Theory of Flight

6.08 Aircraft Stability

References: FTGU pages 24-25

6.08 Aircraft Stability

- Definitions
- Longitudinal Stability
- Lateral Stability
- Directional Stability

Definitions

Stability is how an aircraft reacts to disturbances while in flight.

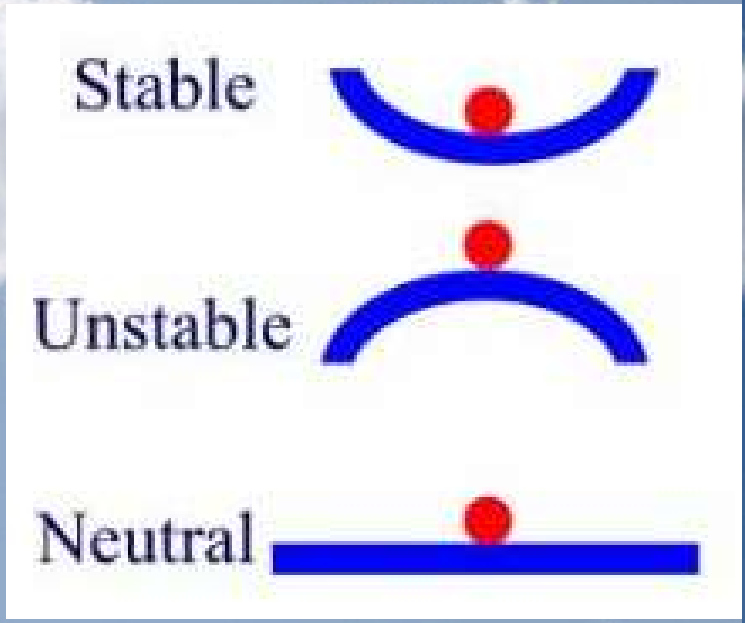
All aircraft have some form of inherent stability built into the design.

Two types of stability are dynamic and static.

Positive: airplane will return to its position

Negative: airplane will tend to move further away from its position

Neutral: airplane will neither return to its position nor continue to change



Definitions

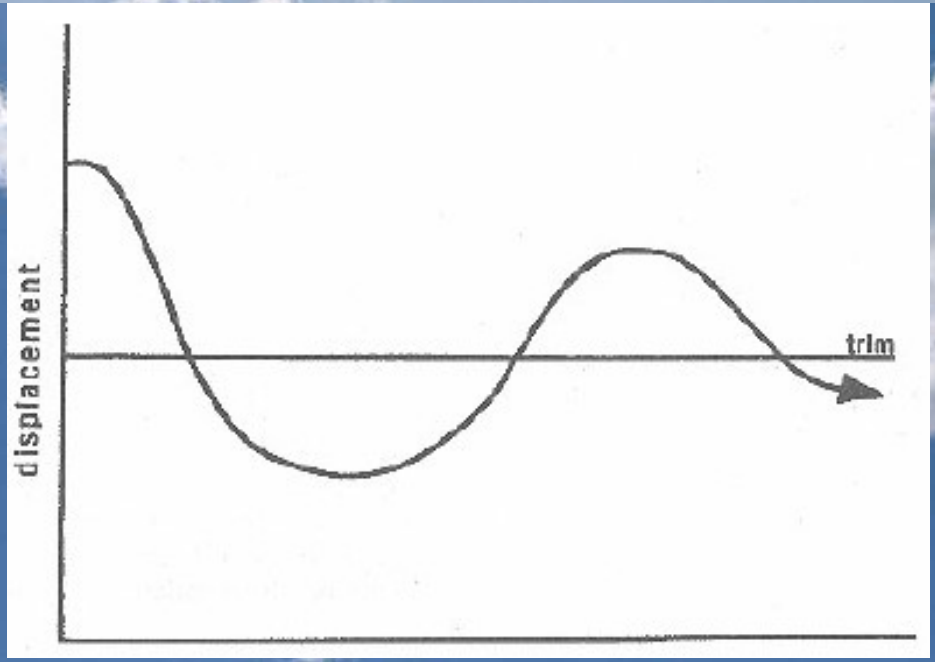
Static Stability

- The ***initial*** tendency of an aircraft, when disturbed, to return to its original position

Definitions

Dynamic Stability

- The ***overall*** tendency of an aircraft, when disturbed, to return to its original position



