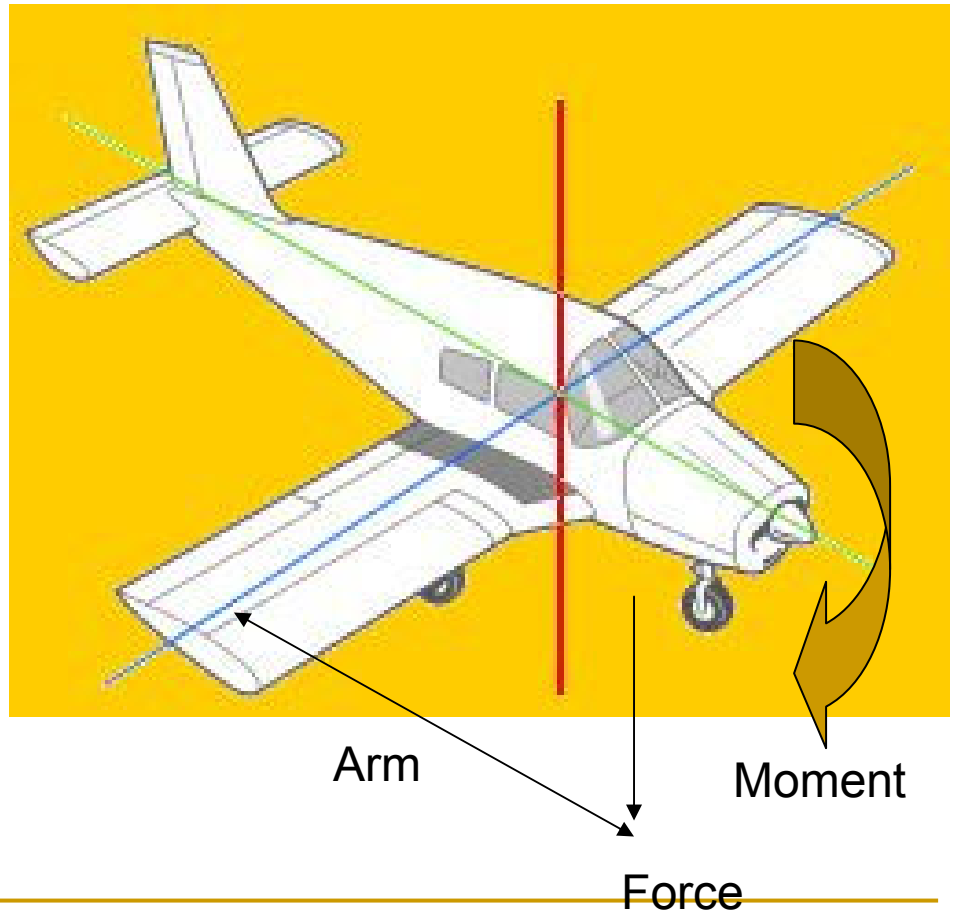
