AVIATION HIGH SCHOOL

Teach Science, Technology, Engineering, and Math through an exciting introduction to the aviation industry

FACILITATOR GUIDE

Brittany D. Hagen, Sarah K. Anderson, Leslie M. Martin, and Paul R. Snyder

AVIATION SUPPLIES & ACADEMICS, INC.
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Leslie Martin is an Associate Professor for the John D. Odegard School of Aerospace Sciences at the University of North Dakota in Grand Forks, North Dakota. She holds a Bachelor of Science in Aeronautics Commercial Aviation and a Master of Science in Education. Professor Martin teaches a wide variety of courses from Private Pilot to Certified Instrument Flight Instructor ground school and is a flight instructor and check pilot for UND Flight Operations. She also works part-time at the Grand Forks Public School District teaching a high school course titled Aviation Technology I to high school sophomores, juniors, and seniors. Professor Martin's research interests include Automatic Dependent Surveillance–Broadcast, weather technology in the cockpit, and unmanned aircraft systems (UAS).

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TO THE FACILITATOR

"The fascination of flight can't be expressed with words. But it really lies beyond the capabilities of human endeavor. Once you've experienced it, you'll never be able to forget it."[1]
—Friedrich Oblessor, 127 victories WWII

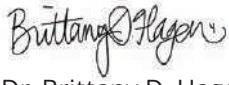
ALONG WITH Aviation Supplies & Academics, Inc. (ASA), we have created this *Facilitator Guide* and corresponding interactive *Student Notebook* to address a growing need for solid instruction, inquiry, and development of future-ready competencies in aviation at the high school level. The aviation industry continues to experience a shortage of professionals, and our goal with this curriculum is to help develop interest prior to collegiate training. We know facilitators of a high school introduction to aviation course may come from a variety of backgrounds; you may be an aerospace mechanic, engineer, private pilot, military personnel, airline pilot, or high school career and technical education teacher. Whatever background you bring to teaching, the goal of helping students experience the fascination of flight and a career in the aviation industry remains the same.

We hope you find the *Aviation High School Facilitator Guide* and *Student Notebook* two effective tools for introducing students to aviation. This guide provides you with curriculum for fourteen essential topics divided into chapters to engage the next generation of the aviation workforce. It has been backward-designed; that is, goals were set before choosing instructional methods and forms of assessment. We know that the industry offers great career opportunities. Through these lessons, students are provided with an understanding of the science of flight, the history of aviation, and possible career paths within the industry. *Aviation High School* also covers physics, the relationships of weight and balance, principles of navigation and flight control, ground and airport operations and services, and Federal Aviation Administration (FAA) regulations. The curriculum is intended to be used in a high school setting (grade levels 9–12), and is aligned to Next Generation Science Standards, Common Core State Standards for Math and Language Arts, and North Dakota Aviation Standards.

We also encourage you to check out the supplemental online Instructor Resources and other materials available from Aviation Supplies & Academics, Inc., at **www.asa2fly.com/instructor/avhsfg**. There you will find a variety of information and resources to support your use of the *Aviation High School Facilitator Guide* and *Student Notebook* in your classroom. If you have any comments or questions, please contact us.

Sincerely,

Leslie Martin, M.S.
Associate Professor of Aviation
Aviation High School Teacher



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HOW THIS GUIDE IS ORGANIZED

Your *Aviation High School* complete lesson plans are student-oriented, straightforward, and designed to be easy to follow. Each lesson is planned for a standard, 50-minute lesson time or could be combined to accommodate block scheduling.

Following is an explanation of how each chapter and lesson is organized and the educational tools and activities they include to help you fully utilize this guide and the accompanying student notebook in your classroom.

CHAPTER INTRODUCTION

Each chapter begins with an introductory section that includes information applicable across the entire chapter.