Definitions

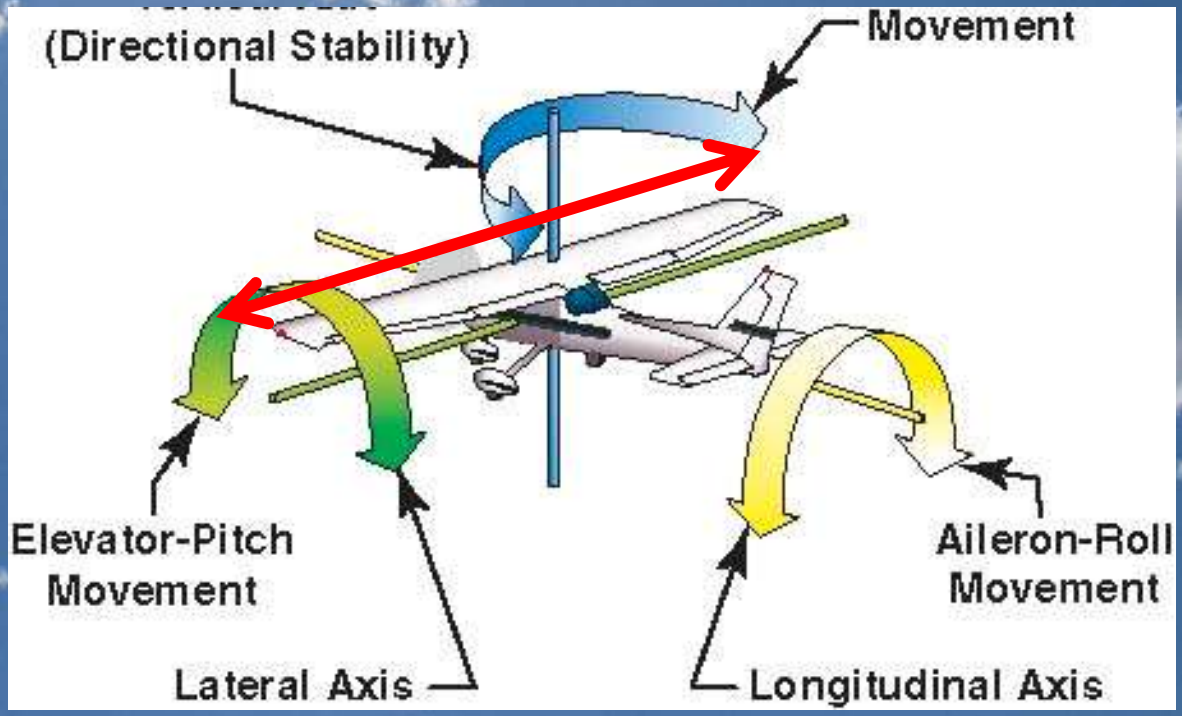
Inherent Stability

- Built in characteristics to enable the airplane to be either stable or unstable

- Stability may be built into each aircraft axis creating
  - Longitudinal stability
  - Lateral stability
  - Directional stability

Longitudinal Stability

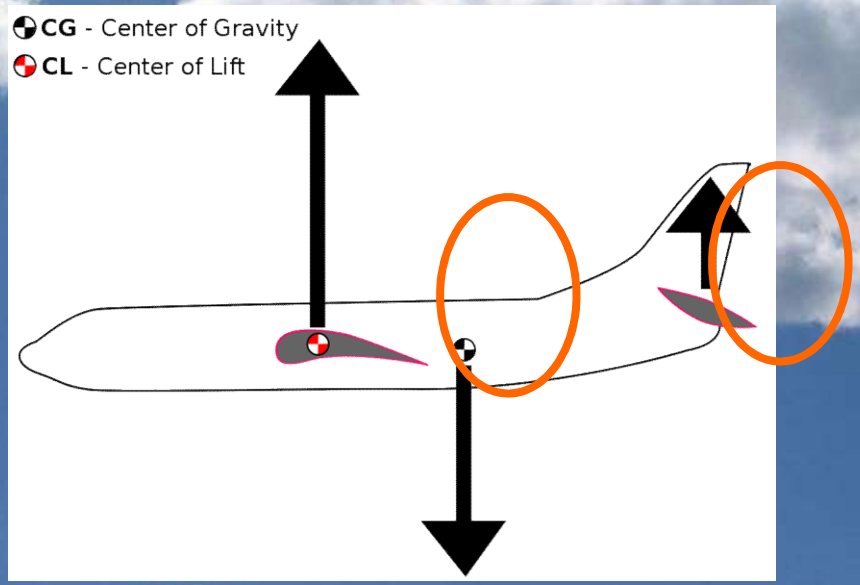
- Stability <u>around</u> the **<u>lateral axis</u>**
- Known as **pitch stability**



