INTRODUCTORY: AERODYNAMICS

DESCRIPTION OF SESSION

In this session, participants will learn about the forces that act on an airplane in flight, as well as the primary control surfaces of a plane.

CATEGORY

- Exploring, Aviation
- U.S. Department of Education, Transportation

OBJECTIVES

By the end of this session, participants will be able to:

- Point out on a model airplane the forces that act on an airplane in flight.
- Explain how an airfoil generates lift, how the primary control surfaces (ailerons, elevators, and rudder) affect the airplane's attitude, and how a propeller produces thrust.
- Demonstrate how the control surfaces of an airplane are used for takeoff, straight climb, level turn, climbing turn, descending turn, straight descent, and landing.

PREPARATION

It is highly recommended that this activity be conducted at a real airplane parked on a ramp or in a hangar. If an airplane is not available or is not feasible, use a remote control model airplane that has all the required surfaces and controls. If a model plane is used instead of a real plane, the size of the group should be reduced.

SUPPLIES

- Airplane(s) or remote control model airplane(s)
- Pens or pencils (one per participant)
- **Angles of Attack** activity sheet (one per participant)
- **Aerodynamic Forces in Flight** activity sheet (one per participant)
- **Aerodynamics Wrap-Up** activity sheet (one per participant)

ADVISOR NOTE: Text in italics should be read aloud to participants. As you engage your post in activities each week, please include comments, discussions, and feedback to the group relating to **Character, Leadership,** and **Ethics**. These are important attributes that make a difference in the success of youth in the workplace and in life.

In this session, the Advisor walks around the plane, pointing out various aerodynamic features such as the airfoils and control surfaces. The emphasis is on aerodynamics, with a focus on the stated objectives. The Advisor should ask questions throughout rather than simply lecture. The simple question "Why?" can often promote discussion and further questions.

ACTIVITIES

Before beginning, discuss safety. Tell participants to watch where they're going, move slowly around the airplane, watch their heads, watch for sharp edges, never touch the propeller, etc. Talk about the propeller and how it can get started on its own. Tell the participants not to touch anything unless you say it's OK.

Activity 1
Airfoils
Discuss Bernoulli's principle early in the session, and pass out the **Angles of Attack** activity sheet. Explain why an airfoil creates lift. A good demonstration of lift is to cut a half-inch strip from a piece of 8.5-by-11-inch paper. Hold the paper to your chin, hanging down, and ask participants to predict what will happen when you blow. Did they expect the paper to rise toward the blown breath?

Starting at the propeller, point out that an aircraft has many airfoils on it. Say: *One of them you're staring at, and it's not a wing. What is it?* Point out the propeller and how it is shaped like an airfoil, and explain how it produces thrust. Ask: *If the prop always spins in a clockwise direction, why does the plane want to turn left?* (Imagine the prop on the end of a boat. Spinning it makes the boat want to move toward the right. Because the prop on a plane is in front, not in back, it wants to go toward the left.)

Working from the front of the plane to the back, point out all airfoils and controls. Point out and discuss the propeller, wing, stabilizer, elevator, and trim tab.

Discuss stalls. Ask: *What causes the plane to not fly?* (The interruption of the airflow over the wing. Flat on bottom and curved on top is important. Changing the shape of the airfoil for any reason—including icing—changes the plane.)

Activity 2
Aerodynamic Forces in Flight
Pass out the **Aerodynamic Forces in Flight** activity sheet, and discuss how the four forces (lift, weight/gravity, thrust, and drag) act in flight.

