



EVERGREEN AVIATION & SPACE MUSEUM

The Evergreen Aviation Museum, co-founded by Delford M. Smith, Chairman and CEO of Evergreen International Aviation, Inc., and his son, Captain Michael King Smith, opened to the public on June 6, 2001, showcasing the famed Howard Hughes' *Flying Boat*, the "Spruce Goose".

Our threefold Mission is:

To Inspire and Educate,

To Promote and Preserve Aviation and Space History,

And to Honor the Patriotic Service of Our Veterans.

The Museum accomplishes this mission through:

- Programs at the Educational Institute for youth, ages K–12
- The collection, preservation and display of historical aircraft and aerospace artifacts
- Special events and recognition ceremonies to honor the patriotic service of veterans, as well as the support of their families

The Evergreen Aviation & Space Museum includes a 121,000 square foot Aviation Museum specifically dedicated to aviation history, and a 55,000 square foot IMAX® 3D Theater that showcases static displays and the Oregon Aviation Hall of Honor. The Museum currently has more than 80 vintage and historic aircraft on display. The Museum is located in the heart of Oregon's wine country, 45 minutes south of Portland (the largest urban metropolitan city in Oregon) and an hour from the Central Oregon Coast.

In June of 2008, an additional 121,000 square foot Space Museum facility will open to the public. This facility is located directly next to the Aviation Museum and will showcase twelve comprehensive galleries dedicated to the history of space exploration and related technologies, which will include Titan II and Titan IV interactive missile exhibits like no other in the world.

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Lesson 1

Lesson 1: Getting to Know the Airplane

Materials

- Butcher paper
- Instructor Transparency: **THE THREE AXES OF FLIGHT**
- Student Handout: **THREE AXES OF FLIGHT**
- Student Handout: **PARTS OF AN AIRPLANE**

Objective

In this activity, students will show what they already know about planes by making a KWL chart (what I know, what I want to know, what I learned) in small groups. They will also be learning about the parts and functions of a plane.

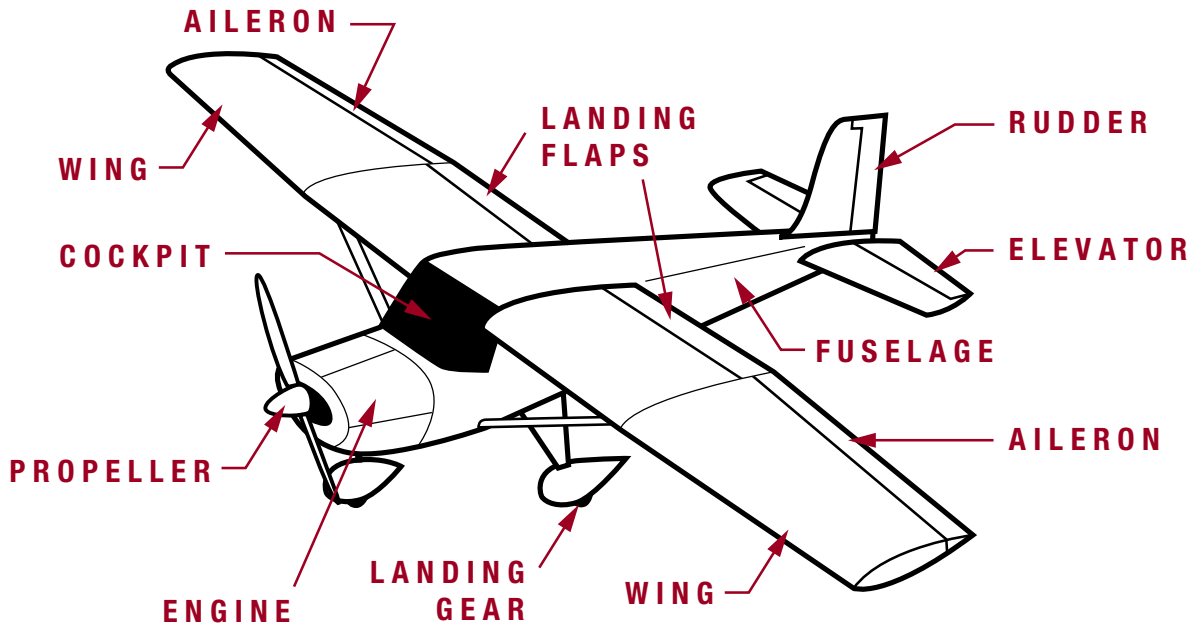
Activity

1. Place students in small groups and give each a large piece of butcher paper. Instruct them to make three columns and title them K, W, and L. Have each group create a list of what they think they know about airplanes under K, and what they want to know under W.
2. Invite each group to share one idea from their K column and one idea from their W column. When they are finished, post the charts on the wall to reflect on.
3. Give each student a copy of the handout, **THREE AXES OF FLIGHT** and use the **THE THREE AXES OF FLIGHT** transparency to talk about the three axes of flight: roll, pitch and yaw. Pitch is controlled by the elevators and makes the plane's nose go up and down. Have the students hold out both hands and make their fingers go up and down to demonstrate pitch. Have your students label *pitch* on their handouts.
4. Roll is controlled by the ailerons and make the plane's wings move up and down. Have students hold out their hands again to demonstrate this movement. Afterwards, have them label *roll* on their handouts.
5. The last axis is yaw, which is controlled by the rudder. Yaw makes the plane's nose move from left to right. Have the students swivel both hands from left to right to demonstrate yaw and then label it on their handouts. Discuss how controlling a plane is different from controlling a car. A car can only go left and right as it goes forward. Airplanes have three movements while it flies forward. Ask, would it be hard to fly a plane?
6. Lastly, give each student a copy of student handout **PARTS OF AN AIRPLANE** and use the transparency **THE THREE AXES OF FLIGHT** to discuss and guide your students to label the different parts of the plane and the function of each part. Spend extra time on the aspects that students didn't list under the "What I Know" section of the charts. Make sure to highlight the elevator, ailerons, and rudder.
7. After visiting the museum, have the students update the KWL chart to show what they learned during this unit.

