BASICS FOR AIR TRAFFIC CONTROL – PRINCIPLES OF FLIGHT

MODULE OVERVIEW

Purpose: The purpose of this module is to provide basic aeronautical information that will help you communicate with pilots concerning the operation of their aircraft.

MODULE OUTLINE

Lesson: Basic Aeronautical Information

Purpose: The purpose of this lesson is to describe the forces that give an aircraft lift and move it through the air.

Objectives:

- Identify primary and secondary sources of lift
- Identify types and parts of airfoils
- Identify forces affecting flight, their interrelationships, and their effects on aircraft performance

Topics:

- Theories of Flight
  - Bernoulli's Principle
  - Newton's Third Law of Motion
- Knowledge Check
- Relative Wind
- Airfoils
  - Types of Airfoils
  - Parts of an Airfoil
  - Angle of Attack
  - Camber
  - Wing Planforms
- Knowledge Check
- Forces Affecting Flight
  - Four Forces Affecting Flight
  - Interrelationship of Lift and Weight
  - Interrelationship of Thrust and Drag
- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

Lesson: Effects of Atmosphere on Aircraft Performance

Purpose: The purpose of this lesson is to explain how atmospheric conditions affect aircraft performance.

Objective:

- Identify effects of altitude, temperature, and pressure on aircraft performance

Topics:

- Atmospheric Properties
  - Nature of the Atmosphere
  - Atmosphere and Temperature
  - Altitude and Pressure
  - Water Vapor/ Humidity
  - Density and Density Altitude
- Effects of Atmosphere on Aircraft Performance
  - Effects of Altitude on Performance
  - Effect of Temperature on Performance
  - Effect of Humidity on Performance
  - Combined Effects on Performance
- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

Lesson: Primary and Secondary Flight Controls

Purpose: The purpose of this lesson is to explain aircraft flight controls and helicopter aerodynamics.

Objectives:

- Identify functions of primary and secondary flight controls and the movement around the aircraft axes
- Identify helicopter aerodynamics and controls

Topics:

- Rotational Axes of Aircraft
  - Longitudinal Axis (Roll)
  - Lateral Axis (Pitch)
  - Vertical Axis (Yaw)
- Knowledge Check
- Primary Control Surfaces
  - Ailerons
  - Elevator
  - Rudder
- Knowledge Check
- Secondary Control Surfaces
  - Trim Tabs
  - Flaps
- Knowledge Check
- Basic Helicopter Dynamics
- Helicopter Controls
  - Throttle
  - Collective
  - Cyclic
- Autorotation

Video – Autorotation (1:08 mins.)

- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

Lesson: Hazards Affecting Flight

Purpose: The purpose of this lesson is to explain different hazards that affect flight.

Objective:

- Describe hazards that affect flight

Topics:

- Stalls

Video – Stalls – Wind Tunnel (1:14 mins.)

- Icing
  - Structural Icing
  - Pitot-Static System Icing
  - Carburetor Icing
- Aircraft System Failures
  - Electrical Failures
  - Mechanical Failures
  - Hydraulic Failure
  - Engine Failure
  - Engine Fire
- Knowledge Check
- Review/Summary

Question and Answer Session

Video – A Lesson in Flight (25:19 mins.)

Question and Answer Session – *Parking Lot*

Activity – Principles of Flight

Question and Answer Session – *Parking Lot*

End-of-Module (EOM) Test

INTRODUCTION

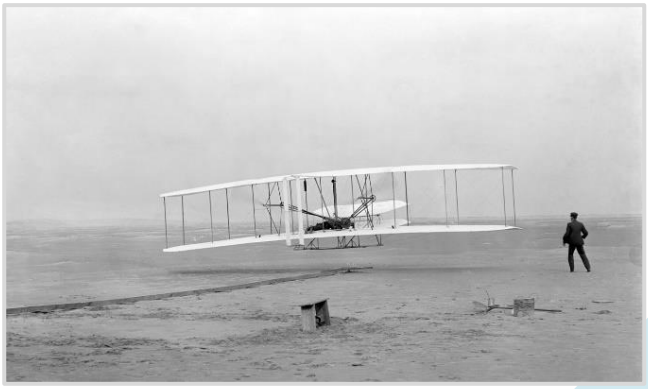
LESSONS	■ Basic Aeronautical Information ■ Effects of Atmosphere on Aircraft Performance ■ Primary and Secondary Flight Controls ■ Hazards Affecting Flight
TOTAL ESTIMATED RUN TIME	4 hrs. 42 mins.
MODULE CONTENT	■ Module Overview ■ Lesson: Basic Aeronautical Information ■ Q&A Session – Parking Lot ■ Lesson: Effects of Atmosphere on Aircraft Performance ■ Q&A Session – Parking Lot ■ Lesson: Primary and Secondary Flight Controls ■ Q&A Session – Parking Lot ■ Lesson: Hazards Affecting Flight ■ Q&A Session – Parking Lot ■ Video – A Lesson in Flight (25:19 mins.) ■ Q&A Session – Parking Lot ■ Activity – Principles of Flight ■ Q&A Session – Parking Lot ■ End-of-Module Test

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Instruct students to select ***Principles of Flight*** module link within Blackboard ■ Instruct students to read the module introduction and then wait quietly for additional instructions	Blackboard
	EST. RUN TIME
	2 mins.

What forces did Orville and Wilbur Wright have to overcome in order to get this aircraft off the ground?

Knowledge of basic aerodynamics will help you communicate accurately and professionally with pilots concerning their aircraft. This knowledge will be used daily on a routine basis. Occasionally, during an aircraft emergency, an understanding of basic aerodynamics may be invaluable to you as an air traffic control specialist.

The purpose of this module is to provide basic aeronautical information that will help you communicate with pilots concerning the operation of their aircraft.



FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Basic Aeronautical Information*** lesson in Blackboard ■ Instruct students to navigate to the ***Basic Aeronautical Information*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 20 mins.

BASIC AERONAUTICAL INFORMATION

Purpose: The purpose of this lesson is to describe the forces that give an aircraft lift and move it through the air.

Objectives:

- Identify primary and secondary sources of lift
- Identify types and parts of airfoils
- Identify forces affecting flight, their interrelationships, and their effects on aircraft performance

References for this lesson are as follows:

- FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge

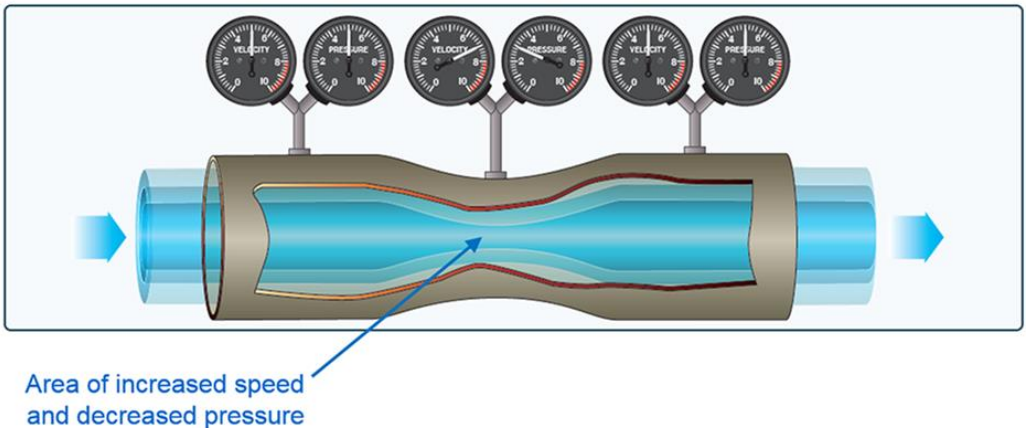
Theories of Flight

To understand what allows an aircraft to fly (how an airplane produces lift), basic knowledge of Bernoulli's Principle and one of Newton's Laws is necessary.

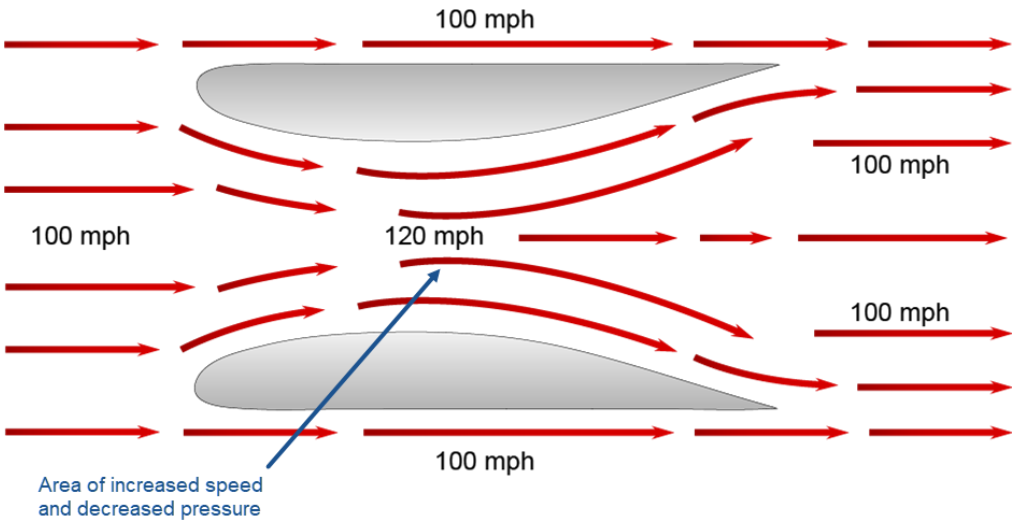
Bernoulli's Principle

Bernoulli's Principle states, in part, that "the internal pressure of a fluid (liquid or gas) decreases at points where the speed of the fluid increases."

- Flow through a tube with a reduced cross sectional area increases fluid speed and decreases fluid pressure

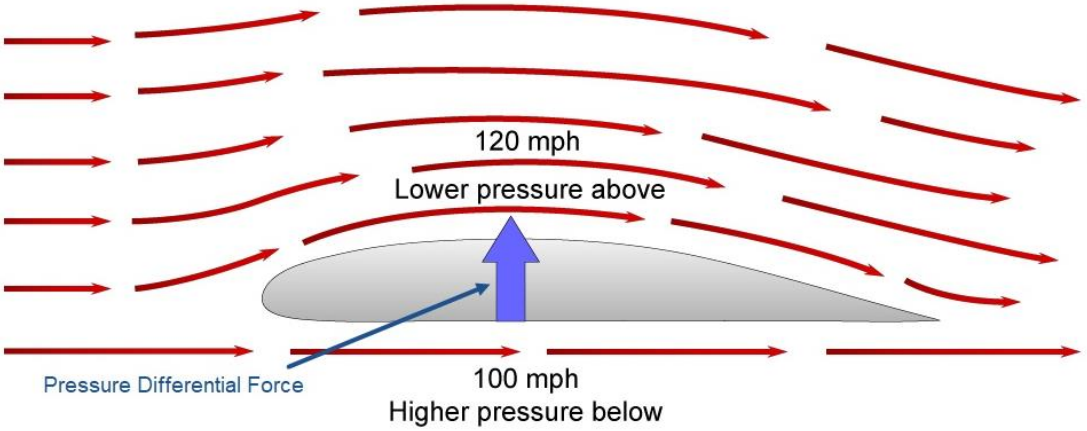


The tube can be replaced by two airfoils and cause the same effects.



The pressure differential around an airfoil is the primary source of lift.

