descriptions as the curriculum nears development in 2018 and 2019