AOPA’s Aviation STEM Curriculum

9th grade

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HIGH SCHOOL AVIATION STEM CURRICULUM

The Basics -

• Three Career and Technical Education pathways
  Pilot
  Aerospace engineering
  Drones (UAS)

• Industry credential in each pathway

• Four year program, can implement individual courses

• Thanks to donations to the AOPA Foundation, this curriculum is offered at no charge to high schools.
## FOUR YEAR CURRICULUM OUTLINE

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<th>9th Grade</th>
<th>10th Grade</th>
<th>11th Grade</th>
<th>12th Grade</th>
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<tr>
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<td>Semester 1</td>
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*HIGH SCHOOLS POWERED BY AOPA*
Lesson Resources

Lesson Plans
PowerPoints
Student Projects
Student Notes
Student Activities
Student Assessments
Teacher Notes
Teaching Aids
ESSENTIAL UNDERSTANDINGS

1. Historically, aviation and aerospace technology have evolved as concerns about efficiency and safety have been addressed. (EU1)

2. Innovators in the world of aviation used combinations of engineering design and the scientific process to advance aviation technology and procedures, and improve aviation safety. (EU2)

3. Career pathways have developed to support advances in aviation and aerospace technology and safety. (EU3)

4. Careers in aviation and aerospace cover a multitude of interests and skill sets. There is a place for everyone in aviation. (EU4)

5. Government agencies work to make aviation and aerospace safer and more efficient. (EU5)
SEM 1 – PRINCIPLES OF AVIATION AND AEROSPACE

Unit 1  Aviation and Aerospace Today
Unit 2  Taking Flight – Early Aviation Innovations
Unit 3  From Theory to Practical Reality – Rapid Developments in Powered Flight
Unit 4  To the Stars – Making Jet and Space Travel Possible
Unit 5  Creating the Future – What’s New and Next in Aviation and Aerospace
HEAVY LIFT ROCKET ACTIVITY

Task: Design a balloon rocket to carry weights to the ceiling.
Unit 2 Taking Flight - Early Aviation Innovations

HOT AIR BALLOON ACTIVITY

Task: Design a hot air balloon, test, modify, and fly again.
Unit 2 Taking Flight- Early Aviation Innovations
LESSON: Build and Test a Wind Tunnel

LESSON MATERIALS INCLUDED:
Lesson Plan
PowerPoint
Student Notes
Teacher Aid
Student Activity
BUILD AND TEST A WIND TUNNEL

Lesson

ESSENTIAL UNDERSTANDINGS

Historically, aviation and aerospace technology have evolved as concerns about efficiency and safety have been addressed. (EU1)

Innovators in the world of aviation use engineering design and the scientific process to advance aviation technology and procedures, and improve aviation safety. (EU2)

ESSENTIAL QUESTIONS

1. Should the Wright Brothers be viewed as leaders in aviation or contributors?

Students Will Know
- How the Wright Brothers improved their designs through the use of a wind tunnel
- Which airfoils create more lift by looking at their shape and characteristics

Students Will Be Able To
- Describe the scientific process the Wright Brothers used to solve the power, control, and lift problems they encountered. (DOK-L2)
- Analyze the historical significance of the Wright Brothers and others who made contributions to early powered flight. (DOK-L4)
Lesson Summary

This lesson is day three through seven of Unit 2, Section D. Section D comprises eight days.

Day 1-2: The "Wright" Approach
Day 3-7: Build and Test a Wind Tunnel
Day 8: The "Wright" Attitude

Throughout the multi-day lesson, students will build a wind tunnel as a class and then build airfoils to test in the wind tunnel. The class will start with a video about a very precise wind tunnel used today. The students will then explore the reasons why the Wright Brothers built a wind tunnel and the process they used to test airfoils.

Students will then build a wind tunnel, learn about airfoils, build their own airfoils, and test their airfoils. It will take about two lessons to build the wind tunnel, an additional two lessons to build their airfoils and the airfoil mount, and one final day to test the airfoils, summarize their findings, and present them to the class. Students will build and test airfoils in small groups.

The teacher will use a 3-2-1 exercise to help students reflect on what they've learned.

Background

The students have been learning about the Wright Brothers and their decision to measure the lift and drag on their various airfoils using a simple wind tunnel. They built airfoils, tested them, identified areas for improvement and then re-tested the designs. They were the first to use this process to systematically test their theories and design their gliders and airplanes.

Safety
- Actively supervise students during the activity. Be ready to offer guidance in situations where safety could be compromised.
- Make sure students use proper protection, have available insulated gloves for handling hot objects and pads for setting down objects with heated surfaces.
- Explain how to safely store sharp objects on an active workspace when they are not in use. Students should not be holding sharp objects or tools when they are not in use.
- Sharp tools should be stored in their protective cases when they are not in use.

