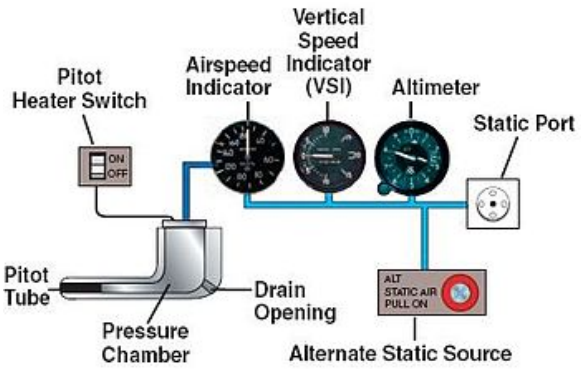
Operation of Systems

Objective	
To ensure the applicant learns and can describe the principles of operation for the systems installed in their airplane.	
Purpose	
In order to operate safely and efficiently, all pilots must be familiar with the systems that are installed on the airplanes they are flying. This lesson introduces pilots to the basic principles of operation of many common airplane systems.	

Schedule	**Equipment**
• **Ground Lesson**: 30 minutes • **Student Q&A**: 10 minutes	• Airplane POH • Whiteboard / Markers (optional)
Student Actions	**Instructor Actions**
• Ask any questions, receive study material for the next lesson. • Watch linked video. • Review listed references.	• Deliver the ground lesson (below). • Answer student questions.

Completion Standards

- Student can describe and explain the basic operational principles of the following systems:
  - The Primary and Secondary Flight Controls
  - The Engine and Propeller System
  - The Fuel, Ignition, and Oil Systems
  - The Electrical System, Avionics
  - The Pitot-Static and Gyroscopic Instruments
  - The Landing Gear
  - Anti-Ice or De-Ice Systems (if installed)

References

- Wren Aviation, LLC - “Constant Speed Prop Basics”
    - YouTube - https://www.youtube.com/watch?v=QKfQ6f6R82Y
- FAA-H-8083-3B (Airplane Flying Handbook) - Chapter 11 [Transition to Complex Airplanes]
- FAA-H-8083-25B (Pilot’s Handbook of Aeronautical Knowledge) - Chapter 7 [Aircraft Systems]
- FAA-S-ACS-6B (Private Pilot ACS) - Area I Task G
- FAA-S-ACS-7A (Commercial Pilot ACS) - Area I Task G
- FAA-S-8081-6D (CFI PTS) - Area III Task C