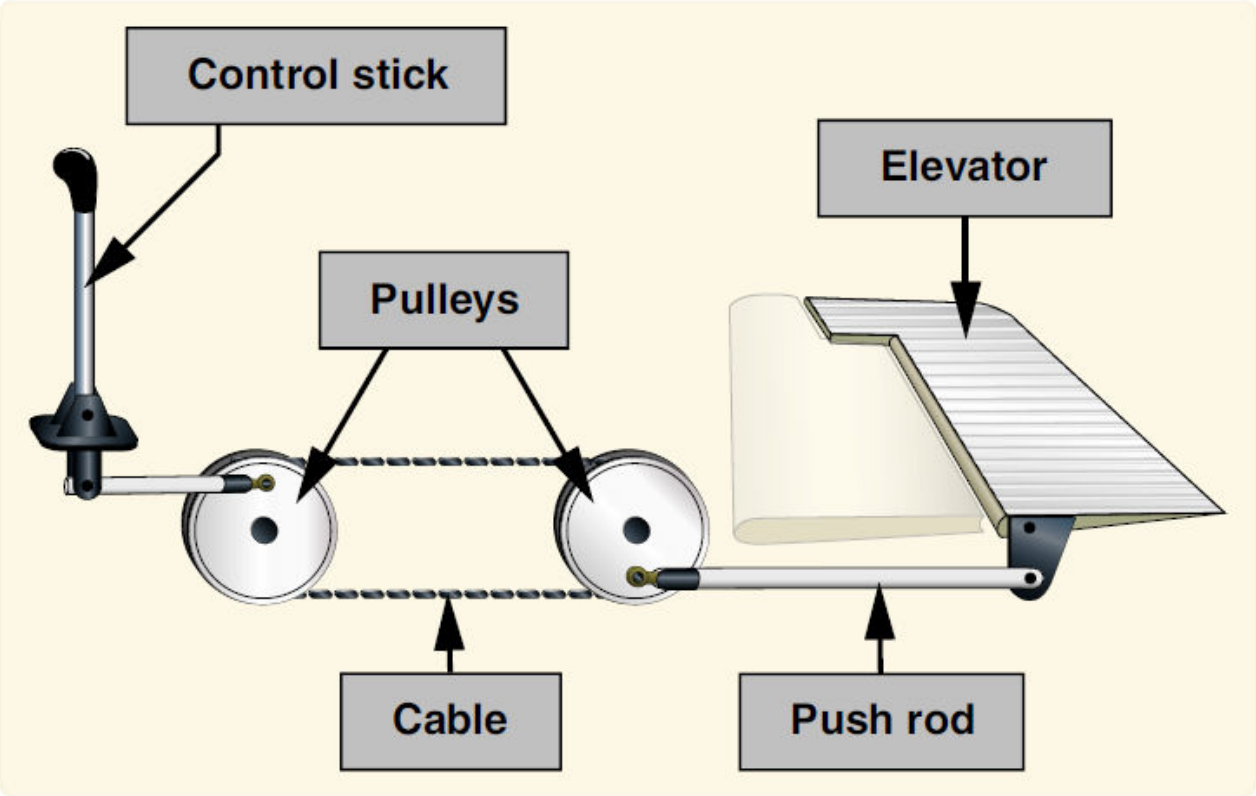
Stability and Flight Controls

