



Theory of Flight



6.09 Flight Instruments and Performance Factors

References:

FTGU pages 32-34, 39-45



6.09 Flight Instruments and Performance Factors

- MTPs:
 - Pitot Static Instruments
 - Asymmetric Thrust
 - Precession
 - Slipstream
 - Climbing
 - Gliding

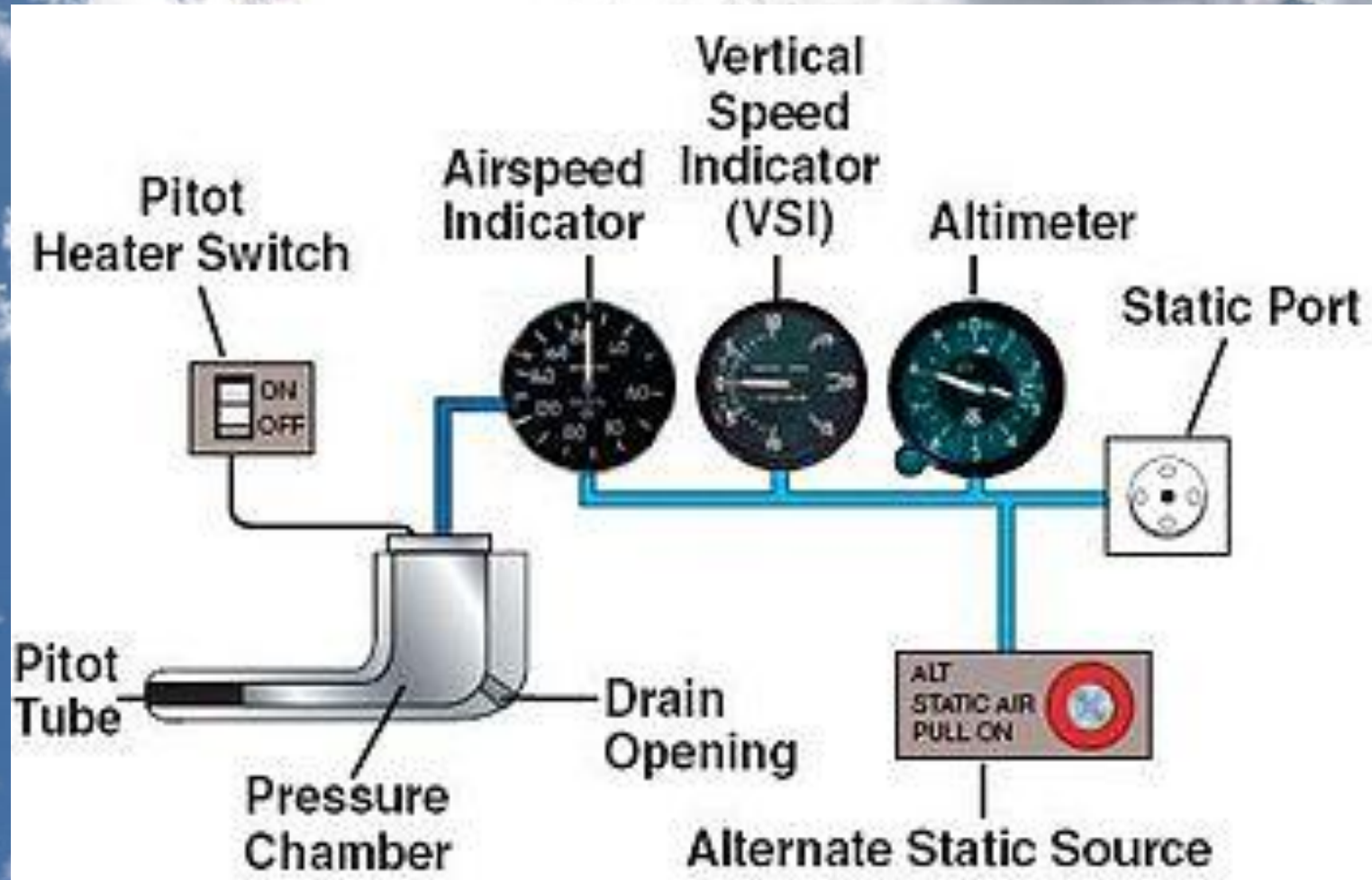


Pitot Static Instruments

- There are three pressure instruments
 - The Altimeter
 - The Vertical Speed Indicator (vsi)
 - The Air Speed Indicator (asi)
- There are two pressure sources
 - Static Pressure
 - Pressure surrounding the aircraft
 - Pitot Pressure
 - Pressure created by forward motion of the aircraft
 - Also called dynamic pressure



