Overview

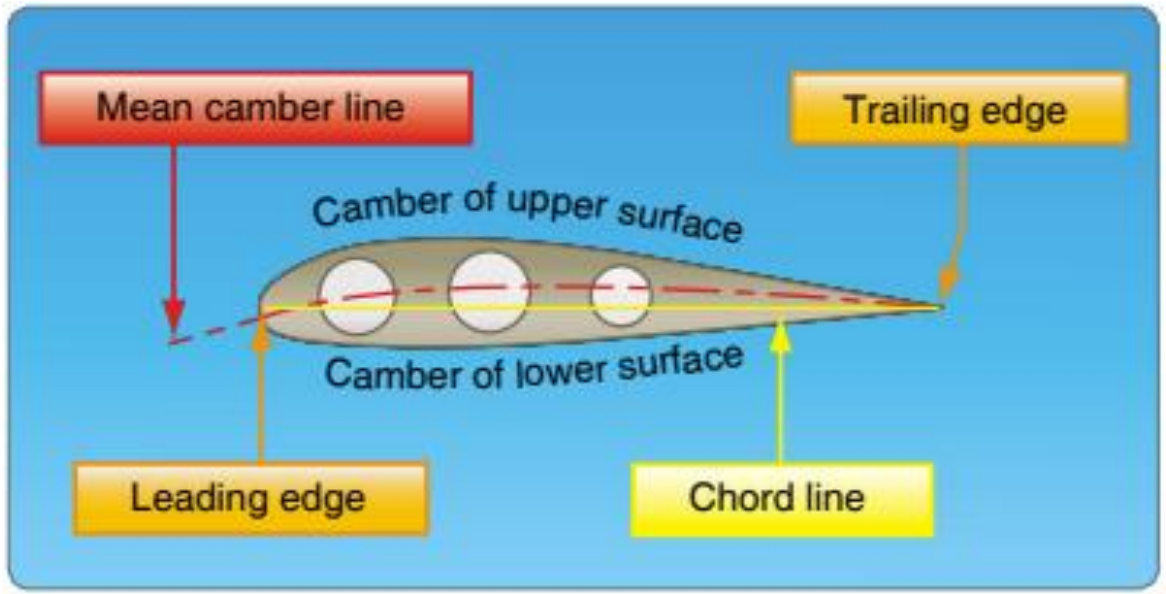
- What
  - Characteristic forces of flight
  - Why and how the airplane performs the way it does
- Why
  - The competent pilot must have a well-founded concept of the forces which act on the airplane, the advantageous use of these forces, as well as the limitations of the particular airplane

Content

- Airfoil Design
- Wing Planform
- Stability and Controllability
- Left Turning Tendency
- Load Factors
- Wingtip Vortices

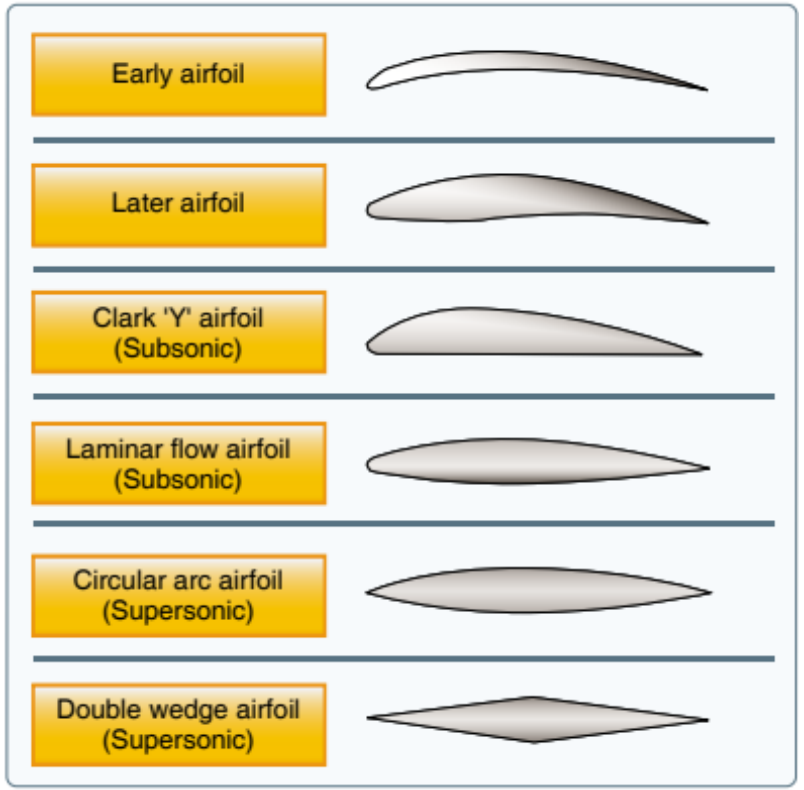
Airfoil Design: Basics

- Terminology
  - Camber
  - Leading / Trailing Edge
  - Chord Line
  - Mean Camber Line