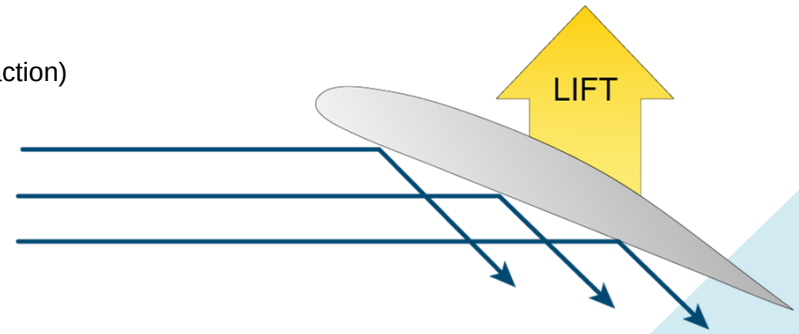
- A pressure differential occurs when there is a pressure difference between opposing sides of a surface
- A pressure differential causes the higher pressure area below the airfoil to try to equalize pressure by pushing (lifting) the airfoil toward the lower pressure area above
- This lift is the result of Bernoulli's Principle



Newton's Third Law of Motion

For every action, there is an equal and opposite reaction. A secondary source of lift is an upward force generated by air striking the underside of an airfoil and being deflected downward.

- In this graphic:
  - Air is striking the underside of an airfoil (action)
  - The wing is being pushed up (reaction)



Knowledge Check A

REVIEW what you have learned so far about basic aeronautical information. ANSWER the questions listed below.

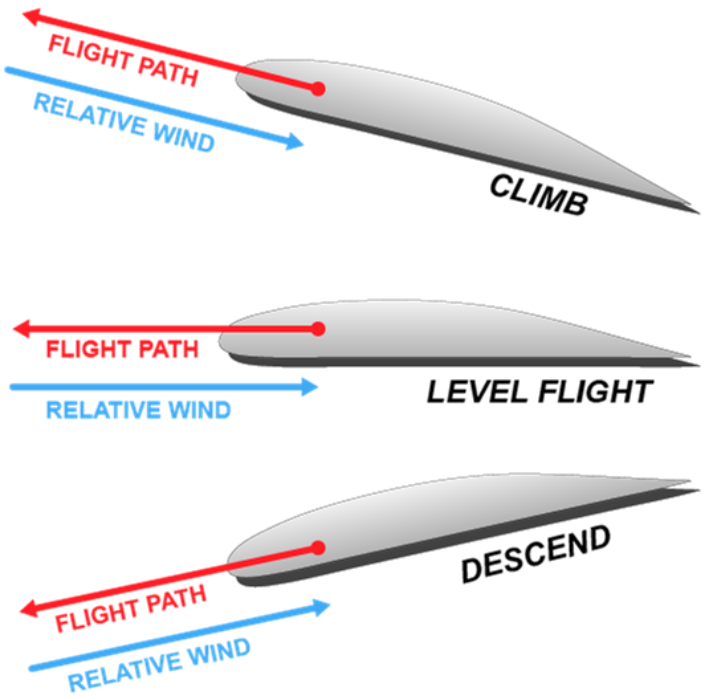
1. The primary source of lift on an airfoil is created by a differential in _____. *(Select the correct answer.)*
   - ❑ Temperature
   - ❑ **Pressure**
   - ❑ Reaction

2. The statement "the internal pressure of a fluid decreases at points where the speed of the fluid increases" is a part of _____. *(Select the correct answer.)*
   - ❑ **Bernoulli's Principle**
   - ❑ Newton's Law of Motion
   - ❑ Hindenburg's Theory

Relative Wind

Relative Wind is the direction of the airflow produced by an object moving through the air.

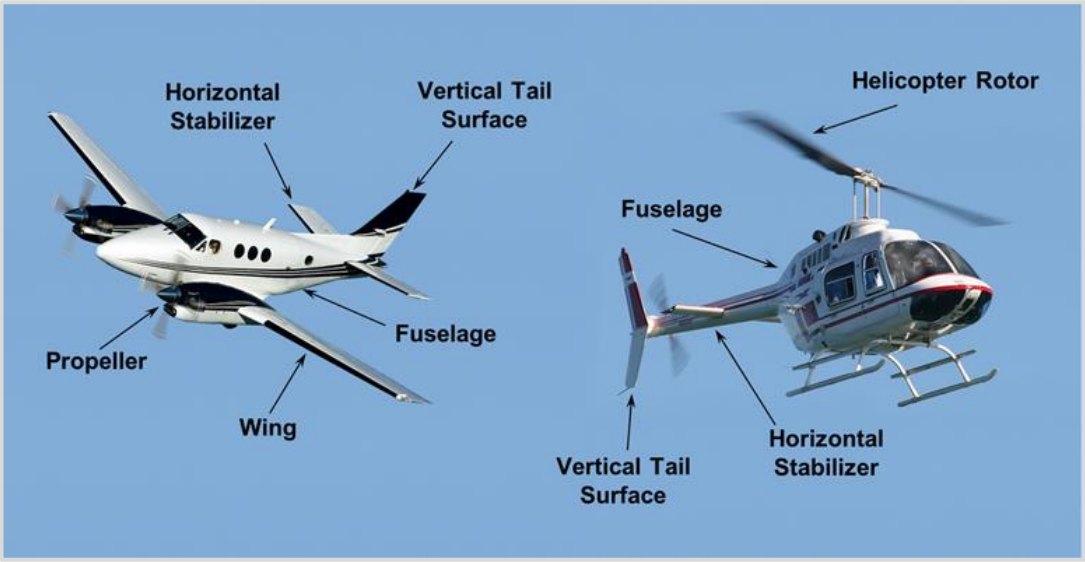
- The relative wind for an aircraft in flight flows in a direction parallel with and opposite to the direction of flight
- The actual flight path of the aircraft determines the direction of the relative wind



Airfoils

Types of airfoils on aircraft are:

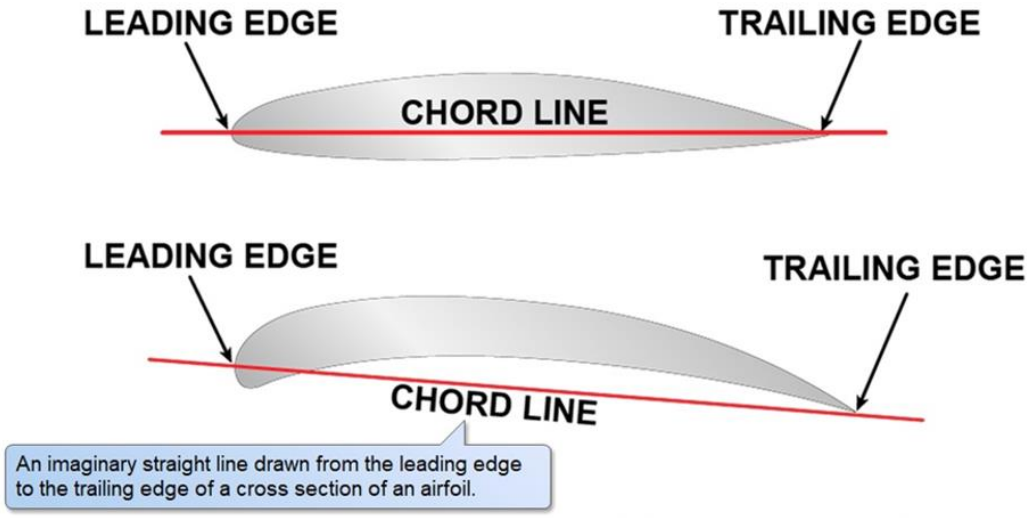
- Wing
- Propeller
- Helicopter rotor
- Horizontal stabilizer
- Vertical tail surfaces
- Fuselage



The three principal airfoils that produce lift on an aircraft are:

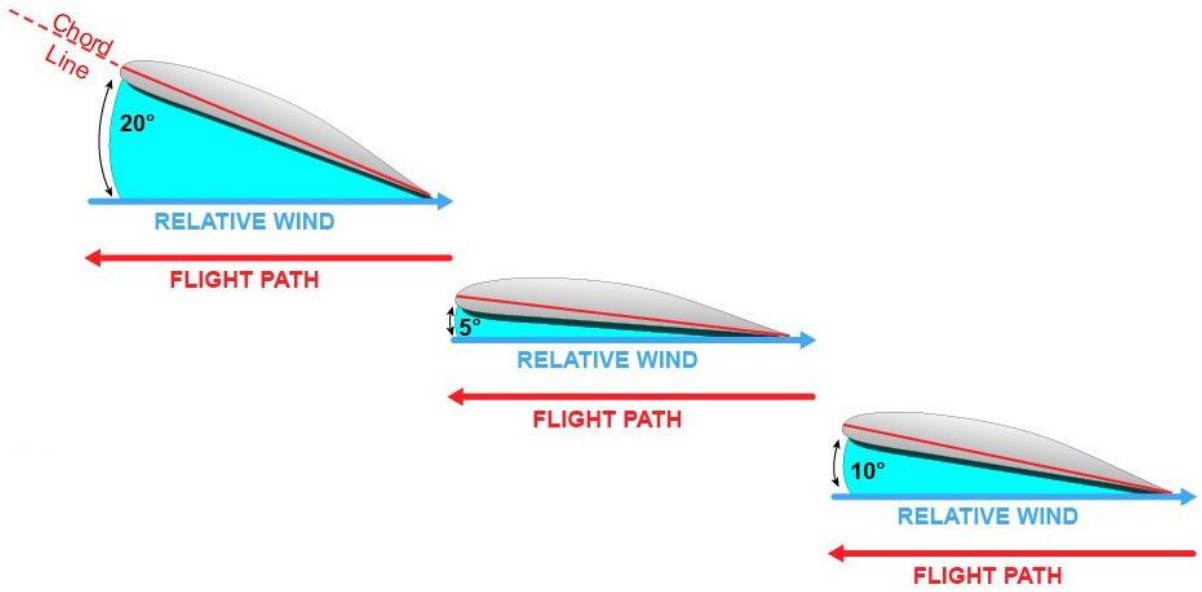
- Wing
- Horizontal tail surfaces
- Propeller (lift produced in a forward direction)

Parts of an Airfoil



Angle of Attack

The **angle of attack** is the angle at which relative wind meets an airfoil. It is the angle that is formed by the chord of the airfoil and the direction of the relative wind.

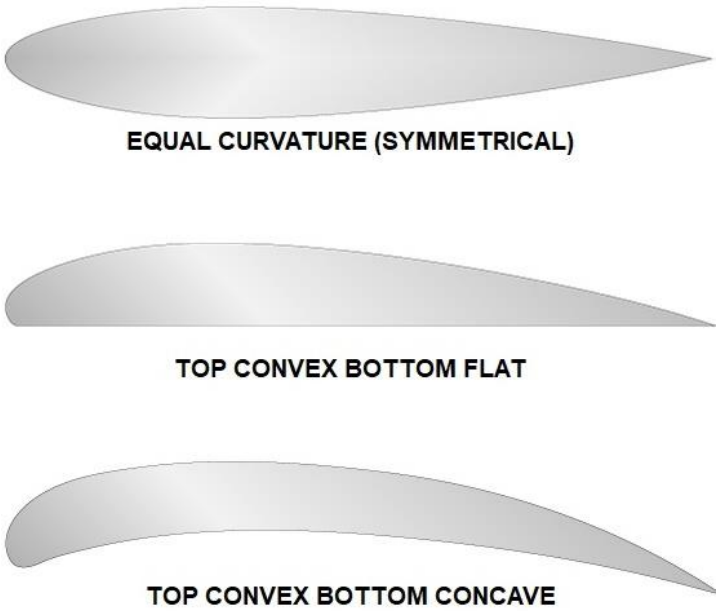


Note: *The angle of attack is based on the relative wind, not the ground.*

Camber

The **camber** of an airfoil is the characteristic curve of its upper and lower surfaces. Generally, the upper camber is more pronounced, while the lower camber is comparatively flat. This causes the velocity of the airflow immediately above the wing to be much higher than that below the wing.