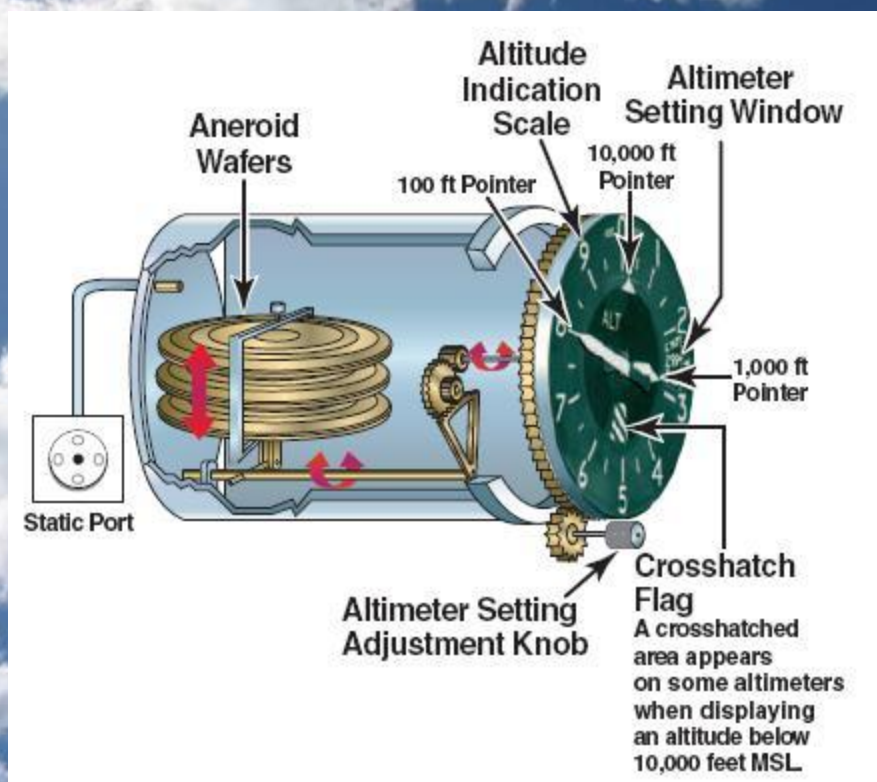
Pitot Static Instruments





The Altimeter

- The Altimeter
 - Operates on static pressure
 - Higher pressure → Lower altitude
 - Aneroid capsules or wafers expand and contract, mechanically moving the needles





Altimeter Markings

- Small hand reads tens of thousands of feet
- Medium hand reads thousands of feet
- Large hand reads hundreds of feet