Lesson 1

Instructional Information

Airplane Parts



Plane Vocabulary

AILERONS: Used by the pilot to change the roll of the airplane or left to right action.

COCKPIT: Where the pilot sits to command and control the aircraft.

ELEVATORS: Located on the lower part of the tail, these two moveable flaps change the pitch or the up-down action.

ENGINE: Provides power to move the plane forward, generates thrust.

FUSELAGE (BODY): Where passengers and cargo are carried. The wings and tail are connected to the fuselage.

LANDING FLAPS: Lowers to slow the plane for landing.

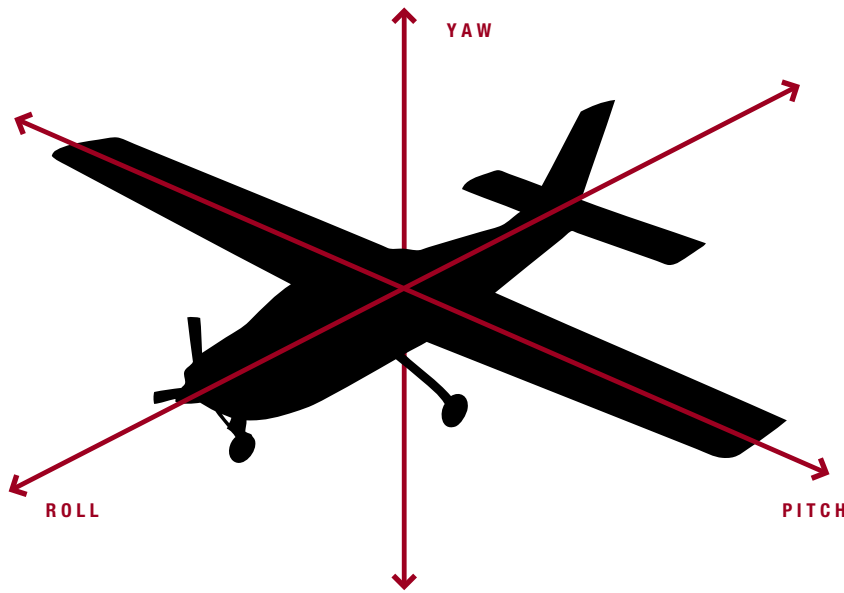
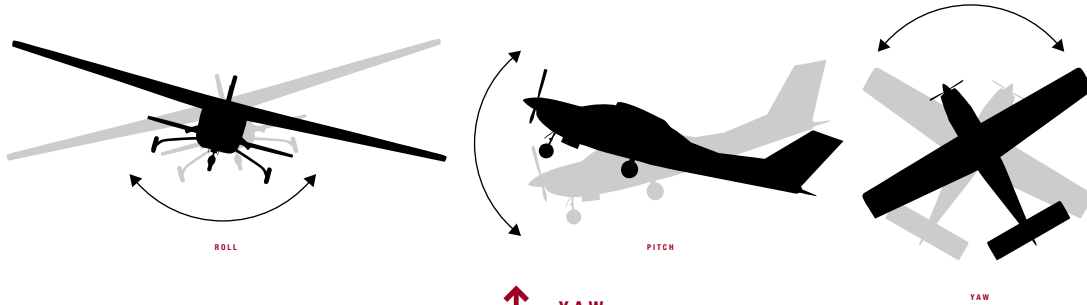
LANDING GEAR: Attached to the bottom, this gear supports the plane's weight and lets the plane move on land or water while taking off, landing, or taxiing.

PROPELLER: Two or more twisted blades spun by the engine. It pulls or pushes the plane through the air.

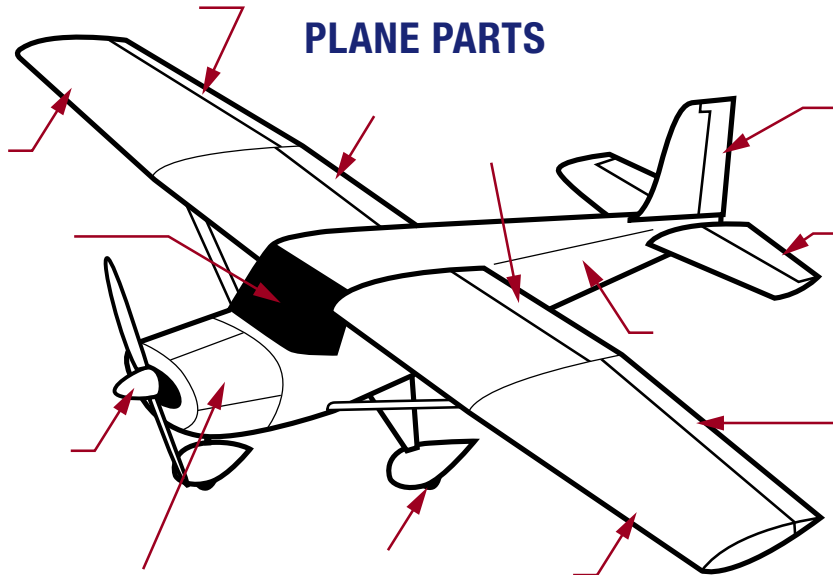
RUDDER: Located on the upper part of the tail, this part changes yaw or the side to side action.

WING: Supports the airplane during flight and generates lift.