UNIT 2 D (Day 3-7) BUILD AND TEST A WIND TUNNEL LESSON PLAN

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NGSS STANDARDS

Three-dimensional Learning

• HS-ETS1-1 - Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
  - Science and Engineering Practices
    - Asking Questions and Defining Problems
    - Constructing Explanations and Designing Solutions
  - Disciplinary Core Ideas
    - ETS1.A: Defining and Delimiting Engineering Problems
  - Crosscutting Concepts
    - Systems and System Models
    - Influence of Science, Engineering, and Technology on Society and the Natural World
• HS-ETS1-2 - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
  - Science and Engineering Practices
    - Constructing Explanations and Designing Solutions
  - Disciplinary Core Ideas
    - ETS1.C: Optimizing the Design Solution
  - Crosscutting Concepts - none

4. Looking through the viewing window, take note of the weight in grams (to the nearest hundredth) before the salt is turned on.
BUILD A WIND TUNNEL

MATERIALS (Per Wind Tunnel)
- Large pieces of cardboard cut into the following pieces
  - Four (2) 21" x 25" x 8" (these are for the sides)
  - Three (3) 36" x 9" x 8" (these are for the front)
  - Two (2) 14" x 10" x 8" (these are for the back)
  - One (1) 14" x 10" x 8" (these are for the base)
  - Five (5) 6" x 10" x 8" (these are for the supports)

SAFETY
- Actively supervise students during the activity to ensure that they are properly confined, that safety equipment is employed, that proper work practices are used, and that hazards are avoided.
- Students should be instructed to wear safety glasses and to avoid touching hot objects or supports while they are being used.
- Sharp tools should be stored in their protective cases as soon as they are not in use.

Measure and cut the pieces of cardboard

Duct tape three of the four 60" x 8" tunnel pieces together on the long edges. Leave one edge unsealed.

On one end of the 40" x 8" tunnel, glue the strips down using hot glue. This will seal the tunnel and prevent air from escaping.
BUILD AND TEST A WIND TUNNEL – Teaching Aid

4. On the top (stamped) 4" x 8" funnel flap, cut a hole for the intake of your fan. Ensure the hole is smaller than the area of the fan so it can be taped in place from the outside and not fall through the hole. (Ex. 5"x4""). Leave 7/8" x 9/4" holes.

5. Tape the last 4 1/2" x 8 1/2" tunnel piece into place to make a square hole. Tape the Lewis onto the tunnel from the outside.

6. Tape the four triangular-shaped cardboard pieces for the intake together, and then tape them around the fan. Glue them so that you seal the area around the fan with duct tape as best you can.

7. Make two support stands to hold up the tunnel. Cut four rectangular pieces of cardboard at the proper height. Cut a slit halfway down each piece and slide them together to make an "X".

8. Duct tape or hot glue the stands to the bottom of the tunnel.

9. Duct tape the tunnel to the intake.
BUILD AND TEST A WIND TUNNEL – Presentation

AIRFOIL TERMINOLOGY

- **Camber** - the curve of the wing
  - The mean camber is a line drawn between the leading and trailing edge so that the distance between the upper and lower surfaces is equal
- **Max Camber** - measured where there is maximum distance between the chord line and the mean camber line

WHAT THE WRIGHT BROTHERS LEARNED

- By testing more than 200 airfoils, the brothers learned very important factors that influence lift
  - Curved surfaces produce more lift than flat surfaces
  - Curved surfaces also produce more drag; they learned that a curved surface with a small camber was ideal for maximizing lift
  - Airfoils with the curve closer to the leading edge produce more lift
  - Airfoils that are thin and long create more lift
  - Cambered airfoils will create lift at zero angle of attack

HOW DOES ANGLE OF ATTACK AFFECT LIFT?

- Lift is directly affected by angle of attack
  - As the angle of attack increases, so too does the lift produced by the airfoil
  - This is true until the critical angle of attack is reached

- At the critical angle of attack, the boundary layer of air separates from the airfoil and creates drag
  - This is called an “aerodynamic stall”
BUILD AND TEST A WIND TUNNEL – Student Activity

**BUILD AND TEST AIRFOILS**

**Name**

**Class**

You have been learning about the Wright Brothers and their decision to measure the lift and drag on their various wings using a stream wind tunnel. They built airfoils, tested them, recognized areas for improvement, and then redrafted the designs. They were the first to use this process systematically to test their theories and develop their gliders and airplanes.

**WHAT IS AN AIRFOIL?**

Write the definition of the following:

- Leading Edge
- trailing edge
- chord
- span
- angle of attack
- thickness
- airfoil
- symmetrical airfoil
- asymmetrical airfoil
- span

**Characteristics of an airfoil that influence lift**

- Connect surface produces more lift than ____________ surface.
- Curved surface also produces more lift. They tested that a curved surface with a ____________ surface.
- Airfoils with the same close to the ____________ produce more lift.
- Airfoils that are more close to the ____________ produce more lift.
- Airfoil that ____________ surface, it creates lift at zero angle of attack.