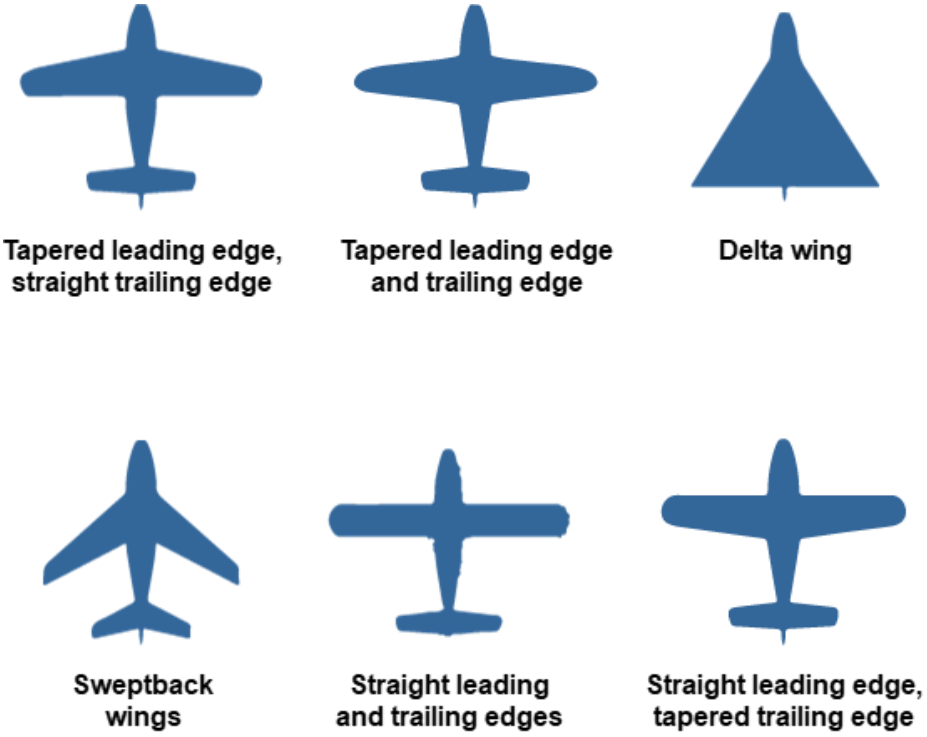
- Lower camber refers to the curvature of the lower surface
- Upper camber refers to the curvature of the upper surface
- The camber or curvature of a wing is designed according to the:
  - Type of aircraft
  - Planned speed of the aircraft
  - Weight of the aircraft
  - Planned use of the aircraft



Wing Planforms

The **wing planform** is the shape or form of a wing as viewed from above. It may be long and tapered, short and rectangular, or various other shapes.

- The planform design is dependent on the use of the aircraft
  - **Examples:** The faster the aircraft, the thinner the airfoil to reduce drag; the thinner the airfoil, the more surface area needed to produce lift
- The amount of lift generated by the wing depends upon several factors:
  - Speed of the wing through the air
  - Angle of attack
  - Planform of the wing
  - Wing area
  - Density of the air
  - Camber



Knowledge Check B

REVIEW what you have learned so far about basic aeronautical information. ANSWER the questions listed below.

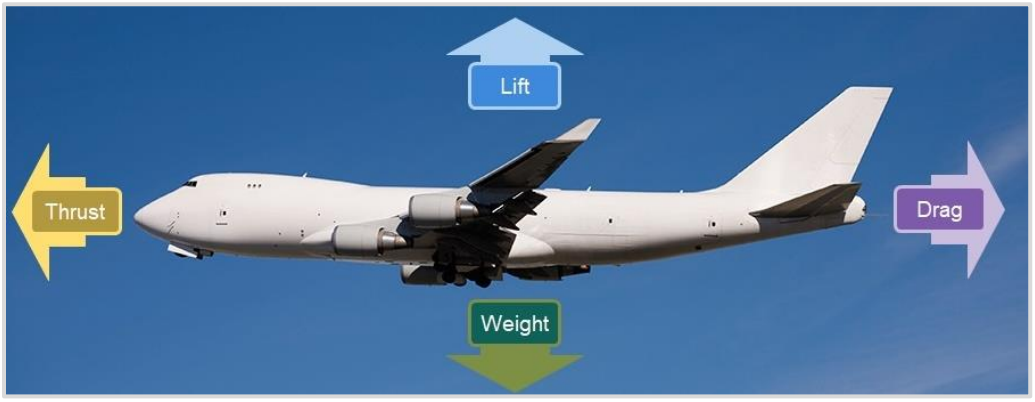
1. What is the curvature of the airfoil from the leading edge to the trailing edge? *(Select the correct answer.)*
   - ❑ **Camber**
   - ❑ Equalizer
   - ❑ Airfoil line

2. What are the three principal airfoils? *(Select all correct answers that apply.)*
   - ❑ **Wing**
   - ❑ Fuselage
   - ❑ **Horizontal tail surfaces**
   - ❑ **Propeller**
   - ❑ Tail rudder

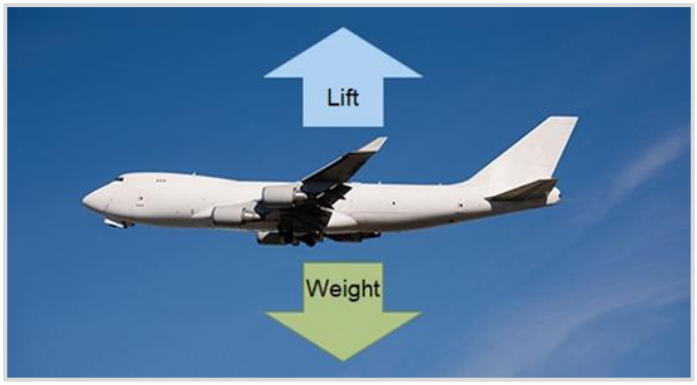
Forces Affecting Flight

Four Forces Affecting Flight

Lift	Drag	Weight	Thrust
Upward force created by an airfoil when it is moved through the air.	Rearward-acting force that resists the forward movement of the airplane through the air.	Downward force that tends to draw all bodies vertically toward the center of the Earth.	Man-made force that pulls or pushes the aircraft through the air.



Interrelationship of Lift and Weight



- In straight and level flight (constant altitude), lift counterbalances the aircraft's weight, or:
  - When lift and weight are in equilibrium, the aircraft neither gains nor loses altitude
- If lift is greater than weight, the aircraft will climb
- If weight is greater than lift, the aircraft will descend

Interrelationship of Thrust and Drag

- In straight and level flight, thrust and drag are equal in magnitude if a constant airspeed is being maintained
- Thrust is controlled by the throttle
  - As more throttle is applied, more thrust is produced
- When the thrust of the propeller is increased, thrust momentarily exceeds drag and the airspeed will increase, provided straight and level flight is maintained
  - With an increase in airspeed, drag increases rapidly
  - As soon as thrust and drag become equalized, the airspeed will again become constant

Knowledge Check C

REVIEW what you have learned so far about basic aeronautical information. ANSWER the questions listed below.

1. Match the terms with the definitions. Enter your answers in the spaces below.

b	The angle at which relative wind meets an airfoil.	a.	Relative wind
c	The characteristic curve of an airfoil's upper and lower surfaces.	b.	Angle of attack
d	The shape or form of a wing as viewed from above.	c.	Camber
a	The direction of the airflow produced by an object moving through the air.	d.	Wing planform

Basic Aeronautical Information Summary

It is hard to imagine how a 735,000-pound aircraft is able to get off the ground and stay airborne. The mechanics of flight are highly complex. Learning the basic flight principles will allow you to more effectively perform your job as an Air Traffic Controller.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in the ***Basic Aeronautical Information*** lesson ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 15 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Effects of Atmosphere on Aircraft Performance*** lesson in Blackboard ■ Instruct students to navigate to the ***Effects of Atmosphere on Aircraft Performance*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 20 mins.

EFFECTS OF ATMOSPHERE ON AIRCRAFT PERFORMANCE

Purpose: The purpose of this lesson is to explain how atmospheric conditions affect aircraft performance.

Objective:

- Identify effects of altitude, temperature, and pressure on aircraft performance

References for this lesson are as follows:

- FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge
- The Aeronautical Information Manual (AIM)

Atmospheric Properties

The atmosphere is an envelope of air that surrounds the Earth and rests upon its surface. It is as much a part of the Earth as is land and water. The atmosphere is made up of a mixture of gases that reaches almost 350 miles from the surface of the Earth.

Nature of the Atmosphere

Three key properties of the atmosphere that affect air density and aircraft performance are:

- Temperature
- Altitude
- Water vapor (humidity)

Note: *References to aircraft performance in this lesson include length of takeoff roll, initial rate of climb, and length of landing roll.*

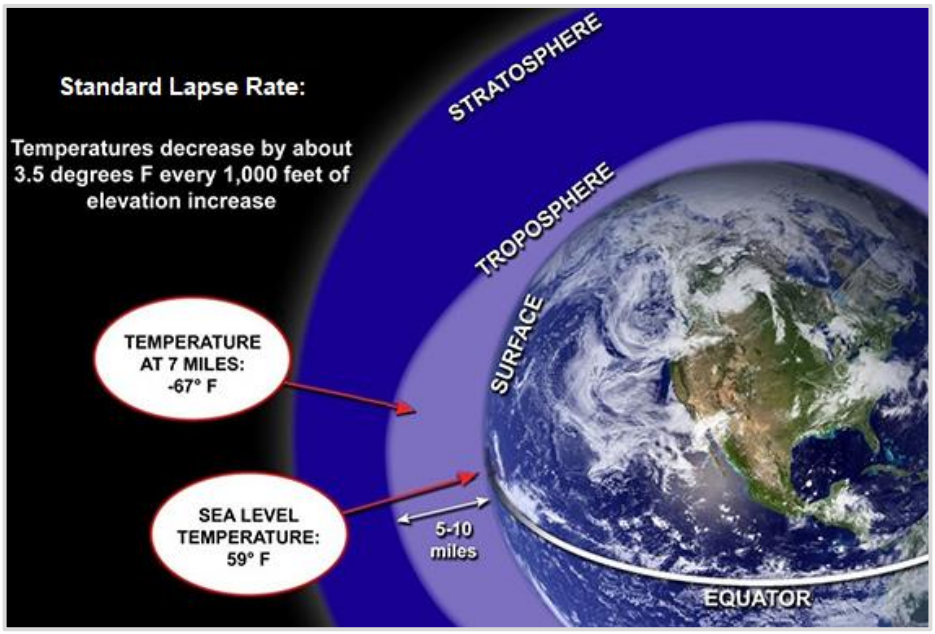
Atmosphere and Temperature

Near the surface, the air is relatively warm from contact with the Earth.

- Surface temperatures change frequently and are relatively warmer during the day and summer and cooler during night and winter
- Due to constantly changing atmospheric conditions, a standard reference was developed
- The standard surface temperature at sea level is 15º Celsius (59º Fahrenheit)

As altitude increases, temperature decreases.

- A decrease of temperature with an increase in altitude is called a lapse rate
- The standard lapse rate is approximately 2ºC (3.5º Fahrenheit) per thousand feet
- Cold air is more dense than warm air



Altitude and Pressure

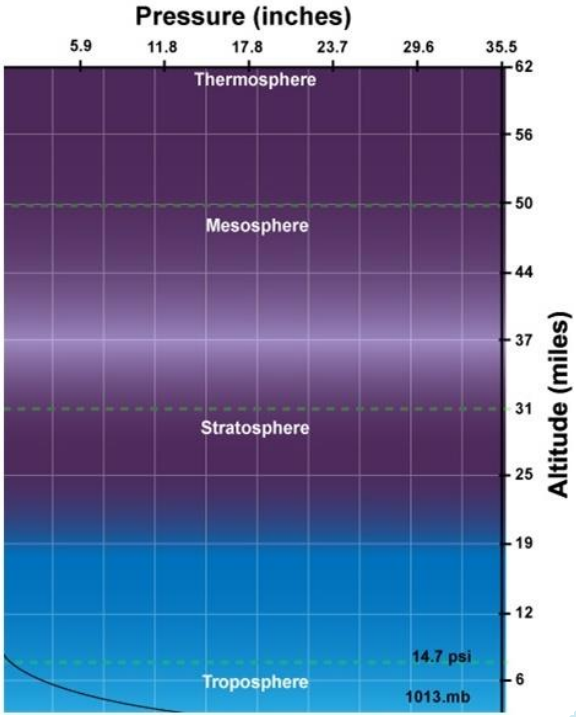
A body of air as deep as the atmosphere has tremendous weight.