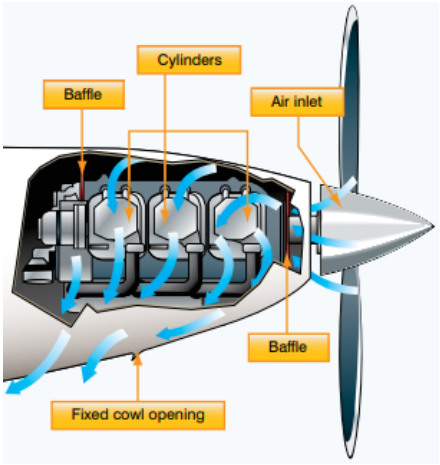
Ground Lesson Outline

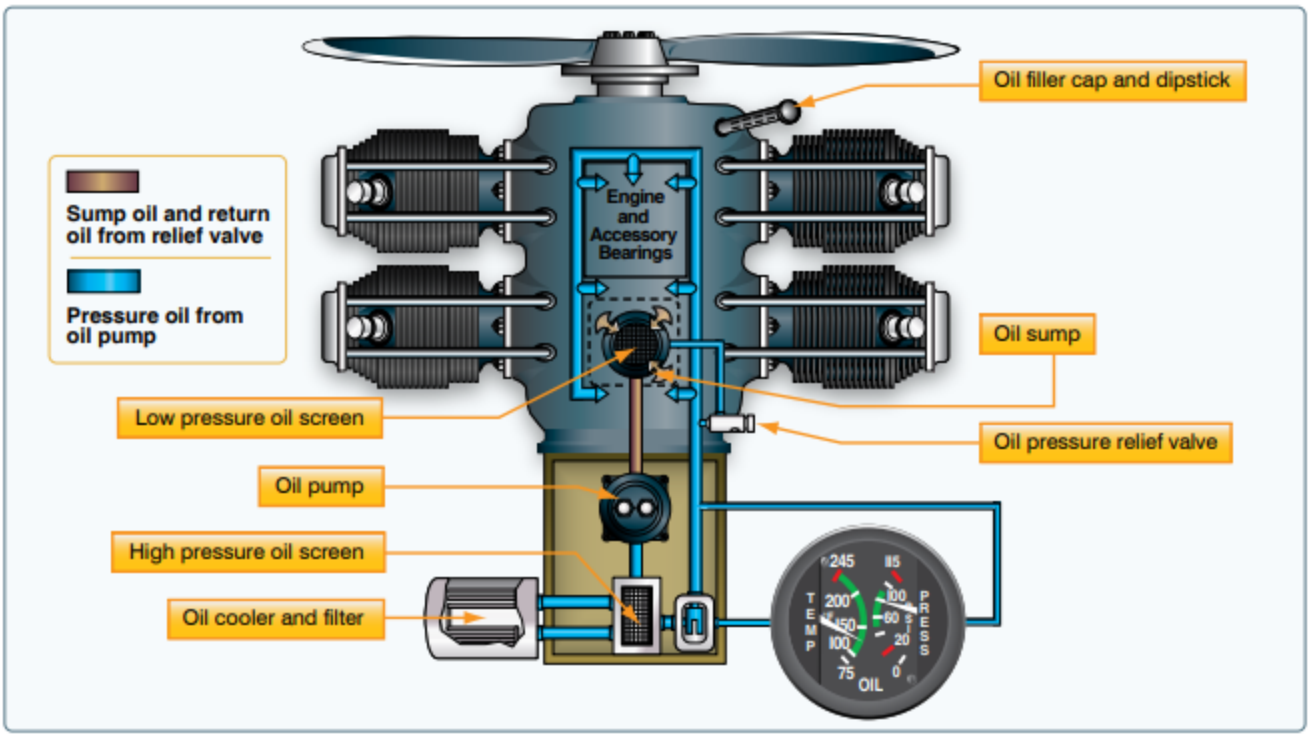
- Description of Systems - Refer to POH Section 7 (Systems)
- Primary and Secondary Flight Controls
    - Elevator, Ailerons, Rudder
    - Flaps
- Trim Tabs
- Powerplant and Propeller
    - Horizontally Opposed, Air-Cooled Engine
    - Dual Magneto Ignition
    - Carburetor vs Fuel Injection
    - Mixture Control / EGT
    - Fixed vs Constant Speed Propellers
        - How A Constant Speed Propeller Works
- Landing Gear
    - Fixed vs Retractable Gear Systems
- Fuel, Oil, and Hydraulic
    - Fuel - Two tanks, gravity fed
    - Oil - 8 qts total
- Electrical
    - 28V System, Alternator and Battery
- Avionics including Autopilot
    - Dual G5s
    - Garmin 530W
    - King NAV/COM Radios
- Pitot/Static System
    - Airspeed Indicator
    - Altimeter, Vertical Speed Indicator
- Gyro and Vacuum Instruments
    - Attitude Indicator, Directional Gyro - Vacuum-powered Gyro or AHRS
        - Gyroscopic Rigidity in Space, Precession
    - Turn Coordinator - Electrically Powered Gyro
        - Measures rate of turn by sensing precession
- Environmental
- Deicing and Anti-icing
    - Pitot Heat
    - Windscreen Defrost

