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Aircraft, Powerplant, Systems, and Aerodynamics

Private Pilot Ground Lesson 1

Relevant FARs

CFR § 61.105(b) - Aeronautical Knowledge, Required Areas
Area
(1) Applicable Federal Aviation Regulations of this chapter that relate to private pilot privileges, limitations, and flight operations;
(2) Accident reporting requirements of the National Transportation Safety Board;
(3) Use of the applicable portions of the "Aeronautical Information Manual" and FAA advisory circulars;
(4) Use of aeronautical charts for VFR navigation using pilotage, dead reckoning, and navigation systems;
(5) Radio communication procedures;
(6) Recognition of critical weather situations from the ground and in flight, windshear avoidance, and the procurement and use of aeronautical weather reports and forecasts;
(7) Safe and efficient operation of aircraft, including collision avoidance, and recognition and avoidance of wake turbulence;
(8) Effects of density altitude on takeoff and climb performance;
(9) Weight and balance computations;
(10) Principles of aerodynamics, powerplants, and aircraft systems;
(11) Stall awareness, spin entry, spins, and spin recovery techniques for the airplane and glider category ratings;
(12) Aeronautical decision making and judgment; and
(13) Preflight action that includes - (i) How to obtain information on runway lengths at airports of intended use, data on takeoff and landing distances, weather reports and forecasts, and fuel requirements; and (ii) How to plan for alternatives if the planned flight cannot be completed or delays are encountered.

Relevant ACS

I. Preflight Preparation

Task	***G. Operation of Systems***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-23, FAA-H-8083-25; POH/AFM.
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with the safe operation of systems on the airplane provided for the flight test.
Knowledge	The applicant demonstrates understanding of:
PA.I.G.K1	Airplane systems, to include: ***Note:*** *If K1 is selected, the evaluator must assess the applicant's knowledge of at least three of the following sub-elements.*
PA.I.G.K1a	a. Primary flight controls
PA.I.G.K1b	b. Secondary flight controls
PA.I.G.K1c	c. Powerplant and propeller
PA.I.G.K1d	d. Landing gear
PA.I.G.K1e	e. Fuel, oil, and hydraulic
PA.I.G.K1f	f. Electrical
PA.I.G.K1g	g. Avionics
PA.I.G.K1h	h. Pitot-static, vacuum/pressure, and associated flight instruments
PA.I.G.K1i	i. Environmental
PA.I.G.K1j	j. Deicing and anti-icing
PA.I.G.K1k	k. Water rudders (ASES, AMES)
PA.I.G.K1l	l. Oxygen system
PA.I.G.K2	Indications of and procedures for managing system abnormalities or failures.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.I.G.R1	Failure to detect system malfunctions or failures.
PA.I.G.R2	Improper management of a system failure.
PA.I.G.R3	Failure to monitor and manage automated systems.
Skills	The applicant demonstrates the ability to:
PA.I.G.S1	Operate at least three of the systems listed in K1a through K1l above appropriately.
PA.I.G.S2	Use appropriate checklists properly.

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Reading

- PHAK Chapter 3 – Aircraft Components
- PHAK Chapter 5 - Aerodynamics
- PHAK Chapter 7 – Aircraft systems
- PHAK Chapter 8 – Flight Instruments
- ACS I, Task G

Aircraft Terminology

- According to FAR § 1.1...
- *Aircraft* means a device that is used or intended to be used for flight in the air.
- *Airplane* means an engine-driven fixed-wing aircraft heavier than air, that is supported in flight by the dynamic reaction of the air against its wings.
- *Airframe* means the fuselage, booms, nacelles, cowlings, fairings, airfoil surfaces (including rotors but excluding propellers and rotating airfoils of engines), and landing gear of an aircraft and their accessories and controls.