Three Axes of Flight

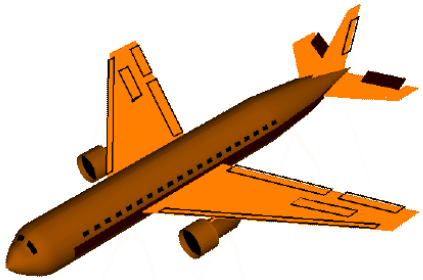
- Longitudinal (green)
  - Nose to tail
- Lateral (blue)
  - Wing tip to Wing tip
- Vertical (red)
  - Top to bottom



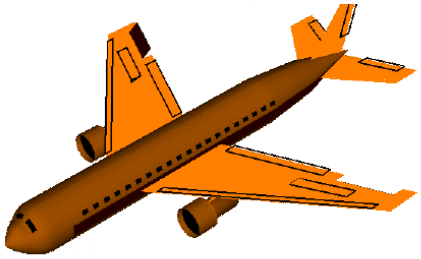
Controls



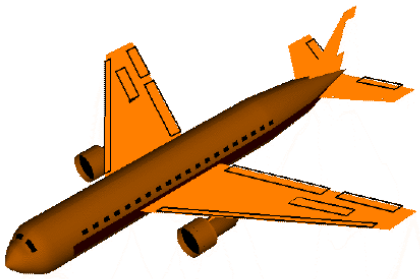
The Flight Controls



- Pitch
  - Motion about the lateral axis
  - Controlled by the elevator



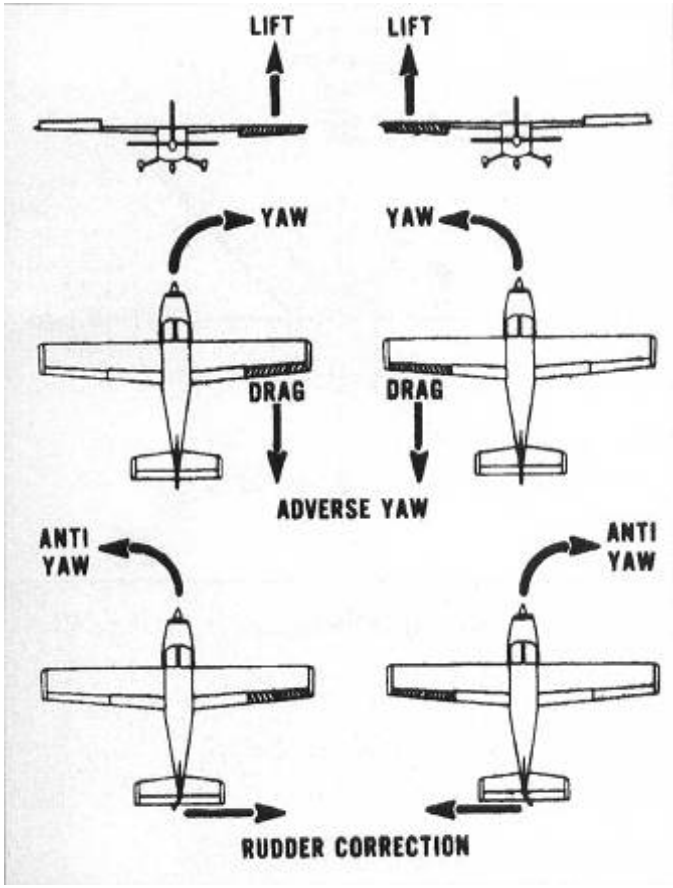
- Roll
  - Motion about the longitudinal axis
  - Controlled by the ailerons



- Yaw
  - Motion about the vertical axis
  - Controlled by the rudder

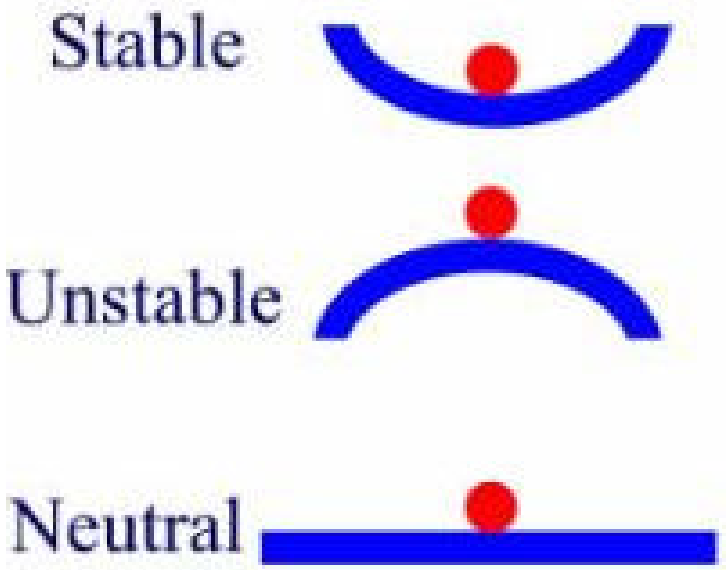
Adverse Yaw
(or why we have a Rudder)

- Induced drag
  - increase in lift = increase in drag
- If we want to roll to left
  - Yoke turns to left
  - Left aileron goes up, right aileron goes down
  - Right wing develops more lift, therefore more drag
  - And Plane tries to yaw in opposite direction to roll



Static Stability

- Positive (stable)
  - Ball returns to starting position when disturbed
- Neutral
  - Ball remains in new position when disturbed
- Negative (unstable)
  - Ball moves away from starting position when disturbed



Static Stability (continued)