- **Standards and Objectives**—The applicable education standards for students who successfully complete activities in each chapter are indicated. These include lesson-aligned high school standards for North Dakota aviation, as authors are affiliated with the University of North Dakota and Mayville State University in North Dakota; Common Core State Standards (CCSS) for Math and Reading and Writing in Technical Subjects; and Next Generation Science Standards (NGSS). From these, lesson-specific measurable objectives can be specified by the facilitator.
- **Essential Questions**—These are questions you want students to be able to answer that point to the big ideas of a subject. A question can be considered essential when it helps students make sense of important but complicated ideas, knowledge, and know-how. A question is essential when it:
  - causes genuine and relevant inquiry into the big ideas and core content;
  - provokes deep thought, lively discussion, sustained inquiry, and new understanding as well as more questions;
  - requires students to consider alternatives, weigh evidence, support their ideas, and justify their answers;
  - stimulates vital, ongoing rethinking of big ideas, assumptions, and prior lessons;
  - sparks meaningful connections with prior learning and personal experiences; and/or
  - naturally recurs, creating opportunities for transfer to other situations and subjects
- **Lesson Outline**—The lessons included in the chapter are listed in order with the lesson numbers, titles, and corresponding *Student Notebook* activities for each.

LESSONS

Each lesson is separated into the following sections:

- **Purpose**—The purpose statement answers for the facilitator and students, "Why do I need to know/do this?" Simply put, when students understand the purpose of a lesson, they learn more. From the purpose statement, the facilitator's expectations can be well communicated in the form of learning goals, and there is clear intent of what the class will be doing and what students should be learning.
- **Accommodations for Students with Learning Needs**—This is included in every lesson as a reminder to the facilitator to plan for and accommodate the needs of learners, particularly those with identified disabilities. Lessons may be changed to accommodate your students with learning differences by referring to their personalized learning plan, Individualized Education Program (IEP), and/or 504 plans and working with special education and support staff in your school. A resource list of school accommodation and modification ideas for students who receive special education services from the PACER Center is linked in each lesson for convenient access (**https://www.pacer.org/parent/php/PHP-c267.pdf**).
- **Preparation**—This section notes materials that should be ready and accessible before the beginning of each class period and should be previewed before each lesson. Following are some of the resources needed throughout the course:
  - › *Aviation High School Student Notebook*
  - › FAA *Pilot's Handbook of Aeronautical Knowledge* (FAA-H-8083-25)
  - › FAR/AIM (Federal Aviation Regulations/Aeronautical Information Manual) or **eCFR.gov**
  - › FAA *Instrument Flying Handbook* (FAA-H-8083-15)
  - › FAA *Airplane Flying Handbook* (FAA-H-8083-3)
  - › FAA *Helicopter Flying Handbook* (FAA-H-8083-21)
  - › *Chart Supplements U.S.*
  - › Piper Archer (PA-28-181) Pilot's Operating Handbook (POH)
  - › Current VFR Sectional Chart for your local area (laminated)
  - › CP-1 Sectional Plotter
  - › E6-B Flight Computer
- **Directions:**
  - › **Introductory Activity**—This is also known as a hook, anticipatory set, or previewing strategy that is designed to grab the student's attention. It re-engages students in the topic being studied, builds excitement to learn, and puts students in a receptive frame of mind for the lesson.
  - › **Steps**—The step-by-step set of instructions for carrying out the lesson. You may want to discuss the plan with students before they begin the lesson so they know what to expect. Embedded in the steps of the lessons are common elements.
    - – *Multiple instruction strategies:* The type of instruction in each lesson is varied because transfer and retention are enhanced when multiple strategies are used to learn something; these include direct, indirect, independent, experiential, and interactive teaching methods.

- *Active processing:* The learner actively engages in cognitive processing for learning to occur, acting on instructional inputs to generate, reorganize, self-explain, or otherwise go beyond the presentation of material.
- *Formative assessment:* Assessment is conducted by the facilitator to monitor student learning, address problems immediately, and provide ongoing feedback that can be used by students to improve their learning; these checks for understanding are typically not graded.

› **Concluding Activity**—Closure strategies are done in a few minutes at the end of the lesson to help students organize their learning, to reinforce major points, to check on student learning, or to clarify any confusion. It brings the lesson to an end and helps students to make sense of what they just learned. Often this step can serve as a formative or summative assessment method.

- **Facilitator Information**—This includes content-specific information such as examples of images, completed graphic organizers, or exam questions that are helpful to the facilitator to prepare for the lesson and to reference during the lesson.