Longitudinal Stability

Longitudinal stability is affected by:

- Size and position of horizontal stabilizer
- Position of the C of G



Longitudinal Stability

Centre of Gravity (CG) is **forward**

- Overall weight of aircraft increases as the required down loading on the horizontal tail surface increases to maintain AoA
- Increased takeoff roll distance, required takeoff speed is higher
- Increase in drag with needed increases in lift
- Stall speed increases, caused by increased load on wing
- CG **too far** forward, may not rotate on takeoff or hard to flare for landing

Centre of Gravity (CG) is **aft**

- Poorer stall recovery
- Stall speed decreases, caused by decreased load on wing
- CG **too far** rearward, stall recovery may be impossible! Very Dangerous!

Longitudinal Stability

A – forward CG

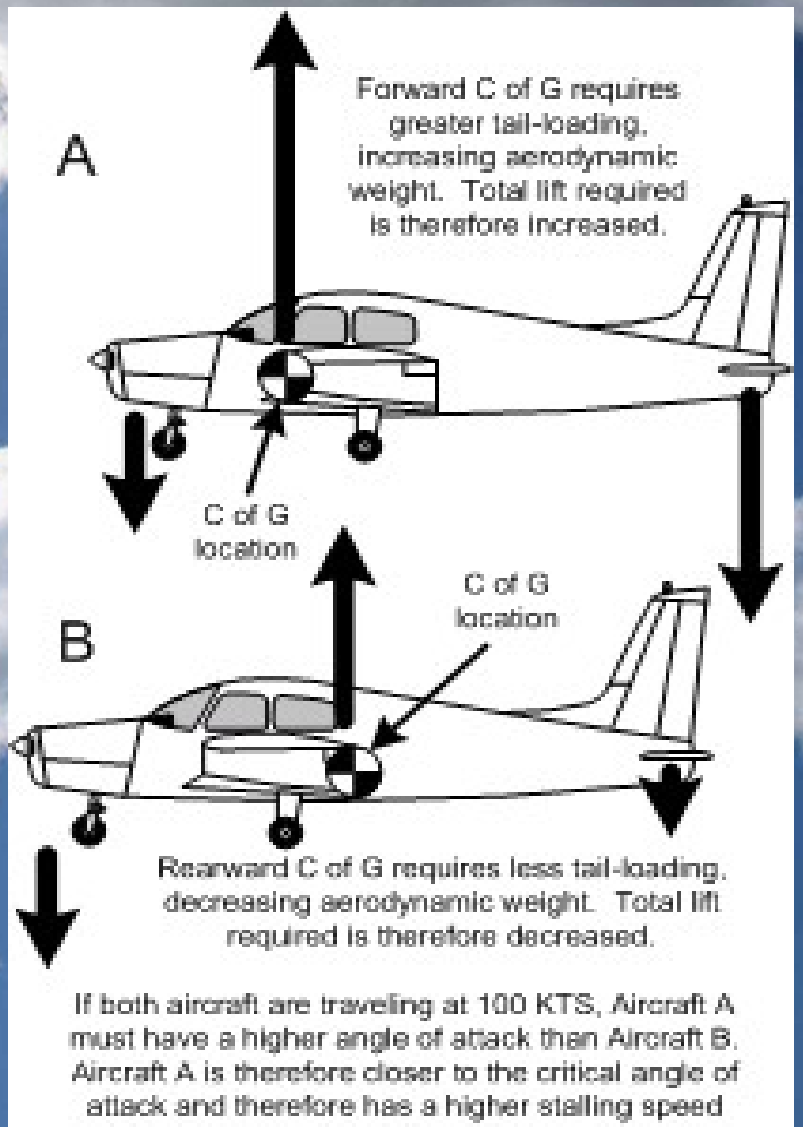
STALL SPEED INCREASES

also MORE STABLE and CRUISES SLOWER THAN AN AFT CG

B – aft or rearward CG