- The weight of the atmosphere on an average person is about 20 tons

Pressure is the result of the weight of the air above the measurement position.

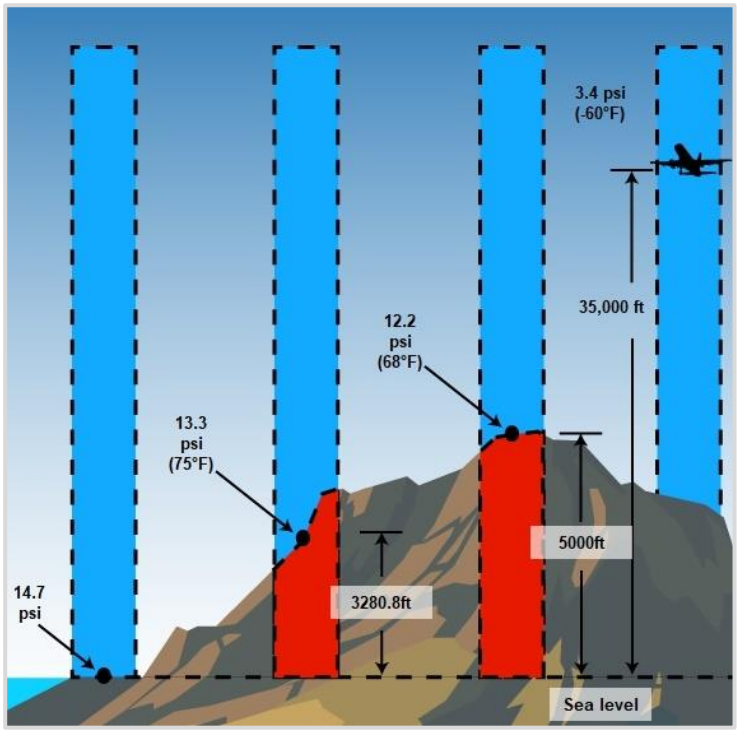
- The average pressure at sea level is 14.7 pounds per square inch (psi), which corresponds with 29.92 inches of mercury

Note: *In the atmosphere, both temperature and pressure decrease with altitude and have conflicting effects upon density. However, the fairly rapid drop in pressure as altitude is increased usually has the dominant effect. Hence, pilots can expect the total air density to decrease with altitude*



Pressure decreases with height.

- At higher altitudes, there is less air above the measurement position and less weight
- For example, pressure decreases from 14.7 psi at sea level to 12.2 psi at 5,000 feet above sea level and to 3.4 psi at 35,000 feet (FL 350)
- Lower pressure results in less dense air



Water Vapor/Humidity

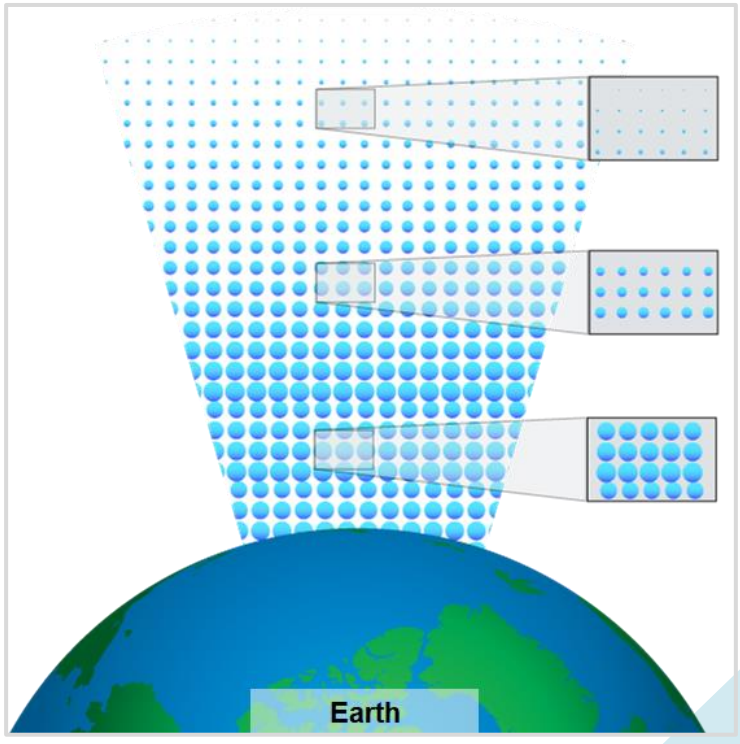
Moisture in the atmosphere is the invisible gas called water vapor.

- The higher the temperature, the greater amount of water vapor the air can hold
- Water vapor is lighter than air; consequently, moist air is lighter than dry air
- An increase in water vapor (higher humidity) results in a decrease in air density

Density and Density Altitude

Density is the mass of air per unit volume and is often described by the term density altitude.

- Density altitude is a term used to correlate aircraft performance, in a nonstandard atmosphere, to an altitude in the standard atmosphere corresponding to a particular value of air density
- Density altitude calculations are used by pilots to determine aircraft performance characteristics given the existing atmospheric conditions
- As the density of the air increases (lower density altitude), aircraft performance increases; conversely, as air density decreases (higher density altitude), aircraft performance decreases
- A decrease in air density means a higher density altitude; an increase in air density means a lower density altitude

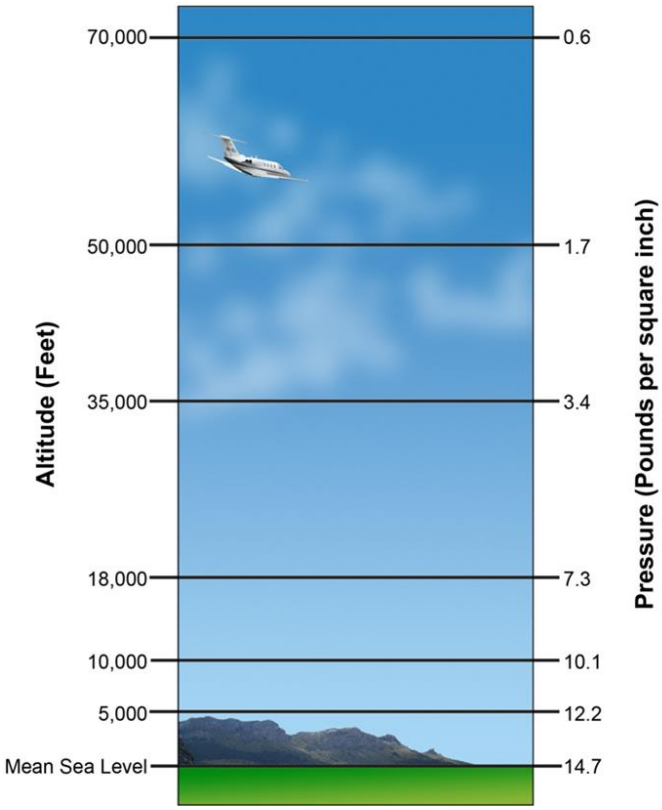


Density altitude is the vertical distance above sea level in the standard atmosphere at which a given air density is to be found.

Increased density altitude, such as in mountainous and high terrain areas with warm and humid air, can greatly reduce aircraft performance, including:

- Longer takeoff roll
- Longer landing roll
- Slower climb rate
- Reduced engine power output
- Landing speed increased

***Note**: The effects of high-density altitude on aircraft performance are going to greatly impact controller workload, e.g. more spacing required, slower climbs, more time to clear the runway, etc.*

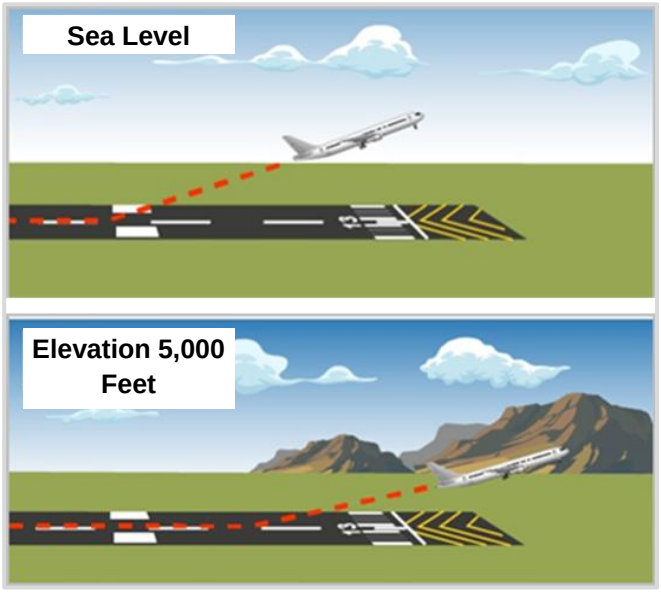


Effects of Atmosphere on Aircraft Performance

Effects of Altitude on Performance

An increase in altitude decreases atmospheric pressure and increases density altitude, which has a pronounced negative effect on flight. At higher elevation airfields:

- The length of the runway needed for takeoff roll will be increased
- The climb performance of an aircraft will be diminished
- The length of the runway needed for the landing roll will be increased
- The amount of power an engine can produce will be decreased



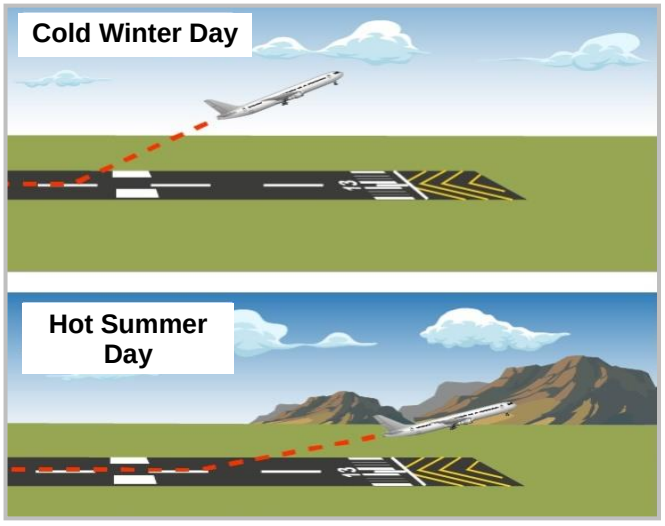
Effect of Temperature on Performance

Atmospheric density varies with temperature.

- When the air is heated, it expands and, therefore, has less density, increasing the density altitude

On a hot day, as compared to a cold day:

- Takeoff roll will be longer
- Rate of climb will be slower
- Landing speed will be faster
- Engine power output will be decreased



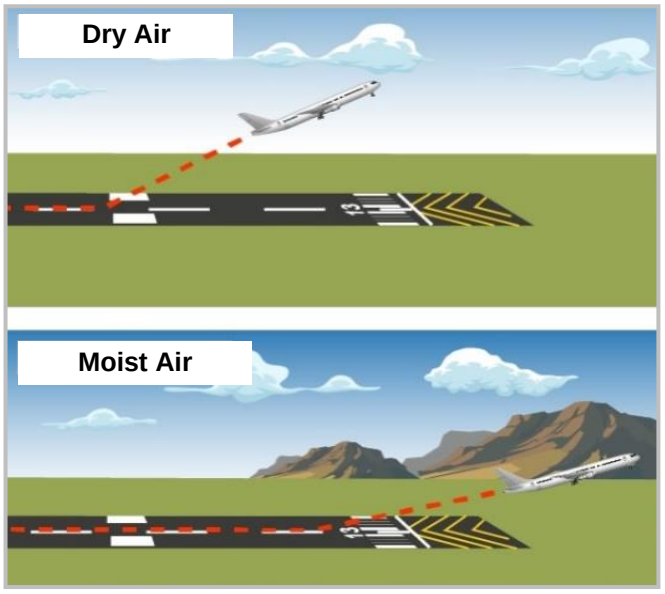
Effect of Humidity on Performance

Water vapor (humidity) is lighter than air; consequently, humid air is lighter than dry air. Therefore, as the water content of the air increases, the air becomes less dense, increasing density altitude and decreasing performance.