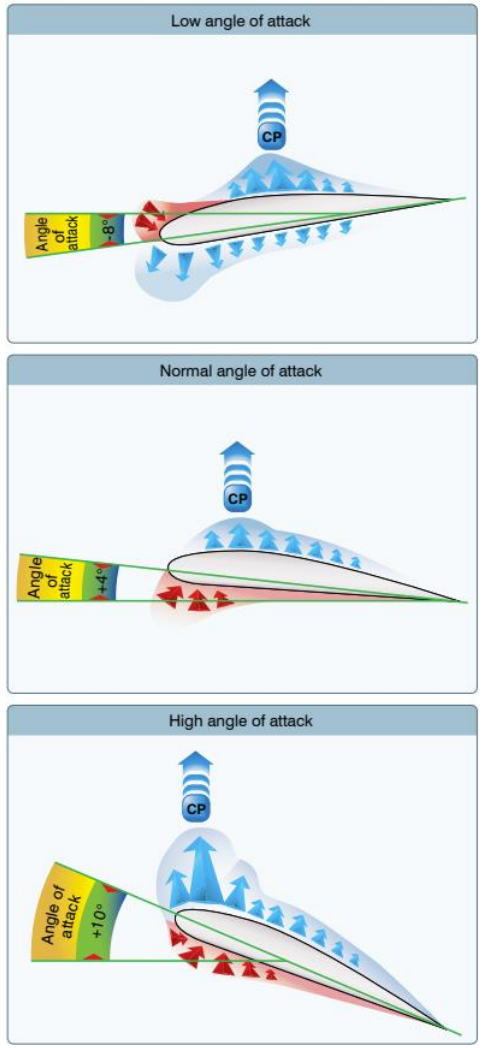
Airfoil Design: Lift & Design Characteristics

- Low Pressure Above
  - Faster moving air (Bernoulli)
  - Downwash (Newton's 3rd Law)
- High Pressure Below
  - Air Deflection (Newton's 3rd Law)
  - Stagnation Point (Bernoulli)
- Aircraft weight, speed, and purpose dictate airfoil design