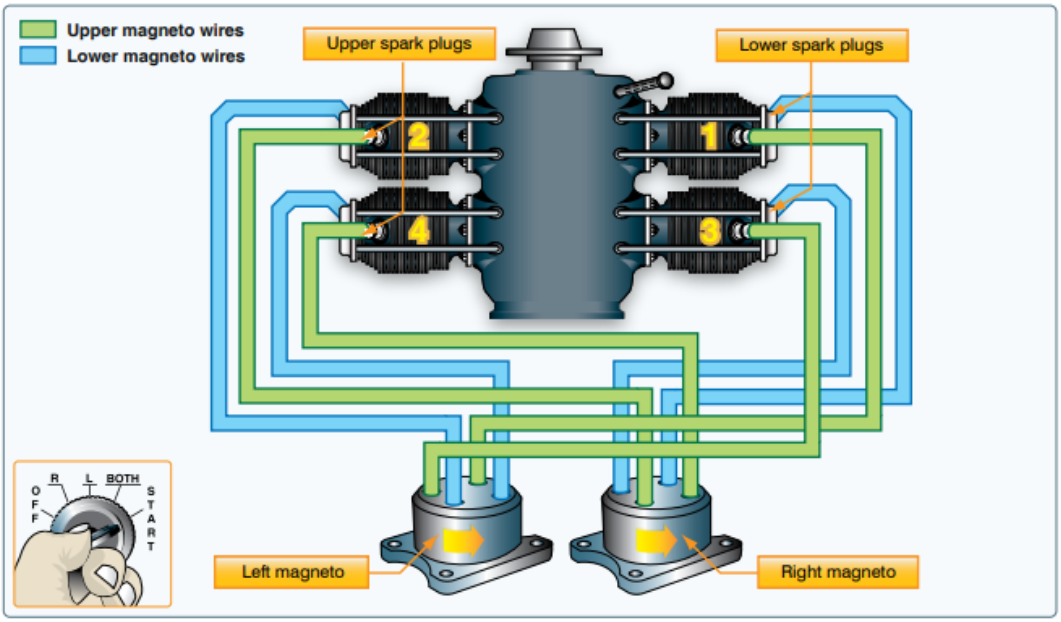
Ground Lesson Supplement

- **Primary and Secondary Flight Controls, Trim Tabs**
  - See related lesson on *Airplane Flight Controls* (Area II, Task E) and *POH Section 7 [Systems]* for Airplane-specific information.

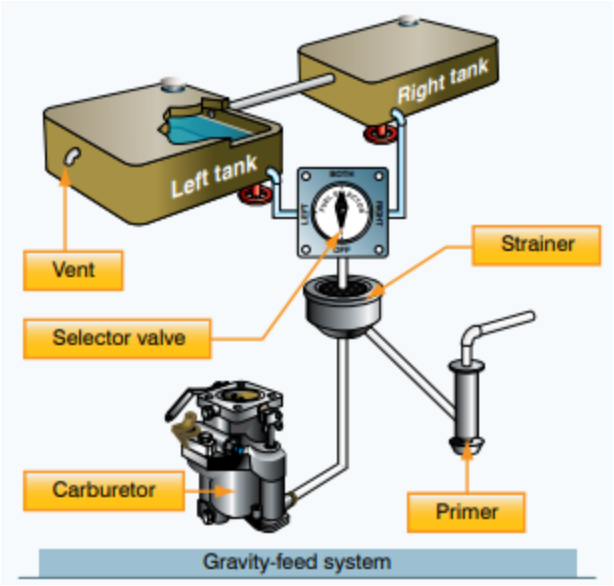
- **Airplane Piston Engines** - Most small training airplanes have *reciprocating* engines (*piston-powered* engines, similar to a car). Most of these are *air-cooled, horizontally-opposed* engines, with a *wet sump* oil system. Unlike a car, airplane engines usually generate their own spark (independent of the electrical system) using a *magneto ignition* system. Most airplanes have *dual* magnetos, leading to two spark plugs per cylinder, which fire simultaneously for more complete combustion.