Increased humidity (decreased air density) has a less pronounced effect on density altitude than altitude and temperature but can still have a pronounced effect on flight.

On a humid day, as compared to a dry day:

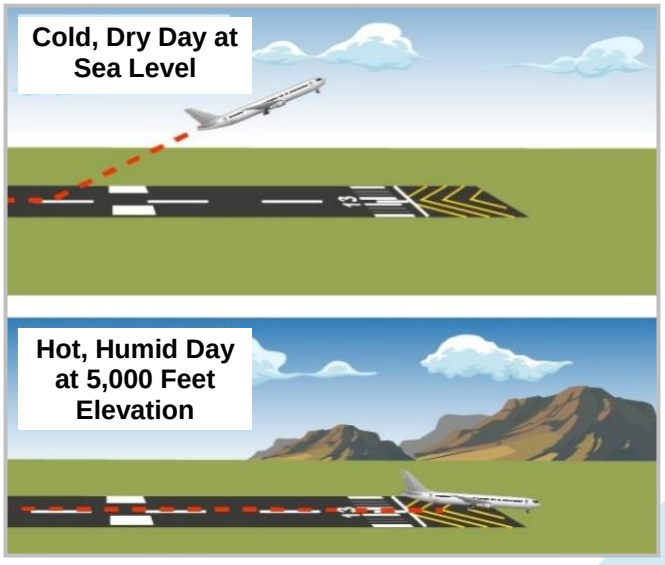
- Takeoff roll will be longer
- Rate of climb will be slower
- Landing speed will be faster
- Engine power output will be decreased



Combined Effects on Performance

High elevation airfields with hot and humid conditions will have very poor aircraft performance.

- Length of runway needed for takeoff roll will be increased
- Initial climb performance of an aircraft will be diminished
- Length of runway needed for landing roll will be increased
- Engine power output will be decreased



Knowledge Check D

REVIEW what you have learned so far about effects of atmosphere on aircraft performance. ANSWER the questions listed below.

1. The key properties of the atmosphere that affect air density and aircraft performance are: *(Select all correct answers that apply.)*
   - ❑ **Altitude**
   - ❑ Airfoils
   - ❑ **Temperature**
   - ❑ Turbulence
   - ❑ **Humidity**

2. What is the result of the weight of the air above the measurement position? *(Select the correct answer.)*
   - ❑ Density
   - ❑ **Pressure**
   - ❑ Precipitation

3. What are some of the ways increased density altitude can reduce aircraft performance? *(Select all correct answers that apply.)*
   - ❑ **Longer takeoff roll**
   - ❑ Shorter landing roll
   - ❑ **Slower climb rate**
   - ❑ **Reduced engine power**
   - ❑ **Increased landing speed**

4. How would temperature affect aircraft on a hot day? *(Select all correct answers that apply.)*
   - ❑ **Longer takeoff roll**
   - ❑ **Faster landing speed**
   - ❑ Increased engine power
   - ❑ **Slower rate of climb**

5. How would increased humidity affect aircraft performance? *(Select all correct answers that apply.)*
   - ❑ **Longer takeoff roll**
   - ❑ **Faster landing speed**
   - ❑ Increased engine power
   - ❑ **Slower rate of climb**

Effects of Atmosphere on Aircraft Performance Summary

Atmospheric conditions will make a difference in your job. On a warm day, you might direct air traffic differently than on a cold day. On a humid day, you might direct air traffic differently than on a dry day. Gaining a basic knowledge of how the atmosphere affects aircraft is essential to the safety of the pilots and passengers in your airspace.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in the ***Effects of Atmosphere on Aircraft Performance*** lesson ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 20 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Primary and Secondary Flight Controls*** lesson in Blackboard ■ Instruct students to navigate to the ***Primary and Secondary Flight Controls*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 30 mins.

PRIMARY AND SECONDARY FLIGHT CONTROLS

Purpose: The purpose of this lesson is to explain how flight controls work to control the movement of an aircraft and helicopter aerodynamics.

Objectives:

- Identify functions of primary and secondary flight controls and the movement around the aircraft axes
- Identify helicopter aerodynamics and controls

References for this lesson are as follows:

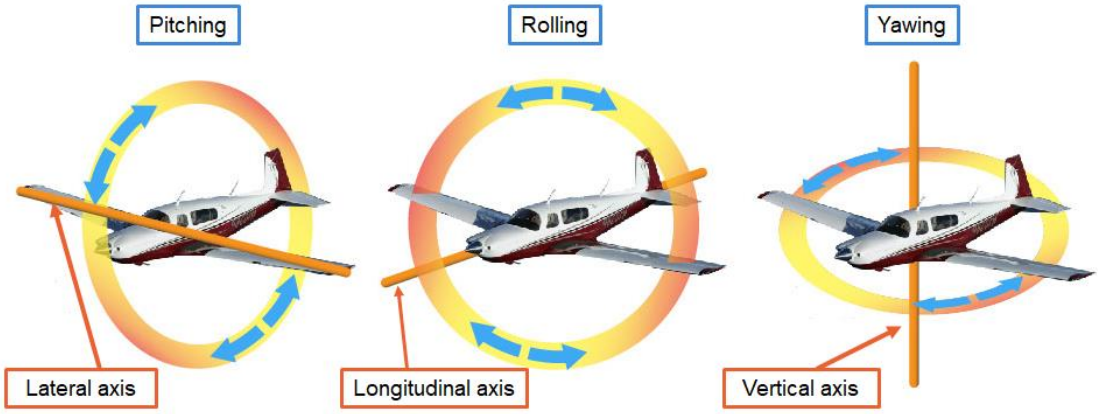
- FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge
- FAA-H-8083-21, Rotorcraft Flying Handbook

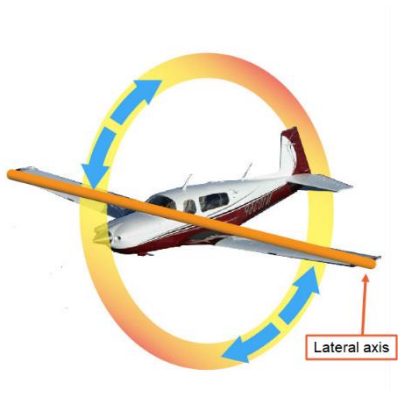
Rotational Axes of Aircraft

An axis is a straight line about which a body rotates. An aircraft has three axes of rotation.

- Longitudinal axis (roll)
- Lateral axis (pitch)
- Vertical axis (yaw)

The directions of rotation are always relative to the pilot view.



Longitudinal Axis (Roll)	The longitudinal axis is an imaginary straight line through the fuselage, nose to tail. ■ Movement around the longitudinal axis is called the roll movement ■ Controls angle of bank	
Lateral Axis (Pitch)	The lateral axis is a line through the wing from wingtip to wingtip. ■ Movement around the lateral axis is called the pitch movement (nose up, nose down) ■ Controls angle of attack and aircraft pitch attitude	
Vertical Axis (Yaw)	The vertical axis is a line through the center of gravity from top to bottom. ■ Movement around the vertical axis is called yaw movement ■ Controls left-to-right alignment of the longitudinal axis with respect to the relative wind ■ Controls the streamlined motion of the aircraft	

Knowledge Check E

REVIEW what you have learned so far about primary and secondary flight controls. ANSWER the question listed below.

1. The three rotational axes on an aircraft are: *(Select all correct answers that apply.)*
   - ❑ **Roll**
   - ❑ Trim
   - ❑ **Pitch**
   - ❑ **Yaw**

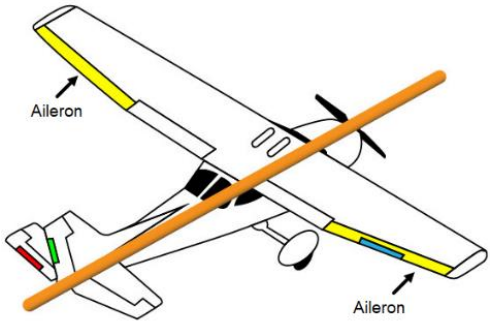
Primary Control Surfaces

Control of the aircraft movement about its three axes of rotation is affected by the primary control surfaces.

- Ailerons (controls roll)
- Elevator (moves as a unit; controls pitch)
- Rudder (controls yaw)

Ailerons

Ailerons are hinged surfaces normally mounted on the outboard trailing edge of the wings. The ailerons rotate the aircraft around the longitudinal axis.



Movement of Ailerons

Left and right ailerons move simultaneously but in opposite directions.

- Lift increases on the down aileron, decreases on the up aileron

Moving ailerons induces adverse yaw.

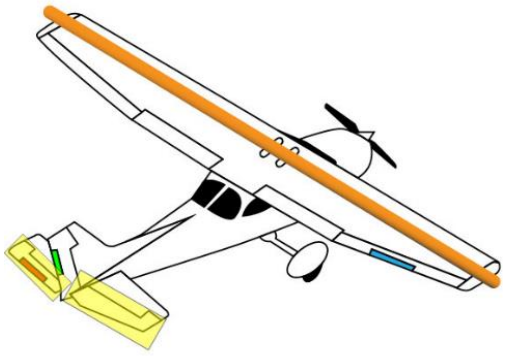
- Adverse yaw is the tendency of the nose of the aircraft to yaw in the opposite direction of the turn
- Adverse yaw is caused by the drag of the “down” aileron

The control yoke controls the ailerons. The control yoke turns left or right, rotating the aircraft in whichever direction it is turned.

Normal state	
Left rotation	
Right rotation	

Elevator

The elevator is a hinged surface normally located on the rear of the horizontal stabilizer.



The elevator rotates the aircraft around the lateral axis.

- The elevator controls the pitch and angle of attack of the aircraft
- On some aircraft, the entire horizontal tail surface moves; this is also known as a stabilator

***Note**: The stabilator is a single-piece horizontal tail surface on an airplane that pivots around a central hinge point. A stabilator serves the purposes of both the horizontal stabilizer and the elevators.*

Movement of Elevator

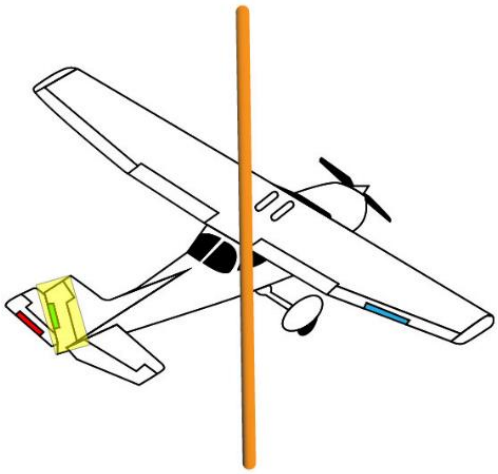
The control yoke moves forward and backward to control the elevator.

- Yoke pulled back, elevator would be up, nose up
- Yoke pushed forward, elevator would be down, nose down

Rudder

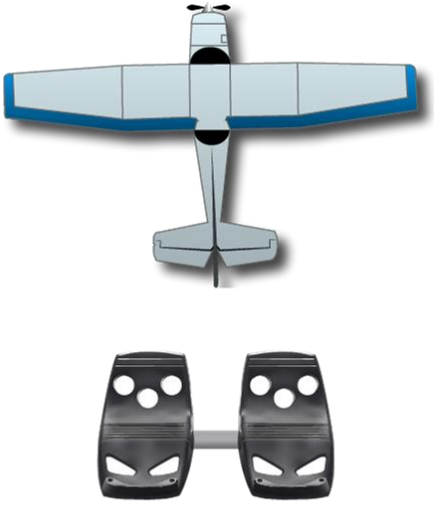
The rudder is in the aft of the vertical stabilizer.

The rudder rotates the aircraft around the vertical axis. The rudder controls the yaw of the aircraft.

