

HOW DO WING AREA, WING ANGLE AND WING CAMBER AFFECT LIFT?

INTRODUCTION

This lesson will allow students to use FoilSim software to explore how wing area, wing shape and wing angle affects the force of lift and an airplane's ability to fly.

LEARNING OUTCOMES

- Students will gain an understanding of how wing area, shape and angle affect flight.
- Students will examine examples of wings and describe how changes in wing area, wing camber and wing angle can be used to increase lift.

CURRICULUM ALIGNMENT

EXPLORING TECHNOLOGY SYSTEMS 8108 BLUEPRINT -

004.02 Apply design and problem solving concepts and principles.

005.02 Use computers and other tools of technology in various applications.

NORTH CAROLINA ESSENTIAL STANDARDS – 7TH GRADE SCIENCE

7.P.1 Understand motion, the effects of forces on motion and the graphical representations of motion.

7.P.1.2 Explain the effects of balanced and unbalanced forces acting on an object

CLASSROOM TIME REQUIRED

This lesson should take approximately 60 minutes.

TEACHER PREPARATION

Teacher need to become familiar with how the FoilSim program works and work through the lesson to identify any potential issues students may experience.

Group the students in pairs so that they can help each other with making changes to the program and for the think-pair-share type activities.

MATERIALS NEEDED

- A computer with FoilSim III installed for each student or pair of students
- Lift Simulation Data Sheet
- Pencil and paper

TECHNOLOGY RESOURCES

Each student should have a computer with FoilSim III installed. The program can be downloaded for free from <http://www.grc.nasa.gov/WWW/K-12/airplane/foil3.html>. You may run the simulation in a web browser but it is recommended that you download and install the software so you do not need to worry about connection speeds.

The pairs created for think – pair – share type activities can also share a computer to use the simulation program but should have their own paper project log.

It would be helpful if the teacher had a computer that could be displayed for the class to see however talking the students through the activities is also an option.

PRE-ACTIVITIES FOR STUDENTS

Remind students will continue to keep a project log. This can be paper and pencil or computer word -processing file. Some work with paper and pencil will be required even if the project log is kept electronically.

ACTIVITIES

Direct students to start the FoilSim program. Students should make a list of things that they observe and a list of questions that they generate as they explore. If students are reluctant to start, direct them to begin by sliding the angle, camber and thickness slider bars.

Explain to students that the image they see is a side view of a wing. Draw a 3D sketch on the board to show students the portion of the wing being shown in the simulation. Tell students that together you will be exploring to see how different factors affect the force of lift.

Have students click the reset button and set the values as directed below to observe the changes in variables.

Students will use the worksheet to record data so that they can refer to the numbers when trying to answer the questions at the end of the activity. They should conclude that camber, angle and area all increase lift when they are increased. A special note is mentioned about angle since too great an angle results in stall.

CHECK THE EFFECTS OF WING AREA

In our last lesson we learned to calculate wing area and we learned that lift is the force created by a special interaction with the air as it moves over the wing causing the plane to be pushed upward. How do you think that

wing area will affect lift? Discuss with your partner and record your thoughts in your project log. Then we will try the simulation program and test our hypothesis or guess.

1. Click on the flight button to set Airspeed = 100 mph and Altitude to 0 feet.
2. Click on Size and set Area to 10 sq. ft.
3. Click on shape and set Thickness to 1, Camber to 0 and Angle to 5 degrees.
4. Record the amount of lift on your worksheet under the start column. (This should be 138 lbs.).
5. Predict what you think will happen when you double the wing area. Write the value under the prediction column.
6. Double the Area to 20 sq. ft. and record the value under the double column. (This should be 276 lbs.)
7. Predict what you think will happen when you divide the wing area in half. Write the value under the prediction 2 column.
8. Half the Area to 5 sq. ft. and record the value under the half column. (This should be 69 lbs.)
9. Show the students that the data proves that as wing area is increased, lift also increases.

CHECK THE EFFECTS OF CAMBER

The second item we will check is the Camber of the wing. Remember that camber is the term that describes the curvature or shape of the wing.

1. Change the thickness to 20 and slide the camber slider to see the variety of possible curves.
2. How do you think that camber will affect lift? Discuss with your partner and record your thoughts in your project log.
3. Click on the flight button to set Airspeed = 100 mph and Altitude to 0 feet.
4. Click on Size and set Area to 100 sq. ft.
5. Click on shape and set Thickness to 1, Camber to .2 and Angle to 0 degrees.
6. Record the amount of lift on your worksheet under the start column. (This should be 64 lbs.).
7. Predict what you think will happen when you double the camber. Write the value under the prediction column.
8. Double the Camber to .4 sq. ft. and record the value under the double column. (This should be 127 lbs.)
9. Predict what you think will happen when you divide the camber in half. Write the value under the prediction 2 column.
10. Half the Camber to .1 sq. ft. and record the value under the half column. (This should be 32 lbs.)
11. Show the students that the data proves that as camber is increased, lift also increases.