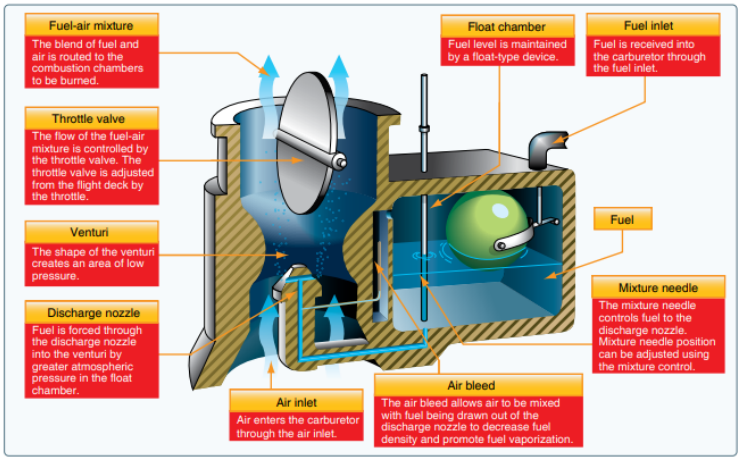






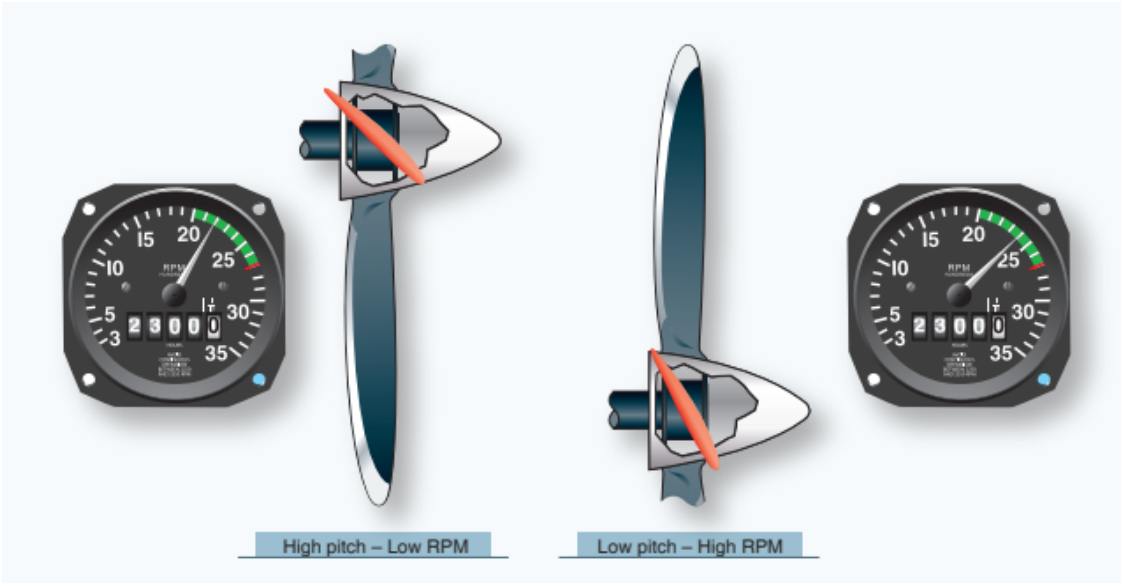
- **Fuel System** - Many training planes have a simple, *gravity-fed* fuel system. Generally these engines also introduce fuel using a *carburetor*, which atomizes (finely disperses) fuel using the *venturi effect*.