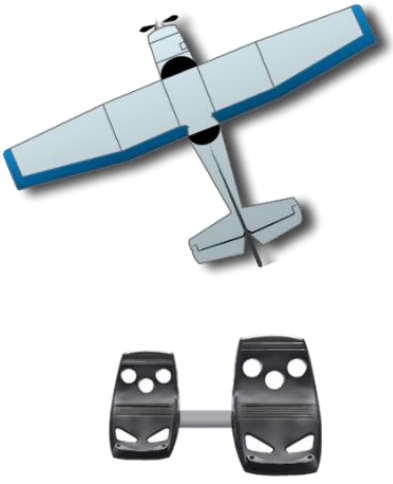


Movement of Rudder

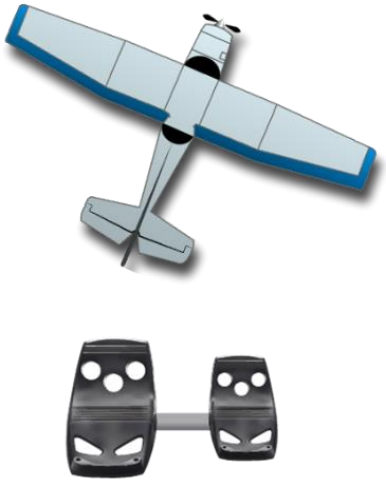
The rudder is controlled by rudder pedals.



Depress left pedal, aircraft will yaw left



Depress right pedal, aircraft will yaw right



Knowledge Check F

REVIEW what you have learned so far about primary and secondary flight controls. ANSWER the questions listed below.

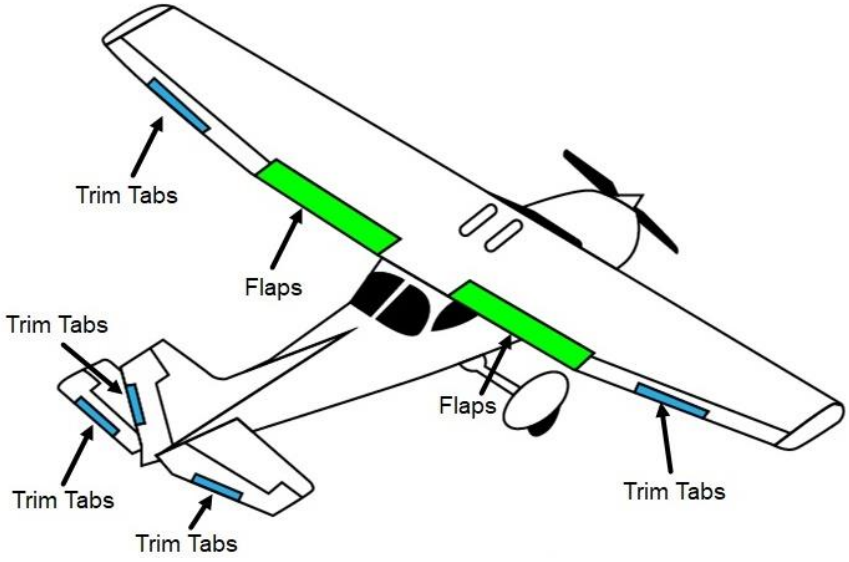
1. Which two movements are controlled by the control yoke? *(Select the correct answer.)*
   - ❑ Pitch and yaw
   - ❑ **Roll and pitch**
   - ❑ Yaw and roll

2. Identify the primary control surfaces with their locations on the aircraft. Write the answer on the correct line.

Secondary Control Surfaces

Secondary control surfaces include:

- Trim tabs
- Flaps



Trim Tabs

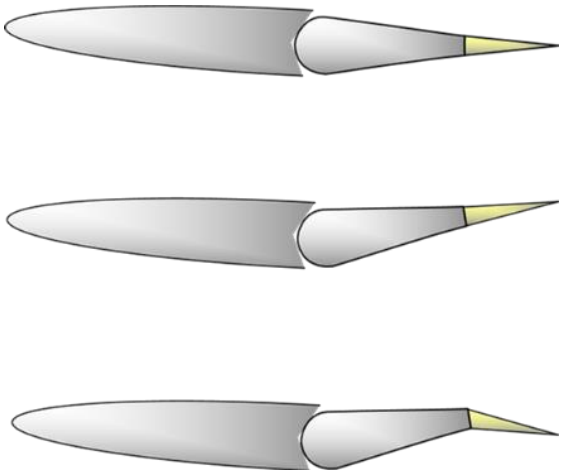
Trim tabs are small, adjustable, hinged surfaces on the trailing edge of the primary control surfaces. The purpose of trim tabs is to lessen the manual pressure the pilot must apply to the control surfaces.

- Aileron trim tabs are generally used on large aircraft
- Elevator and rudder trim tabs are common on all aircraft

Elevators and Trim Tabs

Trim tabs hold the control surface in position aerodynamically.

- Control surface can still be moved by pilot
- Relieves pressure on controls



Trim Tab Control

Trim tab controls are either manual or electric.

***Note**: Some light airplanes have trim tabs that are ground adjustable.*

Flaps

Flaps are located inboard on the wing's trailing edge and are used to increase lift. Flaps are extended in increments described as degrees from the full up position of 0 degrees.

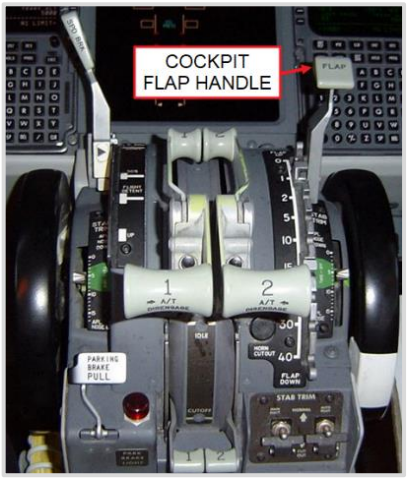
- Usually, three or four positions can be selected, i.e., 10, 20, 30, 40 degrees
- Flaps extend on both wings at the same time

The extension of the flaps increases the camber and, on some types, increases the wing area.

- Increases lift
- Increases drag
- Lowers stall speed
- Allows steeper approach to runway without increased speed

Flaps are mostly used for takeoff and landing.

Cockpit Flap Handle



Flaps are adjusted:

- Manually
- Electrically
- Hydraulically

Knowledge Check G

REVIEW what you have learned so far about primary and secondary flight controls. ANSWER the questions listed below.

1. Which of the following is a primary control surface? *(Select the correct answer.)*
   - ❑ Variable pitch propeller
   - ❑ Flap
   - ❑ **Rudder**

2. The extension of flaps causes an increase in _____. *(Select the correct answer.)*
   - ❑ Stall speed
   - ❑ Airspeed
   - ❑ **Drag**

Basic Helicopter Aerodynamics

The forces acting on helicopters are the same as those acting on fixed-wing aircraft.

- Lift
- Thrust
- Weight
- Drag

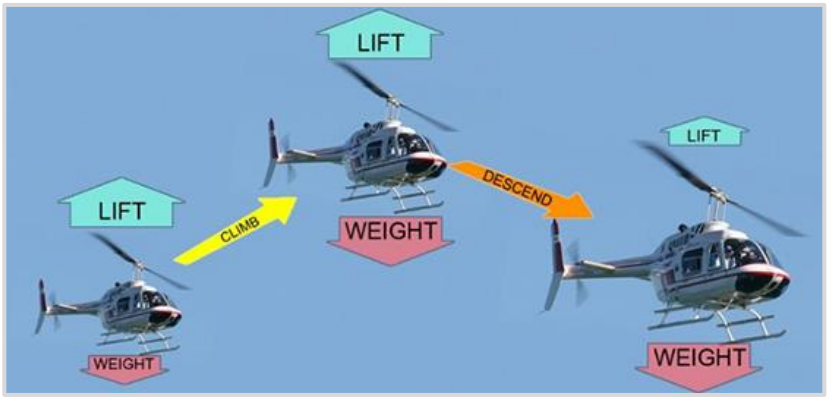
Lift is provided by rotor blades.

- Each blade is shaped like an airfoil
  - Bernoulli's Principle applies
- The rotor blades are moved through the air by the engine; when the blades are in motion, they act as a wing

Relationship of Lift and Weight in a Hover

A combination of Revolutions Per Minute (RPMs) and blade pitch controls:

- Vertical ascent
  - Lift is greater than weight
- Hovering
  - Motionless flight over a reference point
  - Constant heading and altitude
  - Thrust and lift equals weight and drag
- Vertical descent
  - Weight is greater than lift



Helicopter Controls

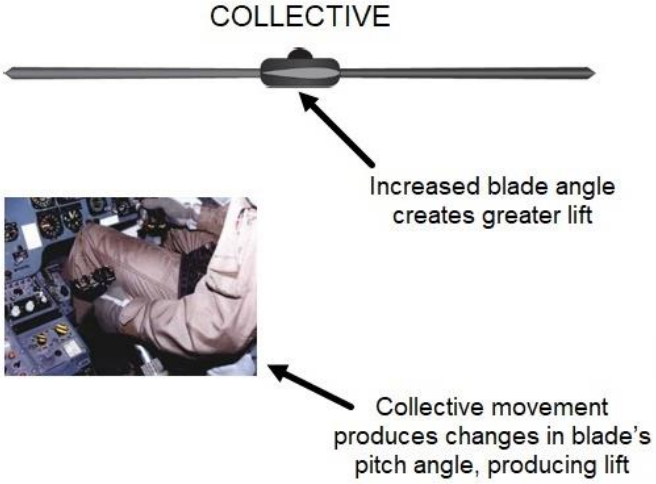
Throttle

The throttle is mounted on the forward end of the collective pitch lever in the form of a motorcycle type twist grip. The function of the throttle is to regulate the RPMs.

Collective

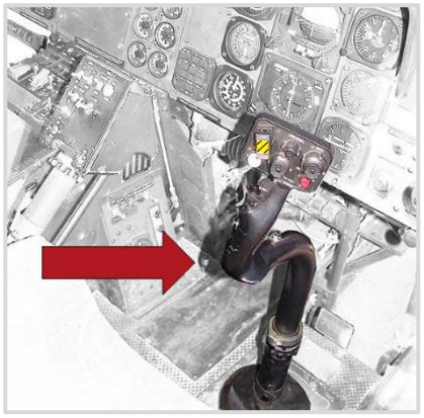
The collective controls the pitch of the rotor blade (angle of attack). The greater the blade angle, the greater the lift produced.

Note: *It is important to note that communications with helicopters in flight are limited at times because the pilot has both hands on the controls.*



Cyclic

The **cyclic** controls the tilt of the rotor blade, which controls the direction of flight.



The cyclic is pushed in the direction that the helicopter is to be moved.

- The tilt of the rotor blades creates thrust in the direction of movement

Autorotation

Autorotation is the state of flight where the main rotor system is being turned by the action of relative wind rather than engine power.

- Allows the aircraft to make a controlled landing when the engine is no longer providing power

A helicopter transmission is designed to allow the main rotor to rotate freely in its original direction if the engine stops.

- At the instant of engine failure, the blades will be producing lift and thrust as a result of their angle of attack and velocity
- As the helicopter descends, the upward flow of air provides sufficient thrust to maintain rotor RPMs and lift throughout the descent

Video – *Autorotation* (1:08 mins.)

Knowledge Check H

REVIEW what you have learned so far about primary and secondary flight controls. ANSWER the question listed below.

1. Helicopter controls include: *(Select all correct answers that apply.)*
   - ❑ **Throttle**
   - ❑ **Collective**
   - ❑ Aileron
   - ❑ **Cyclic**

Primary and Secondary Flight Controls Summary

Gaining a basic knowledge of aircraft flight controls and aerodynamics will help you communicate accurately and professionally with pilots concerning their aircraft. This knowledge could be invaluable to you in your role as an air traffic control specialist in the case of an aircraft emergency.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in the ***Primary and Secondary Flight Controls*** lesson ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 20 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Hazards Affecting Flight*** lesson in Blackboard ■ Instruct students to navigate to the ***Hazards Affecting Flight*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 15 mins.

HAZARDS AFFECTING FLIGHT

Purpose: The purpose of this lesson is to explain different conditions and situations that create hazards that affect flight.