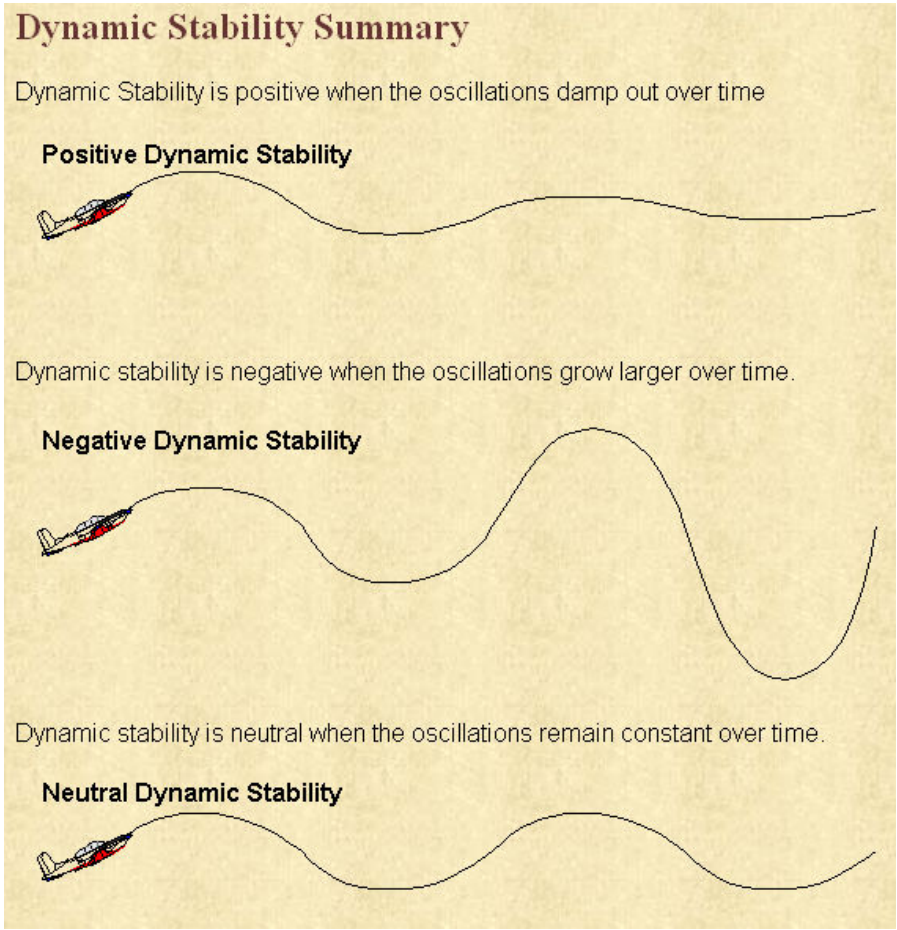
Positive Stability

Neutral Stability

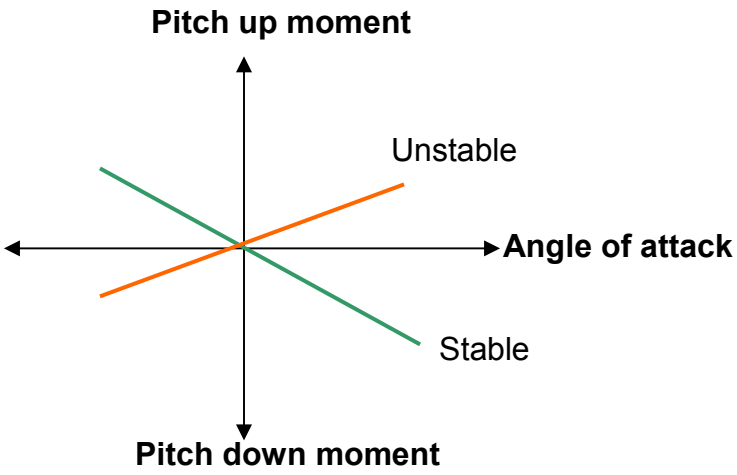
Negative Stability

Dynamic Stability

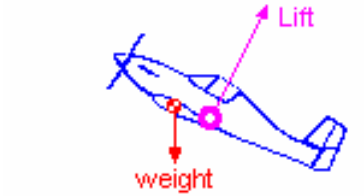
- Positive
  - Oscillations decrease in amplitude with time
- Neutral
  - Oscillations are constant in amplitude with time
- Negative
  - Oscillations increase in amplitude with time
- Above are all types of Positive Static Stability
- Link to animation of dynamic longitudinal stability



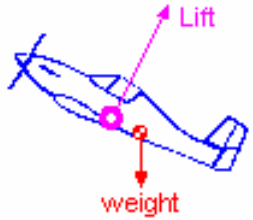
Longitudinal Stability



- Stability about lateral axis
- AKA Pitch Stability
- Dependent on location of Center of Gravity
  - CG too far forward
    - Stable (too stable)
  - CG too far aft
    - Unstable
    - Stall Recovery Difficult
    - JAS 39 Gripen Crash 1
    - JAS 39 Gripen Crash 2