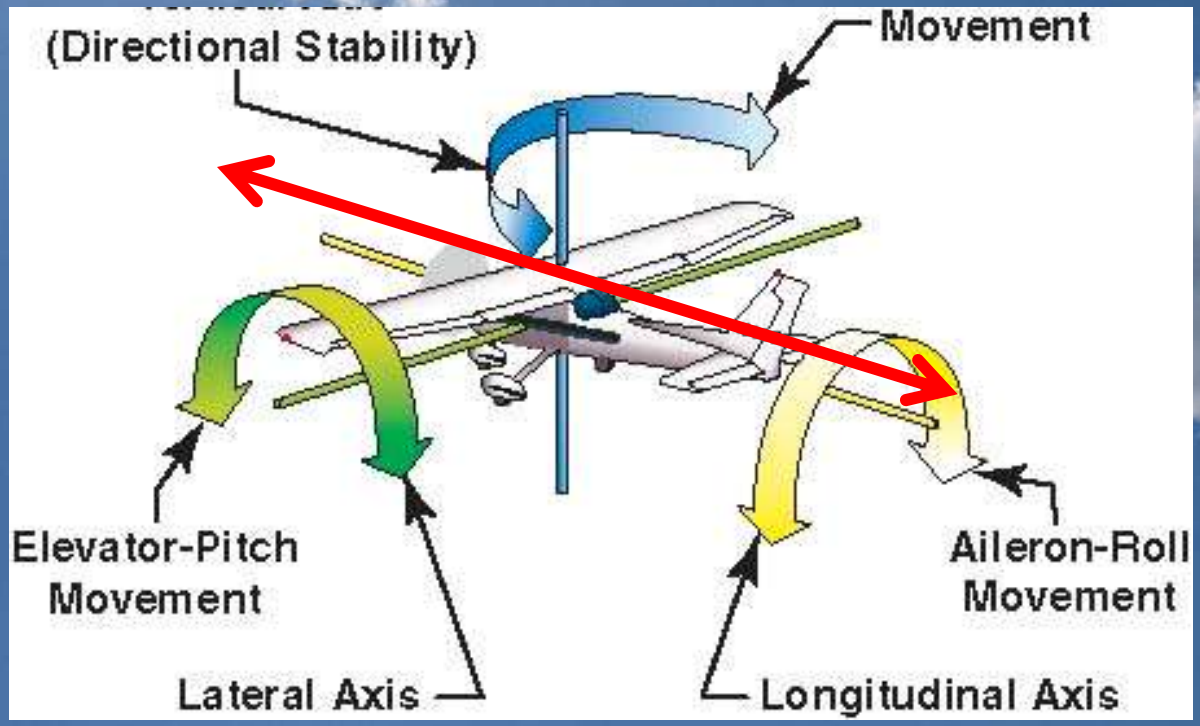
STALL SPEED DECREASES

also LESS STABLE and CRUISES FASTER THAN A FORWARD CG



Lateral Stability

- Stability around the **longitudinal axis**
- Known as **roll stability**

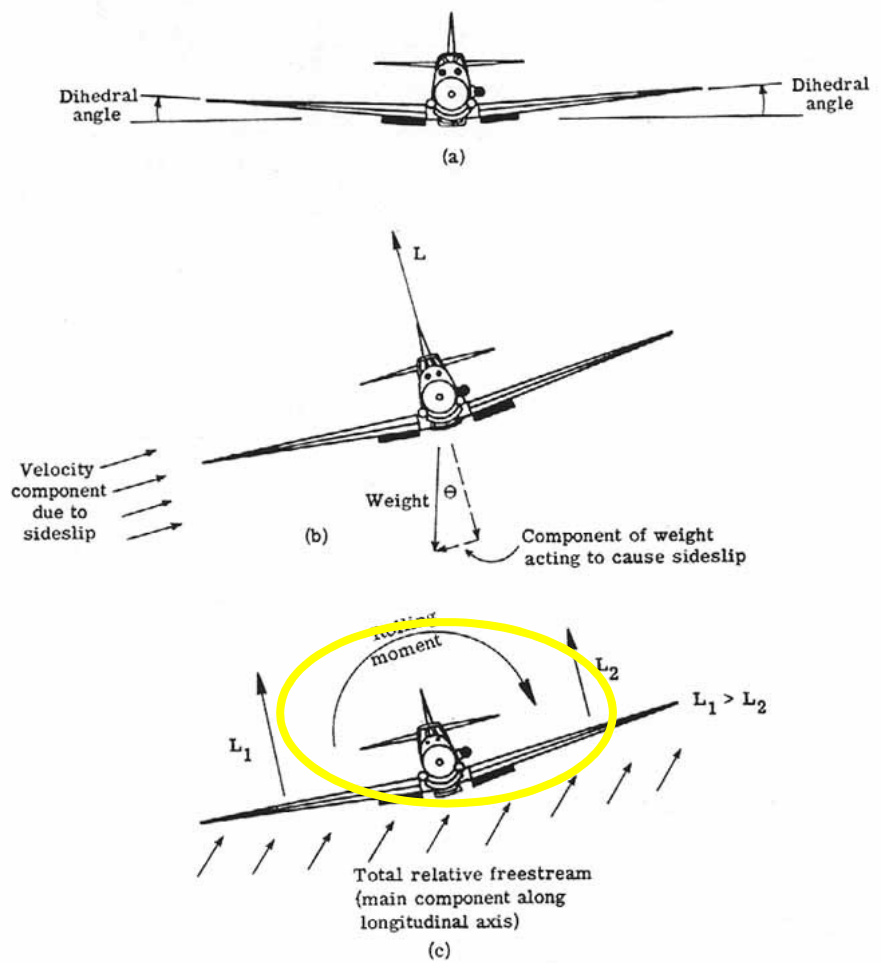


Lateral Stability

Lateral stability is created through

- Dihedral
- Keel effect
- Sweepback wings

Lateral Stability



Dihedral

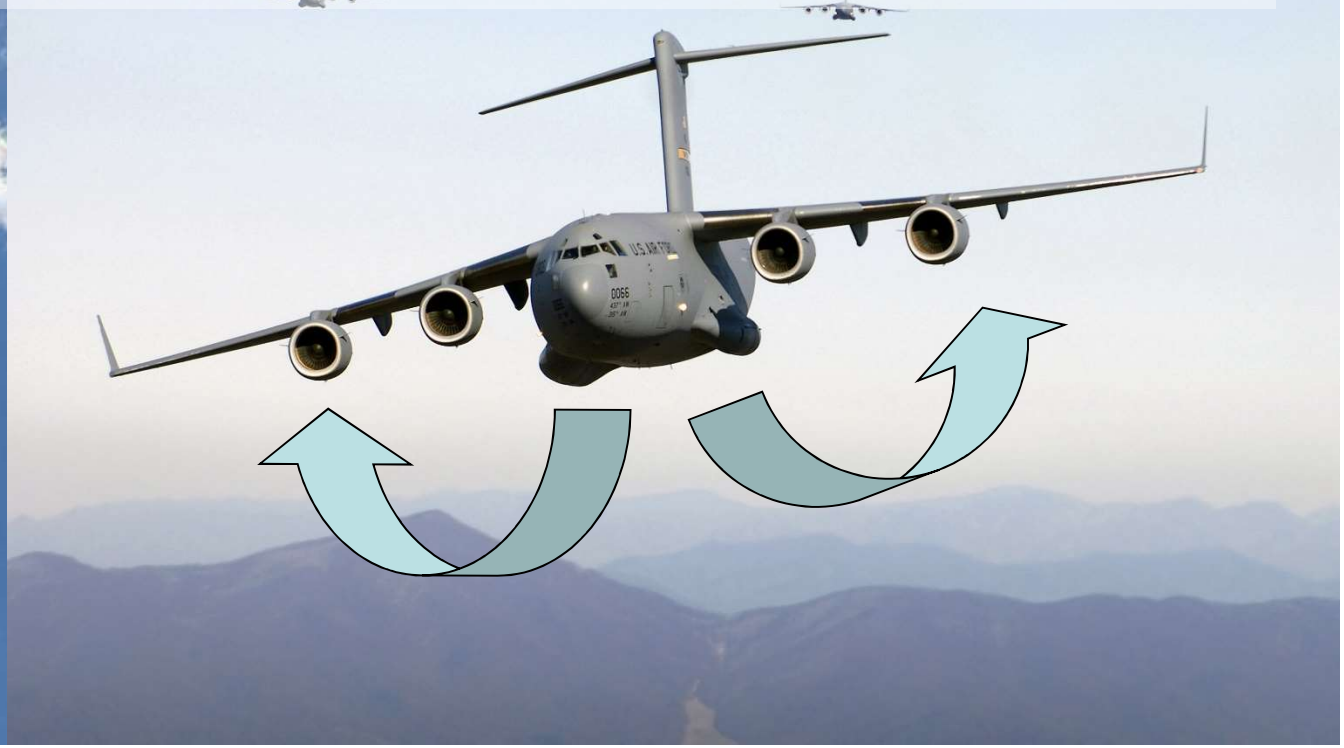
Is the angle that each wing makes. The wing tip higher than the wing root.

