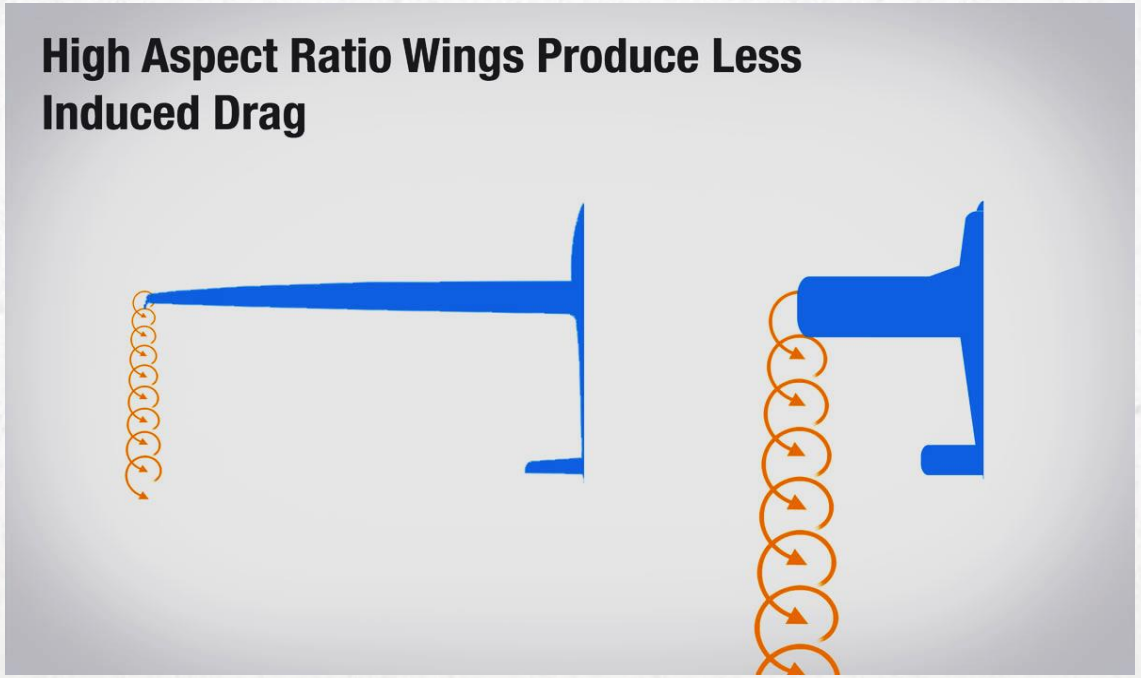
THEORY OF FLIGHT PART II

"REMEMBER, YOU FLY AN AIRPLANE WITH YOUR HEAD, NOT YOUR HANDS AND FEET."

QUICK REVIEW

QUICK REVIEW

- What is an aspect ratio? How is it computed?
- An aircraft with a higher aspect ratio will generate more/less lift?



QUICK REVIEW

- How do spoilers differ from speed brakes?