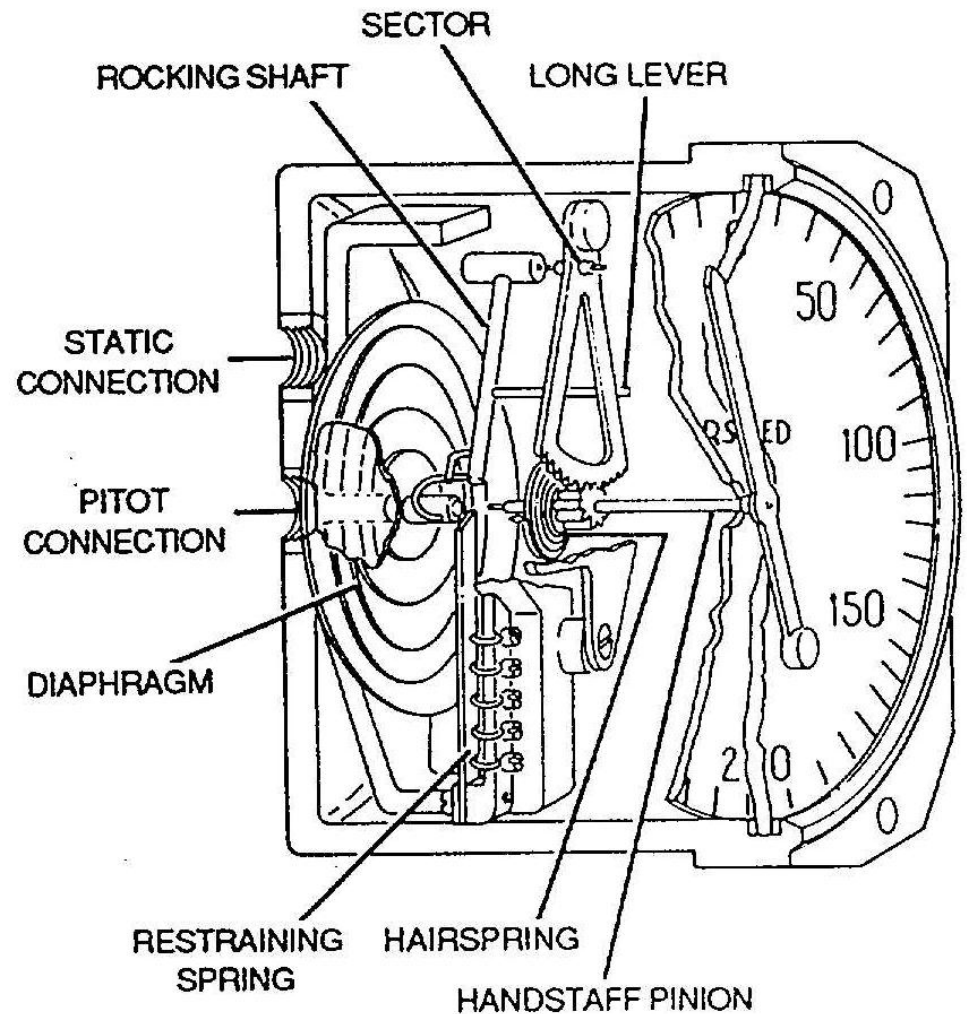
Altimeter Errors

- Pressure Error
 - Different pressures exist in different locations
 - The altimeter setting compensates for changes in pressure
- Temperature Error
 - There is seldom standard temperature with a standard lapse rate
- Mountain Effect Error
 - Air is deflected around mountains
 - According to Bernoulli's Principle, the pressure in the airflow drops, which will affect the altimeter reading



The Airspeed Indicator

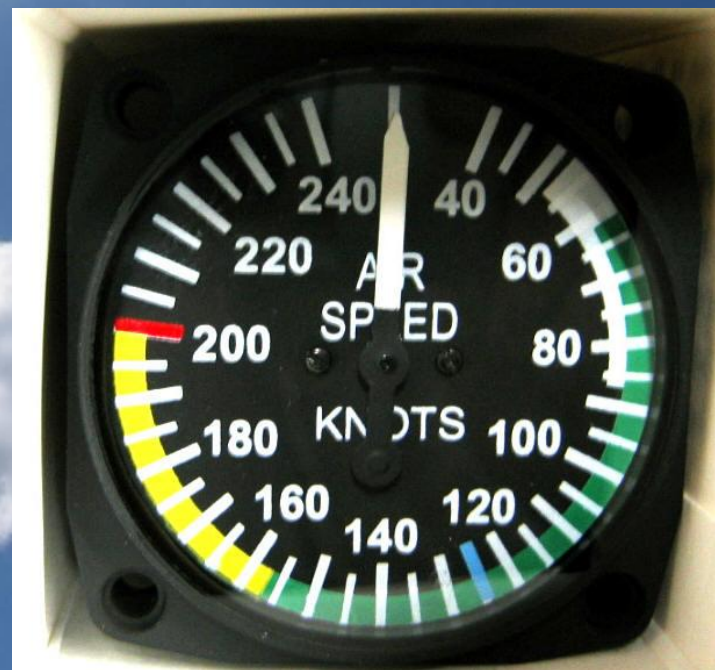
- Reads airspeed (not ground speed)
- Measures the difference between static and pitot pressure





ASI Markings

- Marked in Knots or MPH
- Red: V_{NE}
- Yellow: Caution Range
 - Highest point V_{NE}
 - Lowest point V_{NO}
- Green: Normal Range
 - Highest point V_{NO}
 - Lowest point V_{SL}
- White: Flaps Range
 - Highest point V_{FE}
 - Lowest point V_{SO}