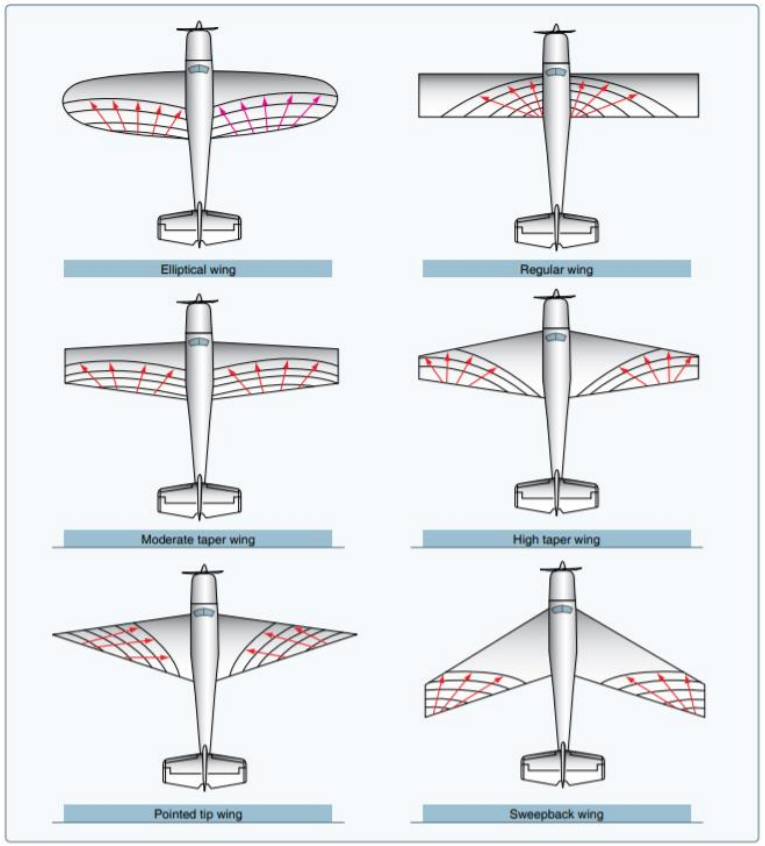
Airfoil Design: Pressure Distribution

- Pressure varies with AOA
- Center of Pressure
  - Average of the pressure variations at a given AOA
  - Higher AOAs: CP moves forward
  - Lower AOAs: CP moves aft
- Affects aerodynamic balance and controllability



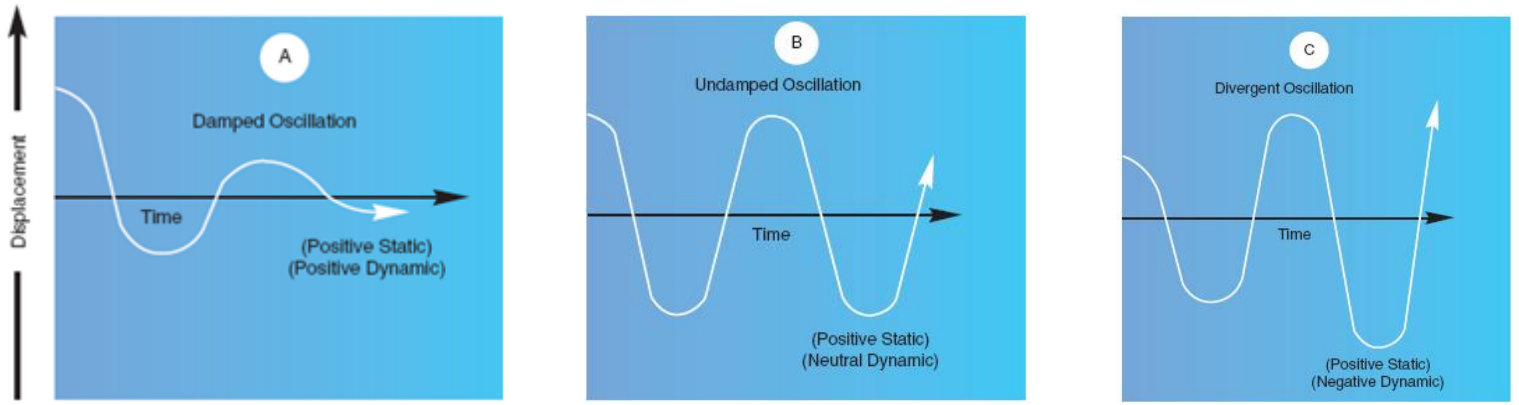
Wing Planform

- Planform: Outline of the wing from above
  - Varies with desired aerodynamic characteristics
  - Taper, Aspect Ratio & Sweepback affect planform
- Aspect Ratio (AR) – Ratio of wing span to chord
  - Primary factor in determining lift / drag ratio
  - Increased AR decreases drag, and vice versa
- Taper - Decrease of chord from root to tip
  - Generally decreases drag / increases lift
  - Reduces weight of wing
- Sweepback – Rearward slant of the wing
  - Can also have forward sweep
  - Helps with lateral stability in low-speed planes



Stability & Controllability

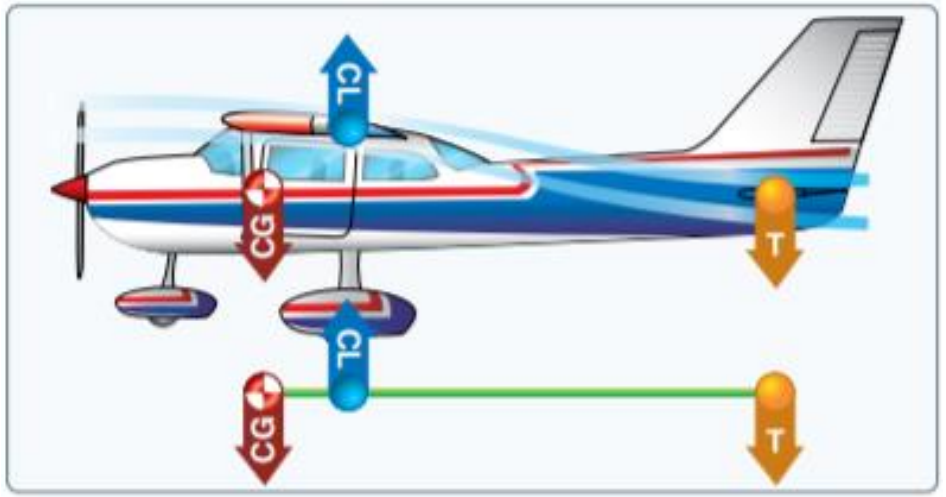
- Stability – Inherent quality to correct for disturbances and return to the original flight path
  - Static Stability – Aircraft's initial tendency when disturbed
    - Positive: Returns to original state Negative: Trends away from original state Neutral: Remains in new condition
  - Dynamic Stability – Aircraft's response over time when disturbed
    - Positive, Negative, and Neutral – same as Static Stability, but over time