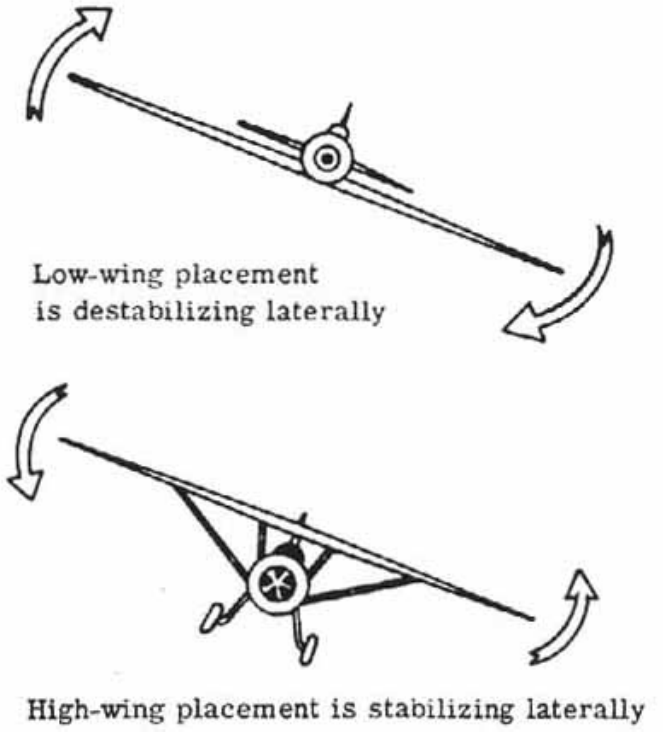
When the CG is ahead of NP the weight tends to correct the upset = Stable



When the CG is behind NP the weight worsens the uppset = Unstable

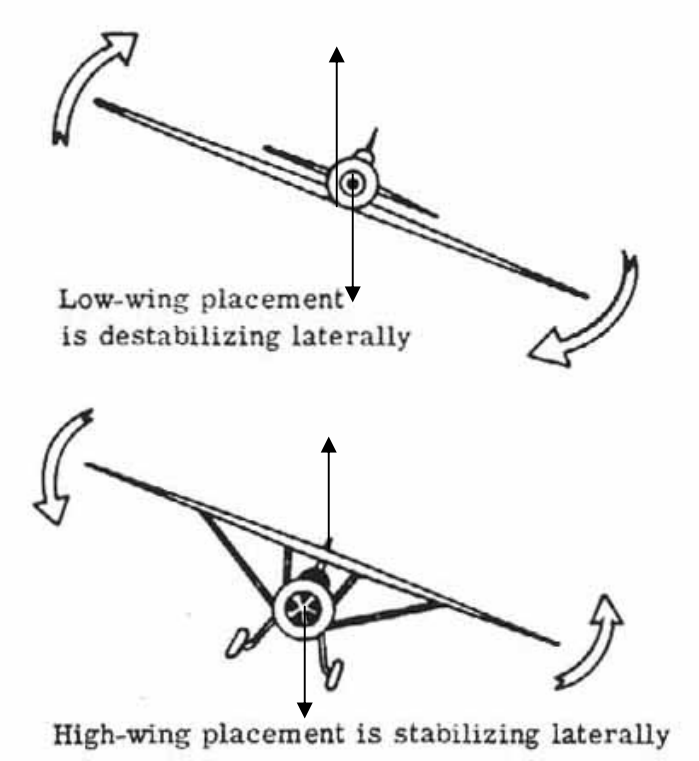
Lateral Stability

- Stability about longitudinal axis
- AKA Roll Stability
- Can be influenced by
  - Dihedral
  - Sweepback
  - High vs. Low Wing