Some “V” Speeds

- V_{NE} : Never Exceed Speed
- V_{NO} : Maximum Structural Cruising Speed or Normal Operating Limit Speed
- V_{SL} : Power Off Stalling Speed (clean configuration)
- V_{FE} : Maximum Flaps Extended Speed
- V_{SO} : Power Off Stalling Speed (flaps and gear down)
- V_A : Manoeuvring Speed
- V_B : Maximum Gust Intensity Speed



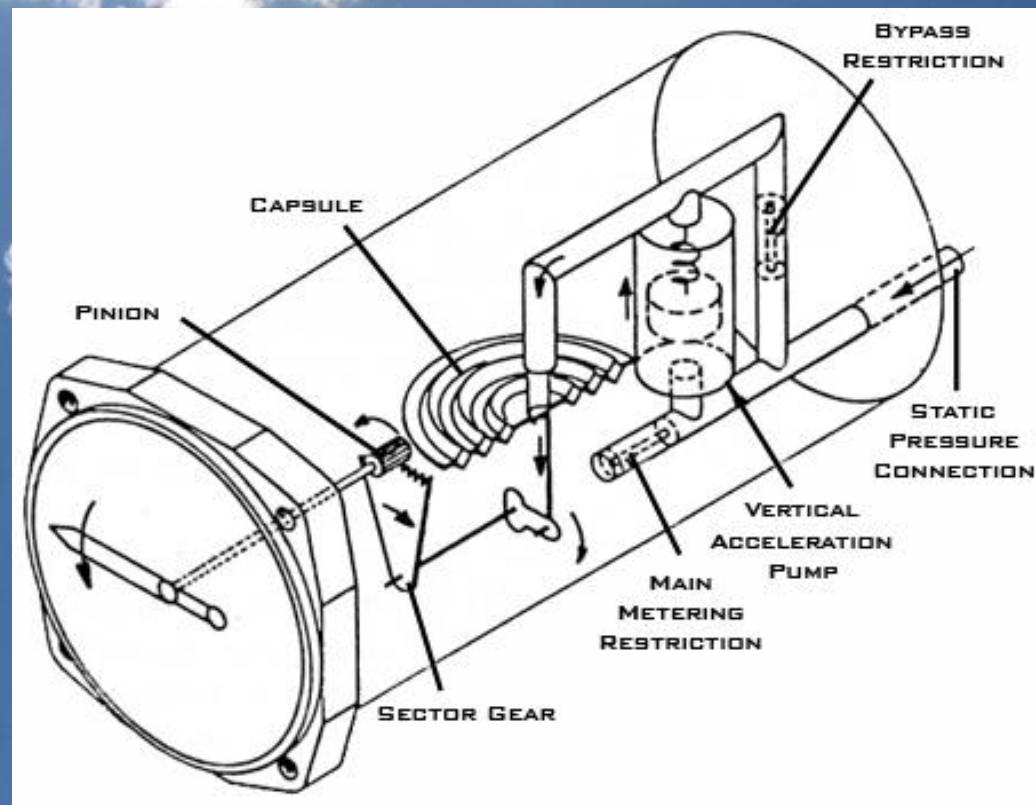
ASI Errors

- Density Error
 - Nonstandard pressure or alt other than 0'ASL
- Position Error
 - Eddies or the angle the pitot tube meets relative airflow
- Lag Error
 - Mechanical friction
- Icing Error
 - Ice covering the intake of the pressure sources
- Water Error
 - Water in the system



Vertical Speed Indicator

- Reads Vertical Speed
- Measures the rate of change in static pressure





VSI Markings

- The VSI is marked in positive and negative feet per minute or knots of vertical speed





VSI Errors

- Lag
 - The change in altitude must occur before the VSI can register the change
 - If pitch changes are slow, the lag will be less intense than if the pitch changes are sudden



Asymmetric Thrust

- Caused by the descending blade of the propeller having a greater angle of attack than the ascending blade
 - High angles of attack and high power settings
- Use right rudder to compensate



