Objectives	▪ Understand the basics of the 4 forces of flight, turning tendencies, stability, and the cause and avoidance of wingtip vortices
Elements	▪ Intro ▪ lift ▪ Airfoil shape & design ▪ Load factor ▪ Weight ▪ Thrust ▪ Turning tendencies ▪ Drag ▪ Wingtip vortices ▪ Stability and controllability
Schedule	▪ Review lesson objectives ▪ Review lesson material ▪ Conclusion & Review
Equipment	▪ White Board / Markers ▪ Miniature Aircraft ▪ References ▪ iPad
CFI Actions	▪ Present lesson ▪ Use teaching aids ▪ Ask/ answer questions
Student Actions	▪ Participate in discussion ▪ Take notes ▪ Ask / answer questions ▪ Chair Fly at home
Completion Standards	▪ The student will understand how the principles of flight are at play while the airplane is flying.

Additional Notes: _____
_____
_____
_____

CE = Common Error

Introduction

Attention

Ever wanted to know how planes fly?

Overview

Review objectives / Elements

What

The principles of flight explain how and why our airplane can fly

Why

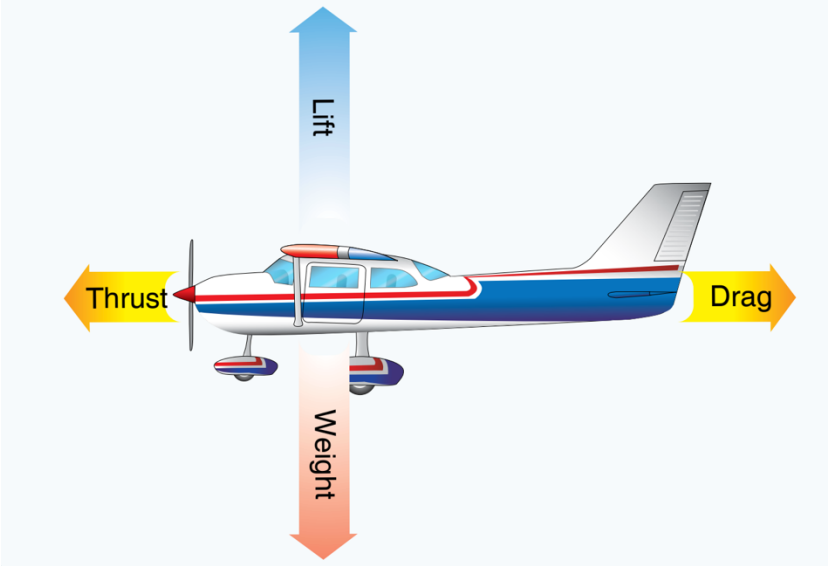
It is important to know these principles as they improve your knowledge of how to use the flight controls

How

Intro – Forces of Flight

Terminology

- **Lift** – A component of the total aerodynamic force on an airfoil and acts perpendicular to the relative wind
- **Weigh**t – The force exerted by an aircraft from the pull of gravity
- **Thrust** – The forward aerodynamic force produced by the propeller, fan, or turbojet engine as it forces mass of air to the rear, behind the aircraft
- **Drag** – The net aerodynamic force parallel to the relative wind, usually the sum of two components; induced and parasite drag
- **Chord line** – An imaginary straight line drawn through an airfoil from the leading edge to the trailing edge
- **Relative wind** – Direction of the airflow produced by an object moving through the air. The relative wind for an aircraft is parallel and opposite of the flight path. Flight path determines relative wind
- **Angle of attack** – The angle at which the relative wind meets an airfoil. It is formed by the cord line of the wing and the relative wind

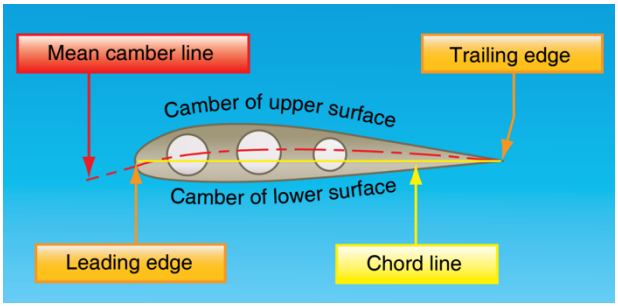


Lift

- Lift – A component of the total aerodynamic force on an airfoil and acts perpendicular to the relative wind
- Lift formula: Lift = ½ p$C_l v^2 S$
    - P = RHO or a pressure constant
    - C_L = Coefficient of Lift – A way to measure lift as it relates to the angle of attack
        - Determined by wind tunnel tests and based on airfoil design and angle of attack
    - V = Velocity
    - S = Surface Area (constant)
- The amount of lift generated is controlled by the pilot and the design of the wing
    - The pilot changes the AOA, airspeed, or shape of the wings which in turn changes the lift being produced