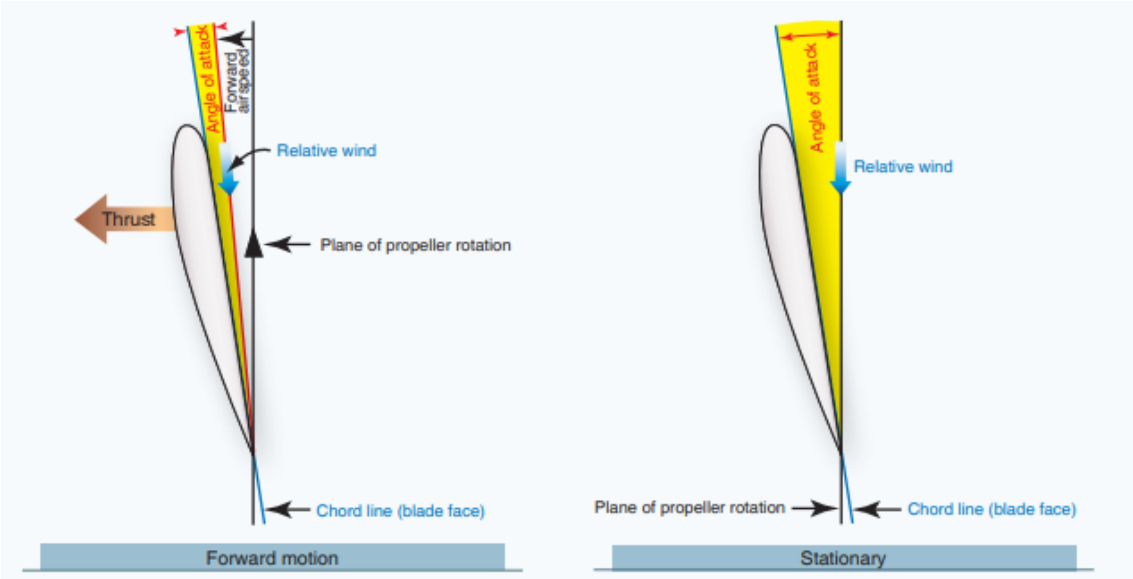


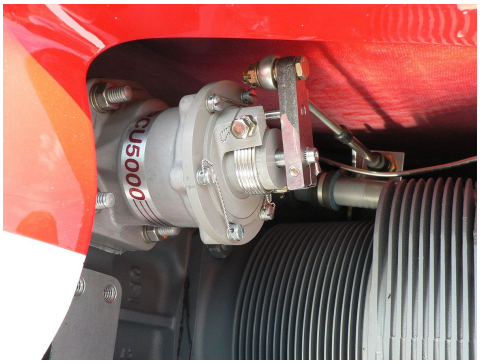


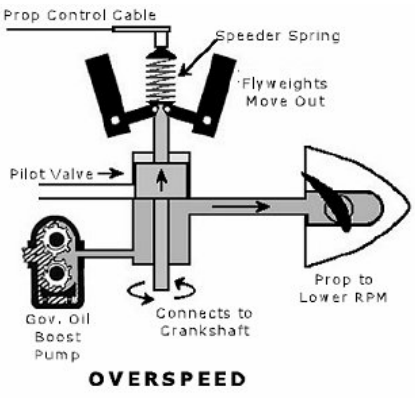
- **Constant Speed Propellers** - Many training airplanes have *fixed-pitch* propellers, which are simply rotating, curved airfoils (wings). Like all wings, these operate at some *angle of attack*. This is not adjustable in flight, and has to be chosen at the time of manufacture. Because drag varies greatly depending on angle of attack, being able to change AoA dynamically is useful. Therefore, some airplanes have *constant-speed propellers*, which continuously vary the AoA in order to maintain a fixed engine speed.
    - **Principle of Operation** - Constant-speed propellers use a *governor*, which is configured to maintain a specific RPM by adjusting a *speed spring*. The governor controls the propeller pitch by directing engine oil to the propeller hub, or releasing engine oil.

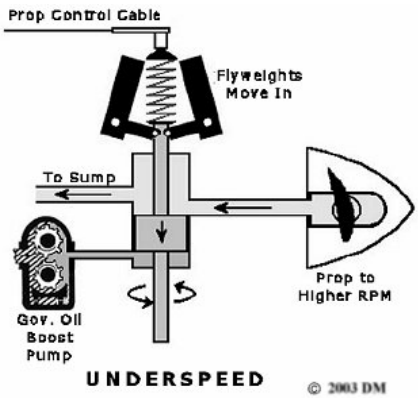
- **Governing Range** - The range of propeller blade pitch movement is limited by the high and low pitch stops. Depending on airspeed, this may cause the engine to turn slower or faster than the configured engine RPM.