CHECK THE EFFECTS OF ANGLE

Remember that the angle of a wing is the angle that is made between the line of the wing chord and the line of the fuselage. This angle can be changed to affect the amount of lift that is caused by the wing.

1. How do you think that wing angle will affect lift? Discuss with your partner and record your thoughts in your project log.
2. Click on the flight button to set Airspeed = 100 mph and Altitude to 0 feet. Click on Size and set Area to 100 sq. ft.
3. Click on shape and set Thickness to 1, Camber to 0 and angle to 2 degrees.
4. Record the amount of lift on your worksheet under the start column. (This should be 555 lbs.).

5. Predict what you think will happen when you double the angle. Write the value under the prediction column.
6. Double the Angle to 4 degrees and record the value under the double column. (This should be 1092 lbs.)
7. Predict what you think will happen when you divide the wing angle in half. Write the value under the prediction 2 column.
8. Half the Angle to 1 degree and record the value under the half column. (This should be 280 lbs.)
9. Show the students that the data proves that as wing angle is increased, lift also increases.
10. Ask the students to try the angle at 10, 15 and 20 degrees. (Results will be 2587, 3294, and 2551 lbs. of lift). Ask them to explain why the lift drops to a lower value at 20 degrees. Tell the students that this can be explained by what is called "stall". An airplane will stall when the wing angle becomes so great that the airflow over the wing can no longer generate enough lift to overcome the forces of gravity and drag.
11. Based on our data we can see that wing area, camber, and angle all increase lift as they are increased even though there are some exceptions such as stalling. Students should see that their numbers support what you are telling them. If questions arise have them repeat the necessary steps to get the correct data.

GUIDED PRACTICE

Using a computer display or handouts, show pictures of planes with various wing areas, wing angles and wing cambers. Students will see two at a time and will select the option that will provide the greatest amount of lift.

ASSESSMENT

Students will receive a handout showing examples of wing area, wing camber and wing angle. Students will be asked to describe, using sketches if necessary, how each one could be changed to generate more lift for the plane.

MODIFICATIONS

Pre-prepared notes can be made available for students that have difficulty reading or taking notes. Students can be paired so that at least one of the students is capable of reading the simulation program.

ALTERNATIVE ASSESSMENTS

Arrangement can be made for students with special needs to have the directions read to them and to answer the questions orally.

CRITICAL VOCABULARY

Lift – force that overcomes gravity created by airflow over the wing of a plane

Camber – Shape or curvature of the leading edge of the wing

Angle- Angle of the wing in relation to the underneath of the plane and the ground

Wing Area - The space included in the boundary of the outline of the wing

WEBSITES AND RESOURCES

Airplane Parts and Functions

<http://www.grc.nasa.gov/WWW/K-12/airplane/airplane.html>

Investigating the Aerodynamics of Flight

http://www.juliantrubin.com/encyclopedia/aviation/bernoulli_principle.html

Airfoils and Airflow

<http://www.av8n.com/how/htm/airfoils.html>

Lift and Drag

<http://www.pbs.org/wgbh/nova/space/lift-drag.html>

Bernoulli Principle Animation

http://mitchellscience.com/bernoulli_principle_animation

AUTHOR INFORMATION

Russell Sparks teaches Exploring Technology to students in 6th – 8th grades at East Wilkes Middle School, Wilkes County Schools

Exploring Technology is an entry level CTE course giving an overview of various areas of technology and careers associated with these areas. The externship involved work in the applied engineering school of Wilkes Community College and local aerospace industries. Mr. Sparks was introduced to the tools and concepts used to prepare students for careers in the aerospace industry and given an opportunity to see the industry processes. Lyndell Duvall, Chair of Applied Engineering Technologies, Industrial and Engineering Technology at Wilkes Community College mentored Mr. Sparks.

ACKNOWLEDGEMENT

Lesson developed through the Flight Fellowships: STEM in Aerospace Science and Aeronautics, a program of the Kenan Fellows Program and the North Carolina Science, Mathematics and Technology Education Center.

Funding provided for the Flight Fellowships by NASA K-12 Cooperative Agreement #NNX10AU89A.



KENAN FELLOWS PROGRAM