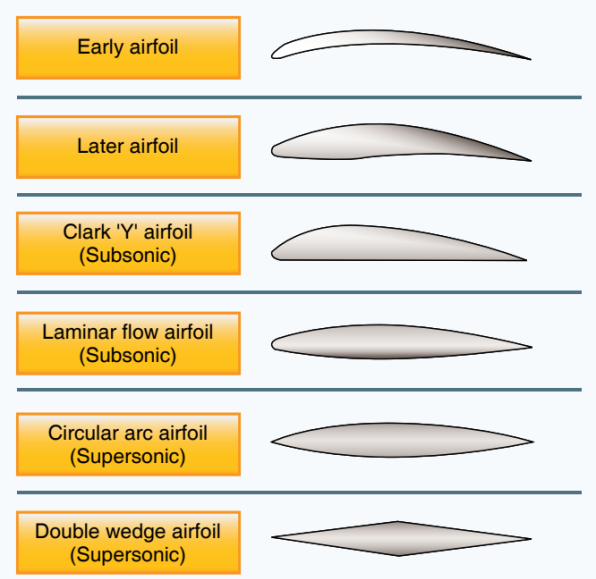
Airfoils

- An airfoil is a structure designed to create a reaction when air moves over it.
- Draw airfoil and describe each part
- Principles of lift:
    - Bernoulli's principle – As velocity of a fluid increases, the pressure decreases
        - Demonstrate using the paper method
        - Draw an airfoil and explain how this principle comes into play



    - Newtons 3rd law – Every action has an equal and opposite reaction
        - Draw on board
        - Show video of the newton's cradle thing

Some different types of airfoils:



- Have student draw these designs in the wind tunnel app
  - Concave airfoils are most efficient
  - No one airfoil is perfect for every flight requirement

Load Factor

- Any force applied to an aircraft to deflect it from a straight-line result in a load factor
- This is measured in G's
- Section 2 of the poh provides load limitations for an aircraft. This is usually expressed as a positive and negative load limit.
  - Many aircraft have different load limits depending on the class
- The load limits are the maximum load the wings can support before structural damage
  - These are important to know to prevent the pilot from exerting dangerous loads on the aircraft
- As load factor increases, stall speed does as well
  - This could result in accelerated maneuver stalls

Weight

Definition

- The force of gravity which acts vertically though the center of gravity of the plane towards the center of earth
  - The combined load of the plane, crew, fuel, cargo or bags (literally everything)
- Weight pulls the airplane down due to gravity
  - In straight and level flight the airplane holds altitude because the vertical component of lift = weight
  - If lift becomes less than weight, the plane descends, vice-versa

Thrust

Definition

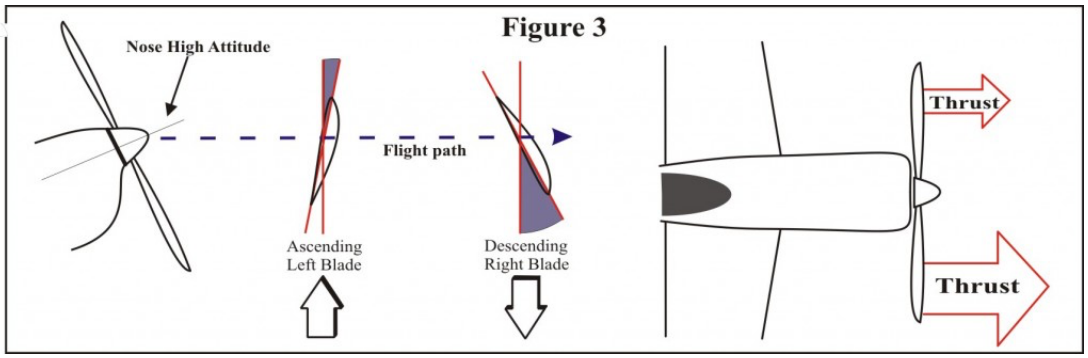
- **Thrust** – The forward aerodynamic force produced by the propeller, fan, or turbojet engine as it forces mass of air to the rear, behind the aircraft