ASSESSMENTS

Assessment should provide evidence for the facilitator that students have learned and that they have met the objectives of a lesson or chapter. Activities included in each lesson can serve as measures of progress as well as assessment for you and your students. You will see various activities that can serve as informal (formative) and formal (summative) assessments for you to determine if students have met the learning goals. Formative assessment measures if the students are meeting the objectives *during* the lesson. These are often called checks for understanding. Summative assessment measures if the students have met the intended objectives *at the end* of the lesson. Formative and summative assessment methods can be interchangeable. For example, an ungraded quiz used as a formative assessment might also be used as a summative assessment at the end of a lesson or unit. Work that is formatively checked during lessons might be summatively assessed in a portfolio. Some examples of assessments include:

- rubrics
- exams
- checklists
- quizzes
- papers
- quick writes
- demonstrations of skills
- presentations
- graphic organizers
- inquiry projects
- simulations
- research projects
- informal observations of students working
- interviews
- real-life applications of skills (e.g., flight planning, scholarship and certificate applications)

AIRCRAFT REFERENCES

In this guide, lessons are structured to reference small general aviation aircraft, specifically the Piper Cherokee Archer (PA 28-181) and Cessna 172. If the facilitator is more familiar with a different type of aircraft, the authors suggest adding in personal examples or switching references to an aircraft that makes sense given resources and access to particular types of aircraft.

DEMONSTRATING CONCEPTS WITH FLIGHT SIMULATION AND/OR SMALL UNMANNED AIRCRAFT SYSTEMS (sUAS)

The authors recommend that key concepts of aeronautical knowledge and flight be demonstrated, if possible, using flight simulation and/or commercially available small unmanned aircraft systems (sUAS). Lesson plans can be implemented without flight simulation or a sUAS. However, simulation and sUAS utilization is encouraged as a way to engage and motivate students. Any lesson can be enhanced using simulation and sUAS at the facilitator's discretion. For example, in Chapter 8: Aerodynamics of Flight, the forces of thrust, lift, drag, and weight are learned. During or after a lesson, simulation or sUAS could be used to increase active processing and reinforce concepts taught through explicit instruction (e.g., interactive lecture).

We recommend the use of a basic aviation training device (BATD) or the following flight simulation equipment and sUAS options due to ease of use and cost.

1. Flight simulation equipment could include:
   - Computer
   - Flight simulation software (e.g., X-plane, RealFlight Simulator, Zephyr)
   - Control yoke or joystick
   - Rudder pedals
   - Throttle quadrant
2. Small Unmanned Aircraft Systems (sUAS) available with educational discounts:
   - Parrot Mambo (**edu.parrot.com**)
   - DJI (**store.dji.com/education**)

The authors have identified locations within lessons where a simulator or sUAS activity is either included or would be appropriate, designated with the icon shown on the right.

THE DESIGN PROCESS

The engineering design process is a series of steps that engineers follow when they are trying to solve a problem and design a solution for something; it is a methodical approach to problem solving. In this guide, projects are included that utilize this process according to the following steps:

1. **Imagine** solutions to the problem.
2. **Plan** steps you will take.
3. **Create**—follow your plan and test your design.
4. **Improve**—learn from mistakes and try again.
5. **Present**—share your design.

The authors encourage you to explore opportunities that naturally occur in the classroom to adapt lessons in this guide into design activities.

INQUIRY QUESTIONS

This curriculum is grounded on a set of inquiry questions that define the important essential skills, core concepts, and supportive content; they are also intended to engage students' genuine curiosity. The questions are an invitation to think and take action—not to simply recall, summarize, or detail facts—and they are integrated across all the topics/lessons included in this introduction to aviation. Inquiry questions should be posted in the classroom and included in written course outlines so that students can immediately see that they will have to think through answers.

1. How does this aviation topic facilitate social, economic, scientific, and/or cultural exchange/change?
2. What larger concept, issue, or problem underlies this topic in aviation?
3. What do you notice about how things work in this aviation topic?
4. What are some things we could not do without understanding this topic in aviation?
5. If we changed one thing about how this works, what do we think would happen?
6. How do small changes in aviation affect the larger system?
7. What is the impact of this part of aviation on society?
8. How does this part (e.g., ATC, airports, UAS, flight training, etc.) of the aviation industry affect the other parts?
9. What mistakes have been made in aviation? What did we learn from them? What changes were made?
10. What are current issues in aviation? What caused them? What is a viable solution? What would be consequences of the solution?
11. Can you suggest a different way of doing this in aviation?
12. What conclusions about this topic can be made?
13. What patterns can you see across topics in aviation?
14. What reasons might there be for these patterns?
15. How do you think technology might change how we do this in the future?
16. How will automation and/or autonomous operations change how this is accomplished in the future?