THE THREE AXES OF FLIGHT



PLANE PARTS

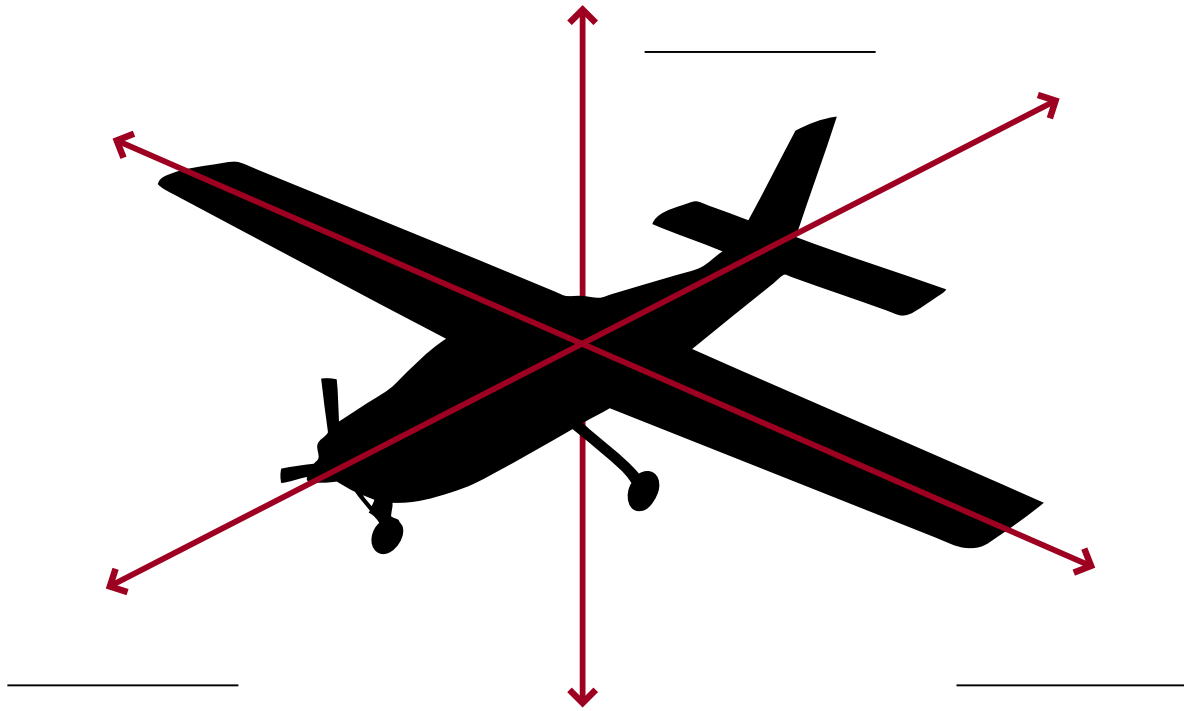


AVIATION & SPACE

THREE AXES OF FLIGHT

Name: _____

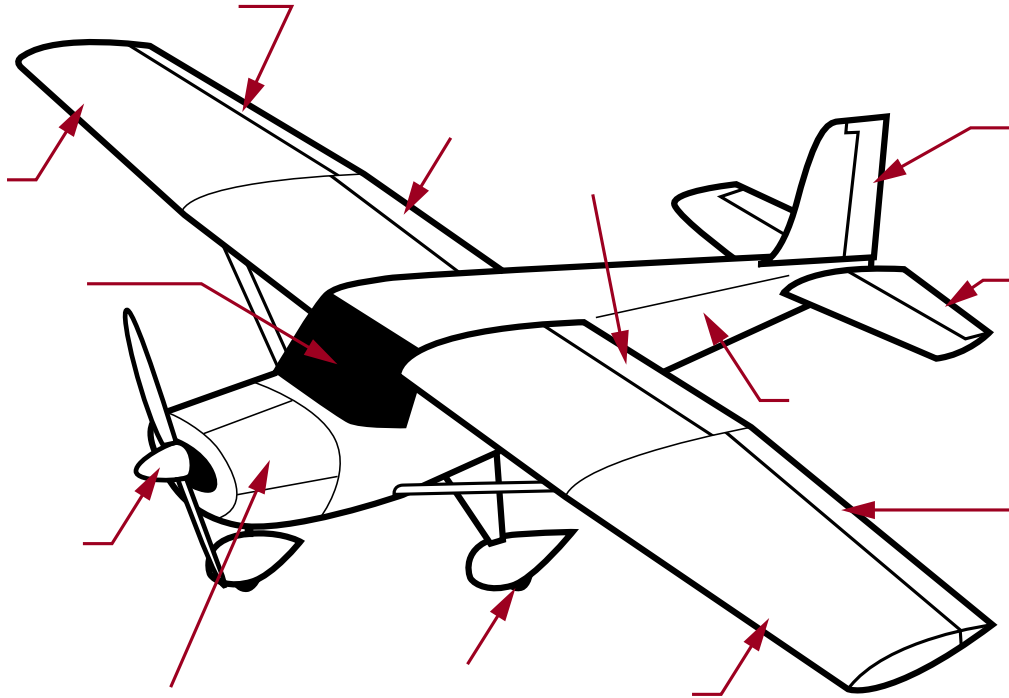
Label the three axes of flight (roll, pitch, yaw) on the plane below.



PARTS OF AN AIRPLANE

Name: _____

Label and color the different parts of the airplane below:



Airplane Vocabulary

- Ailerons:** Used by the pilot to change the roll of the airplane or left to right action.
- Cockpit:** Where the pilot sits to command and control the aircraft.
- Elevators:** Located on the lower part of the tail, these two moveable flaps change the pitch or the up-down action.
- Engine:** Provides power to move the plane forward, generates thrust.
- Fuselage (Body):** Where passengers and cargo are carried. The wings and tail are connected to the fuselage.
- Landing Flaps:** Lowers to slow the plane for landing.
- Landing Gear:** Attached to the bottom, this gear supports the plane's weight and lets the plane move on land or water while taking off, landing, or taxiing.
- Propeller:** Two or more twisted blades spun by the engine. It pulls the plane through the air.
- Rudder:** Located on the tail, this part affects the yaw or the side to side action.
- Wing:** Supports the airplane during flight and generates lift.

Lesson 2

Lesson 2: Understanding Air**Materials**

- Instructor Transparency: **FORCES OF FLIGHT**
- Student Handouts: **FORCES OF FLIGHT**
- Student Handout: **NAME THAT FORCE**
- Large pieces of cardboard

Objective

In this activity, students will learn about the forces of flight by using a piece of cardboard to demonstrate how air flows by doing simple experiments.