Downgoing wing = greater angle of attack = increased lift

Lateral Stability

Keel Effect

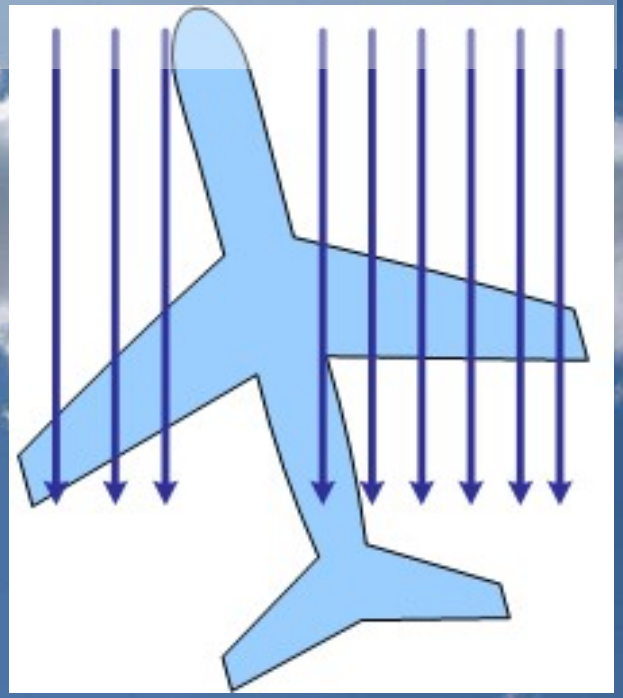
- Weight of the aircraft acts like a pendulum, weight under the wings, to swing aircraft back into position
- Natural feature of high wing aircraft



Lateral Stability

Sweepback

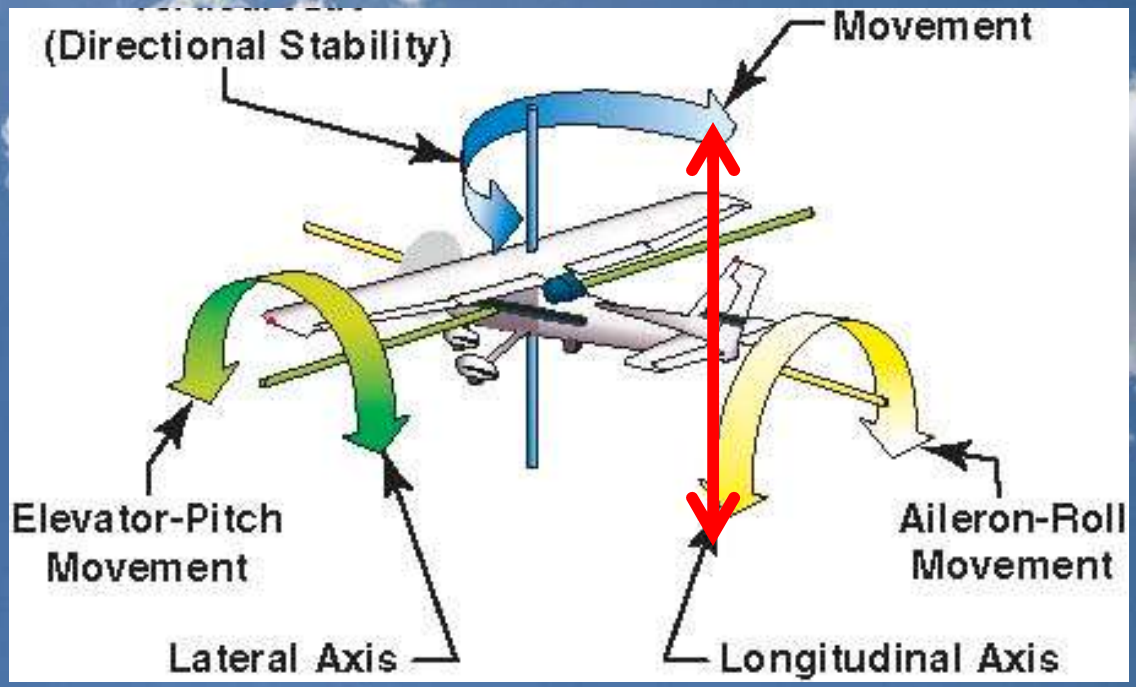
- Leading edge of the wing slopes backward
- When one wing is dropped, the lowered wing produces more lift than the raised wing and the original position is restored