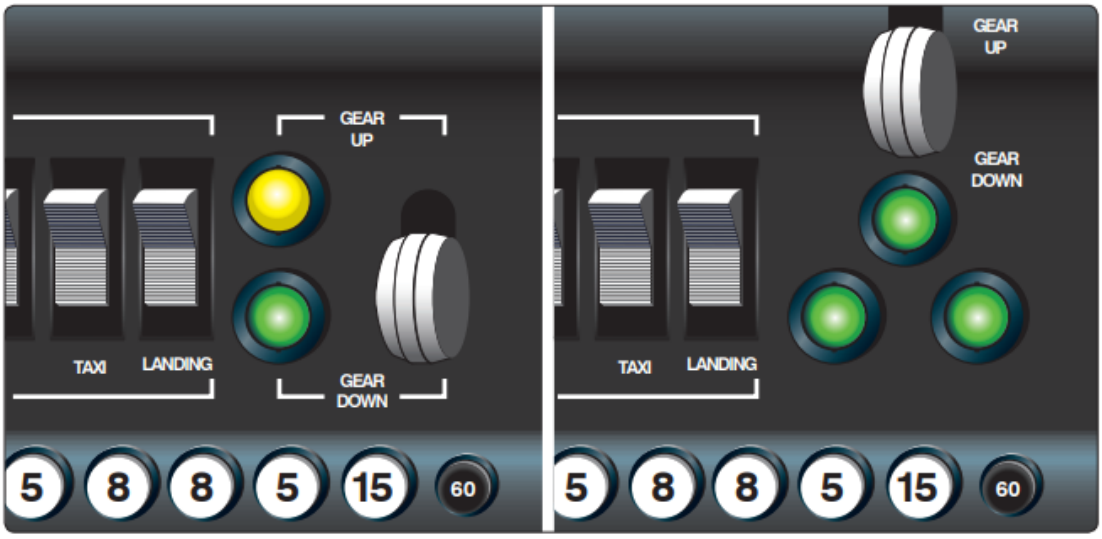


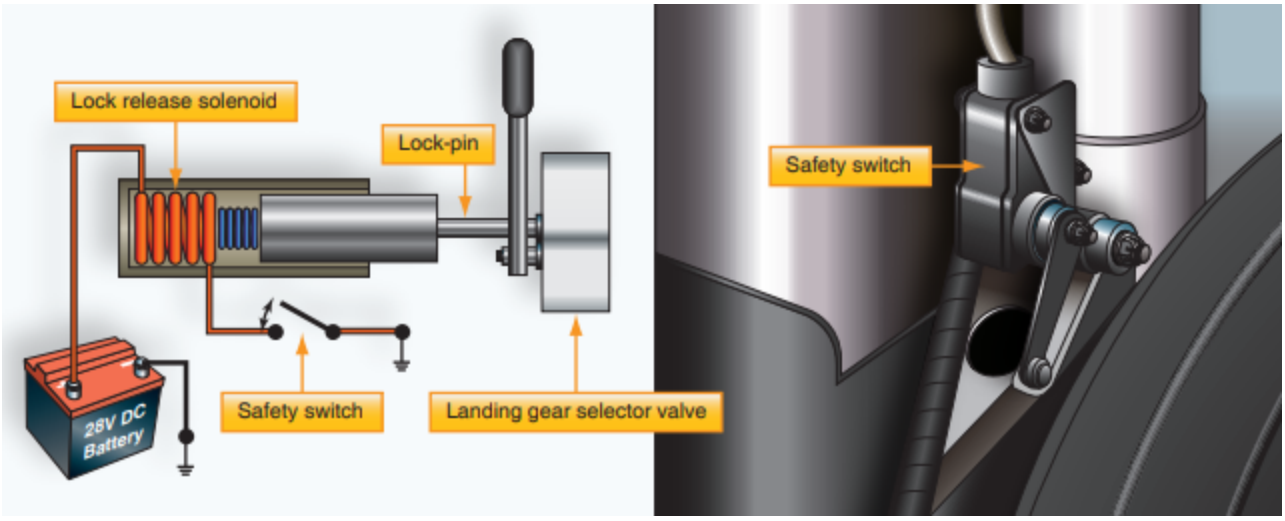






- **Retractable Gear Systems** - Some airplanes have *retractable landing gear* systems, which retract the landing gear into the fuselage to reduce drag during flight. These systems generally have a *landing gear position switch*, *landing gear position indicators*, *safety switches* (which operate the indicators), *emergency release systems*, and a series of mechanical or hydraulic connections to the actual landing gear.