Objective:

- Describe hazards that affect flight

References for this lesson are as follows:

- AC 00-6, Aviation Weather
- FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge
- Aeronautical Information Manual (AIM)

Stalls

Stalls are the most common cause of light aircraft accidents. A stall occurs when the airfoil (wing) exceeds the "critical angle of attack," which is approximately 15 to 20 degrees on most airfoils.

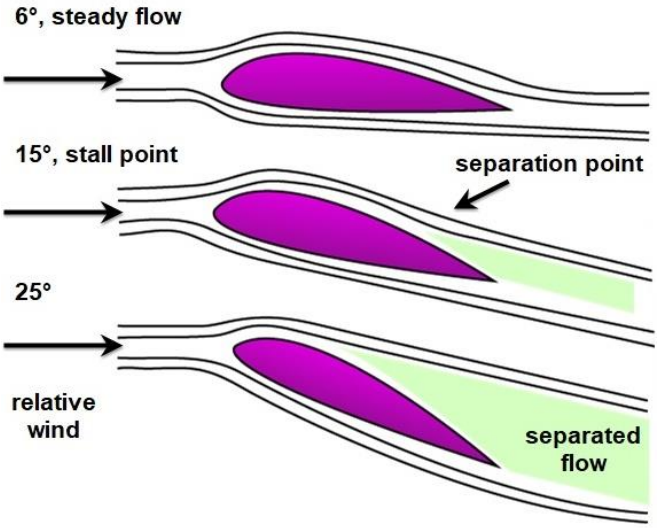
- During flight, the airstream remains attached to the wing surface and lift is produced when operating within the normal angle of attack range
- As the critical angle of attack is approached, the smooth flow of the airstream begins separating from the rear of the upper wing surface and ceases to produce lift
- As the critical angle of attack is exceeded, the separation of smooth flow moves forward to the area of the highest camber and creates a wing stall

Causes of Stalls

The three primary causes of stalls are:

- Insufficient airspeed
- Excessively violent flight maneuvers
- Severe wind shear

Video – *Stalls – Wind Tunnel* (1:14 mins.)



Icing

The three primary types of icing are:

- Structural icing
- Pitot-static system icing
- Carburetor icing

Structural Icing

Structural icing changes the shape of the airfoil.

- The greatest hazard of this type of icing is airfoil distortion, which disrupts smooth airflow reducing lift and also adds weight
- Many IFR-equipped aircraft have anti-icing and/or deicing equipment

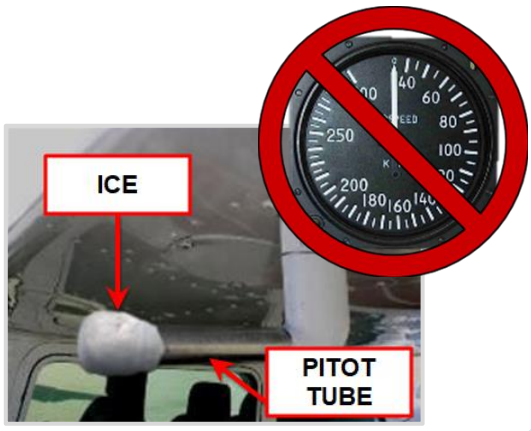
Pitot-Static System Icing

When pitot tube icing occurs, the airspeed indicator becomes unreliable.

- Pitot heat is used on many aircraft to prevent icing

Although rare, when static vent icing occurs, all three instruments are affected, e.g., airspeed, vertical speed indicator, and altimeter.

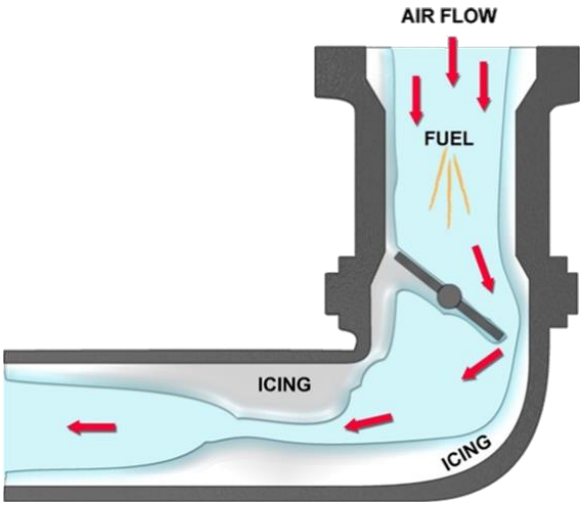
- An alternate static air vent, although not as accurate, is installed inside the cabin on some aircraft



Carburetor Icing

Carburetor icing reduces the fuel/air flow to the engine.

- This can cause complete engine failure by starving the engine of fuel and air
- Occurs most often between 20-70° F under conditions of high humidity
- Lowered pressure and vaporization in the carburetor lowers the temperature of the fuel/air mixture to the point where any water vapor or moisture present will freeze, forming ice or frost inside the carburetor
- Carburetor ice can be cleared by adding carburetor heat, which recirculates heated air from engine, but this is primarily for anti-icing, not de-icing



Aircraft System Failures

Aircraft system failures may occur due to:

- Electrical failures
- Mechanical failures
- Hydraulic failure
- Engine failure
- Engine fire

When you become aware of an unusual situation, use all available resources to assist the aircraft and notify your supervisor.

Electrical Failure

During partial electrical failure, some instruments and systems are affected.

When complete electrical failure occurs, there is a loss of:

- Some instruments
- Flaps on some aircraft
- Radios and navigation and transponder equipment
- Lights

Air traffic controllers should be aware of these losses and assist in any way possible, e.g., priority handling, clear conflicting traffic, alert emergency equipment.

Mechanical Failure

Mechanical failures include:

- Landing gear
- Blown tire
- Wheel off
- Panel off
- Flight controls
- Windshield

Hydraulic Failure

Hydraulic failure affects landing gear, flaps, and brakes on some aircraft.

Handling a hydraulic failure may require long runways, emergency equipment, etc.

Engine Failure

Engine failure may affect:

- Engine-driven vacuum system for instruments
- Hydraulic power
- Electrical power
- Pressurization

Engine failure may result in:

- Loss of altitude
- Forced landing

Air traffic controllers should assist pilots by advising them of the nearest airport suitable for landing.

Engine Fire

An engine fire is usually controllable.

- The indication to the pilot of an engine fire is via the fire warning light

A cabin/cockpit fire is extremely serious.

Specialists who are advised by pilots of a fire warning light or a cockpit/cabin fire may expect either a bailout or a request for immediate landing.

Knowledge Check I

REVIEW what you have learned so far about hazards affecting flight. ANSWER the questions listed below.

1. The most common cause of light aircraft accidents is: *(Select the correct answer.)*
   - ❑ Icing
   - ❑ **Stalls**
   - ❑ Mechanical failures
   - ❑ Engine fires

2. Pitot tube icing causes which of these instruments to become unreliable? *(Select the correct answer.)*
   - ❑ Altimeter
   - ❑ Vertical speed indicator
   - ❑ **Airspeed indicator**
   - ❑ Fuel level indicator

Hazards Affecting Flight Summary

Stalls, ice, and system failures are all hazards that can happen to an aircraft, without warning, at any time. Gaining a basic understanding of these hazards will better prepare you in determining how best to assist the aircraft for a successful flight and safe landing.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in the ***Hazards Affecting Flight*** lesson ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 10 mins.

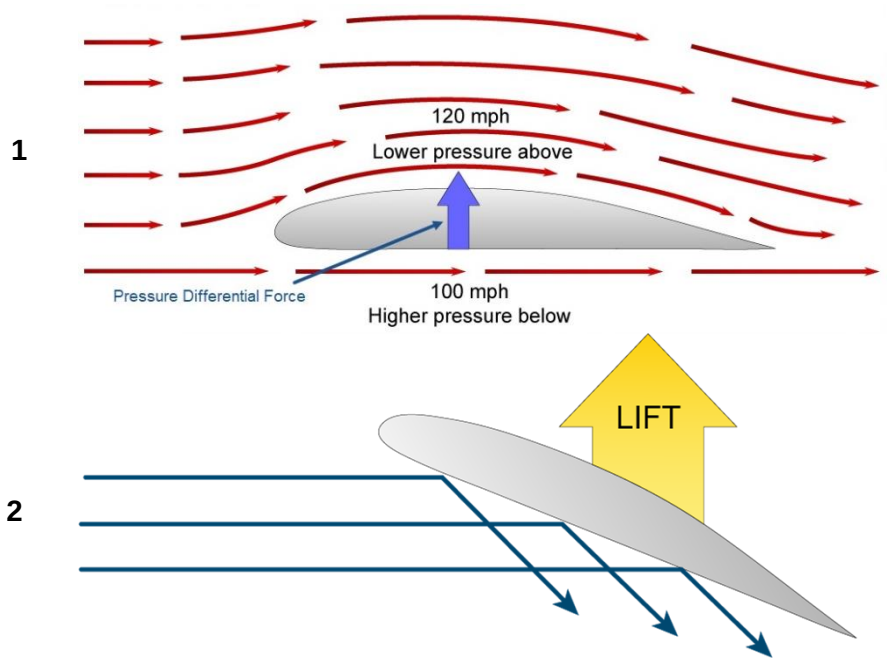
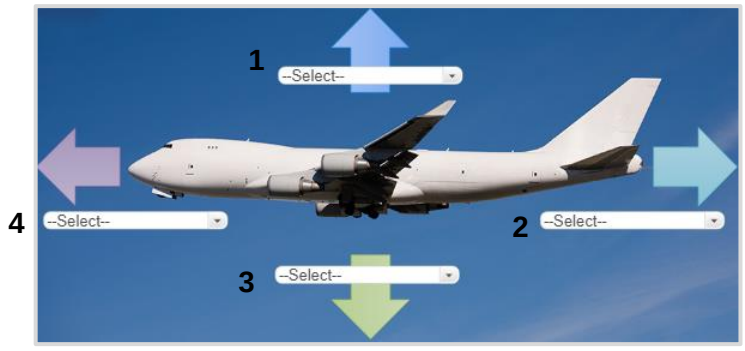
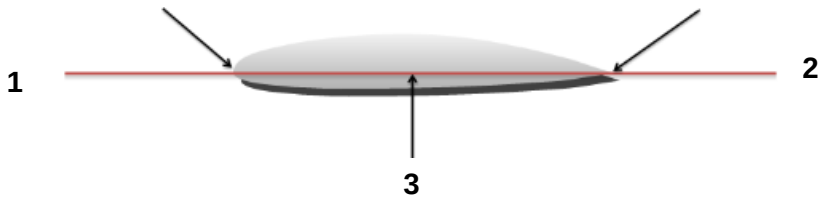
FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *A Lesson in Flight*** video in Blackboard ■ Instruct students to locate ***A Lesson in Flight*** video in Blackboard ■ The video will be viewed individually ■ ***Note:*** Movie controls in BB are limited to “Play” and “Pause” while not in full screen ■ Instruct students to select the link to play video ■ At the end of the video, a question and answer session will be conducted to discuss key points presented	Video **EST. RUN TIME** 25 mins.