Directional Stability

Stability around the **vertical or normal axis**

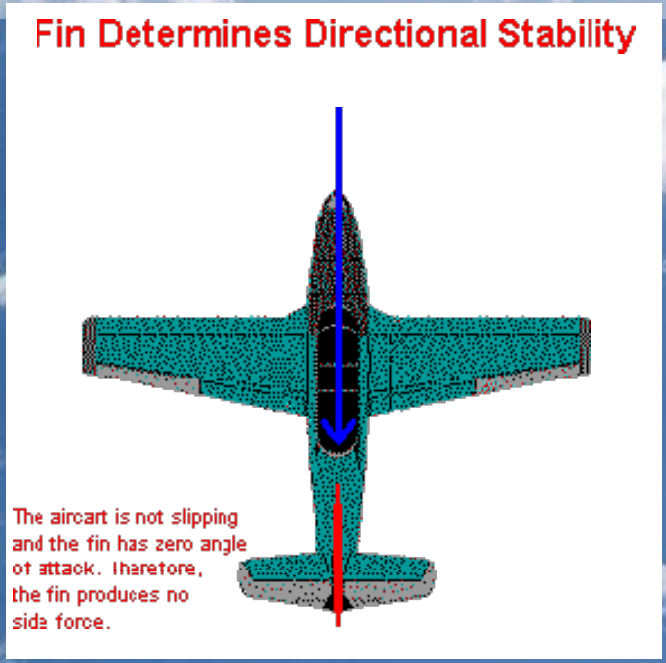
Known as **yaw stability**

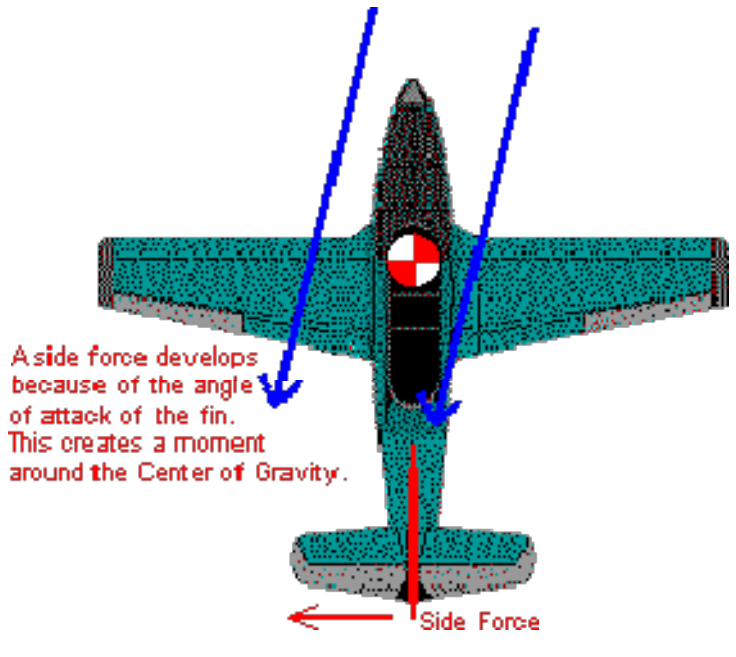


Directional Stability

Vertical Tail Surface (fin and rudder)