How

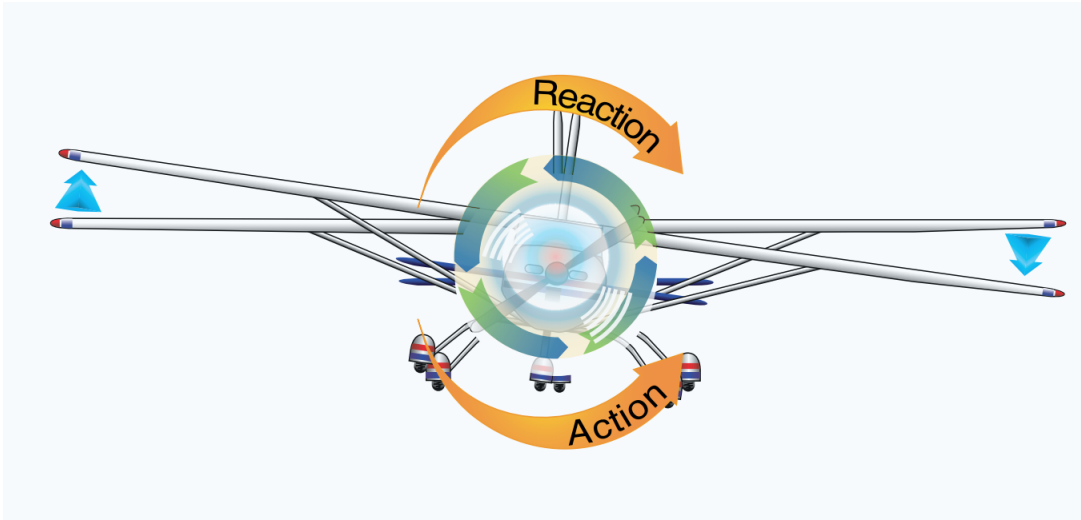
- The propeller is an airfoil that creates lift in the forwards direction

Turning Tendencies

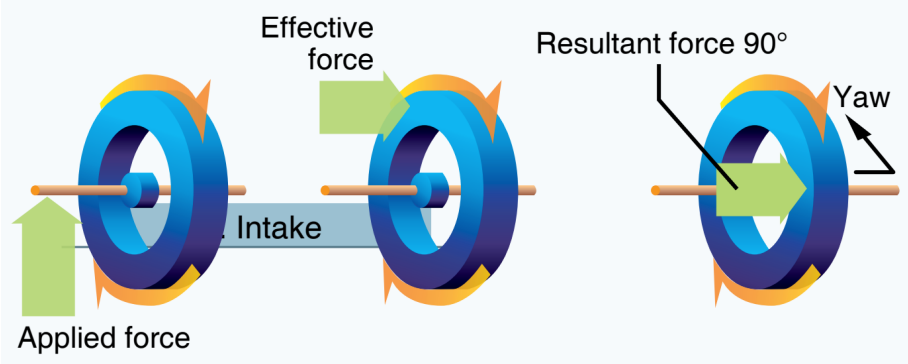
- **P- Factor: A tendency for an aircraft to yaw to the left due to the descending propeller blade on the right side producing more thrust than the ascending blade on the left. This occurs the aircraft's longitudinal axis is in a climbing attitude**



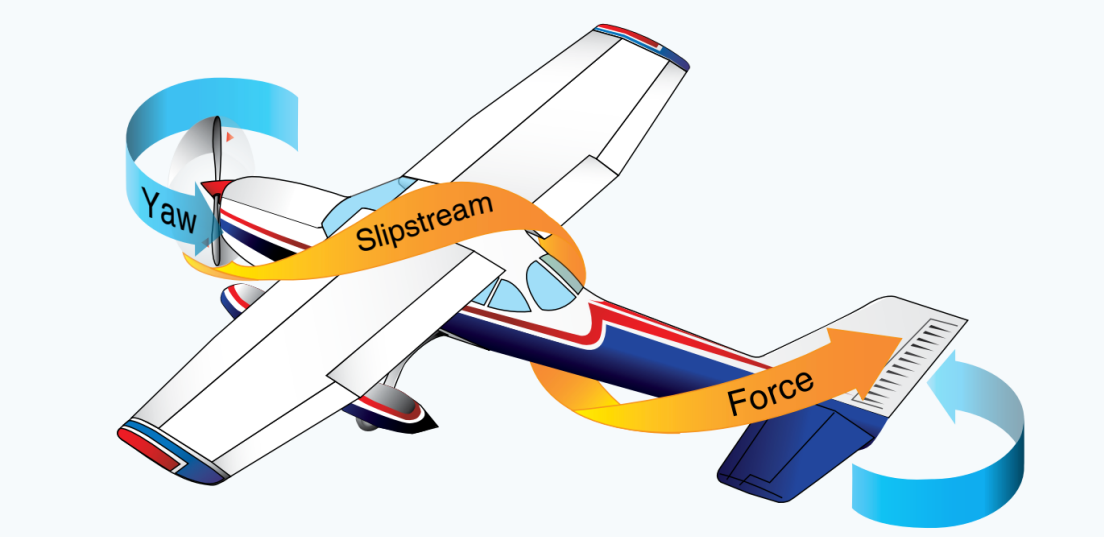
- **Torque Effect: Newtons 3rd law makes to so that since the engine is turning one way, this causes the fuselage to turn the opposite way**