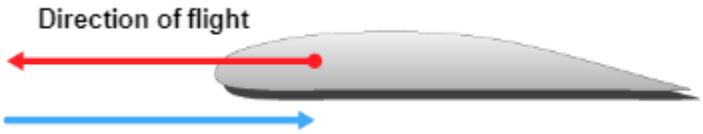
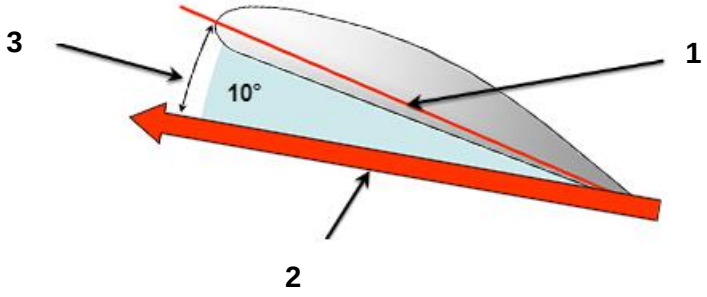
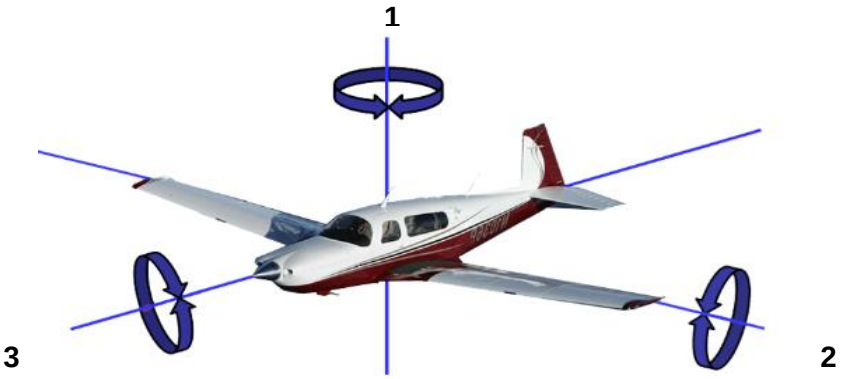
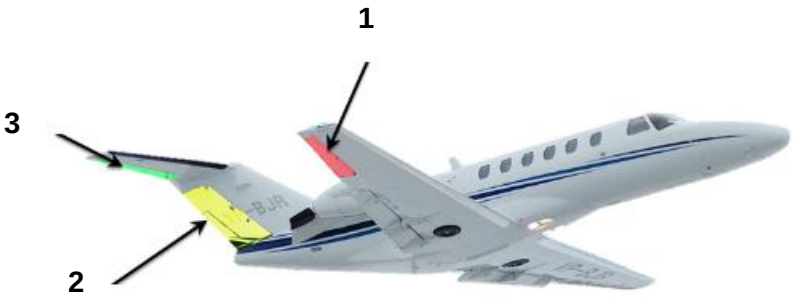
FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in video ***A Lesson in Flight*** ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 10 mins.

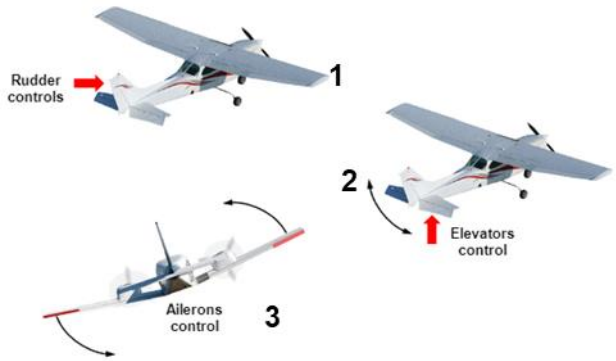
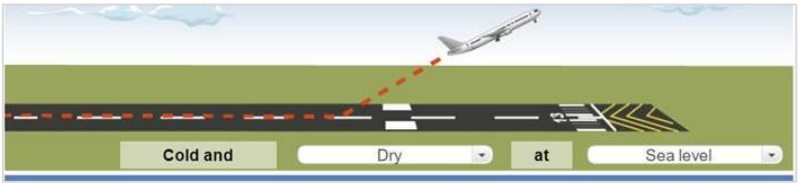
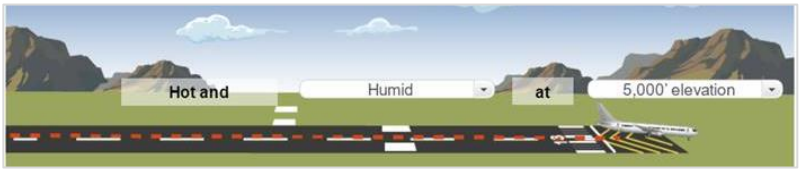
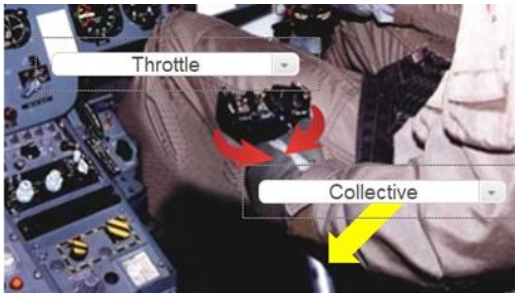
FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Principles of Flight*** activity in Blackboard ■ Instruct students to navigate to the ***Exercises and Activities*** folder in Blackboard ■ Instruct students to locate student activity ***Principles of Flight*** ■ The activity will be performed individually ■ Instruct students to answer each question ■ At the end of the exercise, the activity will evaluate the students’ performance ■ Suggest allowing opportunities to repeat the activity during periods of down time	Activity **EST. RUN TIME** 20 mins.

ACTIVITY: PRINCIPLES OF FLIGHT (ANSWER KEY)

Note: *The questions in the key and their distractors may appear in a different order than displayed here due to activity question randomization.*

Question	Answer
1. The creation of lift is explained by two propositions. Using the drop-down menus, identify these propositions.  	1. **Bernoulli's Principle** 2. **Newton's Third Law of Motion**
2. Accessing the drop-down menus, identify the forces affecting an aircraft in flight.  	1. **Lift** 2. **Drag** 3. **Weight** 4. **Thrust**
3. An airfoil creates lift. Using the drop-down menus, identify the parts of an airfoil.  	1. **Leading edge** 2. **Trailing edge** 3. **Chord line**

Question	Answer
4. For an aircraft in flight, wind flows in a direction parallel with and opposite to the direction of flight. Identify this type of wind. 	**Relative wind** Straight line wind Periodic wind Trade wind
5. Lift is increased or decreased as the pitch of the airfoil is changed. Using the drop-down menus, identify the three components that affect lift. 	**1. Chord line** **2. Flight path** **3. Angle of attack**
6. Changes in an aircraft's attitude are described as movement about three axes. Accessing the drop-down menus, identify these movements. 	**1. Vertical** **2. Lateral** **3. Longitudinal**
7. Using the drop-down menus, identify the primary control surfaces affecting movement about the axes. 	**1. Aileron** **2. Rudder** **3. Elevator**

Question	Answer
8. Using the drop-down menus, identify the term associated with the movement of each aircraft.  	**1.** **Yaw** **2.** **Pitch** **3.** **Roll**
9. Air density greatly affects aircraft performance. Select the three variables that determine air density.	**Altitude** **Temperature** **Humidity** Condensation Wind
10. Accessing the drop-down menus, indicate the conditions that affect aircraft performance. **1**  **2**  	**1.** **Dry; Sea level** **2.** **Humid; 5,000' elevation**
11. The rotor blade of a helicopter is an airfoil and functions the same as a wing on a conventional aircraft. Identify the three devices that control the rotor blade.	**Throttle** **Cyclic** **Collective** Engine Propeller
12. Accessing the drop-down menus, label the flight controls.  	**1.** **Throttle** **2.** **Collective**

Question	Answer
13. Lift is created as air flows smoothly over an airfoil. A stall occurs when the _____ is exceeded.	**Critical angle of attack** Critical cord angle Maximum angle of attack Relative wind speed
14. Air stops flowing smoothly over an airfoil with an angle of attack between _____ degrees.	**15 and 20** 5 and 10 10 and 15 20 and 25

SUMMARY

The purpose of this module was to provide basic aeronautical information that will help you communicate with pilots concerning the operation of their aircraft.

In accordance with FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge; the Aeronautical Information Manual (AIM); FAA-H-8083-21, Rotorcraft Flying Handbook; and AC 00-6, Aviation Weather; you should now be able to:

- Identify primary and secondary sources of lift
- Identify types and parts of airfoils
- Identify forces affecting flight, their interrelationships, and their effects on aircraft performance
- Identify effects of altitude, temperature, and pressure on aircraft performance
- Identify functions of primary and secondary flight controls and the movement around the aircraft axes
- Identify helicopter aerodynamics and controls
- Describe hazards that affect flight

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content ■ Instruct students to prepare for the End-of-Module test by putting away their Student Guides	Facilitated Discussion **EST. RUN TIME** 15 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Principles of Flight End-of-Module Test*** link in Blackboard ■ Instruct students: ○ Clear desks ○ Do not write anything during or after the test ○ Navigate to the ***Principles of Flight End-of-Module Test*** link in Blackboard ○ Once they are satisfied with their responses, click “Save and Submit;” do not click “OK” to review results until directed to do so ○ Choose “Cancel” if they receive a warning message that the test has unanswered questions; choosing OK will submit the test and not allow them to go back and answer the questions ○ Leave the room after submitting the test and return at the “Be Back” time ■ ***Note:*** *This test is scored but not graded* ■ During test, monitor students to ensure a secure testing environment ■ Identify the most commonly missed questions by reviewing student statistics in Blackboard ■ Instruct students to click “View Results” when ready to review commonly missed questions ■ Review commonly missed questions with students	Blackboard Assessment **EST. RUN TIME** 20 mins.

END-OF-MODULE TEST (ANSWER KEY)

Note: *Test questions in Blackboard are presented to the students in random order. Please be aware the test key question order will not match the student version.*

1. A secondary form of lift is a(n) _____ generated by air striking the underside of the airfoil and being deflected _____. *(Select the correct answer.)*
   - ❑ **Upward force; downward**
   - ❑ Downward force; upward
   - ❑ Pressure differential; over the wing
   - ❑ Upward force; over the wing

   Reference(s): FAA-H-8083-25, Chap. 4

2. An imaginary straight line from the leading edge to the trailing edge of a cross section of an airfoil is called the _____.
   - ❑ **Chord line**
   - ❑ Camber
   - ❑ Relative wind
   - ❑ Angle of attack

   Reference(s): FAA-H-8083-25, Chap. 5

3. What is used to determine the angle of attack? *(Select the correct answer.)*
   - ❑ **Relative wind and chord line**
   - ❑ Chord line and the ground
   - ❑ Flight path and upper camber
   - ❑ Flight path and relative wind

   Reference(s): FAA-H-8083-25, Chap. 4

4. Which of the following is **NOT** a principal airfoil that produces lift on an aircraft? *(Select the correct answer.)*
   - ❑ **Thrust**
   - ❑ Wing
   - ❑ Propeller
   - ❑ Horizontal tail surfaces

   Reference(s): FAA-H-8083-25, Chap. 3

5. What force in flight counteracts lift? *(Select the correct answer.)*
   - ❑ **Weight**
   - ❑ Pressure
   - ❑ Thrust
   - ❑ Relative wind

   Reference(s): FAA-H-8083-25, Chap. 4

6. How does atmospheric density affect an aircraft during takeoff on a hot summer day? *(Select the correct answer.)*
   - ❑ **Takeoff roll will be longer and rate of climb will be slower**
   - ❑ Takeoff roll will be shorter and engine output will be decreased
   - ❑ Rate of climb will be quicker and engine output will be increased
   - ❑ Rate of climb will be shorter and takeoff will be shorter

   Reference(s): FAA-H-8083-25, Chap. 4

7. If a pilot adjusts the pitch and yaw, the aircraft is moving along the _____ and _____ axes. *(Select the correct answer.)*
   - ❑ **Lateral; vertical**
   - ❑ Longitudinal; vertical
   - ❑ Longitudinal; lateral
   - ❑ Lateral; horizontal

   Reference(s): FAA-H-8083-21, Chap. 3

8. What is the basic purpose of the autorotation maneuver in a helicopter? *(Select the correct answer.)*
   - ❑ **Provide a controlled landing when the engine is not supplying power**
   - ❑ Conserve fuel during cruise flight
   - ❑ Maintain a constant altitude
   - ❑ Allow hovering flight in a strong wind

   Reference(s): FAA-H-8083-21, Chap. 4

9. What occurs with pitot tube icing? *(Select the correct answer.)*
   - ❑ **Airspeed indicator becomes unreliable**
   - ❑ Complex engine failure can occur
   - ❑ Airspeed drops
   - ❑ Increased weight occurs on instruments

   Reference(s): FAA-H-8083-25, Chap. 7