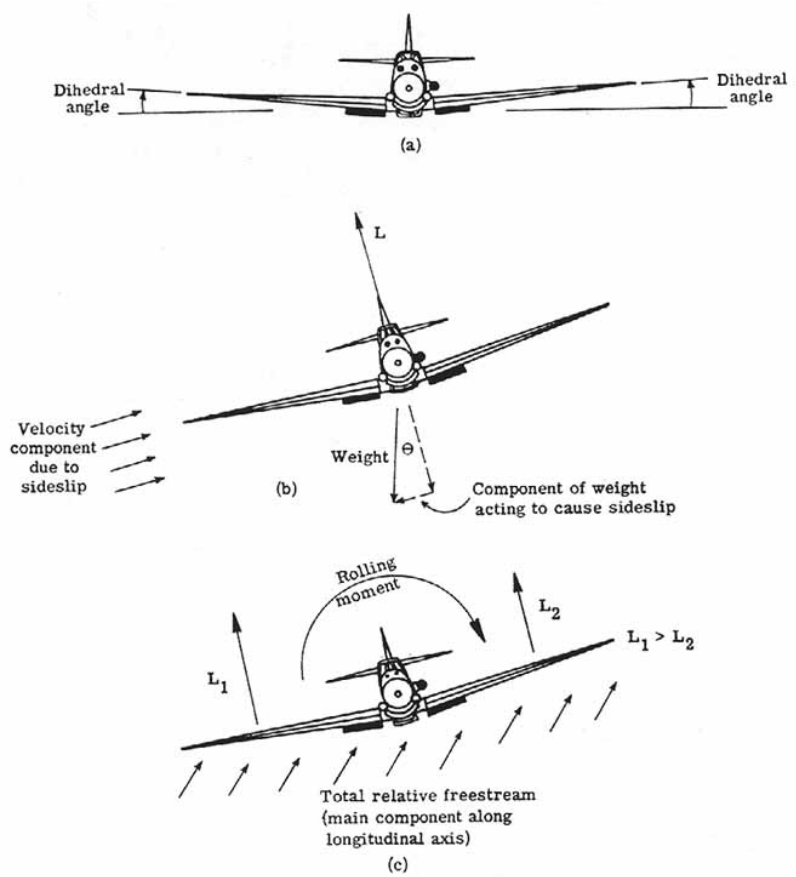


Increasing Lateral Stability

Wing Placement

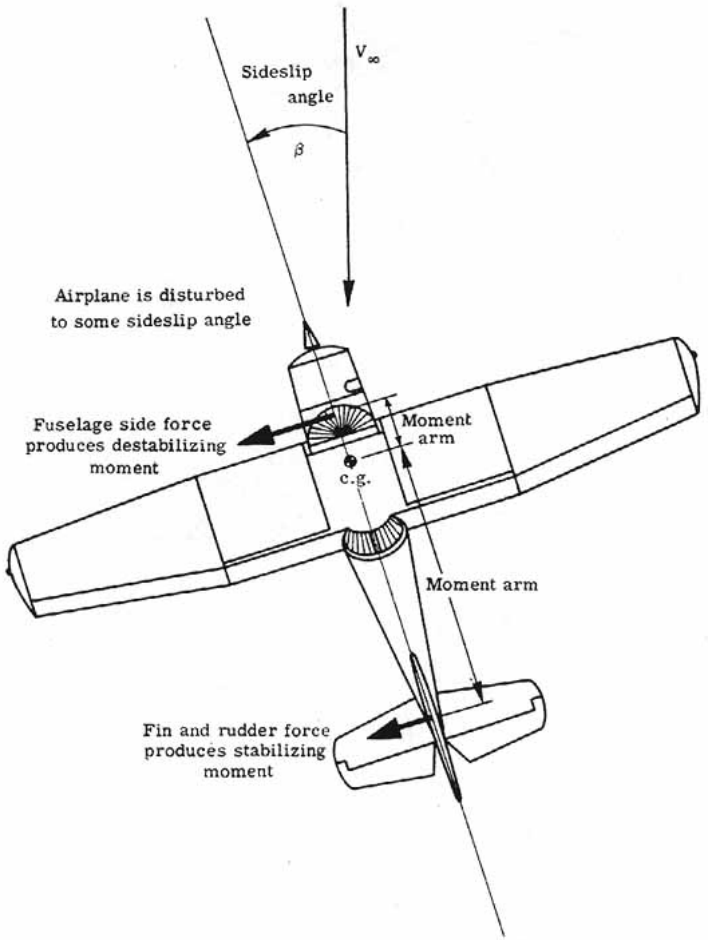


Dihedral



Directional Stability

- Stability about vertical axis
- Influenced by size and location of vertical stabilizer
  - Similar to weather vane or feathers on an arrow



