WHAT FORCES THAT AFFECT FLIGHT?

INTRODUCTION

This lesson will give students the basic knowledge needed to understand airplanes and the forces that allow them to fly. Students will learn to calculate the wing area and wing loading of a plane.

LEARNING OUTCOMES

Students will know the four basic forces that affect flight. Students will understand how to calculate wing area and wing loading.

Students will label a force diagram of an airplane. Students will calculate the wing area and wing loading of a sample plane.

CURRICULUM ALIGNMENT

EXPLORING TECHNOLOGY SYSTEMS 8108 BLUEPRINT

007.03 Design and fabricate a transportation vehicle.

COMMON CORE STANDARDS - MATH

Geometry 7.G - Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.

> 6. Solve real world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

The Number System 7.NS - Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.

> 3. Solve real-world and mathematical problems involving the four operations with rational numbers

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

Three 45-minute class periods

TEACHER PREPARATION

Consider how you want the students to launch the planes to ensure safety and to maintain order. Make several copies of the plane ahead of time to become familiar with how to make the plane, to give students a visual as they try to build their planes and to use for students that are not able to make the plane in the allotted time.

MATERIALS NEEDED

Multi-Speed Fans with 4 or 5 students at each fan. Fewer can be used increases class time needed for the activity.

For each student

- Drawing Paper (81/2 x 11)
- Paper Airplane Building Instruction Sheet
- Lesson One Assessment Sheet
- Transparency of a grid

TECHNOLOGY RESOURCES

Each student should have a computer with word processing software. Students can complete this activity with paper and pencil if computer with word processing software is not available.

Teacher should have a way of drawing sketches of planes for display to the class. This can be projected from a computer or drawn on a whiteboard with markers.

PRE-ACTIVITIES FOR STUDENTS

Students should be able to use a digital scale to determine the weight of an object.

Inform students that they will be keeping a project log. This can be paper and pencil or a computer word-processing file. Students will record information in this project log as they work through the unit and submit it at the end. Some work with paper and pencil will be required even if the project log is kept electronically.

ACTIVITIES

EXPLORATION – FORCES THAT AFFECT FLIGHT

Give students drawing paper and the Paper Airplane Building Instructions. When the airplanes have been constructed, allow the students to fly them following the launching instructions on the instruction sheet. Students should record their observations and questions on how their planes flew in the project log.

Have students hold planes level out from themselves about 5ft from the floor, drop the planes, and record questions and observations in their project log. Observations should include gliding forward then falling, diving nose-first into the floor, etc. The emphasis should be on gravity pulling the plane to the ground.

Place fans at points around the room. Ask students to try to launch their planes and hit the fan with the fan on low, medium and high speed. Remind them to use the correct launch method stated on the building and launching instruction sheet. Ask students to record observations and questions in their project log. Observations should include the plane gliding smoothly toward the fan with a slight upward or downward slope, the plane being blown backward, upward or downward forcefully. The emphasis should be that the plan is being slowed by "drag" and lifted by the force of the air over the wings.

MODEL LESSON – FOUR FORCES

Draw a sketch of an airplane from the side view on the display or white board. Ask students to copy the drawing into their project log. Ask what forces they observed acting on their plane during their trials. Have students place arrows on the diagram indicating the directions of the forces they observe and write a short statement about why they think each of these movements happened.

CONTENT WRAP UP – FOUR FORCES

Name each force for them (drag, lift, gravity, and thrust) and have them record in their project log.

Discuss with the students that thrust is the force that moves the plane forward. Drag is the force of the air pushing against the plane as the plane moves forward. Compare this to the friction force they experience as they slide their hand over their desk as they push down lightly and then more firmly. Remind them that gravity is the force that pulls objects to the earth making objects with larger mass harder to pick up. Lift is the focus of this lesson. Lift is the force that makes flight possible. As air moves over the wing it interacts in a special way that causes the plane to be pushed upward. Make sure students know that lift will be the focus of our activities.

Draw a second side view sketch of the airplane on the display. Ask students to copy into their project log. Label angle, camber, fuselage, wing, and horizontal and vertical tail wing. Emphasize that angle and camber are two characteristics that affect how much lift is available.

MODEL LESSON – WING AREA

Give students the transparency of a grid paper and have them count the number of unit blocks it takes to cover the wing of their plane and record this in their project log.

Remind students that area is a term that describes the amount of space included within a set of boundaries.