DRAG

PARASITE DRAG

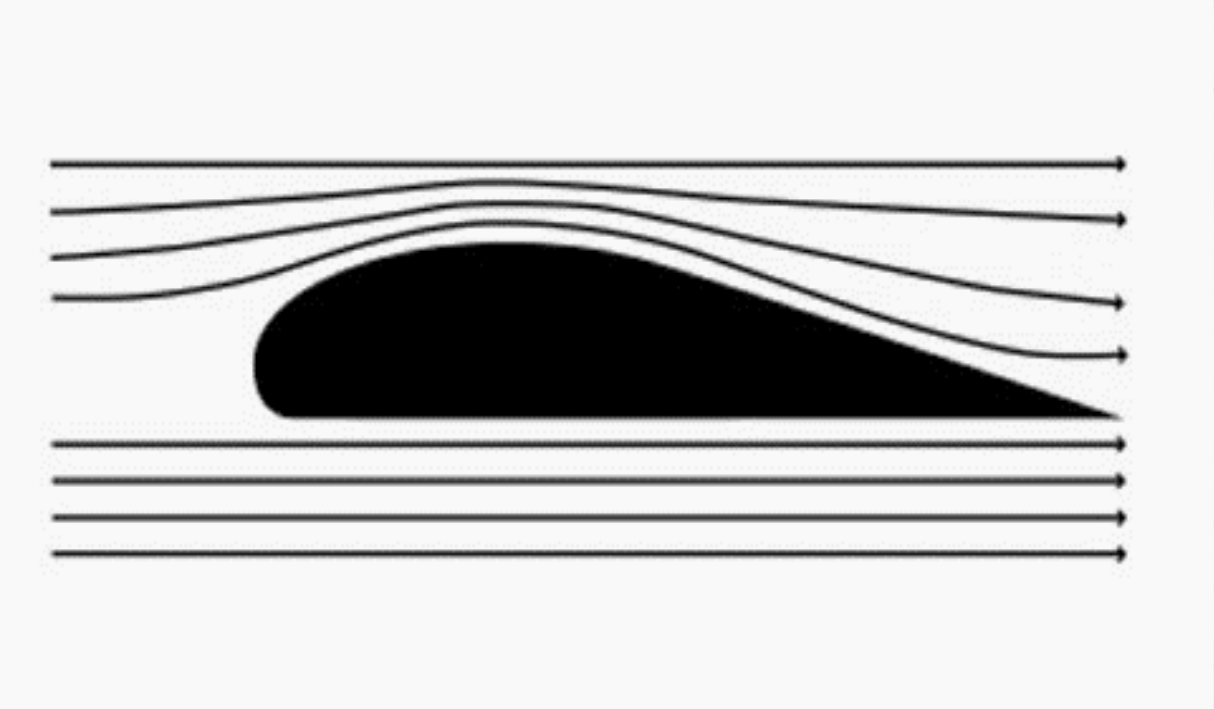
- Created from parts of aircraft that **DO NOT** produce lift
  - ex. Landing gear
- 2 types
  - **Form drag**
    - form or shape of a body on the aircraft ex. fuselage
  - **Skin friction**
    - Tendency of air flowing over a body to cling to its surface ex. dirt, dust, water

INDUCED DRAG

- Created from parts of the aircraft that produce lift
  - ex. wings

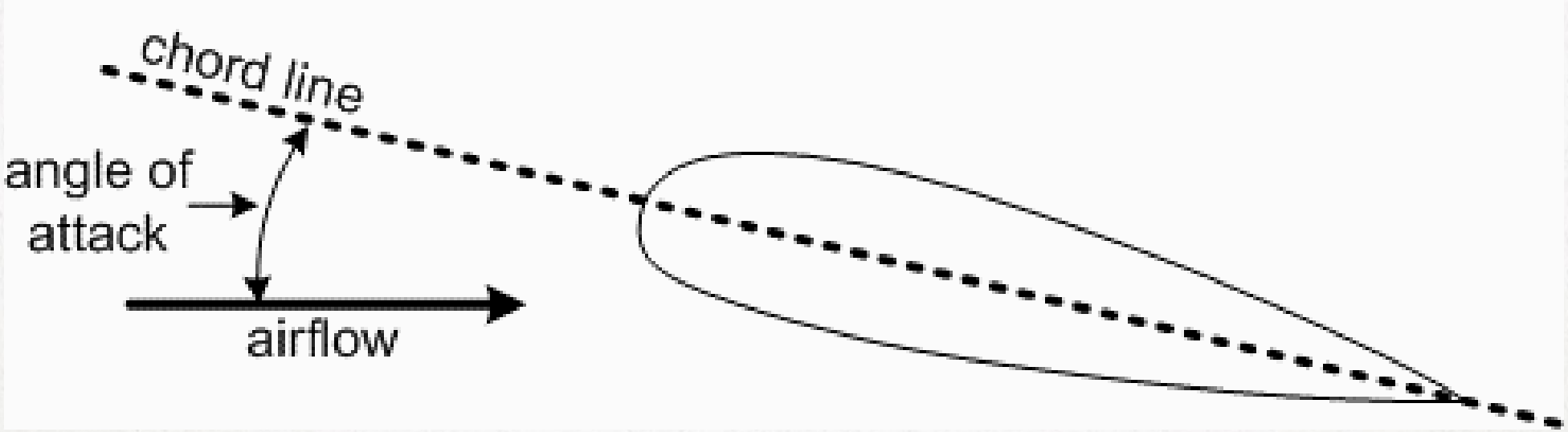
2.1.1 - HOW IS LIFT GENERATED?