- **Gyroscopic Action: The principle of precession states that a force applied to a gyro result in a force taking effect 90 degrees ahead of the direction of rotation**
    - This force can be felt at rotation where it results on a yaw to the right



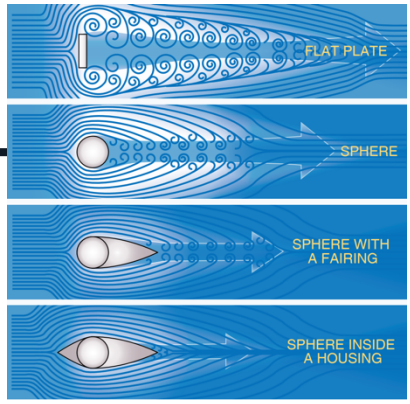
- **Spiraling Slipstream: The fast-spinning propeller creates a spiraling or corkscrew shaped slipstream that hits the vertical stabilizer. This is most noticeable at high propeller speeds and low forwards speed**



Drag

Definition

- Drag is the force that resists movement of an aircraft though the air
- There are parasite drag and induced drag
  - Induced drag increases as airspeed decreases
  - Parasite drag increases as airspeed increases



Parasite Drag

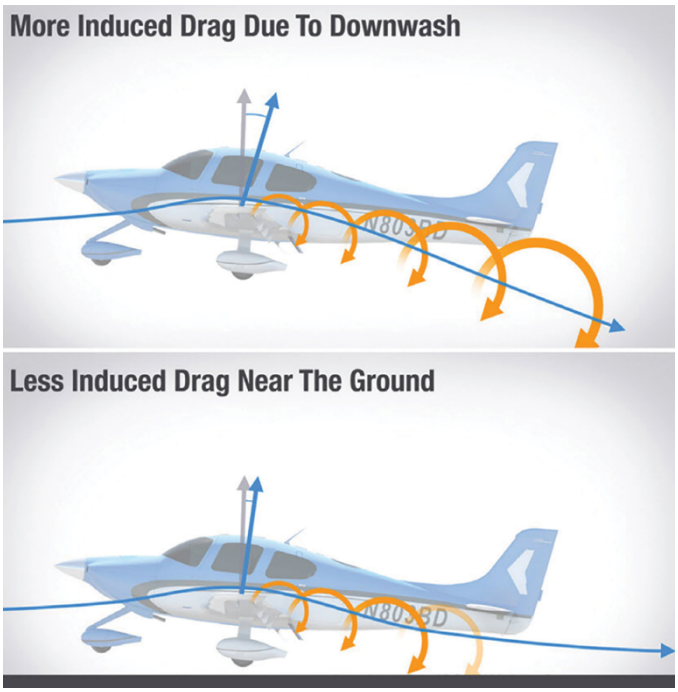
- Parasite drag is drag that is not associated with lift
- **Form Drag:**
  - From drag is drag caused by the shape of the aircraft. Think Lambo vs Jeep. When airflow separates around a surface, the way it splits and rejoins determines the amount of drag.

- Comes from intersections of parts where turbulence, eddy currents or restricted airflow is found
- Common on perpendicular surfaces

- **Skin Friction Drag:**
  - Drag caused by the friction between air and the surface of the airplane
  - No surface is perfectly smooth
  - Molecules that contact the wing are almost motionless, this causes friction with the other molecules

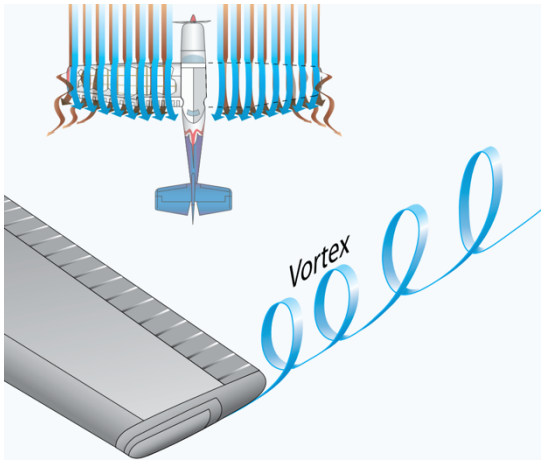
Induced Drag

- Drag associated with lift
- No machine is 100 percent efficient
- Wingtip vortices are created by higher pressure air below the wing moving around the wingtip to the low-pressure air above
- These vortices produce a downwash that is the source of induced drag due to the lift vector pointing towards the back of the aircraft
- Induced drag is most prominent at low airspeed or higher AOA