**BUILD AND TEST**

In small groups, you will build two airfoils out of foam board. Each group will build one symmetrical airfoil of a given chord and one asymmetrical airfoil at a given chord and span. You will test the airfoils in your wind tunnel for lift and drag. You will also test the airfoils in your wind tunnel for lift and drag.

**MATERIALS (per group)**

- Airfoil Model (use a piece of foam board to test both airfoils)
- One (1) 5" x 5" foam board
- Three (3) 5" x 5" foam board
- Box knife
- Measuring tape/marker
- Hot glue gun and glue sticks
- Plastic/tape cutter
- Protractor
- Safety glasses

**SAFETY**

- Use eye protection.
- Wear available lab-styled gloves for handling hot objects and pads for setting down objects with heated surfaces.
- Do not hold sharp objects or tools when they are not in use.
- Sharp tools should be stored in their protective cases as soon as you finish using them.

1. Gather all materials.
2. Measure and cut the foam board pieces needed for the airfoil mount and both airfoils.
BUILD AND TEST A WIND TUNNEL – Student Activity

UNIT 2.3 | BUILD AND TEST A WIND TUNNEL | STUDENT ACTIVITY 1

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SYMMETRICAL AIRFOIL

Sand the third 1/8" piece of wire at both ends. Insert one end of the wire into the leading edge of your airfoil. Using the protractor, measure 0, 15, and 30 degrees angle of attack. Insert the wire into the box of the airfoil that corresponds with the 3 different angles of attack.

TEST YOUR AIRFOILS

Before you built the airfoil, hypothesize which airfoil will create more lift. Now, will angle of attack influence the lift created? Explain your reasoning.

To measure the lift of the airfoil, you will note the weight the airfoil assembly exerts on a digital scale before the wind tunnel is on and while the wind tunnel is on.

1. Place the digital scale inside the wind tunnel.
2. Ensure the digital scale has been "zeroed" out.
3. Place the airfoil mount and the symmetrical airfoil on the scale.
4. Look through the viewing window and note the weight in grams (to the tenth or hundredth) before the wind tunnel is turned on.
5. Turn on the wind tunnel (turn the fan at the highest power setting).
6. After a few moments, take note of the new weight in grams (to the tenth or hundredth).
7. Isolates the weight found in step 6 from the weight found in step 5 to determine the amount of lift generated.
8. Repeat these steps for both airfoils and the different angles of attack.

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<tr>
<th>ANGLE OF ATTACK</th>
<th>WEIGHT IN GRAMS BEFORE</th>
<th>WEIGHT IN GRAMS DURING THE TEST</th>
<th>LIFT GENERATED (g)</th>
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<tbody>
<tr>
<td>SYMMETRICAL AIRFOIL</td>
<td>9 degrees</td>
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<td>30 degrees</td>
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<td></td>
<td>15 degrees</td>
<td>15 degrees</td>
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<td>30 degrees</td>
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<tr>
<td>ASYMMETRICAL AIRFOIL</td>
<td>9 degrees</td>
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<td></td>
<td>30 degrees</td>
<td>15 degrees</td>
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What would you expect if we did the same exercise with the asymmetrical airfoil?

Share your findings
An important aspect of engineering design is presenting your findings. Put together your results to share with the rest of the class. Be prepared to describe what limitations you encountered, errors you made, and ideas you have for improving the design of your airfoil and improving the testing methods.
SEM 2 – EXPLORING AVIATION AND AEROSPACE

Unit 6  Aviation Safety and Oversight
Unit 7  Exploring Careers in Aviation and Aerospace
Unit 8  Aviation Innovation and Problem Solving
Unit 9  Innovation Challenge
Unit 10 Thinking about a Career in Aviation
Accident Case Safety-NTSB “Go Team”

• Can we really know what went wrong?
• Everyone takes a role on the “Go Team”, learn the functions and how they fit together.
• Students present findings and share recommendations.
Unit 7 Exploring Careers in Aviation and Aerospace

• Students will learn more about aviation careers, education, training and certification requirements.

• Careers include:
  Flying aircraft and drones
  Aerospace engineer
  Air Traffic Controller
  Aircraft Mechanic
Innovation Challenge

“PEEP ODYSSEY” INNOVATION CHALLENGE

You are on a team of engineers from a company called SpaceCondo that is working to colonize Mars.

Your team’s challenge is to design and build a self-contained dwelling (a SpaceCondo) for Mars’ newest residents: a family of Peeps.

You will use the engineering design process to design, build and test a SpaceCondo that will protect the Peeps from the harsh environment that exists on Mars, particularly the extremely low atmospheric pressures.
HOW CAN I USE THE AOPA CURRICULUM?

• Will be available on our website, youcanfly.aopa.org/high-school, spring 2018
• Will have webinars in 1st quarter 2018, to share more information as it is available
• Register to receive frequent updates about the curriculum on the AOPA High School website
• Complete an application to use the curriculum
• Professional development for teachers using the curriculum will be available in late June, Frederick, MD, in-person (recommended) and virtually.
• Virtual ongoing professional development - webinars, AOPA Hangar

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