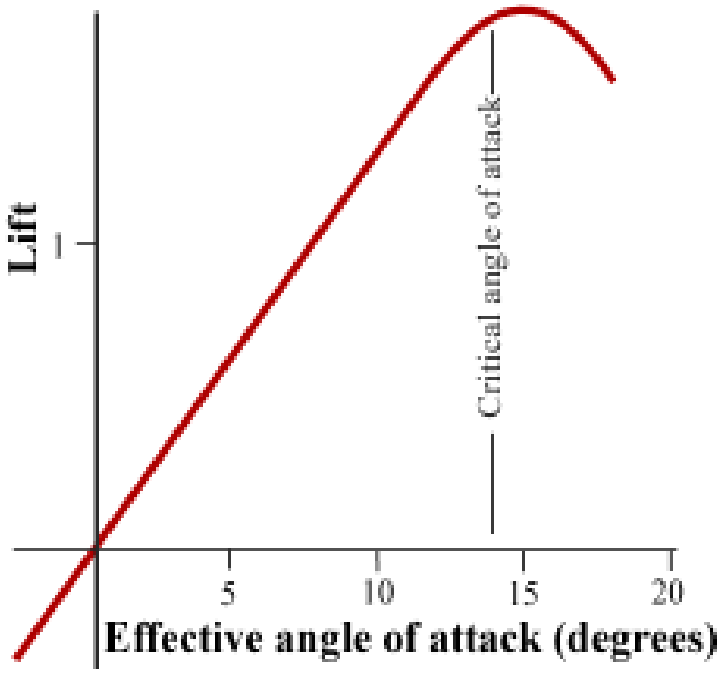
Stall

- At certain angle of attack airflow cannot “stick” to top of wing
- Air flow separation occurs

Stall

- The “critical angle of attack” does not change for a given wing
- Large loss of lift when stalled

- Stall Video
- F-22 Stall Video



Spins

- Uncoordinated stalls result in spins
- Both wings are stalled, 1 wing “more” stalled than other
- Rotating helical downward path
- Easy to recover from in Cessna 172
- You won’t have to do this during training

- Video 1
- Video 2
- Video 3

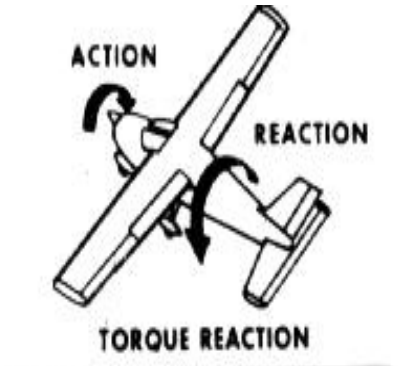
Aerodynamics of Maneuvering Flight

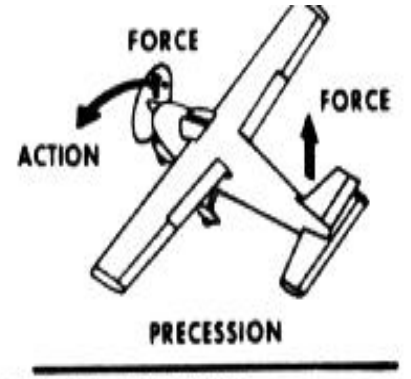
Climbing Flight

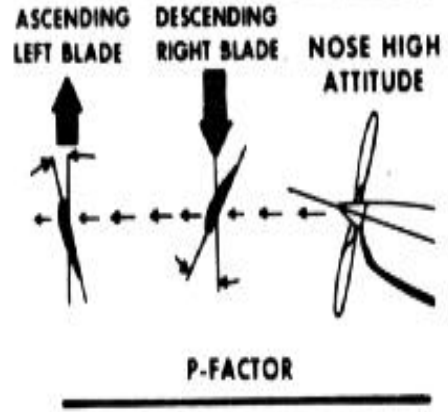
- Airplane climbs due to inclined thrust vector
- 4 Forces are still in equilibrium
- Rate at which airplane climbs determined by excess thrust