Activity

1. In small teams of three to four students, give each a piece of cardboard. To demonstrate drag, tell students that they are going to take turns holding the piece of cardboard flat against their forehead (*Figure 1*) while running forward. On student handout, **FORCES OF FLIGHT**, have them predict what they think they are going to feel. Then invite them to do the experiment and record their team's outcome. Next, have them repeat these steps but this time with the cardboard turned so that the flat side is against the side of their head (*Figure 2*). They will notice that there is less air slowing them down when the cardboard is placed this way.
2. To demonstrate lift, tell students that they are going to take turns holding the cardboard flat on top of their head (*Figure 3*) while running forward. Again, have them predict what it is going to feel like. Then invite them to do the experiment and record the outcome. Next, repeat these steps but instruct them to tilt the front slightly to discover which angle will lift the cardboard as they run. They will come to the conclusion that the cardboard will lift when it is tilted upward slightly, putting more pressure on the bottom of the cardboard. Again, have students write down the outcome of the experiment and record all observations.

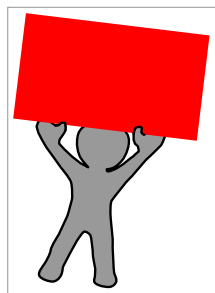


Figure 1: Cardboard flat against your forehead

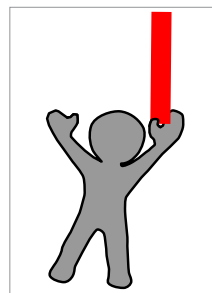


Figure 2: Cardboard flat against the side of your head

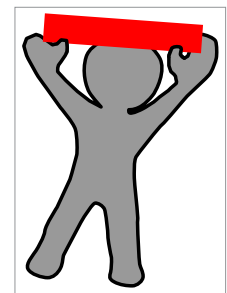


Figure 3: Cardboard flat on top of your head and then angled

3. Bring the class together to discuss what the experiments taught them about air. Use teacher transparency, **FORCES OF FLIGHT**, to explain the forces of flight. To further review these concepts, have the students complete student handouts, ***NAME THAT FORCE**.

*Answer key for page 1 of **NAME THAT FORCE**: 1. thrust, 2. lift, 3. gravity, 4. drag
 Answer key for page 2 of **NAME THAT FORCE**: 1. B, 2. C, 3. B

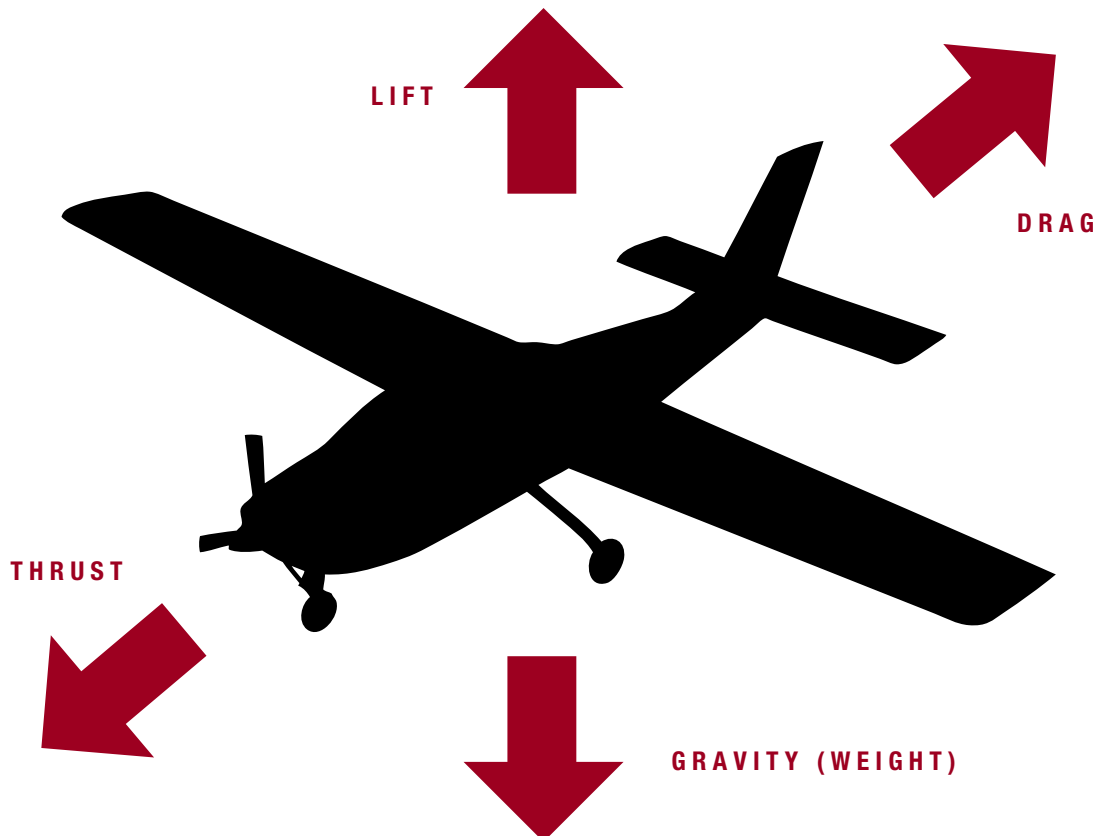
FORCES OF FLIGHT

Lift: As a plane moves forward, air molecules move over and under the wing. Because the wing is curved on top and flat on the bottom, the air molecules are forced to move much quicker on top. Since these molecules are moving so quickly there is less pressure being put on the wing from above, but the air underneath maintains a constant speed and rate of pressure. This difference causes the plane to lift off the ground. The theory on fluid movement is called Bernoulli's Principle.

Thrust: An aircraft uses propellers and an engine to make it move forward. These forces act to increase an airplane's speed.

Drag: This force opposes the forward motion and slows airplanes. Another name for drag is air resistance. Shape and speed of an aircraft determine the amount of drag it has. Thrust is used to overcome this force. Examples of drag are easily found in everyday life. When you place your hand outside of a car window, the pressure forcing your hand backward is drag.