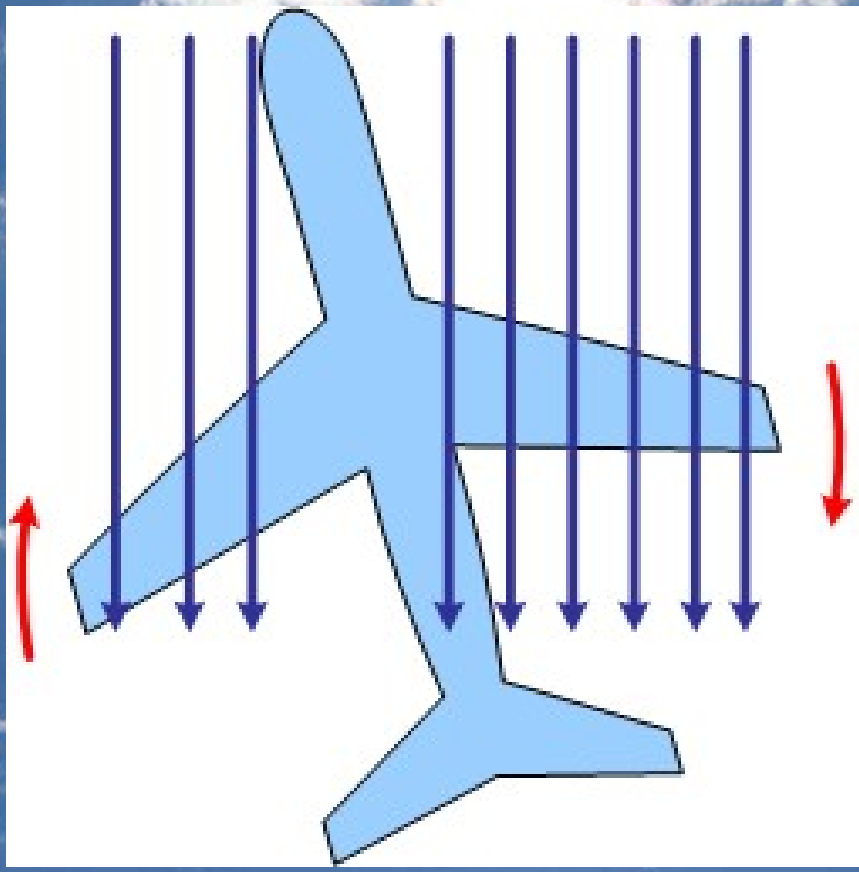
- Airplanes have a tendency to fly directly into the relative airflow due to the vertical tail surface
- When disturbed, the relative airflow will hit the side of the vertical tail surface and push it back into alignment





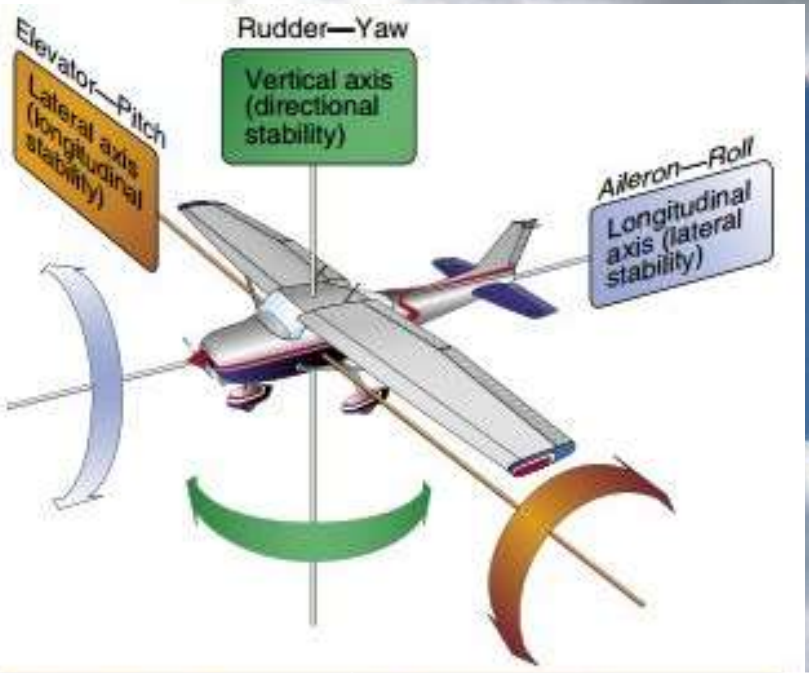
Directional Stability

Sweep Back



As right wing migrates forward (yaw), sweptback design produces a simultaneous increase in lift. As the wing's lift increases, induced drag increases, resulting in wing returning rearward.

Stability Review



Type of Stability	Axes of Rotation	Airplane Movement	Primary Control Surface
Lateral	Longitudinal	Roll	Aileron
Longitudinal	Lateral	Pitch	Elevator/Stabilator
Directional	Vertical	Yaw	Rudder

Confirmation Check

Confirmation Check

1. What is the difference between dynamic stability and static stability?
2. Lateral stability happens around which axis?
3. Directional stability happens around which axis?
4. Dihedral is?
5. Match the axis with the factors affecting them

Longitudinal Stability _____

Lateral Stability _____

Directional Stability _____

1. Keel effect
2. C of G
3. Sweepback
4. Vertical Stabilizer
5. Horizontal Stabilizer
6. Dihedral

Snowbirds – CT-114