ONLINE INSTRUCTOR RESOURCES

A dedicated website was established to provide you with additional resources to support your classes where the *Aviation High School Facilitator Guide* and *Aviation High School Student Notebook* are in use. Throughout the *Facilitator Guide*, the icon shown on the right appears next to lesson content for which additional outside resources and suggestions are provided in the online Instructor Resources. Direct links to resources referenced in the *Facilitator Guide*, such as videos and articles, are also included for your convenience.

Aviation High School Instructor Resources are available at **www.asa2fly.com/instructor/avhsfg**. To request login information, email **resource@asa2fly.com**.

INCORPORATING CURRENT EVENTS

The facilitator is encouraged to make real-life connections often by bringing current aviation events into the classroom. Recent happenings in the industry may better serve to introduce a lesson than what is included in this guide. The authors encourage you to take advantage of recent news about important people, events, issues, and developments in aviation to encourage students to explore and learn more about aviation.

Many of the chapters conclude with an activity focused on a current event article. The facilitator should select an article that ties into concepts that will be taught in the next chapter as a preview and introduction to upcoming areas of study. Specific articles are suggested in some lessons, but others are open-ended to allow facilitators or students to select current event topics that are the most recent, relevant, and local. Many of the articles suggested for incorporating current events are available on Newsela, aligned with standards and with built-in assessments, but they can also be found on other media outlets through an internet search of the title.

In addition to the current events activities incorporated into the lessons, the *Aviation High School* online Instructor Resources (**www.asa2fly.com/instructor/avhsfg**) provide the facilitator with flexible lesson plans and expanded student activities that can be used for a variety of topics and as frequently as desired. These online resources include a current events lesson plan, anchor standards, assignment description, response form, rubric, student log to record major themes in aviation, guide to annotated text markings, narrative summary frame, and extension activities.

Articles can be from a major news magazine, newspaper, radio/TV segment, or professional organization. Examples of professional organizations that may be good sources for articles and which have current events or issue briefs for reference include American Association of Airport Executives (AAAE), Aircraft Owners and Pilots Association (AOPA), Women in Aviation International (WAI), The Ninety-Nines Inc., University Aviation Association (UAA), National Air Traffic Controllers Association (NATCA), Civil Air Patrol (CAP), Association for Unmanned Vehicle Systems International (AUVSI), and Experimental Aircraft Association (EAA).

EDUCATIONAL STANDARDS CROSS-REFERENCE GUIDE

For more details about how each lesson aligns with specific educational standards and objectives, see the list in the Introduction at the beginning of each chapter.

	English Language Arts / Literacy Key Ideas and Details, Craft and Structure, Integration of Knowledge and Ideas, Range of Reading and level of text complexity.	**Library and Technology** Information and Inquiry, Media and Technology Literacy, Personal Learning and Growth, Responsible Use of Information and Technology
Chapter 1 Aviation Training Requirements	X	X
Chapter 2 Aircraft Basics	X	X
Chapter 3 Airport Operations	X	X
Chapter 4 Weight & Balance and Performance	X	X
Chapter 5 Communications	X	X
Chapter 6 People, Events, and Trends in Aviation	X	X
Chapter 7 Aviation Careers	X	X
Chapter 8 Aerodynamics of Flight	X	X
Chapter 9 Aircraft Systems	X	
Chapter 10 Flight Maneuvers	X	
Chapter 11 Airspace	X	X
Chapter 12 Weather	X	X
Chapter 13 Aeromedical Factors	X	X
Chapter 14 Navigation and Cross Country Flight Planning	X	X

Mathematics Modeling, Number and Quantity, Algebra, Functions, Geometry, Statistics and Probability	**Science** Concepts and Processes of Science, Scientific Inquiry, Physical, Principles of earth and space, Technology and Society, Personal Health, People in Science, Science and Society	**Social Studies** Visual Representations, Research processes, History, Global persons, events, figures and movements	**Career and Technical Education**
	X	X	X
		X	X
		X	X
X	X	X	X
	X		X
	X	X	X
		X	X
X	X		X
	X		X
	X		
		X	X
X	X	X	X
	X		X
X	X	X	X

CHAPTER 8

AERODYNAMICS OF FLIGHT

Introduction

STANDARDS & OBJECTIVES

North Dakota Aviation Content Standards (Grades 10–12)