Weight: Gravity is a force that is constantly pulling us towards the center of the Earth. This gravitational pull creates weight as it pulls down on objects- like us! So airplanes must be made of light materials. As weight increases, the need for lift also increases.



FORCES OF FLIGHT

Name: _____

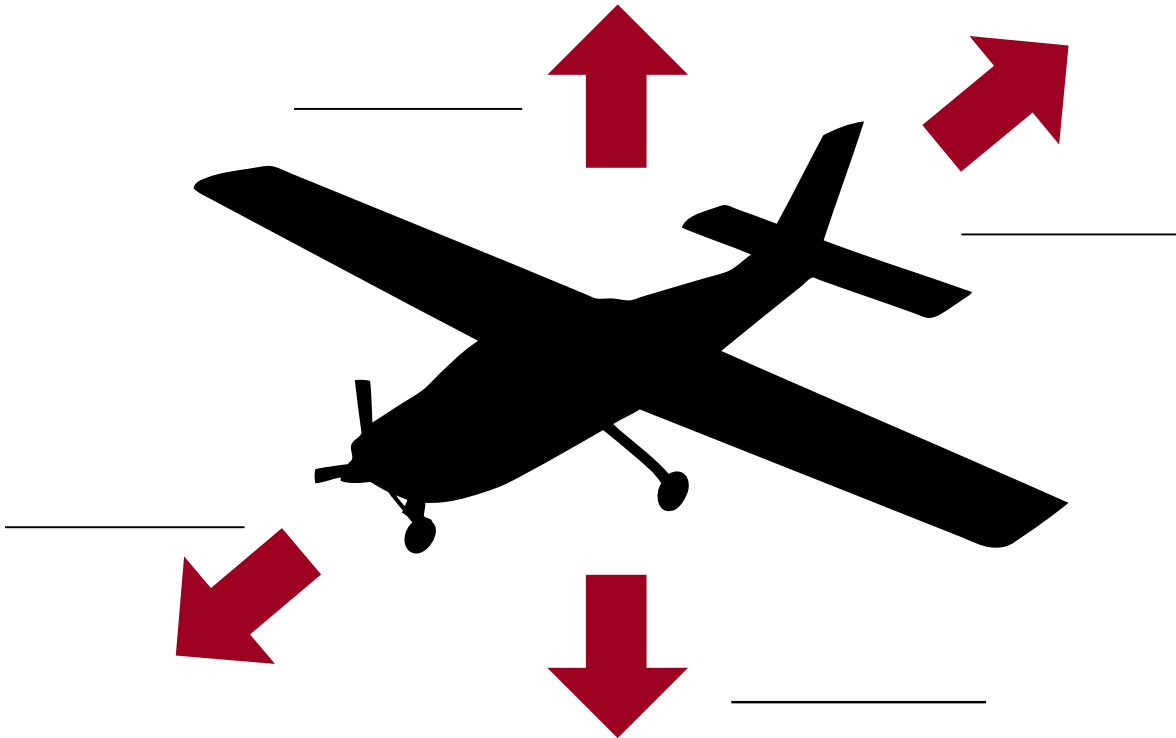
Complete these experiments with your team's piece of cardboard. Make predictions about how the cardboard will affect your run and record your observations below.

| Experiment | Predictions | Outcome |
|---|-------------|---------|
| Run with the cardboard flat against forehead. | | |
| Run with the cardboard flat against your head. | | |
| Run with the cardboard flat on top of your head. | | |
| Run with the cardboard angled slightly on the top of your head. | | |

NAME THAT FORCE

Name: _____

Fill in the blanks around the airplane with the correct force name.



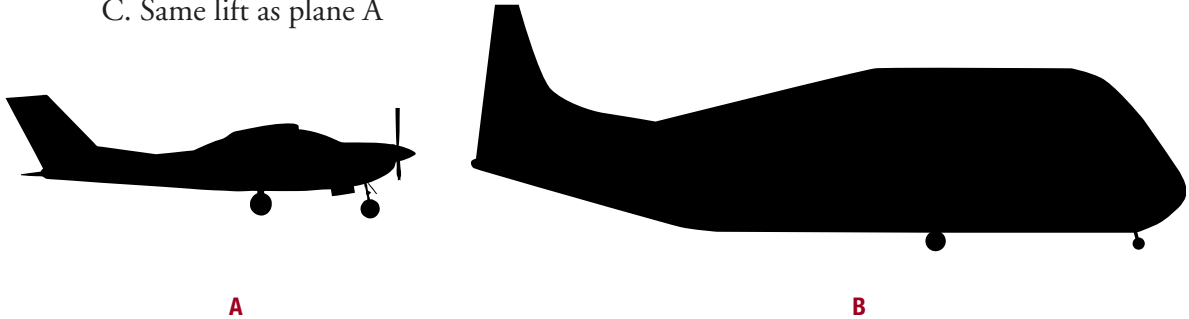
1. A spinning propeller produces _____ to pull the airplane forward.
2. Fast-moving air flowing over the wings creates _____ to push the airplane up.
3. The airplane overcomes _____ to take off into the air.
4. The airplane's forward movement is slowed by _____.

NAME THAT FORCE

Name: _____

1. Plane A is smaller and weighs less than Plane B. Plane B will need to achieve?

- A. Less lift than plane A
- B. More lift than plane A
- C. Same lift as plane A



2. While it is flying at a constant altitude, the thrust, created by the engine of this plane suddenly decreases and is less than the amount of drag. What will this plane do in the sky?

- A. Speed up
- B. Stay the same
- C. Slow down



3. This fire fighting plane just released its load of water over the forest fire, thus decreasing its weight. If the pilot does nothing to the engine controls, what will happen to the plane? It will...