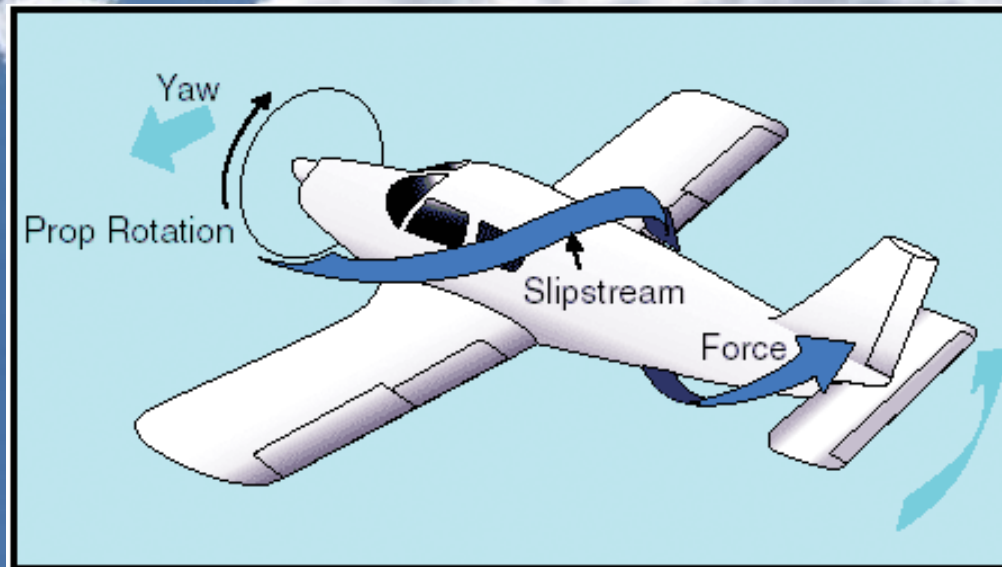
Precession

- The propeller acts as a gyroscope
 - Rigidity in Space
 - A gyro will rotate in the same plane and resist change
 - Precession
 - If forced to change, there is a tendency to rotate 90 degrees to the original axis and rotate parallel to the applied force
- Overcome these tendencies using control inputs as required



Slip Stream

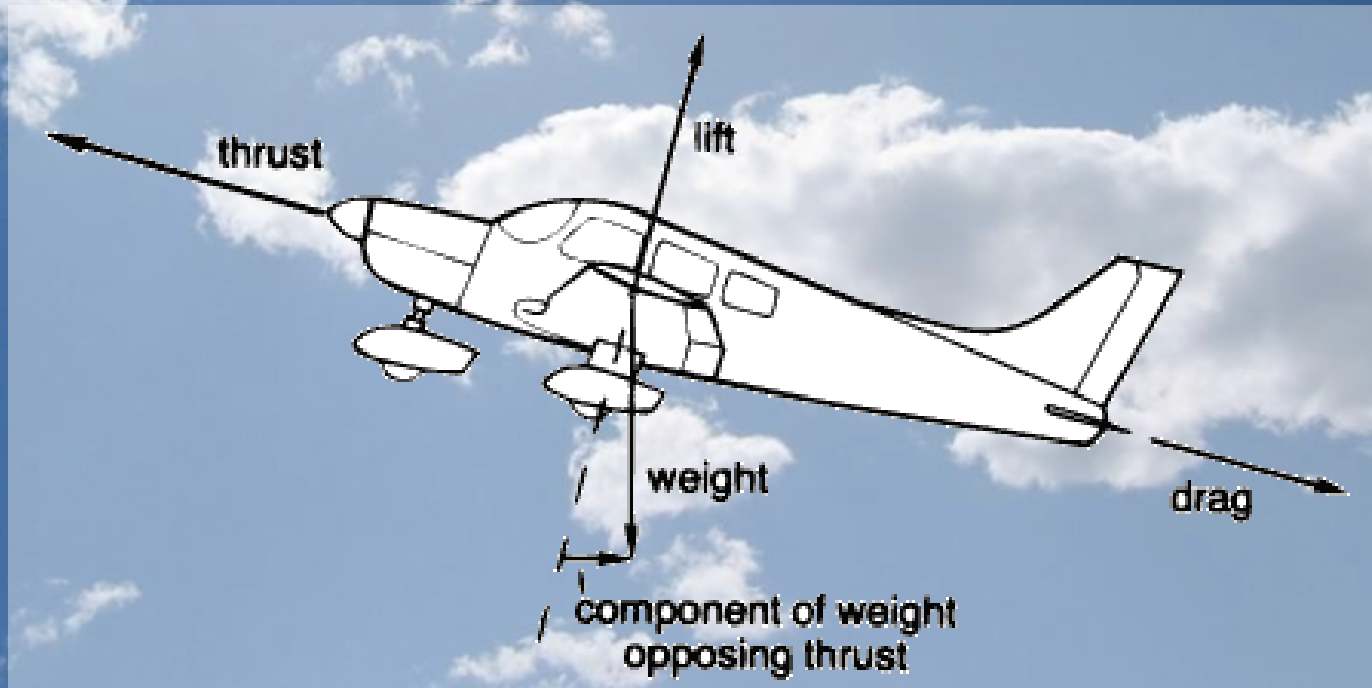
- Air pushed backwards by the propeller has a corkscrew pattern
 - This applies force to one side of the vertical stabilizer
- Offsetting the fin, and rudder input compensates