- **2.1.1**—Explain and describe the relationship the four forces of flight.
- **A.2.1.1**—Identify and describe meaningful relationships between variables of flight.
- **2.1.2**—Define the angle of attack and critical angle of attack.
- **2.1.3**—Describe the types of drag, both parasite and induced.
- **2.1.4**—Explain various wing shapes and how wing tip vortices are created.
- **2.1.5**—Discuss and compare the four main types of wing flaps and the advantages and disadvantages to their uses.
- **2.1.6**—Explain how Newton's Third Law and Bernoulli's principle affect lift.
- **2.1.7**—Identify the parts of an airfoil (e.g., chord line, relative wind, camber, leading edge, trailing edge).
- **2.1.8**—Describe the aerodynamics of a stall.
- **2.1.9**—Define static and dynamic stability.

Note: Standards beginning with "A" indicate the objectives align with but do not exactly match the identified ND Aviation Standards.

Science—Next Generation Science Standards (Grades 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.
- **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.
- **HS-PS2-6**—Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
- **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.

Math—CCSS.MATH.CONTENT (Grades 10–12)

- **HS.S-ID.1**—Represent data with plots on the real number line (dot plots, histograms, and box plots).

Language Arts—CCSS.ELA-LITERACY.CCRA

- **L.1**—Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
- **L.2**—Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
- **SL.2**—Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
- **W.7**—Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
- **W.8**—Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
- **W.9**—Draw evidence from literary or informational texts to support analysis, reflection, and research.

ESSENTIAL QUESTIONS

- How do the four forces of thrust, drag, lift, and weight affect flight?
- How does a pilot control these forces with the use of power and flight controls?
- How do Newton's third law and Bernoulli's principle affect lift?
- Why is it important to be at appropriate airspeed when on the base to final turn in a traffic pattern?
- What is a change that could be made to an aircraft and how would that change impact (either positively or negatively) the performance of that aircraft?

LESSONS

Lesson	Topic	Student Notebook Activities
Lesson 1	Forces of Flight	1. The Four Forces 2. Aerodynamics Graphic Organizer 3. Home Group Questions 4. Acrostic
Lesson 2	Introduction to Airfoils	1. Airfoil Definitions 2. Labeling Airfoil Parts 3. Wing Experiment Questions
Lesson 3	Lift—Newton & Bernoulli	1. Label Diagrams 2. Comprehension Questions Homework
Lesson 4	Drag and Design	1. Semi-Truck Comparison 2. Three-Column Organizer 3. Interactive Lecture Diagram and Notes
Lesson 5	Stalls and Spins	1. Stalls Outline Table 2. Spins Outline Table
Lesson 6	Review: Aerodynamics of Flight	1. Study Guide
Lesson 7	Chapter 8 Exam	1. Article Response and Rubric

LESSON 1

FORCES OF FLIGHT

PURPOSE

The purpose of this lesson is to comprehend the relationship of forces as they act on an aircraft.

ACCOMMODATIONS FOR LEARNING DIFFERENCES

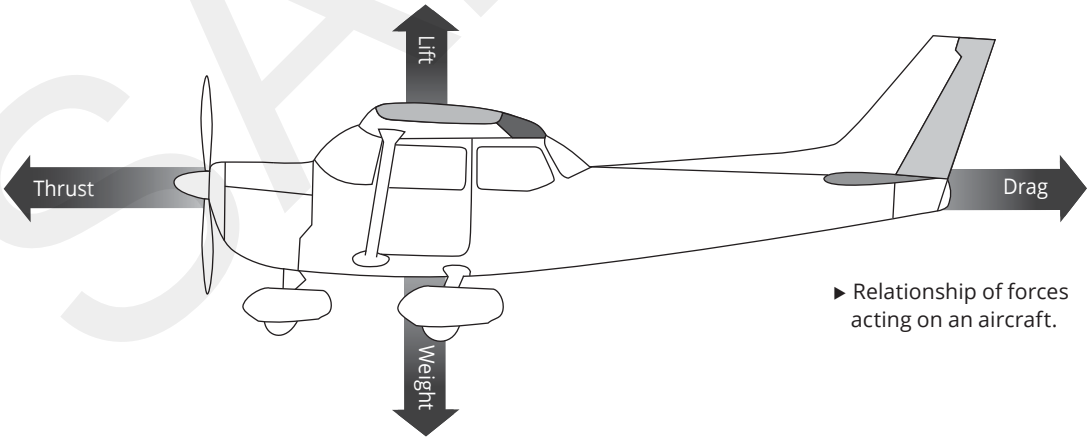
It is important that lessons accommodate the needs of every learner. These lessons may be modified to accommodate your students with learning differences by referring to **www.pacer.org/parent/php/PHP-c267.pdf**.