Draw an overhead view sketch of an airplane on the overhead display or white board. Ask students to copy the sketch into their project log. Label the wing cord and the wingspan. Tell students that this information can be used to calculate wing area another important factor in generating lift.

CONTENT WRAP-UP – WING AREA

1. Draw a square on the white board and divide into nine equal squares. Ask students how many unit blocks are in the square. Count off each unit block and record the total number (9). Check to ensure that students are working along with you in their project log. This is the area of the square.
2. Mark a 1 beside each square for the length and width. Show students the formula l * w and calculate the area to show that it equals 9. Students should record their calculations. Point out that both methods result in the same area.
3. Redraw the square and 9 equal divisions. Show students that the square can be divided into two triangles by drawing a line across the diagonal. Ensure that students are recording on their worksheet. Ask students to count the number of squares in one of the triangles. Count the squares in one triangle making sure the students see that three will be half divisions. Record this total number (4.5). Tell the students that this is the area of the triangle.
4. Show students the formula ½ b*h and calculate the area to show that it equals 4.5. Point out that both methods result in the same area. Notice that adding the area of both halves equals the area of the original square.
5. Redraw the square and the 9 equal divisions. Use a different color maker to divide the square into a 2 x 6 block rectangle and 1 x 3 block rectangle. Further divide the 1 x 3 block rectangle into two triangles so that one of the triangles combined with the 2 x 6 block rectangle forms a trapezoid. Ensure that students are recording on their worksheet. Ask students to count the number of squares in the rectangle and the triangle that make up the trapezoid. Count the blocks that make up the trapezoid, assuring the students that the triangle is made up of a ¾ block, a ½ block and a ¼ block. Record the number (7.5). Tell students that this is the area of the trapezoid.
6. Show students the formula ½(a+b) * h and calculate the area to show that it equals 7.5. Point out that both methods result in the same area.
7. Tell students that the formulas can be used on any item and the results equal counting unit blocks that make up the shapes.
8. Draw a second overhead view sketch of an airplane. Mark out the needed shapes and work through an example to calculate the area of the airplane.
9. Tell students that wing loading is a number that tells us how much plane weight there is for each unit of area. Give them the formula for wing loading and work out an example to show the math required and the units of the final answer.
10. Students should be told that during this unit they will design their own glider to glide for the longest distance. They should make notes in their project log daily concerning what they have learned that can be used in their design.

GUIDED PRACTICE

Ask students to look at the plane they have made. Ask them to take a few minutes and discuss with their partner how they might use shapes to divide the wings into sections so that they can figure out the wing area. Students should sketch out the shapes on the planes so that the teacher can check their success.

When students have successfully marked the wings have them calculate the wing area of the plane. Students should show their calculations on a separate piece of paper to be turned in to the teacher and record the wing area in their project log. When students have completed calculations give them the *transparency of grid* to check their work. Students should then weigh their planes and calculate the wing loading for their plane.

Hold one of the planes in the air in front of the class. Have the class call out the force that is acting as you move the plane up, down, forward, backward. Point to parts of the plane and have the class call out the name of the part.

ASSESSMENT

Students will complete the lesson assessment by labeling the four forces diagram and the plane parts diagram. Students will work out the wing area of a plane given the plane weight.

MODIFICATIONS

For students that have difficulty reading or taking notes, pre-prepared notes can be made available.

Premade airplanes can be used to allow students to participate in later parts of the lesson even if they have difficulty successfully building the airplane.

Students can be paired so that at least one of the students is capable of reading the instruct sheet.

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 works to overcome gravity as air moves over the wings of the plane

Drag – force of friction on an object that works against thrust. (example air moving over plane)

Thrust – force that acts to move an object (example engine creates thrust to move plane forward)

Gravity – gravitational force of the earth that pulls objects to the ground

Camber – the curvature of the leading edge of the wing

Angle of attack– the angle create by the wing in relation to the body of the plane

Span – distance from left to right across a plane at the wing

Chord – distance from front to back across a plane's wing

Wing Area – the surface area bounded by the outline of the wing

Wing Loading – the amount of weight carried by one unit of wing area

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 6^{th} – 8^{th} 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. This will allow him to give his students a better understanding of the steps needed to prepare themselves for the future. Lyndell Duvall, Chair of Applied Engineering Technologies, Industrial and Engineering Technology at Wilkes Community College mentored Mr. Sparks.