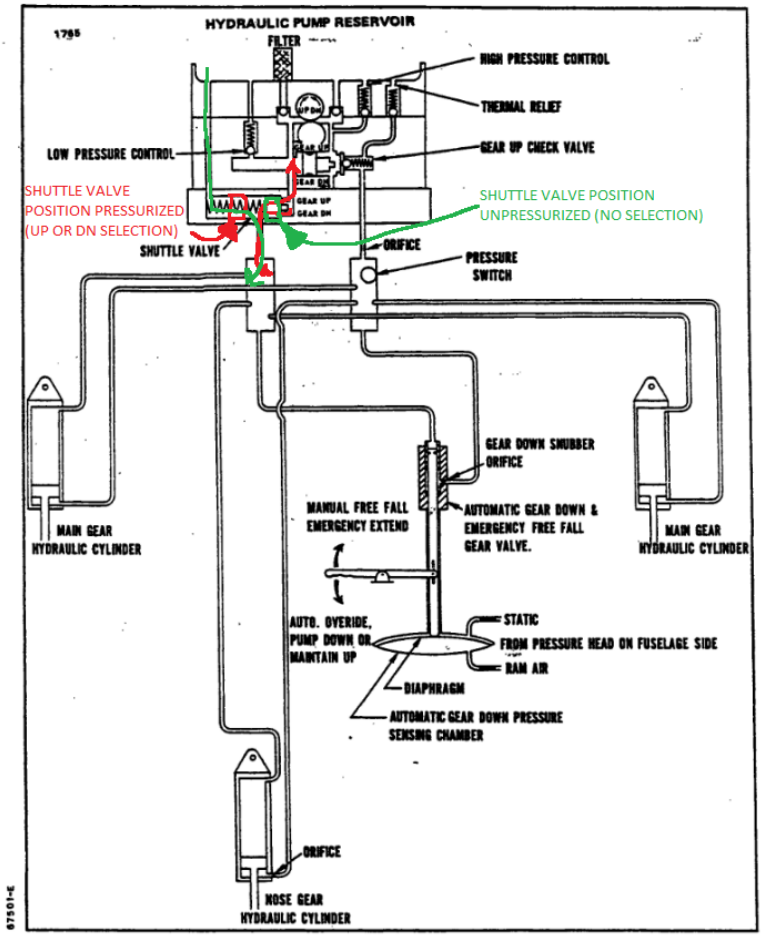
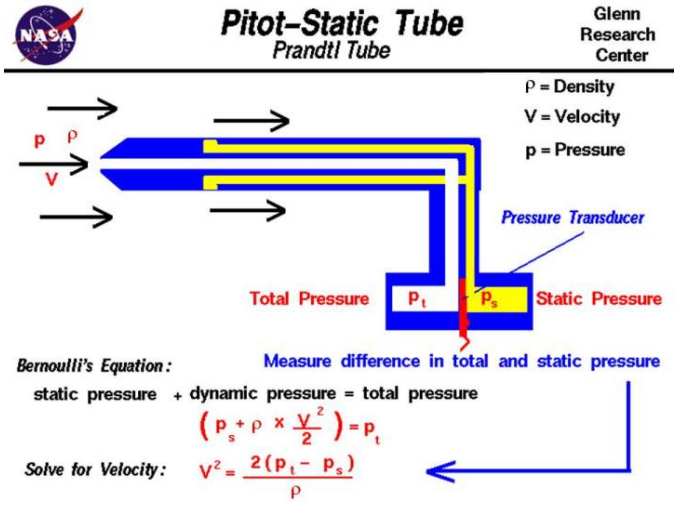
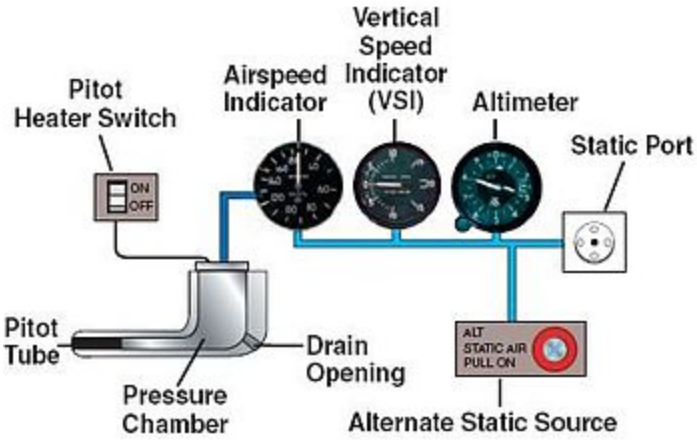