Discuss the following:
- Slipstream, airflow over a wing, angle of attack, and turbulence.
- How the power setting affects the airplane's attitude and how it is used to aid flight.
- How to make sure everything is configured for takeoff.
- Turning. With their arms out at their sides, have participants simulate, using their hands at different angles, what happens to the ailerons in a right-hand turn and a left-hand turn.
- The turn coordinator and the bank and slip indicator on the instrument panel. Demonstrate how the ailerons and rudder are used in coordination to turn the plane. Explain why slips and skids are bad, and how stalls during uncoordinated flight can lead to spins.
- Aerodynamic differences between a level turn and a climbing turn, and the tendency to lose altitude in a turn and why.
- Weight, balance, and the center of gravity and how these are planned for before a flight begins. This is part of the preflight and must include baggage, weights of all passengers, and any cargo. Discuss the calculations, why this is such an important part of flight planning, and why having too much overall weight is bad. Questions like "What happens when too much weight is forward or backward?" can help prompt participation.

Describe density altitude, explaining that hot weather and humid skies rob the airplane of lift and thrust. Use Aspen, Colorado, as an example. Density altitude is not a huge issue in flat Midwestern cities but can be a very big issue elsewhere.

Have students complete the **Aerodynamics Wrap-Up** activity sheet and answer any questions they may have.

Tips and Options

- Close the airplane doors and take off the control lock. When using the yoke and rudder pedals to control the wing and tail surfaces, participants may get distracted. Stay outside and manipulate the controls by moving them manually from the outside.
- If possible, have someone in the cockpit work the ailerons while the group watches them go up and down.
- If possible, have someone in the cockpit work the rudder to demonstrate what happens when the right or left foot pedal is pressed.
- If there is time and the group is small and well-behaved, let participants take turns sitting in the cockpit. Let them manipulate the yoke and rudders.
- Because girls tend to be more hesitant to participate in these activities than boys, try to engage the girls by asking questions, letting them manipulate the plane's surfaces, and having them use their arms to simulate wing activity.

ADVISOR NOTE

Some sample questions are below. They are designed to help the participants apply what they have learned to their own interests. You are welcome to use these questions or develop your own questions that relate to your post or specific focus area.

REFLECTION

- *If you push one aileron down, where does the plane want to go?*
- *Why do ailerons move in opposite directions?*
- *If you pull the rudder to one side, where does the plane want to go?*
- *If you pull the elevator up, where does the plane want to go? What if you push it down?*
- *Why do you think both flaps move in unison?*

Content for this session provided by Youth Aviation Adventure (http://youthaviationadventure.org).

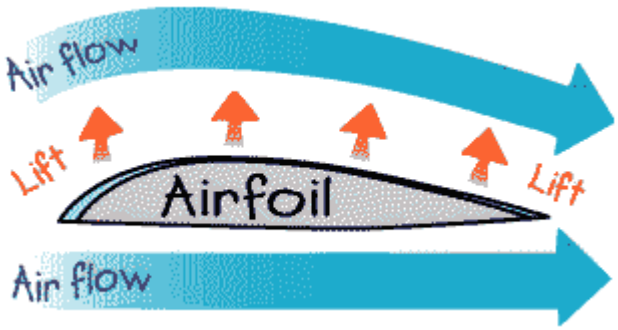
ADVISOR AND OFFICER REVIEW

After the meeting, address the following:

- Identify what was successful about the meeting.
- Identify what needed improvement.
- Schedule an officer and Advisor planning meeting to prepare for the next post meeting or activity.

RESOURCES
Activity 1
Angles of Attack

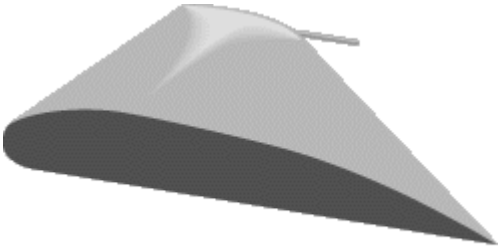
Airfoil with zero angle of attack, showing airflow and lift:



Air moving over the longer distance of the curved upper wing surface must travel faster than the air flowing the shorter distance under the flatter bottom surface of the wing. According to Bernoulli's principle, the difference in the speed of the air, which behaves like a fluid, produces lower pressure above the wing than below it. This pressure difference produces lift.