- Bernoulli's Principle/Newton's Second Law



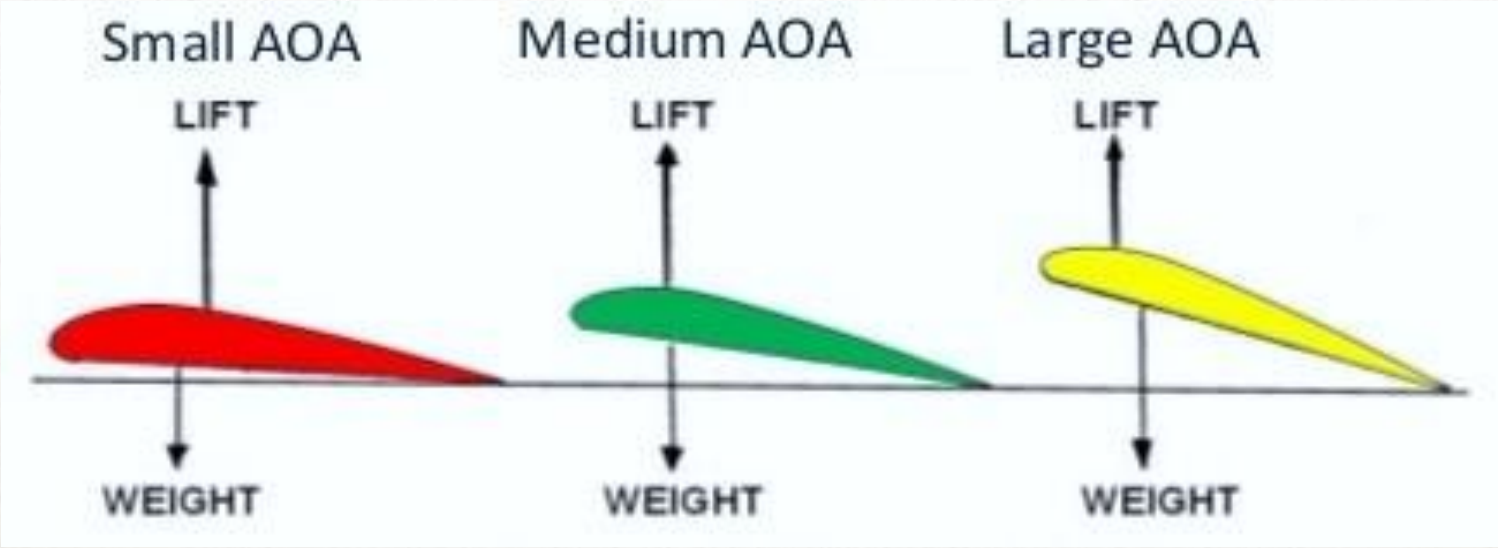
2.1.1 – ANGLE OF ATTACK

- Angle between the **relative airflow** and the **chord**



2.1.1 – CENTRE OF PRESSURE

- The **average location** of all pressures distributed over the airfoil
- Relationship between Angle of Attack and Centre of Pressure
  - As AoA increases up to the point of stall, CoP will move forward; beyond this point it will move backward rapidly