Airplane Anatomy

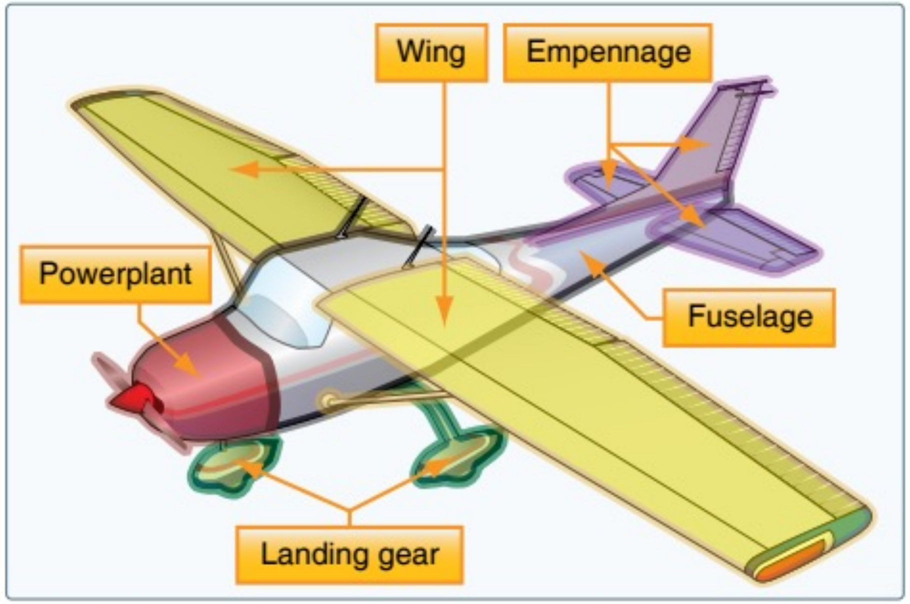

Figure 3-4. *Airplane components.*

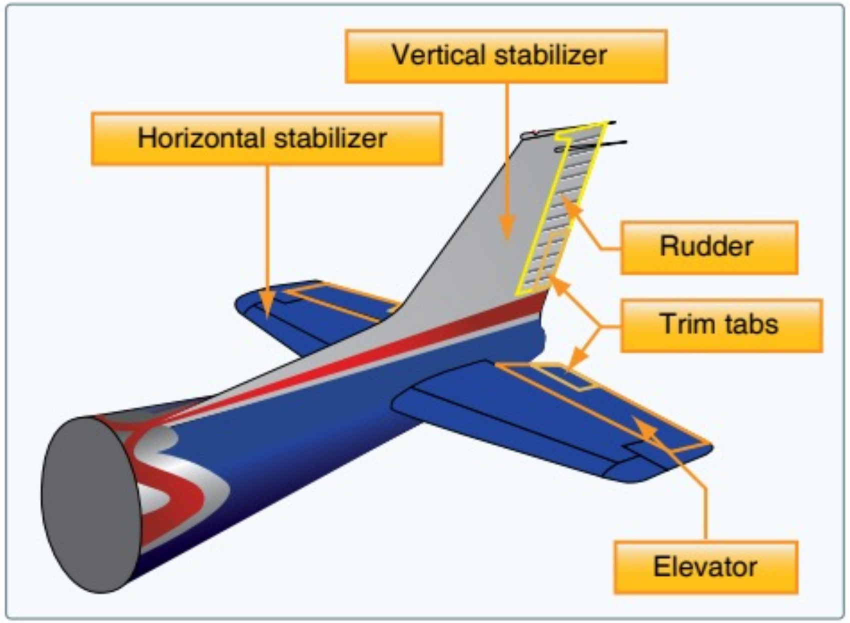

Figure 3-10. *Empennage components.*

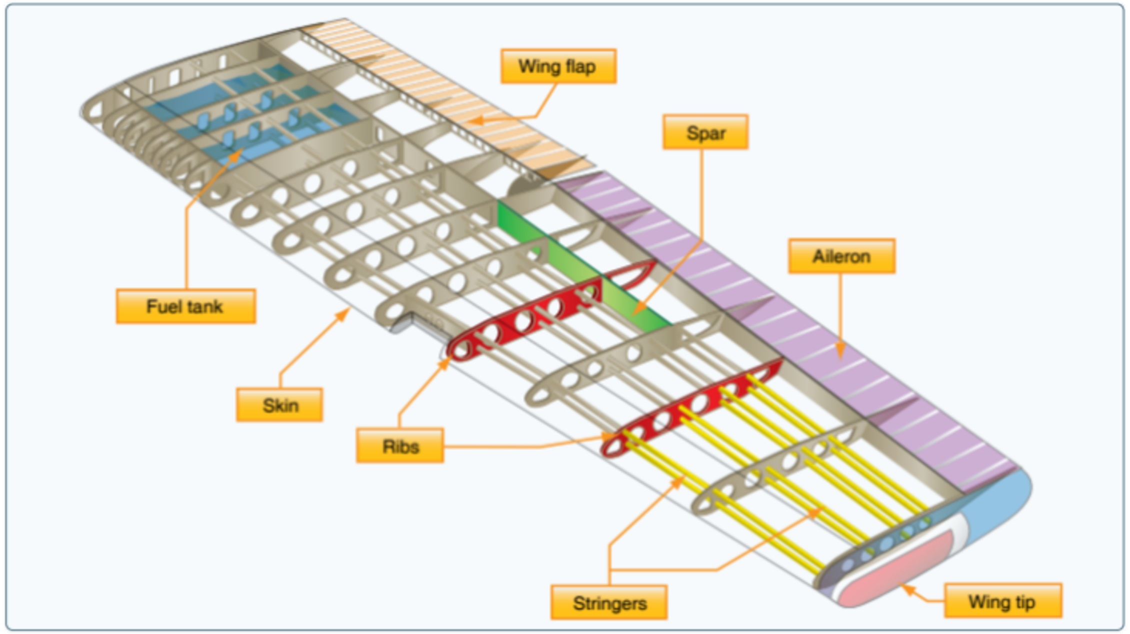

Figure 3-7. *Wing components.*

Primary Control Surfaces	Secondary Control Surfaces
Ailerons	Flaps
Elevator	Trim Tabs
Rudder	