- Stability significantly affects Controllability and Maneuverability
  - Controllability – Quality of the aircraft's response to control inputs
  - Maneuverability – Quality allowing the airplane to be maneuvered easily and withstand stresses

Longitudinal Stability

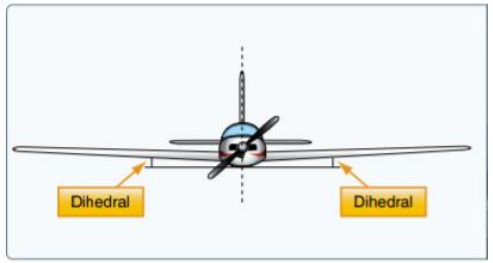
- About the lateral axis (pitch)
  - In a stable aircraft, if the plane is nosed down, the wing / tail moments will bring it back up, and vice versa
- Dependent on 3 factors
  - Location of the wing relative to the CG
  - Location of the horizontal tail relative to the CG
  - Size of the tail surfaces

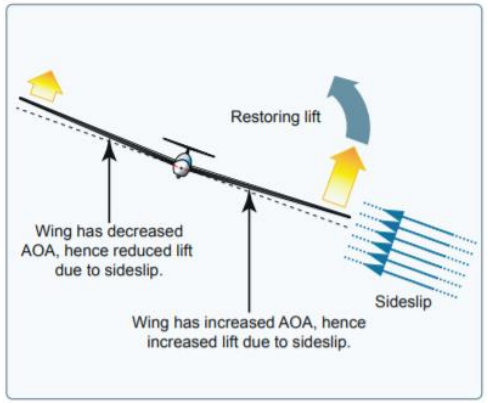


Lateral Stability

- About the longitudinal axis (bank)
- 4 Factors
  - Dihedral
    - Upward angle of the wings from root to tip
  - Sweepback
    - Basically increases effects of dihedral
    - 10 degrees of sweepback = about 1-degree of dihedral
  - Keel Effect
    - Greater portion of the keel is above and behind the CG
  - Weight Distribution