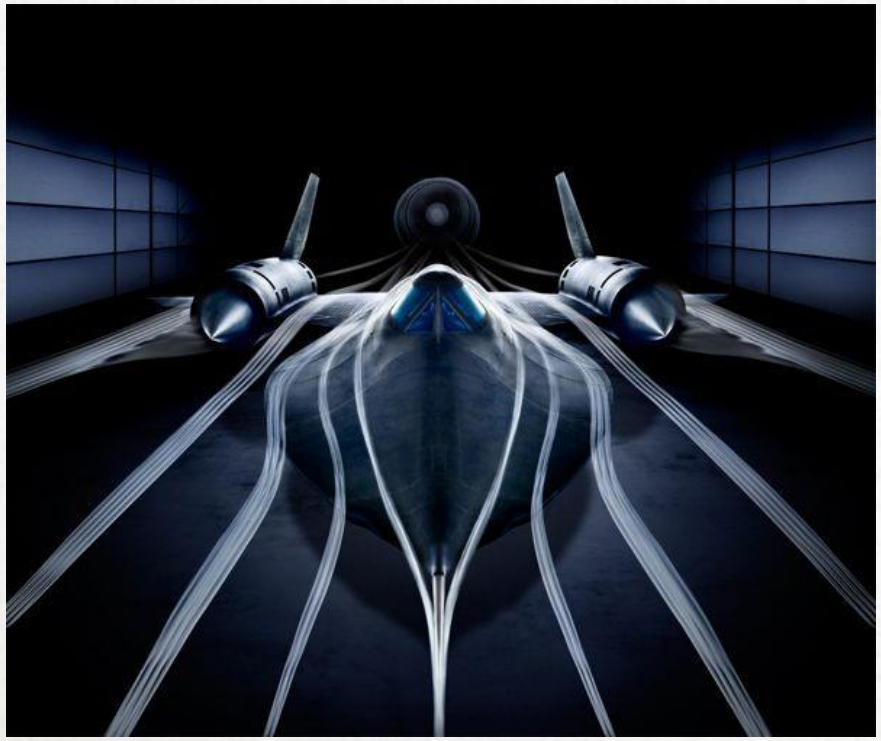
CONFIRMATION - *WUN*

What Pressure is on the top of the wing ? Why?

What happens to the centre of pressure as the wing stall?