- A. Drop down
- B. Rise in the air
- C. Slow down



Lesson 3

Lesson 3: Bernoulli's Principle

Materials

- Cups
- Water
- Drinking straws
- Spoon
- Access to a sink

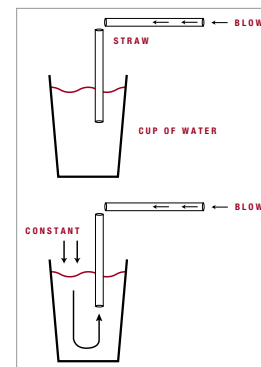
Objective

In this activity, students will conduct two experiments to become familiar with Bernoulli's Principle.

Activity

1. In small groups of three or four students, give each group a cup of water and two straws. Explain that their task is to find a way to get the water out of the cup by only using their two straws. Then give them time to experiment and share their results with the class. Most students will try blowing air into the water, causing bubbles, but the water will not come out of the cup.

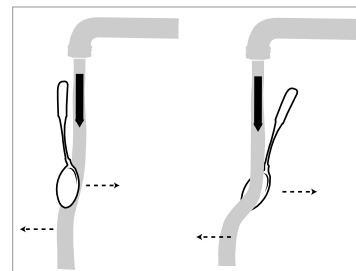
Then explain that the method for extracting water from the glass has to do with changing air pressure. By placing the short straw straight out of the water and the second straw at a 90° angle from the first straw, you can extract the water by blowing fast moving air over the opening of the short straw. This will cause the water to move up the straw and out of the glass. By blowing faster moving air over the opening of the straw students are lowering the air pressure from that at the surface of the water in the glass. High pressure systems always push toward low pressure systems. The slower air on the surface of the water has higher pressure pushing the water up and possibly out of the straw. This is Bernoulli's Principle.



2. Discuss with your class *Bernoulli's Principle and how it applies to aviation.

3. To further their understanding of Bernoulli's Principle, get a small stream of water coming from the sink and explain to the students that you are going to place the back end of a spoon in the stream. Ask them to think about how the water will react. Will it follow the curve or be displaced due to the spoon? Most students will say that the water will expel outward, away from the spoon.

Place the spoon in the stream and observe how the water clings to the curve of the spoon. Have students offer explanations for why the water acted as it did. This experiment demonstrates how water reacts to a curved surface. Air works in the same manner when it flows along a curved wing. Notice how the spoon is pulled into the stream of water. By combining fast moving air over a curved surface of a wing and the angle at which the wing is positioned to the air (angle of attach), a plane produces lift.



*See next page for additional information

Lesson 3

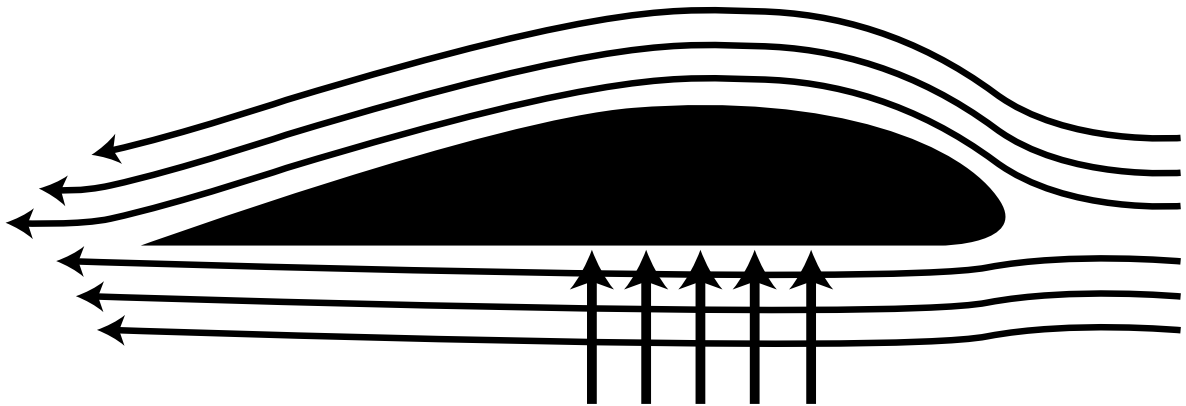
Instructional Information

Bernoulli's Principle: As the speed of a fluid increases, the pressure within the fluid decreases.

Daniel Bernoulli was a Swiss mathematician in the 1700's and made an important discovery about fluids (a fluid is any substance that flows). He found that the faster the fluid flows over a surface, the less pressure it puts on that surface.

But what does this mean for aviation? Since air is a fluid, this principle can be applied to how an airfoil and air pressure cause lift. When an airplane flies, air molecules move above and below the wing. The wings of an airplane are shaped in a way that air moves much quicker on top than below. We call this shape an airfoil. Because the air moving underneath the wing is slower and is applying pressure at a constant rate, it pushes the wing up. The faster the airplane flies, the greater the pressure difference and the greater the lift.

**FASTER MOVING AIR...
...LESS PRESSURE**



SLOWER MOVING AIR...MORE PRESSURE

Extension: Have the students come up with an explanation of why the roof of a house can lift off during a storm with very strong winds. Bernoulli's Principle shows us that the steady air inside the house produces higher pressure than the quick winds blowing across the outside of the house, causing the roof to lift off.

Lesson 4

Lesson 4: Aerodynamics

Materials

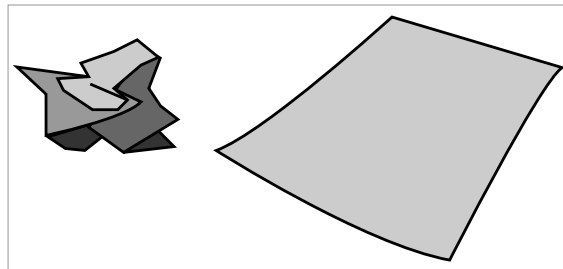
- Three sheets of paper for each student
- Student Handout: **AIRCRAFT DESIGN**
- Airplane Pattern
- Instructor Transparency: **PLANES**

Objective

In this activity, students will learn about the effect that drag has on aerodynamics and how a sleek aircraft design helps an airplane's ability for speed.

Activity

1. Begin the lesson by reviewing the concepts of lift and drag.
2. Have the students get out three pieces of paper for the experiment. One will be loosely crumpled into a ball, another folded into a paper airplane, and the last one will be left unfolded.