PREPARATION

- Class copies of *Pilot's Handbook of Aeronautical Knowledge* (FAA-H-8083-25)

DIRECTIONS

Introductory Activity: Show students the figure below or Figure 5-1 from the *Pilot's Handbook of Aeronautical Knowledge* with the terms and arrows removed or covered up. In pairs or triads, direct students to label the directional arrows with each of the terms—lift, weight, thrust, and drag—in the drawing in Activity 1 (The Four Forces) in the Student Notebook. Within their groups, have students explain to each other what term they placed in each location and the reasons for the placement (for example, lift is put on top of the aircraft because it makes the aircraft go up).



▶ Relationship of forces acting on an aircraft.

Step 2: Show students the correct labels and directions according to the figure shown above and have them self-correct their own labels. Provide a simple explanation of each of the four forces by showing a video that explains how airplanes fly.

Step 3: Students will participate in a jigsaw activity to become experts on one of the four forces and then teach their classmates about it.

1. Divide students into four jigsaw groups of roughly equal numbers of students. These groups will be the "home groups" of the jigsaw. (For additional explanation on the jigsaw activity, see the link to instructions in the online Instructor Resources.)
2. Tell students that they are responsible for teaching one force (lift, weight, drag, or thrust) to their home group they are sitting with now.
3. Now students will leave their home group to sit in a group with the other students assigned to the same force (lift, weight, drag, or thrust); this will be the "expert group" for that force. Ask students to begin reading to themselves or to take turns reading aloud about their assigned force in the *Pilot's Handbook of Aeronautical Knowledge*. When students are finished reading, the group should discuss their segment, fill out the section for their assigned force in Student Notebook Activity 2 (Aerodynamics Graphic Organizer), and decide how they should present to their home groups.
4. Students will regroup with their home groups and work together to answer the questions in Activity 3 (Home Group Questions) in the Student Notebook. Each student is then responsible for teaching their force to their home group. All students are responsible for learning all material, and as other students present information on the forces, they should fill in the other columns in Activity 2 (Aerodynamics Graphic Organizer) to complete it.
5. The facilitator should review all columns collectively to ensure accuracy of the four forces of flight.

Concluding Activity: Give each "home group" of students one of the four forces from the lesson. They must then write a detail or descriptor that starts with each of the letters of the force to form an acrostic. Have students write these on the board and record each in Activity 4 (Acrostic) in their Student Notebooks.

T	L	D	W
H	I	R	E
R	F	A	I
U	T	G	G
S			H
T			T

Example:

Turning tendency
High performance aircraft
RPM
Unaccelerated flight
Speed
Torque

LESSON 2

INTRODUCTION TO AIRFOILS

PURPOSE

The purpose of this lesson is to examine the design of an airfoil and note how it creates lift.

ACCOMMODATIONS FOR LEARNING DIFFERENCES

It is important that lessons accommodate the needs of every learner. These lessons may be modified to accommodate your students with learning differences by referring to **www.pacer.org/parent/php/PHP-c267.pdf**.

PREPARATION

- Class copies of *Pilot's Handbook of Aeronautical Knowledge* (FAA-H-8083-25)
- Sticky notes
- Scrap paper for the wing experiment