2.1.1 - STREAMLINING

- Designing the aircraft in order to minimize drag

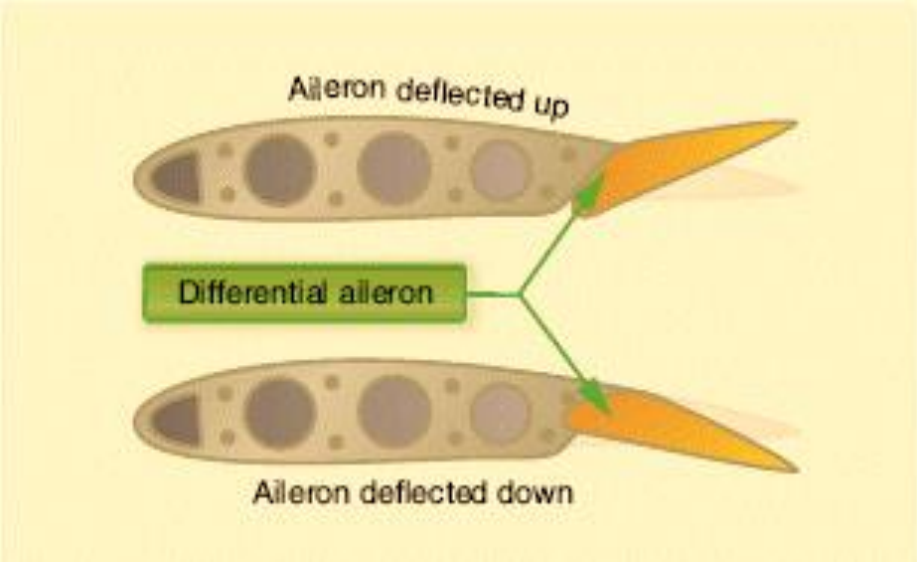


2.1.1 - AILERON DRAG

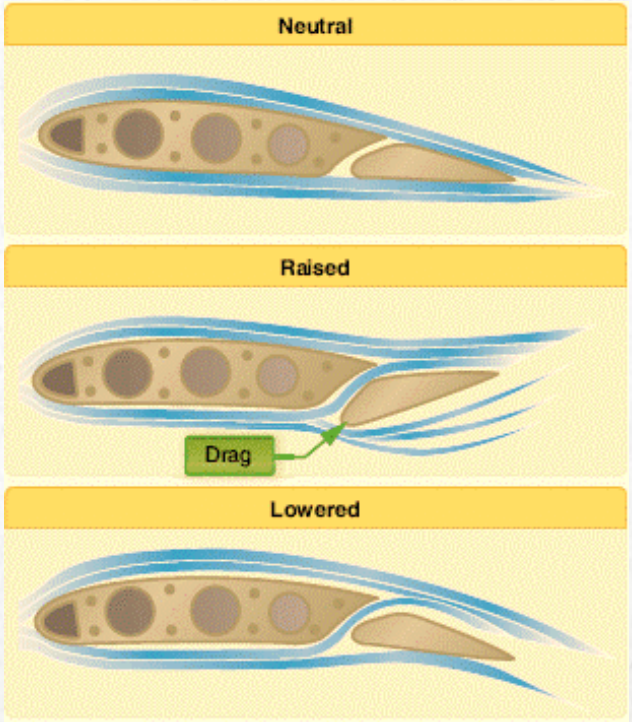
- When banking, the **downgoing aileron** produces more drag than its counter-part
  - As a result, the airplane will **yaw** in the **opposite direction**
- To resolve this problem, two types of ailerons are used
  - **Differential ailerons:** downgoing aileron creates a smaller angle than the upgoing aileron, balancing the drag created
  - **Frise ailerons:** streamlined ailerons that pivot on a hinge and direct airflow
- Overall result: **adverse yaw**