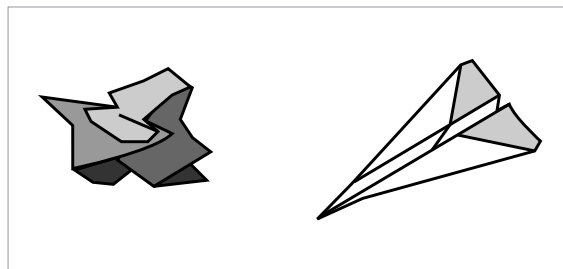


3. Start the experiment by holding up the loosely crumpled sheet and the unfolded sheet. Ask the students which one will fall faster and have them form a hypothesis on student handout **AIRCRAFT DESIGN**. Make sure they include why they think one will fall faster than the other.

4. Have the students drop the two pieces of paper at the same time and record their results and conclusions. Invite students to share their findings. The unfolded paper will fall slower because of the drag (air resistance).

5. Next, have the students hold up the folded airplane and the crumpled piece of paper. Have them predict which sheet of paper will fly farther if thrown with the same amount of force and have them record their hypothesis.

6. Have the students fly the crumpled piece of paper and the folded airplane with the same amount of force. Record your results and conclusions and invite your students to share their findings. The loosely crumpled paper will be affected more by drag than the airplane.



7. Ask students to consider how they could make the paper airplane fly further. Have them record and test their ideas. Now, try adding a * paper clip to the front.

*See next page for additional information

Lesson 4

Talk about each airplane on teacher transparency, **PLANES**. Have students think about how drag might affect airplane design. Air molecules prefer to stick together so when an object interrupts them they have an easier time splitting apart when a slender airplane hits them in comparison to a bus or a large object. If an airplane has a box-like shape, it would be harder for air to flow around its surface and thus slowing the airplane. Faster moving airplanes are sleek and have smaller wings to reduce drag and increase the flow of air. Point out the design of the wings and bodies and how they affect the airplane.

***Extension:** Nearly as important as lift and thrust to an airplane is its center of gravity. This next activity will allow your students to test out how important weight distribution and center-of-gravity are to an airplane. The center-of-gravity (CG) is the point at which an aircraft would balance if it were possible to suspend from a string. You might even want to demonstrate this concept by hanging a paper airplane from a dangling string and finding the CG. Center-of-gravity is the mass center of the airplane. Aircraft engineers spend hours upon hours researching and testing these concepts in wind tunnels and in test flights. Give each student a small paper clip and then allow them to place their paper clip at different locations on their paper airplane. Have them test how their airplane responds depending on where they place their paper clip.

AIRCRAFT DESIGN

Name: _____

| Experiment | Hypothesis | Results | Conclusion |
|--|------------|---------|------------|
| <p>Drop Test</p> <p>Loosely Crumpled Versus Unfolded Piece of Paper</p> | | | |
| <p>Distance Test</p> <p>Folded Versus Loosely Crumpled Piece of Paper</p> | | | |



FOLD 1 (fold flap inward)

FOLD 3 (fold outward)

FOLD 2 (fold in half)

FOLD 1 (fold flap inward)

FOLD 3 (fold outward)



PLANES



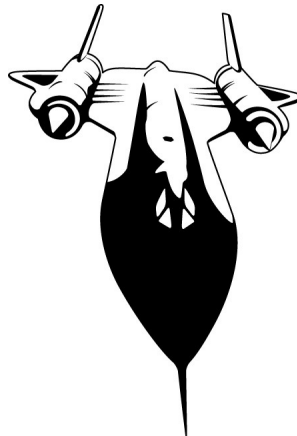
Concorde



DC-3



F-15 Eagle



SR-71 Blackbird

Fun Aviation Facts

- Hot air balloons were used during the Civil War by both the Union and the Confederate armies for spying.
- The Wright Brothers only had a fifth grade education.
- Prior to 1926, a person could fly passengers or goods without obtaining a pilot's license.
- The first animal aviators were a sheep, a duck and a cockerel that were sent aloft in a hot air balloon in 1783.
- Before air traffic control towers were developed, pilots avoided other aircraft by a method called "see and be seen".
- "Air Stewardess" was the official title given to the position that we now refer to as "Flight Attendant". The first Air Stewardess was Ellen Church and she began work with United Airlines in May 1930. She was paid \$125 a month.
- Amelia Earhart was the first woman to fly the Atlantic solo in 1932. She was also the first woman to fly from Hawaii to the mainland and from Mexico to New York City.
- The SR-71 Blackbird can fly at 85,000 feet. That's about 16 miles high. Most commercial airplanes fly about 6 miles above Earth.
- In 1911, Harriett Quimby was the first woman to earn a pilot's license.
- The Boeing-737 uses 5 gallons of fuel per mile. The average car gets 25 miles to the gallon.
- Bessie Coleman was the first black woman to fly. She was also the first black woman stunt and exhibition pilot.
- One wing of a Boeing-747 is big enough to fit 40 middle sized cars on it.
- Charles Lindberg flew nonstop from New York to Paris. The flight was 1,000 miles long and took 33 hours and one half hour to complete. If you were to travel today the flight would take a little over 3 hours.

Oregon State Standards

Lesson 1: Getting to Know the Airplane

Science: Physical Science, *Force: Understand fundamental forces, their forms, and their effects on motion.*

SC.05.PS.03 Describe and compare the motion of objects.

Validation: Students will learn how planes move from a discussion and handout on airplane parts and how they work together as a system.

Language Arts: Reading, *Listen to and Read Informational and Narrative Text: Listen to, read, and understand a wide variety of informational and narrative text across the subject areas at school and on own, applying comprehension strategies as needed.*

EL.05.RE.03 Listen to, read, and understand a wide variety of informational and narrative text, including classic and contemporary literature, poetry, magazines, newspapers, reference materials, and online information.

Validation: Students will be listening to the teacher talk about the parts of a plane and reading along with their handout.