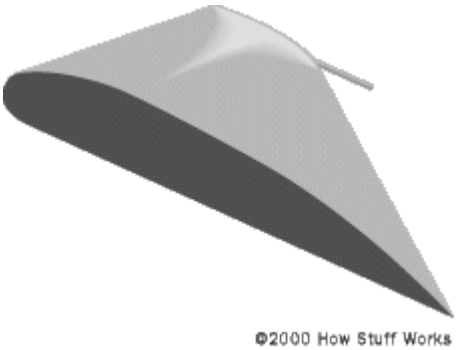
Image courtesy of http://z.about.com/d/inventors/1/0/q/N/wingairflow.gif

Airfoil with shallow angle of attack:



Wings with a shallow angle of attack have less drag but also less lift.

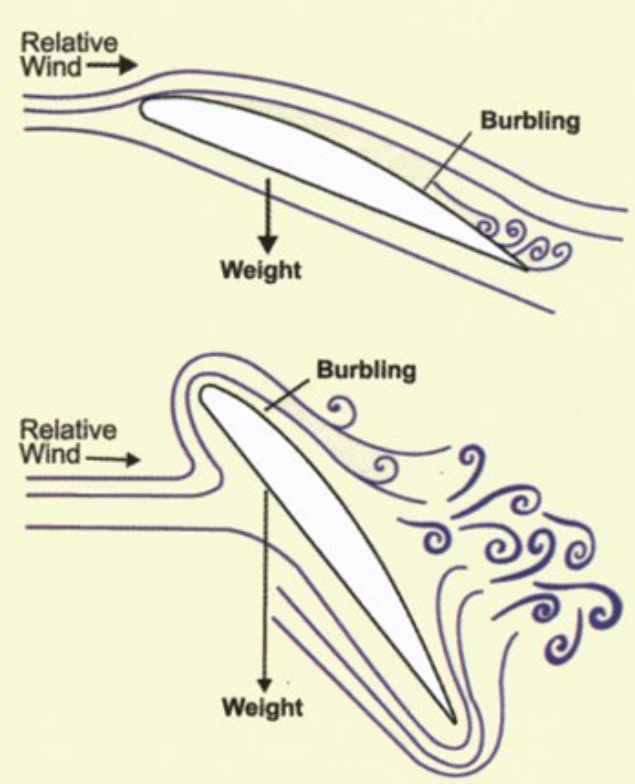
Airfoil with steep angle of attack:



Wings with a steep angle of attack have more drag and more lift. This allows the plane to fly slower.

Photos courtesy of How Stuff Works

Airflow over a wing in flight, at different angles of attack:

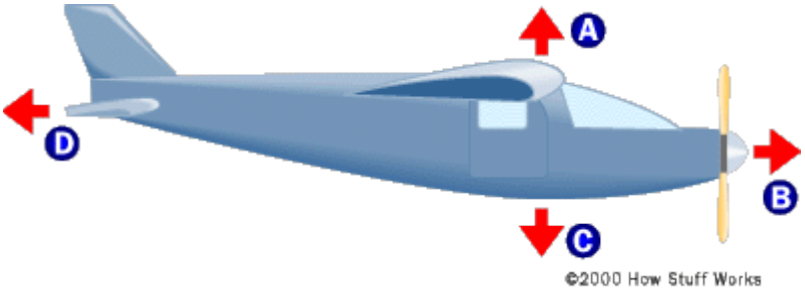


Just before a wing stalls, the airflow “burbles,” or becomes turbulent over the upper surface of the wing. This reduces the efficiency of the airfoil.

Image courtesy of NASA

Activity 2
Aerodynamic Forces in Flight

When in flight, there are four forces acting on a plane: lift, thrust, weight, and drag. When an airplane is in straight and level flight, the four forces are in equilibrium: lift equals weight and thrust equals drag.