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Four Forces of Flight

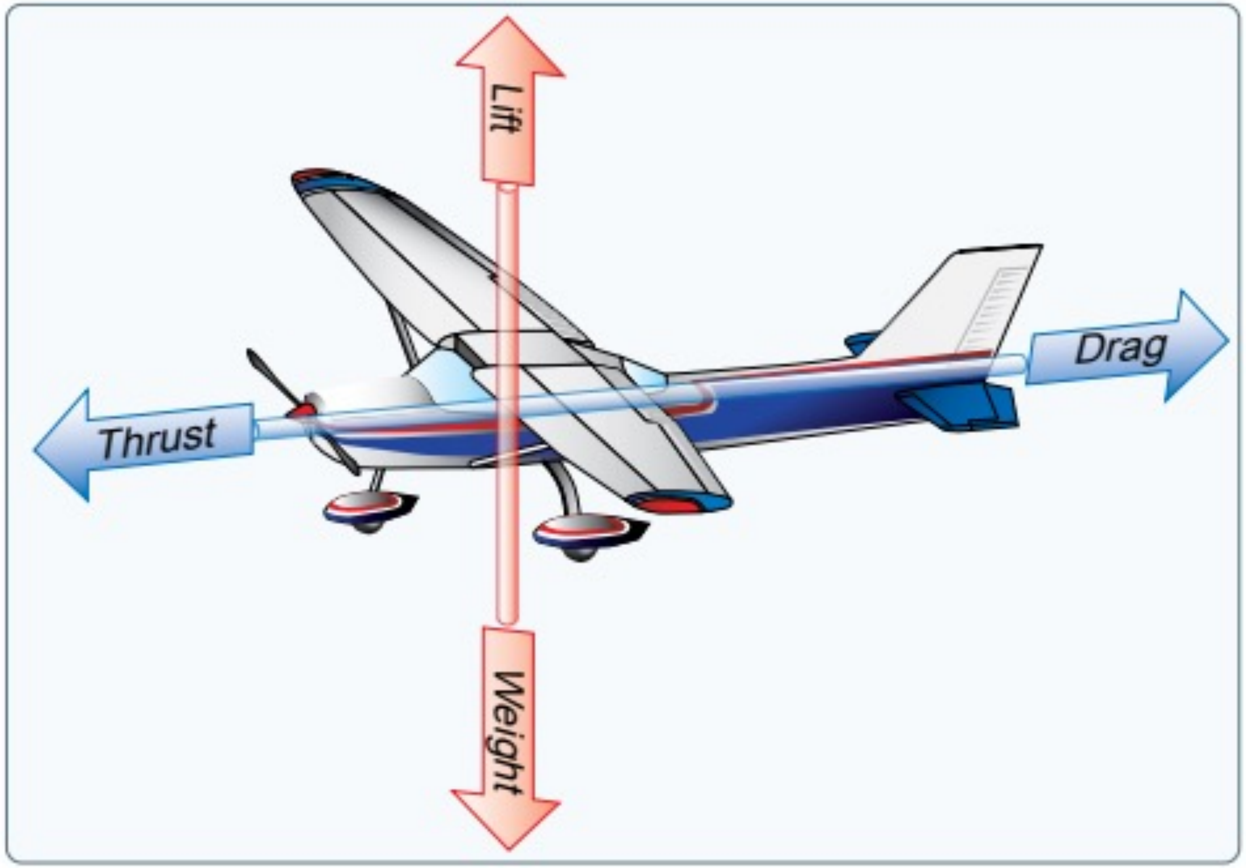

Figure 3-1. *The four forces.*

Lift – produced by the effect of the air acting on the airfoil, perpendicular to the flight path through the center of lift (CL)

Weight – the combined load of the aircraft and its contents pulling the aircraft downward due to gravity

Thrust – force produced by the powerplant/ propeller. It opposes or overcomes the force of drag

