

5.1 Wing Terminology

- ☐ Wing Area (S): The plan surface area of the wing, including the part covered by the fuselage.
- ☐ Wing Span (b): The distance from wingtip to wingtip.
- ☐ Aspect Ratio (AR): The ratio of the wing span squared to the wing area ($AR = b^2/S$). It defines the "slenderness" of a wing.
- High AR wings (long and thin) are found on sailplanes ($AR \sim 35$).
- Medium AR wings are found on transport jets ($AR \sim 12$).
- Low AR wings (short and stubby) are found on fighter jets ($AR \sim 3$).
- ☐ Taper Ratio: The ratio of the tip chord to the root chord ($Taper = C_t / C_r$).
- ☐ Sweep Angle: The angle between the line of 25% chord and a line perpendicular to the root chord.

5.2 Wing Tip Vortices

- On a finite wing, the air from the high-pressure area below the wing's surface will always try to flow around the wingtip to the low-pressure area on the upper surface. This flow creates a powerful swirling vortex at each wingtip.
- ☐ Spanwise Flow: This pressure differential creates a secondary flow pattern on the wing's surface: an outward flow on the bottom surface and an inward flow on the top surface.
- ☐ Vortex Strength: These vortices are strongest when the pressure differential is highest, which occurs at high angles of attack (i.e., when flying slowly).

5.3 Induced Downwash and Induced Drag

- ☐ The powerful wingtip vortices create a large field of downward-moving air behind the wing, known as downwash.

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- ☐ This downwash alters the direction of the relative airflow experienced by the wing, effectively reducing the wing's angle of attack.
- ☐ This change tilts the total lift vector rearward. The horizontal component of this tilted lift vector is a drag force known as induced drag.
- ☐ Induced drag is an unavoidable by-product of lift generation on a finite wing. The stronger the vortices, the greater the induced drag.

5.4 Wake Turbulence

- ☐ The trailing vortices from a large aircraft can be extremely powerful and hazardous to other aircraft, a phenomenon known as wake turbulence.
- ☐ Generation: Wake vortex generation begins when the nose wheel lifts off on takeoff (rotation) and ends when the nose wheel touches down on landing.
- ☐ Vortex Characteristics: Vortex strength is determined by:
 - Gross Weight: Heavier aircraft produce stronger vortices.
 - Airspeed: Slower aircraft produce stronger vortices.
 - Configuration: Aircraft in a "clean" configuration (flaps and gear up) produce stronger vortices for a given speed.
- ☐ Vortex Behavior: The two vortices drift downwards and outwards, separating by about 3/4 of the aircraft's wingspan. They can descend 500-1000 ft and persist for several minutes.
- ☐ Avoidance:
 - Landing: Stay above the preceding aircraft's flight path and land beyond its touchdown point.
 - Takeoff: Rotate prior to the preceding aircraft's rotation point and climb above its flight path.