Dihedral

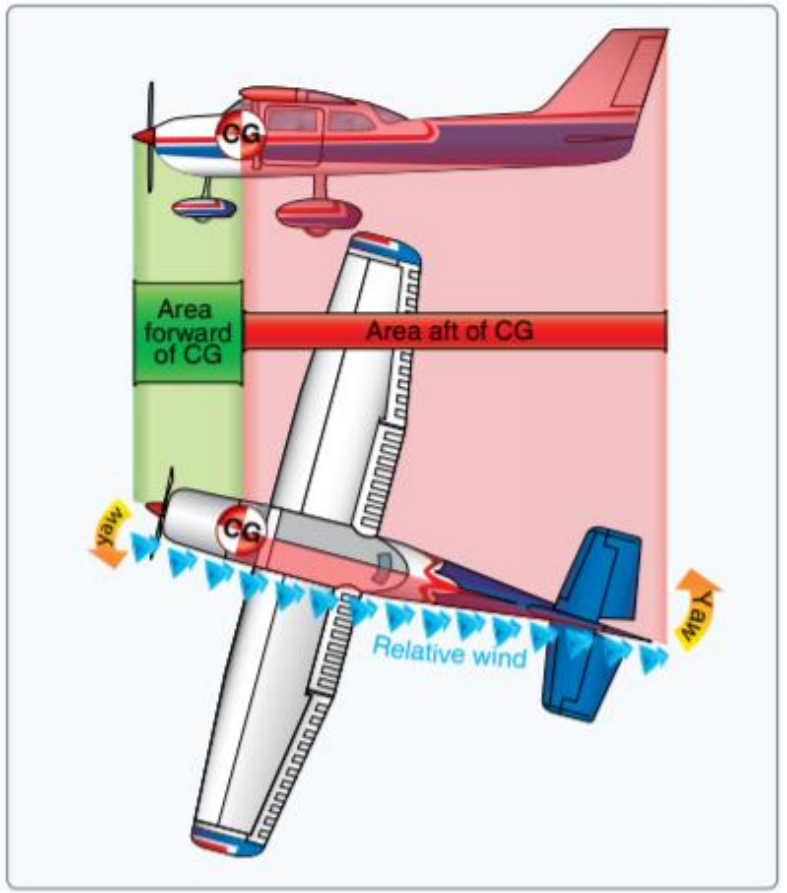




Keel Effect

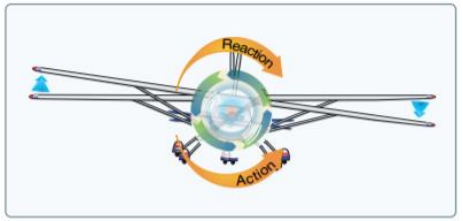
Directional Stability

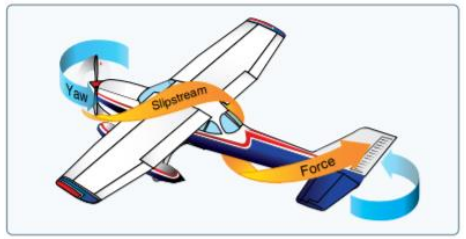
- About the vertical axis (yaw)
- Factors
  - Area of the fuselage aft of the CG
  - Vertical fin

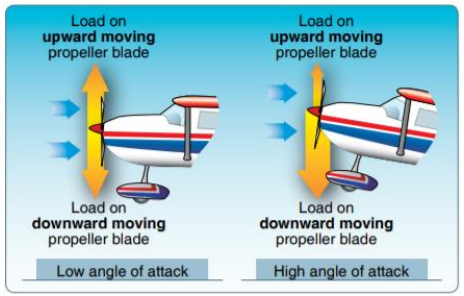


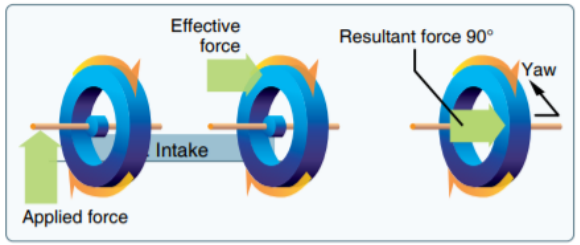
Left Turning Tendency (torque effect)

- Torque Reaction
  - Newton's 3rd Law
  - Engine parts / propeller rotate right, equal force rotates the plane left
- Corkscrew Effect
  - Prop rotation sends air spiraling aft, striking left side of vertical stab
- P-Factor (asymmetric loading)
  - Descending prop blade takes a bigger bite of air than ascending blade
- Gyroscopic Action
  - Precession
  - Most prominent in tail wheel aircraft when tail is raised for takeoff