2.1.1 - AILERON DRAG

DIFFERENTIAL AILERONS

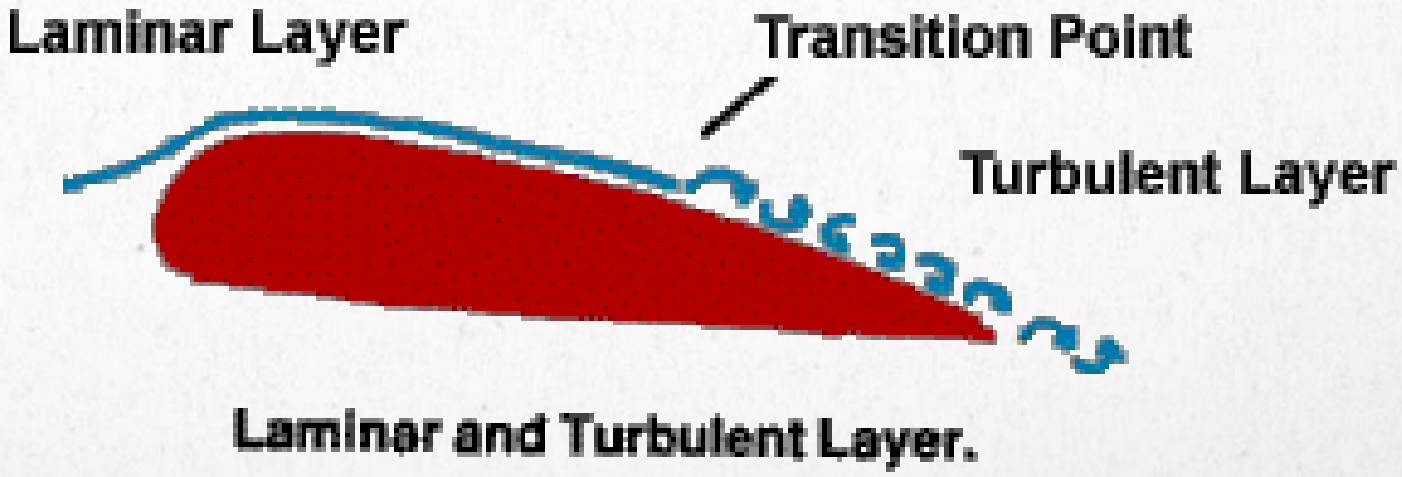


FRISE AILERONS



2.1.1 – BOUNDARY LAYER

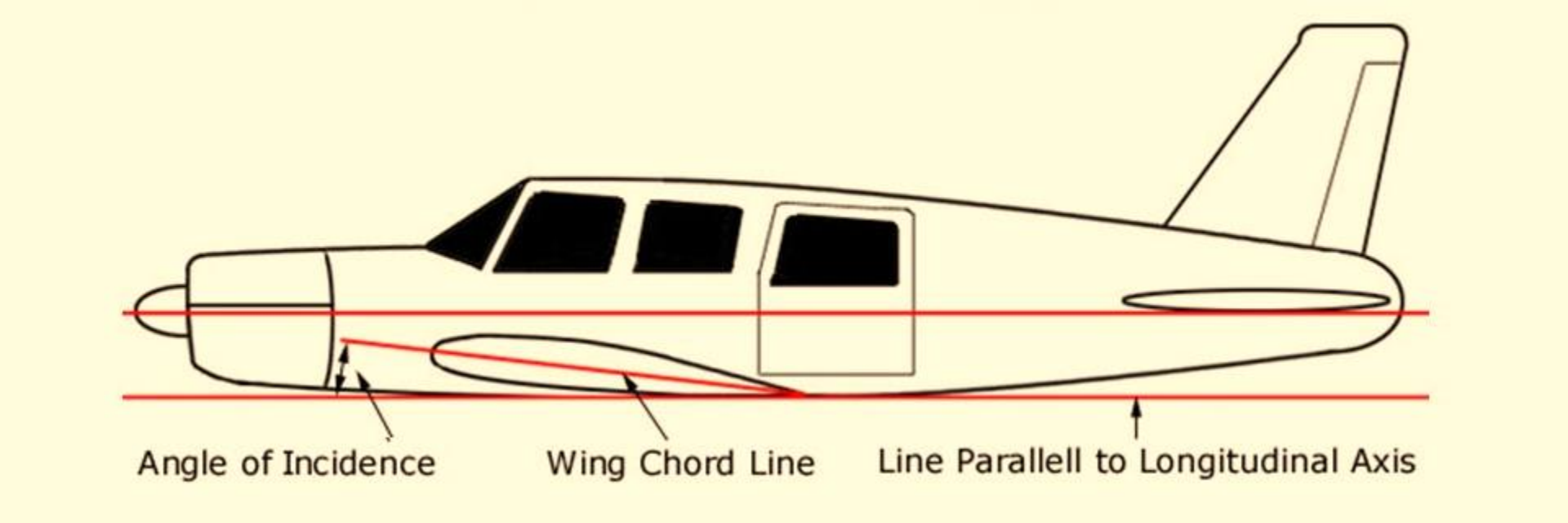
- Thin sheet of stationary air adjacent to the body of the aircraft (i.e. wings)
- As the wing moves through the air the boundary layer goes through 3 stages
  - Laminar layer
  - Transition point
  - Turbulent layer



Laminar and Turbulent Layer.