Drag – a rearward, retarding force caused by disruption of airflow by the wing, rotor, fuselage, and other protruding objects acting opposite to thrust

Aerodynamics of Lift

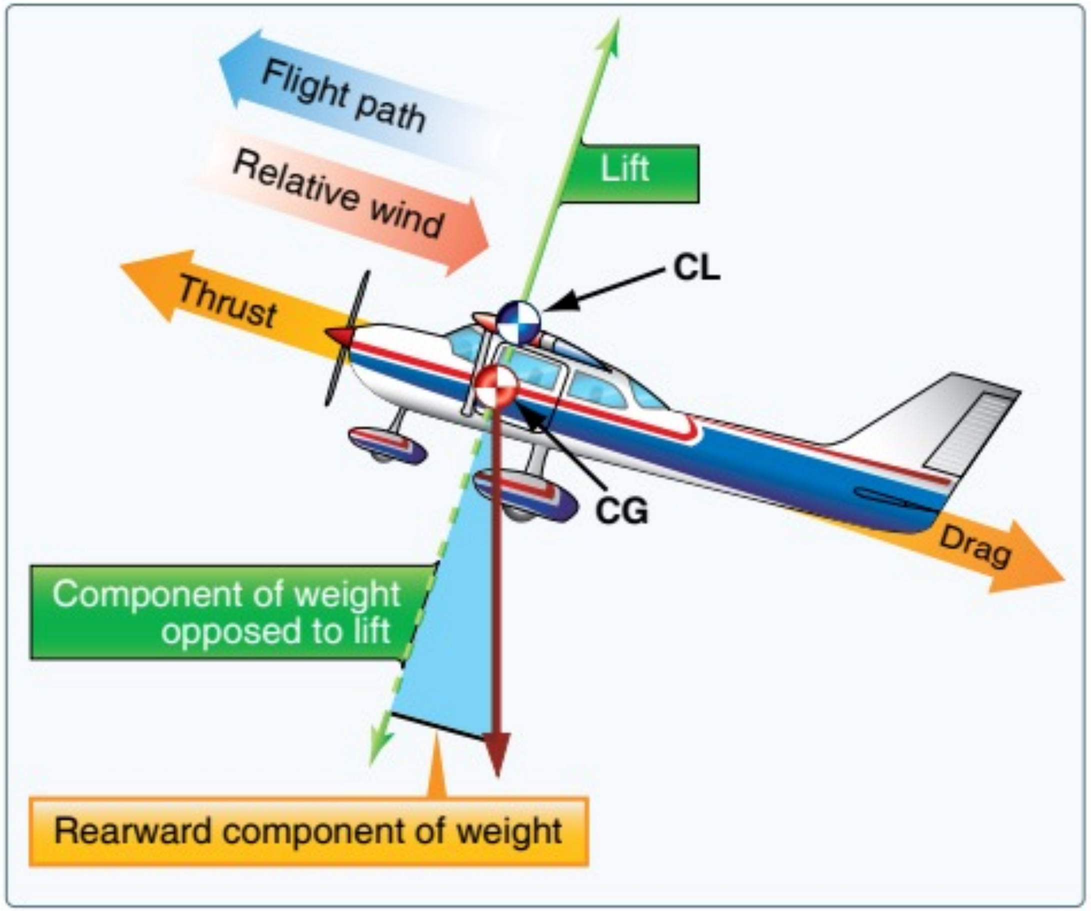

Figure 5-2. *Force vectors during a stabilized climb.*

Lift is the result of

- Angle of Attack (AOA) – angle between the chord line of the airfoil and the direction of the relative wind; air is directed down to push the wing up
- Air coursing over the top of the wing has a lower pressure