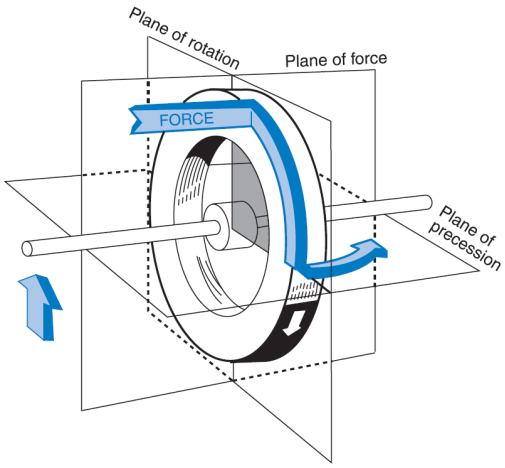
Figure 6-1. Schematic Diagram of Hydraulic System

- **Pitot Static System** - Airplanes sense airspeed by means of the *pitot tube*, which is pressurized by the oncoming airstream during flight. Airspeed can be measured by comparing this pressure (the *dynamic* pressure) to the un-captured airstream (the *static* pressure). The *pitot-static system* refers to the systems which are connected to the pitot and static tubes and lines.
    - Instruments like the *altimeter* and *vertical speed indicator* depend only on static pressure.





- **Gyroscopic and Vacuum Instruments** - The *gyroscopic* instruments rely on the gyroscopic principles of *precession* and *rigidity in space* in order to display airplane attitude, rate of turn, etc.
    - **Vacuum System** - Many older airplanes use a vacuum pump to create a suction which draws air through the gyros and causes them to spin.
    - **Electrical Gyros** - Some gyros are electrically powered.
    - The traditional vacuum-powered instruments are the *attitude indicator* and the *directional gyro* (By relying on *rigidity in space*).
    - The traditional electrically-powered instruments are the *turn coordinator*, which senses the rate of turn. (By measuring *precession*)



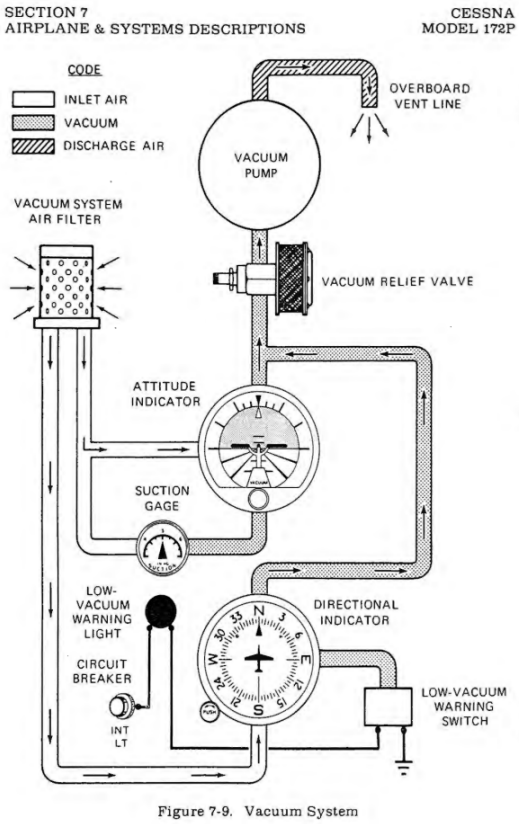


Figure 7-9. Vacuum System