Wingtip Vortices

- **Wingtip Vortices are produced by the "spillage" of higher-pressure air below the wing to the top of the wing starting the whirlpool of air**
- **These are most pronounced when the aircraft is slow, heavy and in the clean configuration**
- **Use the Big spoon little spoon method to avoid wake turbulence**
  - Use caution when landing on parallel or intersecting runways as these can get blown by the wind
  - Avoid runway downwind of the flight path



Stability and Controllability

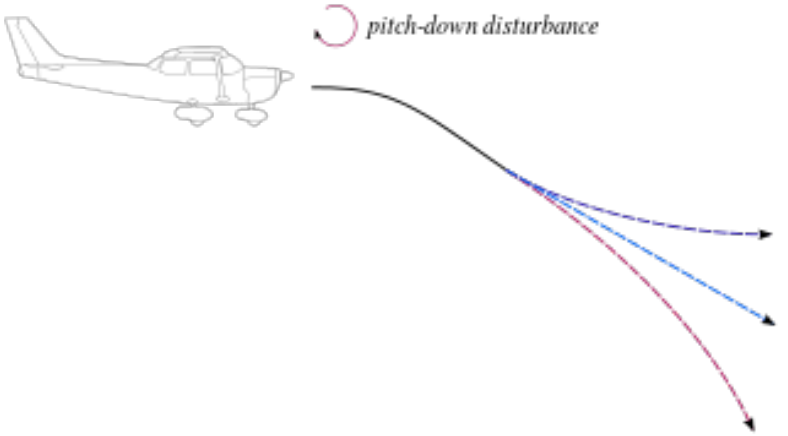
Terms

Maneuverability – The quality of an aircraft that permits it to be maneuvered easily and to withstand the stresses imposed by maneuvers

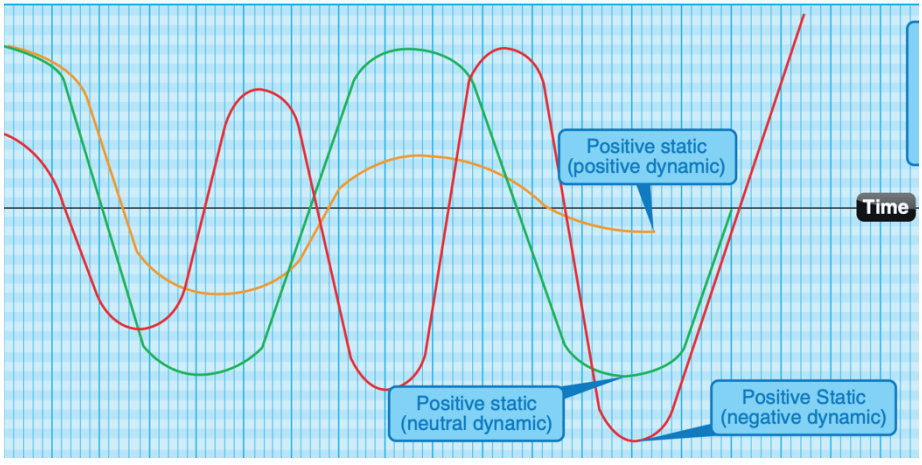
Controllability – The capability of an aircraft to respond to the pilots' controls, especially with regard to flightpath and attitude

Stability – The inherent quality of an aircraft to correct for conditions that may disturb its equilibrium and to return to or to continue its original flight path

- Static stability:
  - Positive Static Stability: aircraft returns to original attitude after being disturbed
  - Neutral static Stability: Aircraft remains in new flight condition after disturbed
  - Negative static stability: Aircraft continues away from original flight path after disturbed



- **Dynamic Stability**
  - **Positive Dynamic Stability:** Oscillations dampen over time
  - **Neutral Dynamic Stability:** Oscillations neither increase or decrease
  - **Negative Dynamic Stability:** Oscillations worsen over time



Conclusion & Review

Review each main lesson point

Review

- **The four forces of flight**
- **Lift theories**
- **Turning tendencies**
- **Load factor**
- **Wingtip vortices**
- **stability**