DIRECTIONS

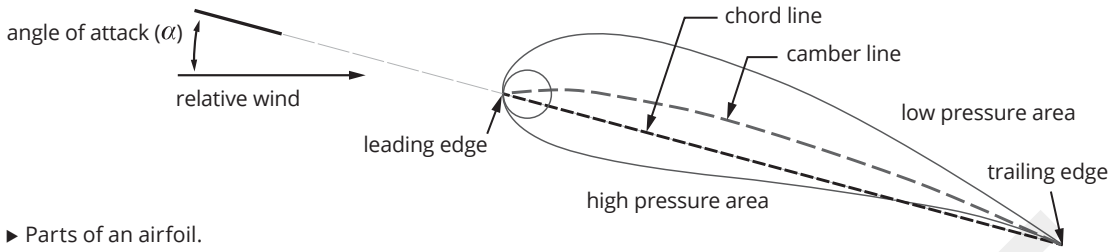
Introductory Activity: Show the class a picture of a Northrop Grumman B-2 aircraft. Ask students to write down on sticky notes the first word that comes to mind when they see this picture. Have them also answer yes or no to the following question: "Do the four forces act differently on this aircraft than on the one you saw in the previous lesson?" Have students bring their notes up to the front of the class and stick them on the board. Organize the sticky notes into groups of similar answers and discuss any answers that relate to the aircraft's aerodynamic airfoil-looking shape. Read and discuss students' yes or no answers to the earlier question. (*Answer:* The forces still act the same.)

Extra credit or critical thinking question: "Why was this aircraft designed this way?"

Step 1: Ask the class to define the term "airfoil." Ask students to give examples both in and outside of aviation. (Example in aviation: pull up a picture of an aircraft and have students list the parts of the aircraft that are shaped like an airfoil; *Answer:* fuselage, wings, propellers, wheel covers, and vertical and horizontal stabilizers. Examples outside of aviation include sports cars, spoilers on cars, windmill blades, etc.)

Step 2: Have the students define the following terms by looking them up in the *Pilot's Handbook of Aeronautical Knowledge* Chapter 5 and recording their answers in the Student Notebook in Activity 1 (Airfoil Definitions): Leading edge, trailing edge, chord line, camber, angle of attack, relative wind, high-pressure area, and low-pressure area.

Once students have defined the terms, have them draw and label the parts of an airfoil in their Student Notebooks in Activity 2 (Labeling Airfoil Parts). Go over the definitions to verify the students have a practical understanding of the terms. Call students up to draw and label the parts of the airfoil on the board.



▶ Parts of an airfoil.

Step 3: Have the class break up into small groups. Students will work in their groups to conduct the wing experiment and record their answers in Activity 3 (Wing Experiment Questions) in their Student Notebooks.

Step 4: Ask a representative from each group to share their selected wing design out loud with the class. As the facilitator, lead a discussion about how their designs did or did not produce lift. Note the different camber of each wing. Aircraft are designed for certain purposes. Compare by showing side-by-side pictures of a fighter jet (pick any fighter) and a training/aerobatic aircraft (e.g., Cessna 172, Piper Archer). Ask students the question, "How do their wings compare?" (*Answers include:* differences in size, camber, the thickness of leading edge. Fighters are designed for maneuverability and speed; they need an airfoil for lift, but they also have a large engine to add thrust for any loss of lift. Training aircraft do not have engines that are big as those in fighters; therefore, the wings need to be sufficient to produce adequate lift for the weight and drag of the aircraft.)

Concluding Activity: Have the students answer the following question on an exit slip: "When looking at a wind farm, why are some windmills turning and others are not? What is different about their angles of attack?" (*Answer:* On some windmills, the blades are feathered, or their angle of attack is zero so the blades are not producing lift.)

FACILITATOR INFORMATION

Directions for Wing Experiment

Directions: Cut your paper to create two pieces that are each 4 by 5 inches. Keep one piece of paper flat and form a slight arch, loop, or hill on top with the other. Tape the two pieces together.

1. Draw what your wing looks like.
2. How does it react when you blow over the top of the wing?
3. How does it react when you blow across the bottom of the wing?
4. Why is there a difference?

Create another wing with a different camber.

5. Draw what your wing looks like.
6. How does it react when you blow over the top of the wing?
7. Which wing performed better?
    a. Why?

FACILITATOR GUIDE

AVIATION HIGH SCHOOL

Brittany D. Hagen, Sarah K. Anderson, Leslie M. Martin, and Paul R. Snyder

This *Aviation High School Facilitator Guide* and corresponding interactive *Student Notebook* address a growing need for solid instruction, inquiry, and development of future-ready competencies and interest in aviation at the high school level. This guide delivers the resources for high school teachers to utilize science, technology, engineering, and math (STEM) instruction to provide an excellent introduction to aviation. The content promotes aviation as an innovative field and includes exploration of aviation as an industry, the study of the fundamentals of flight, and an introduction to the diverse career opportunities available within the industry.

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