EL.05.RE.05 Demonstrate listening comprehension of more complex text through class and/or small group interpretive discussions across the subject areas.

Validation: Students will learn about the parts of a plane by paying attention and being engaged in the group discussion and following the handout.

Language Arts: Reading, *Vocabulary: Increase word knowledge through systematic vocabulary development; determine the meaning of new words by applying knowledge of word origins, word relationships, and context clues; verify the meaning of new words; and use those new words accurately across the subject areas.*

EL.05.RE.10 Develop vocabulary by listening to and discussing both familiar and conceptually challenging selections read aloud across the subject areas.

Validation: Students will make a chart that will prompt discussion and discovery of unfamiliar words. The handout will present the new words with clear explanations.

Language Arts, Speaking and Listening: *Listening: Listen critically and respond appropriately across the subject areas.*

EL.05.SL.08 Interpret a speaker's verbal and non-verbal messages, purposes, and perspectives.

Validation: Students are listening and engaged in what the teacher presents.

Lesson 2: Forces of Flight

Science, Physical Science: *Matter: Understand structure and properties of matter.*

SC.05.PS.03 Describe and compare the motion of objects.

Validation: Students will learn about the four forces of flight and how they affect the movement of an airplane through the air.

Science, Physical Science: *Force: Understand fundamental forces, their forms, and their effects on motion.*

SC.05.PS.04 Identify examples of magnetism and gravity exerting force on an object.

Validation: Students will learn about the force of gravity and how it affects a plane from the class discussion and worksheet.

Science, Scientific Inquiry: *Forming the Question/Hypothesis: Formulate and express scientific questions or hypotheses to be investigated.*

SC.05.SI.01 Make observations. Ask questions or form hypotheses based on those observations, which can be explored through scientific investigations.

Validation: Students will conduct experiments where they will use the scientific method.

Oregon State Standards

Science, Scientific Inquiry: *Collecting and Presenting Data: Conduct procedures to collect, organize, and display scientific data.*

SC.05.SI.03 Collect, organize, and summarize data from investigations.

Validation: Students will record the results from their experiments on forces.

Science, Scientific Inquiry: *Analyzing Data and Interpreting Results: Analyze scientific information to develop and present conclusions.*

SC.05.SI.04 Summarize, analyze, and interpret data from investigations.

Validation: Students will participate in a discussion on the results from the experiments on forces with the class.

Lesson 3: Bernoulli's Principle

Science, Physical Science: *Matter: Understand structure and properties of matter.*

SC.05.PS.01 Identify substances as they exist in different states of matter.

Validation: Students will do an experiment that will help them discover Bernoulli's Principle and how air (as a form of matter) delivers pressure to make planes fly.

Science, Physical Science: *Force: Understand fundamental forces, their forms, and their effects on motion.*

SC.05.PS.03 Describe and compare the motion of objects.

Validation: Students will be experimenting with Bernoulli's Principle and how it is a factor in the force of lift on an airplane.

Science, Scientific Inquiry: *Forming the Question/Hypothesis: Formulate and express scientific questions or hypotheses to be investigated.*

SC.05.SI.01 Make observations. Ask questions or form hypotheses based on those observations, which can be explored through scientific investigations.

Validation: Students will conduct an experiment where they will use the scientific method.

Science, Scientific Inquiry: *Analyzing Data and Interpreting Results: Analyze scientific information to develop and present conclusions.*

SC.05.SI.04 Summarize, analyze, and interpret data from investigations.

Validation: Students will participate in a discussion on the results from the experiments on Bernoulli's Principle with the class.

Language Arts, Speaking and Listening: *Listening: Listen critically and respond appropriately across the subject areas.*

EL.05.SL.08 Interpret a speaker's verbal and non-verbal messages, purposes, and perspectives.

Validation: Students will listen attentively and be engaged when the teacher and classmates are speaking.

Lesson 4: Aerodynamics

Science, Physical Science: *Matter: Understand structure and properties of matter.*

SC.05.PS.03 Describe and compare the motion of objects.

Validation: Students will review how the four forces affect an airplane and describe how an aircraft's shape affects the speed it can reach.

Oregon State Standards

Science, Scientific Inquiry: *Forming the Question/Hypothesis: Formulate and express scientific questions or hypotheses to be investigated.*

SC.05.SI.01 Make observations. Ask questions or form hypotheses based on those observations, which can be explored through scientific investigations.

Validation: Students will conduct an experiment on aerodynamics where they will use the scientific method.

Science, Scientific Inquiry: *Analyzing Data and Interpreting Results: Analyze scientific information to develop and present conclusions.*

SC.05.SI.04 Summarize, analyze, and interpret data from investigations.

Validation: Students will discuss their findings from the aerodynamic experiment as a class.

Language Arts, Speaking and Listening: *Listening: Listen critically and respond appropriately across the subject areas.*

EL.05.SL.07 Ask relevant questions that seek information not already discussed.

Validation: Students will ask questions brought about by the aerodynamic experiment.

Resources

Internet Resources

FAA Education Program

http://www.faa.gov/education_research/education/

Contains aviation information and resources for teachers and students

National Air and Space Museum

<http://www.nasm.si.edu/>

This site has teaching resources, online activities and aviation information for exploring the science of flight

National Coalition for Aviation Education

www.aviationeducation.org

Provides access to teacher resources

NASA Education Program

<http://education.nasa.gov/home/index.html>

Offers classroom activities and educational learning programs

Principles of Aviation

<http://wings.avkids.com/>

Contains lessons, student activities, principles, curriculum bridges and other resources for planning your unit on aeronautics

Helpful Links

HowStuffWorks

<http://www.howstuffworks.com/>

This site offers simple explanations for how things work, including airplanes

InfoUse, in cooperation with NASA

<http://www.planemath.com/>

Contains activities that relate math concepts with aviation

PBS

http://pbskids.org/arthur/parentsteachers/activities/acts/what_flies.html

Offers a lesson on the types of things that fly and other various resources

ProTeacher

<http://www.proteacher.com/110069.shtml>

Provides student activities, experiments and information for aviation studies