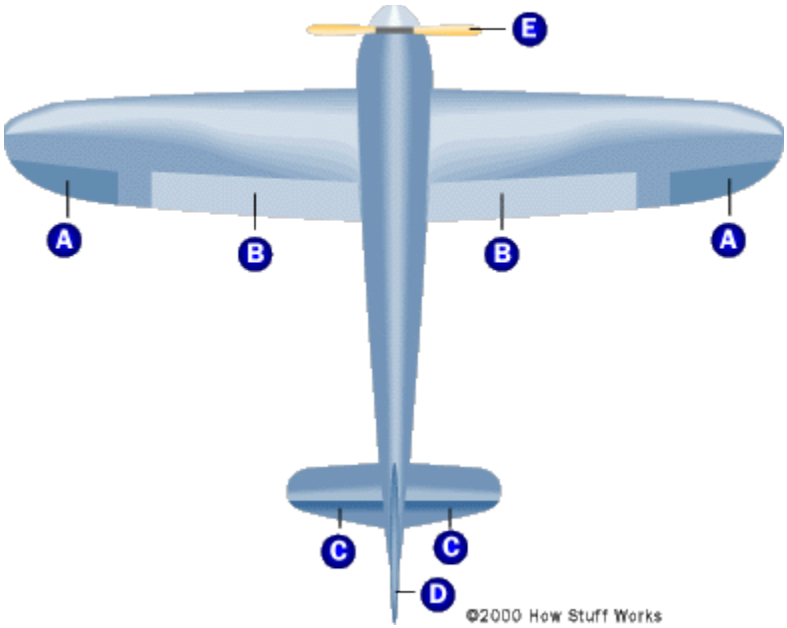
A = Lift B = Thrust C = Weight/Gravity D = Drag

Lift: Air flowing over the wings and the angle of the wing relative to the passing air together move the aircraft upward.

Weight/Gravity: The opposite of lift, weight is a force pulling down on the airplane.

Thrust: A force created by the engine that moves the airplane forward.

Drag: The opposite of thrust, drag is a force that slows the forward movement of the airplane through the air. The surfaces of the plane cause drag as they move through the air.



A = Ailerons **B = Flaps** **C = Elevator** **D = Rudder** **E = Propeller**

Ailerons: Help to turn the plane. They work in opposition to one another. When the right aileron goes up, the left one goes down and vice versa. They change the shape of the plane's airfoil to turn the plane. Ailerons control bank.

Flaps: Help to slow the plane down. Flaps are used most often in landing, when the pilot slows down the plane to an appropriate speed for landing. Flaps change the shape of the airfoil, and both go down or up at the same time and in the same direction.

Elevator: Helps the airplane ascend and descend. When the tail goes up, the front of the plane goes down and vice versa. Elevators control pitch.

Rudder: Together with the ailerons, the rudder helps to turn the plane. The rudder controls the yaw of the plane.

Propeller: Produces thrust, pulling the plane forward.

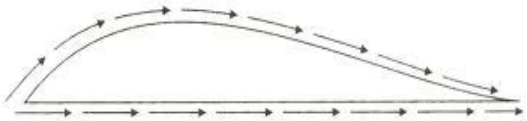
Activity 2
Aerodynamics Wrap-Up

1. Newton's Third Law of Motion states, "For every action there is an equal and _____ reaction."

2. Label the four forces of flight.

3. Bernoulli's principle states that fast-moving air has (more, less)_____ pressure than still air.

4. Indicate on the airfoil diagram which is the high pressure and which is the low pressure.



Use the word bank below to answer 5-8.

5. The flight control that raises and lowers the nose: _____.

6. Like on a boat, this flight control moves the nose right or left: _____.

7. Near the tip of the wing, the flight control that banks the wing for a turn is a(n): _____

8. On each wing is a(n) _____. When lowered for takeoff and landing, it changes the shape of the wing to create more lift.

Word Bank

Rudder *Aileron* *Flap* *Elevator*

Activity sheet developed by Teresa Guillemot, owner of The Practical Aviator.