Critical Angle of Attack – The angle at which air no longer flows smoothly over the wing

Aerodynamics of Lift

Critical angle of attack
Coefficient of lift is hightest

Most lift vs. drag

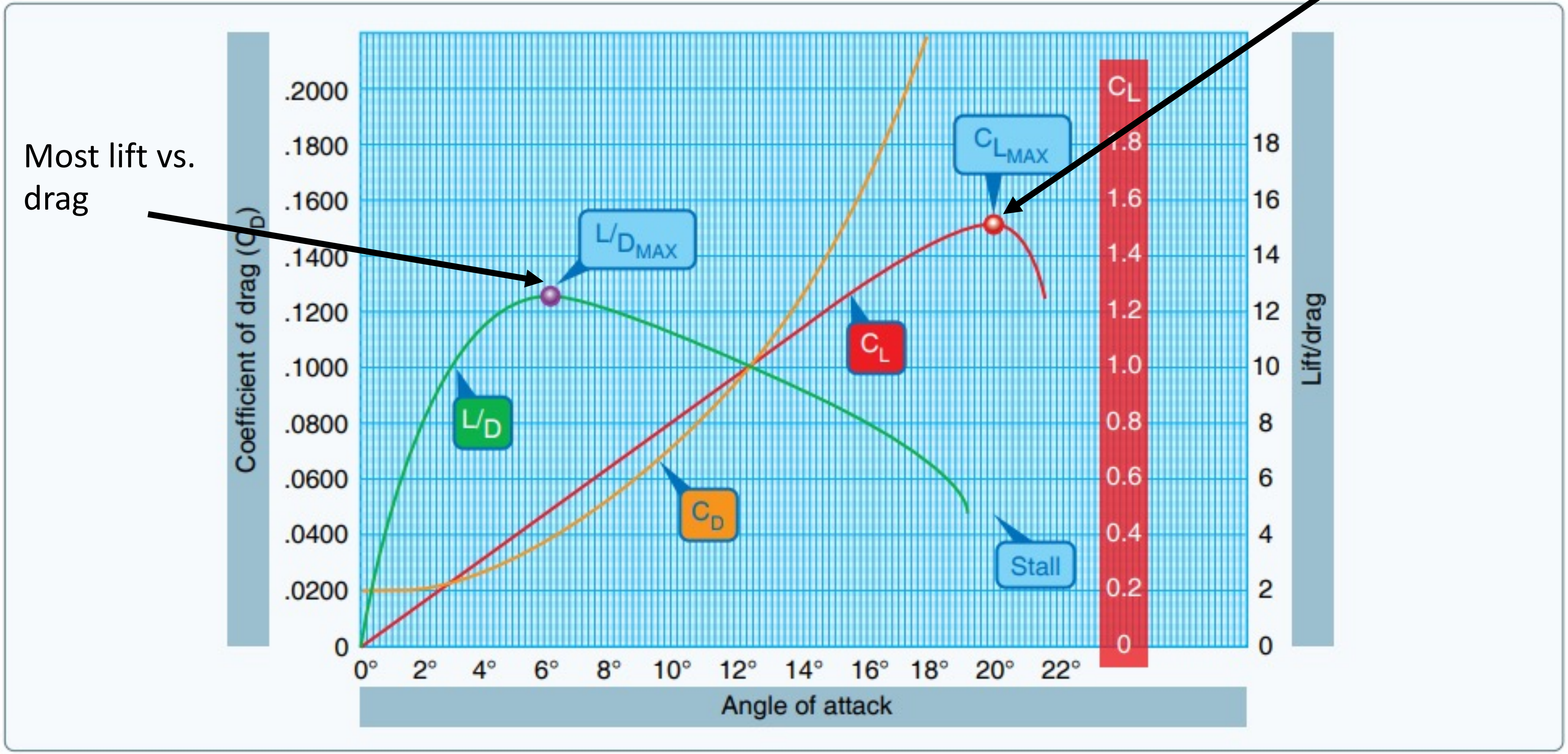

Figure 5-5. *Coefficients of lift and drag at various angles of attack.*

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Aerodynamics of Drag

Induced Drag – Drag as a result of lift, decreases with increasing airspeed.