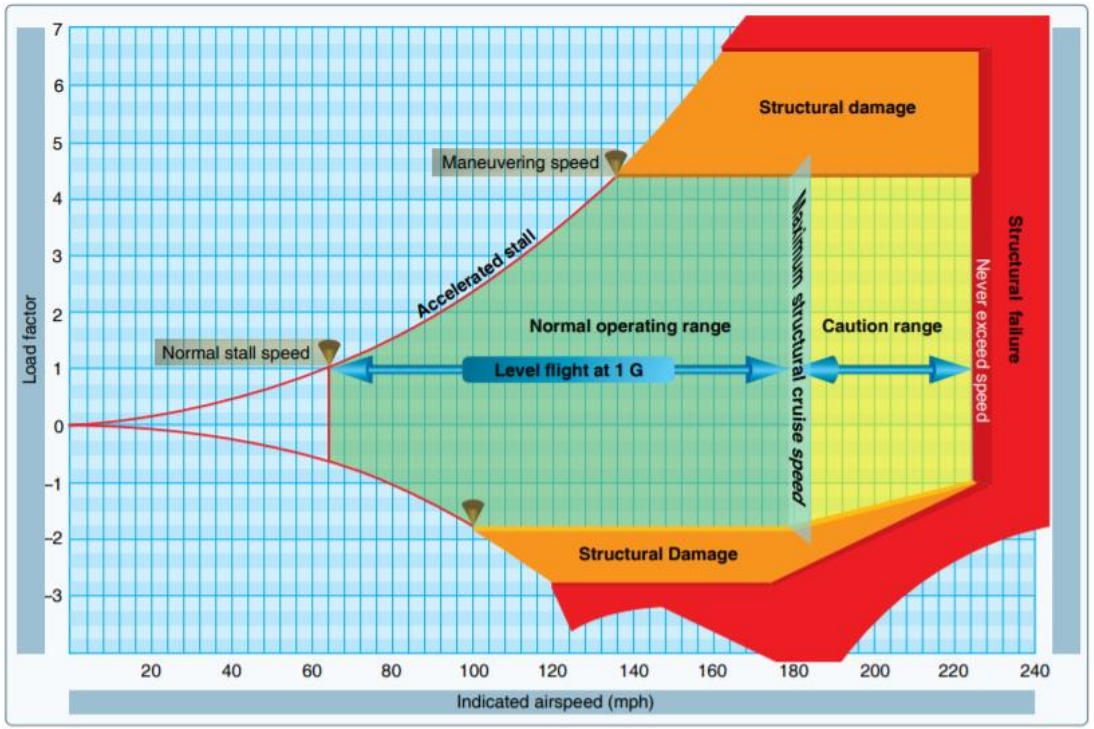






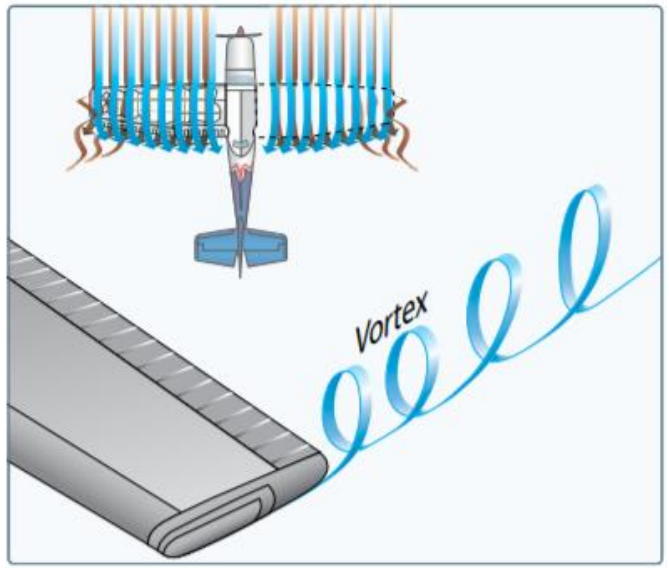
Load Factors

- Ratio of the total air load acting on a plane to the gross weight of the plane (measured in Gs)
- Why it's important
  - Possible to overload the aircraft structure
  - Increasing load factor increases stall speed
- Airplane Design
  - Designed to operate within certain limits
  - Categories: Normal (-1.52 to 3.8 Gs), Utility (-1.76 to 4.4 Gs), Acrobatic (-3 to 6 Gs)
- Vg diagram
  - Lines of Maximum Lift Capability
  - Maneuvering Speed
  - Intersection of Negative Limit Load Factor and Line of Maximum Negative Lift Capability
  - Limit Speed



Wingtip Vortices

- How they Work
  - Occur whenever an airfoil is producing lift
  - Difference in pressure above and below the wing results in fast spinning vortices spiraling off each wingtip
  - Increase induced drag due to energy spent producing the turbulence
- Strength
  - Greater the angle of attack, the stronger the vortices
  - Strongest vortices: Heavy, clean, and slow
- Dangers
  - Hazard to any aircraft significantly lighter than the generating aircraft
  - Can result in aggressive, uncontrollable rolling and structural damage
- Avoidance
  - Takeoff before a prior aircraft's rotation point, climb above their flight path
  - Takeoff after a landing jet's touchdown point
  - En Route: Avoid flying through another aircraft's flight path
  - Land prior to a departing aircraft's takeoff point
  - Stay above a preceding aircraft's path, land beyond their touchdown point
    - Applies to parallel and crossing runways as well



Questions?