2.1.2 ANGLE OF INCIDENCE

- Angle at which the wing is **permanently** inclined to the longitudinal axis
  - Does not change



CONFIRMATION - *TOO*

Why would you want to streamline your aircraft ?

Name the section of air over the wing from the leading edge the trailing edge?

2.1.2 WASH-OUT / WASH-IN

- Reduce the chance of stalling the aircraft
  - Design a wing that stalls at wing root first
  - Gives pilots aileron control
- Wash out
  - Decreasing angle of incidence
  - Decreases lift
- Wash in
  - Increasing angle of incidence
  - Increases lift

2.1.4 – STABILITY

- Stability
  - "**tendency** of an airplane in flight to remain in straight, level, upright flight and to return to this attitude, if displaced, without corrective action by the pilot"
- Static Stability
  - "**initial tendency** of an airplane, when disturbed, to return to the original position"
- Dynamic Stability
  - "**overall tendency** of an airplane to return to its original position following disturbances"

2.1.4 – STABILITY

- 3 Types of Stability
  - **Positive:** develop forces that restores airplanes original position
  - **Neutral:** no forces present; airplane will neither return to original position nor move further away
  - **Negative:** develop forces that moves the airplane further away from the original position

2.1.4 – STABILITY

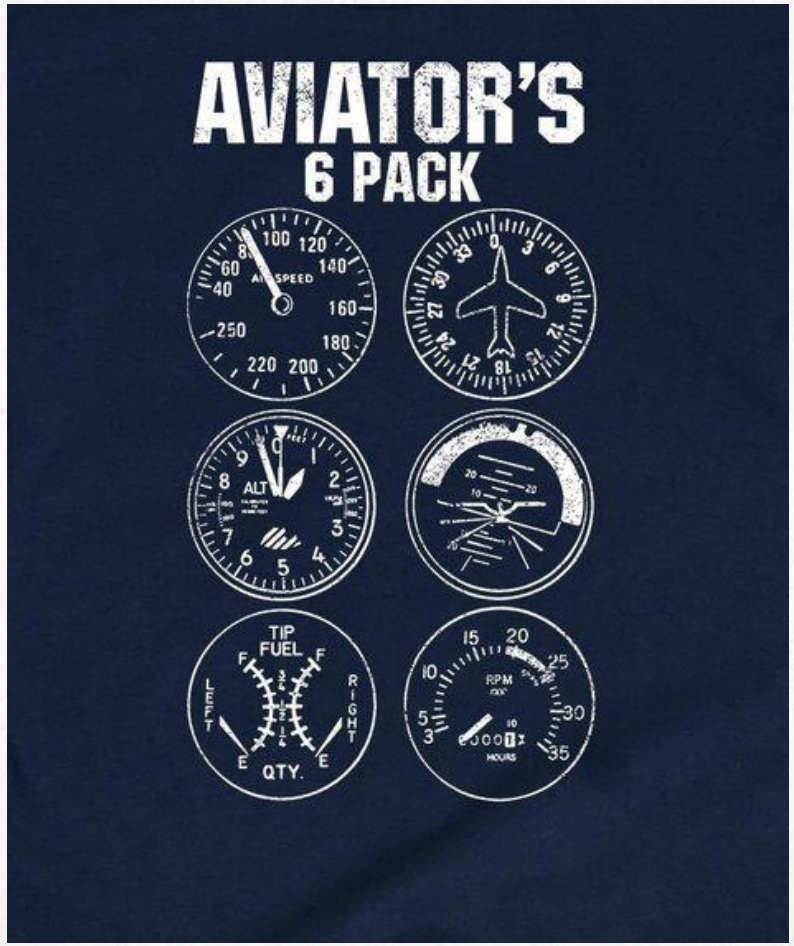
- **Longitudinal Stability**
  - Stability around the lateral axis (pitch stability)
  - Size and position of horizontal stabilizer & position of C of G
- **Lateral Stability**
  - Stability around the longitudinal axis (roll stability)
  - Dihedral, Sweepback, Keel effect, distribution of weight
- **Directional Stability**
  - Stability around the vertical axis (yaw stability)
  - Vertical tail surface (fin)

CONFIRMATION - *TREE*

Around what point is lateral stability based? and what are the factors of lateral stability?