Parasitic Drag – Three types: form drag, interference drag, and skin friction. This is drag caused by pushing an object through 3D space. Increases with increasing airspeed.

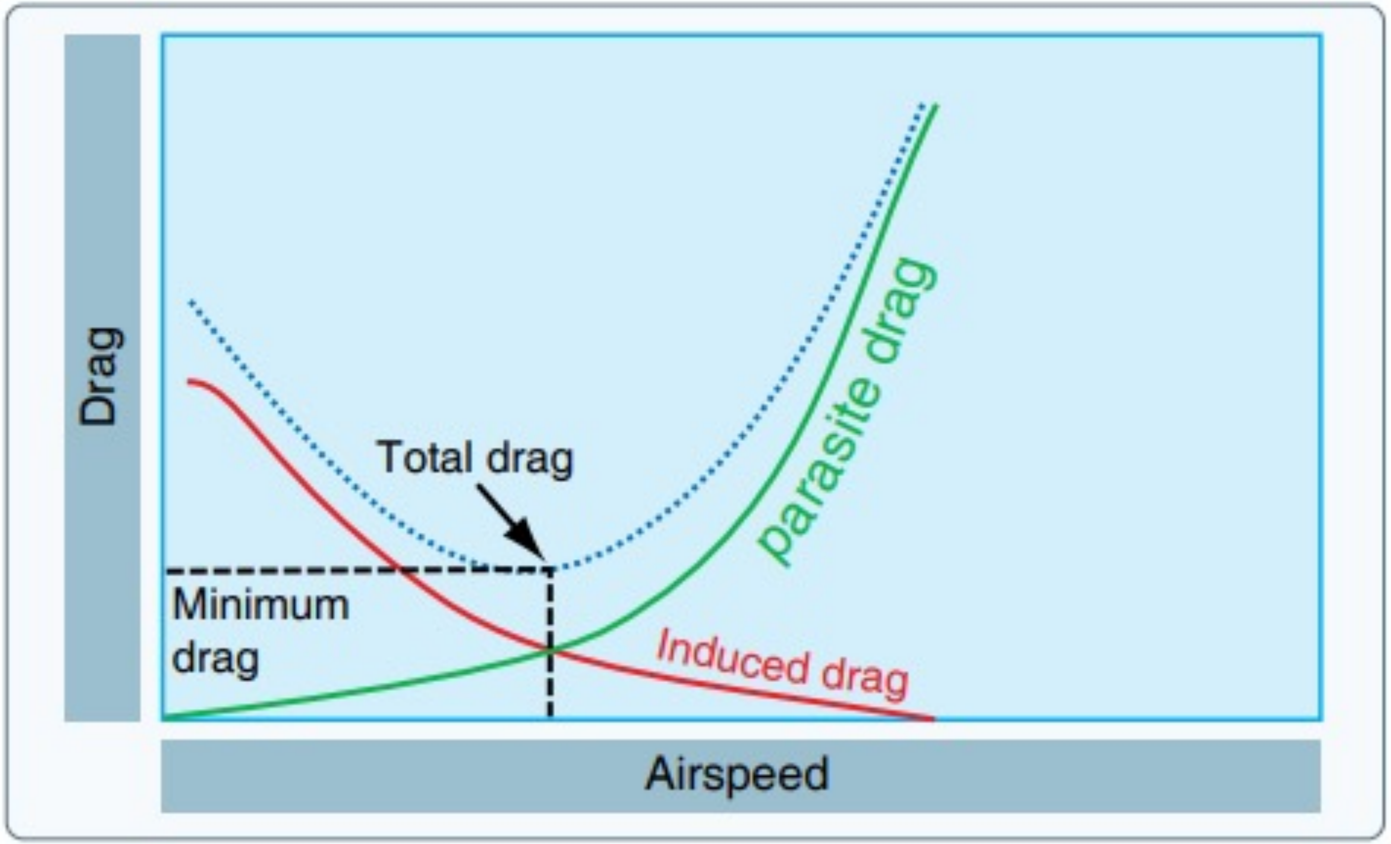

Figure 5-6. *Drag versus speed.*

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Aircraft Motion and Axes