Climbing

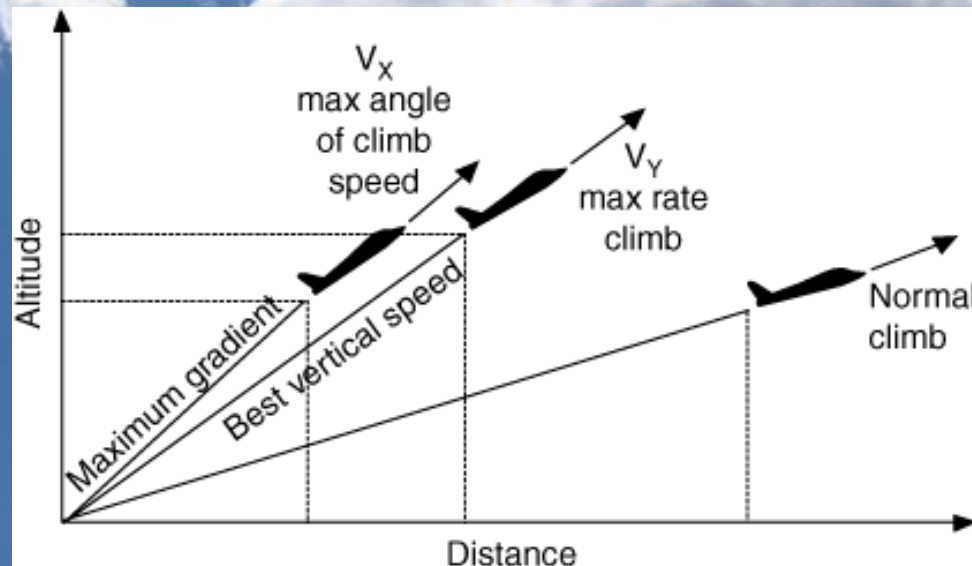
- Climbing changes how forces are applied to the airplane