Left Turning Tendencies

- Torque
- P Factor
- Spiraling Slip Stream
- Gyroscopic Precession
  - This is not always a left turning tendency





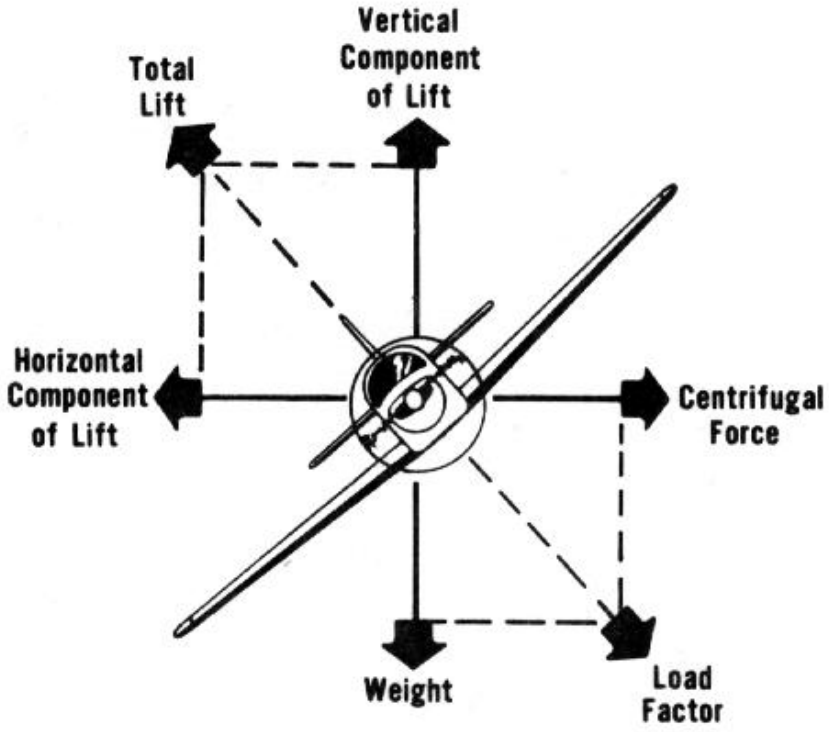


Descending Flight

- Airplane descends when flight path is pointed downward
- 4 Forces are still in equilibrium

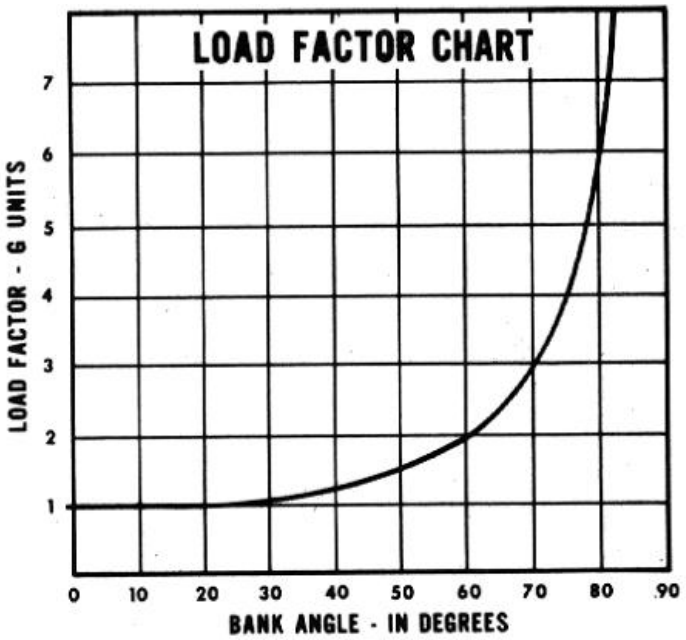
Turning Flight

- Horizontal component of lift turns plane
- Rudder is used to maintain coordination
- 4 forces are not in equilibrium, this is accelerated flight



Load Factor

- Ratio of weight supported by wings to weight of aircraft
- AKA as G's
- A load factor of 2, or 2 G's means wings support twice aircraft weight
- Increasing load factor increases stall speed



$$n = \frac{LIFT}{WEIGHT}$$