What's the key difference between static and dynamic stability ?

BREAK TIME!



2.1.5 – FLIGHT PERFORMANCE FACTORS

- **Torque**
  - Causes the plane to yaw left (propeller spins clockwise)
- **Asymmetric Thrust (P factor)**
  - At high angle of attack, down going propeller has a greater angle of attack
  - More lift is produced from the right side of the plane, causing the plane to yaw left
- **Precession**
  - Change in plane of rotation of gyro
  - Ex: suddenly change from nose up to nose down attitude – plane will yaw to the left

2.1.5 – FLIGHT PERFORMANCE FACTORS

1. **Slipstream**
   - Cork-screw motion of air causes different pressures on either side of the tail
   - Since air flows from high pressure to low, the plane will yaw to the left
   - Corrected by off setting the fin

2.1.5 – FLIGHT PERFORMANCE FACTORS

2. Turns

- The steeper the angle of bank (irrespective of speed), the:
  - Greater the rate of turn
  - Smaller the radius
  - Higher the stalling speed
  - Greater the loading (Gs), 60^{o} turn is 2Gs
- The higher the airspeed (irrespective of angle of bank), the:
  - Slower rate of turn
  - Larger the radius

2.1.5 – FLIGHT PERFORMANCE FACTORS

3. **Stall**
   - Wing becomes incapable of generating enough lift to counteract the weight
   - **Stall at any airspeed/attitude if the critical angle of attack is exceeded**
4. **Spin**
   - Wings are stalled (no aileron control)
   - Plane rotates towards ground at constant and low airspeed
5. **Spiral Dive**
   - Excessive nose down attitude
   - Airspeed is rapidly increasing

SPINS & SPIRAL DIVES

CONFIRMATION - *FOWER*

What's the difference between a spin and a spiral dive ?

What happens to the turn with a steeper angle of bank?

2.2.1 – PITOT STATIC INSTRUMENTS

- Pitot pressure system + Static Pressure source
- 3 Instruments

2.2.1 – ERROR IN PITOT STATIC INSTRUMENTS

- **Altimeter**
  - Pressure error – “from high to low, look out below”, “low to high, clear blue sky”
  - Temperature error – correction card
- **ASI**
  - Density – variable weather
  - Position – corrected using calibration chart
  - Lag – mechanical error
  - Icing – blockage of pitot tube
  - Water – water in the system
- **VSI**
  - Lag – very common

2.2.3 GYRO INSTRUMENTS

- Based on gyroscopic inertia and precession
- 3 Most common instruments
  - **Heading Indicator**
  - **Attitude Indicator** (artificial horizon)
  - **Turn and Slip Indicator**
- Other
  - Turn Co-ordinator
  - Compass (Special)

COMMON GYROSCOPIC INSTRUMENTS

Heading Indicator

Attitude Indicator

Turn and Slip Indicator

CONFIRMATION - *FIFE*

Which one of these is not a error for ASI ?

1. Density
2. Position
3. Lag

Which instrument is connected to the pitot tube?

NEXT WEEK…

- Finished section 1 of 4! (Woohoo!)
- Test next week will cover everything you learned from both classes
  - Approximately 40 questions
  - You will be given 1 hour to complete the test (the 1st hour, so come early!)
- Make sure to practice quiz 1 on the website
  - If you have any questions, use the contact us section of the website
- Next section will be **Radio & Air Law**
- Good Luck!