Climbing

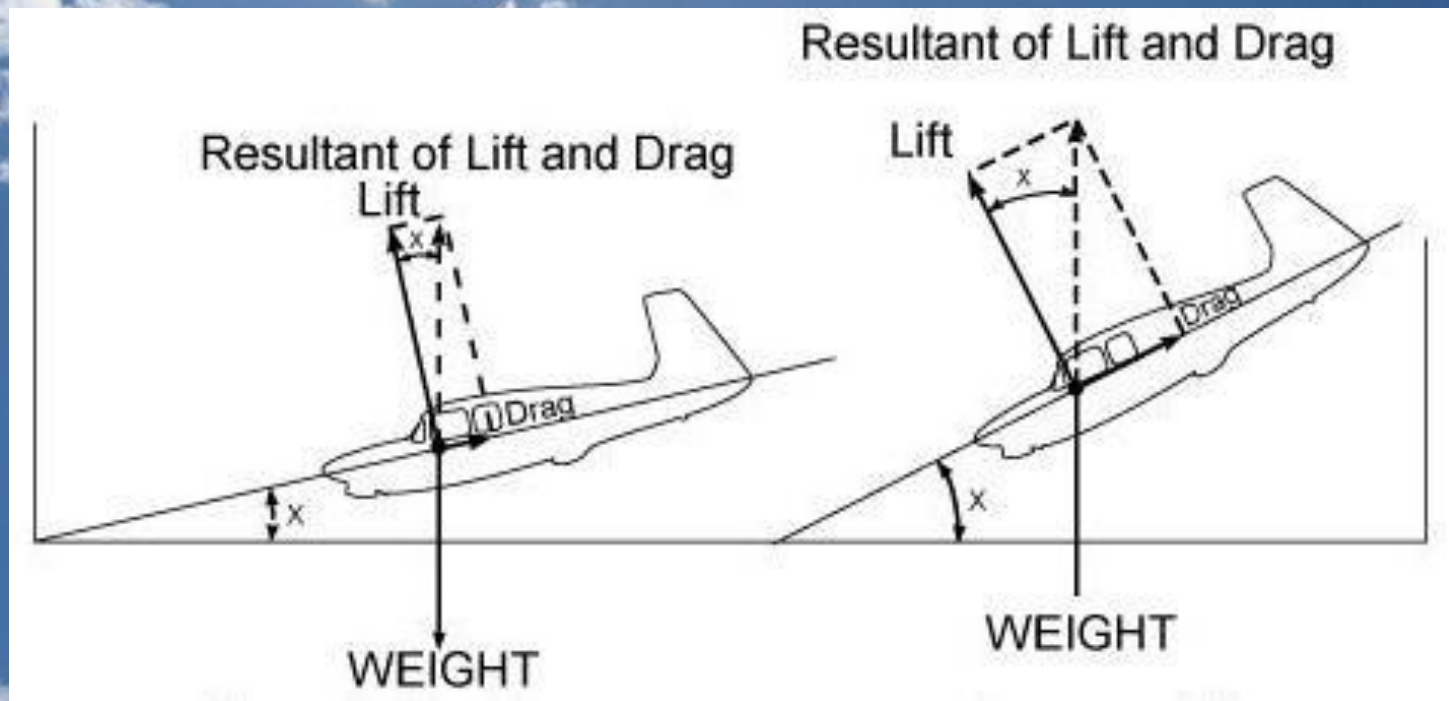
- Best Angle of Climb
 - Best gain for *distance* (by flying V_X)
- Best Rate of Climb
 - Best gain for *time* (by flying V_Y)
- Normal Climb
 - Better engine cooling, control, and visibility over the nose





Gliding

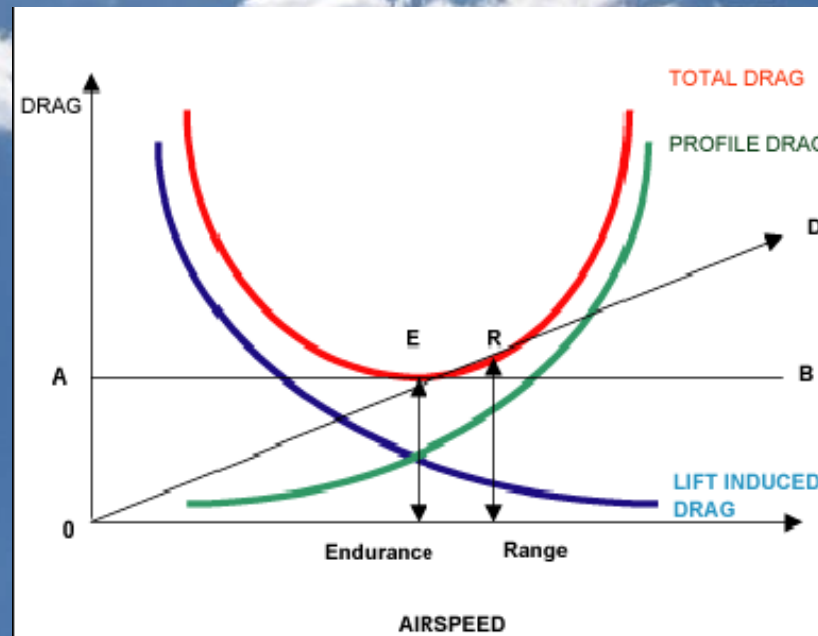
- Gliding also changes how forces act on the airplane





Gliding

- Gliding for Range
 - Best distance covered for altitude (by flying best L/D)
- Gliding for Endurance
 - Best time airborne for altitude (by flying min-sink)





Confirmation

1. What are the pitot static instruments?
2. What is another name for pitot pressure?
3. Which instrument uses pitot pressure?
4. What is the difference between V_X and V_Y ?
5. How does a glider maintain airspeed?



CF-18 with CH-146 Griffon