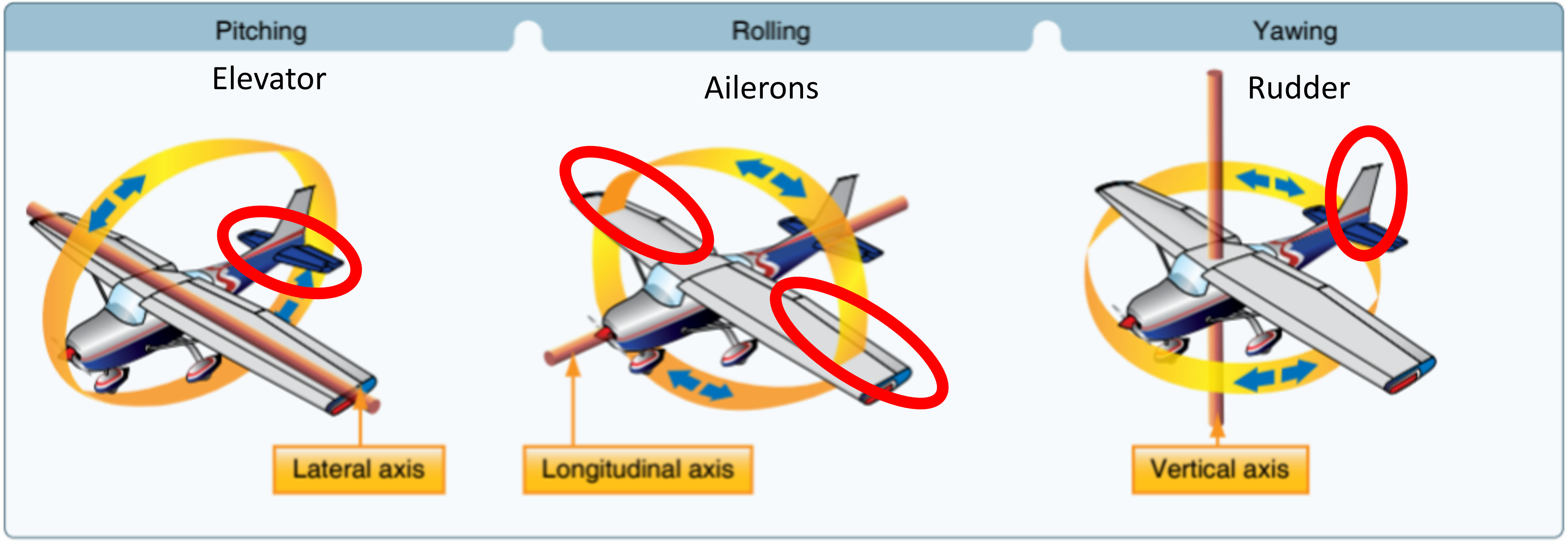

Figure 3-2. *Illustrates the pitch, roll, and yaw motion of the aircraft along the lateral, longitudinal, and vertical axes, respectively.*

Left Turning Tendencies

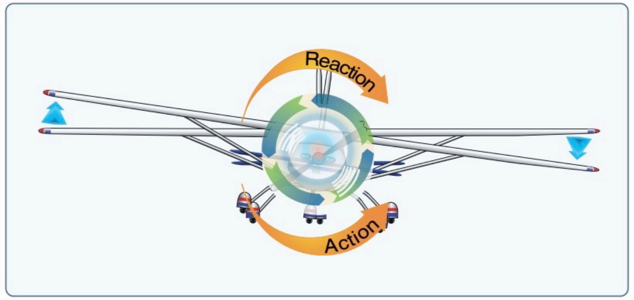

Figure 5-47. *Torque reaction.*

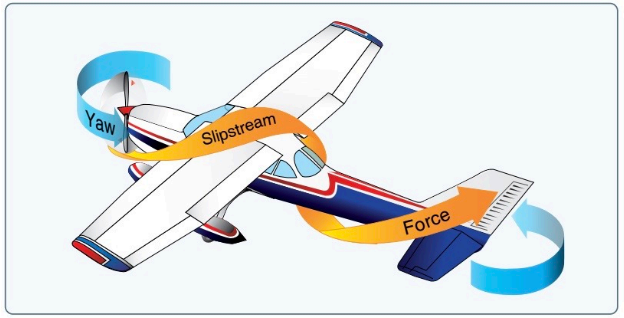

Figure 5-48. *Corkscrewing slipstream.*

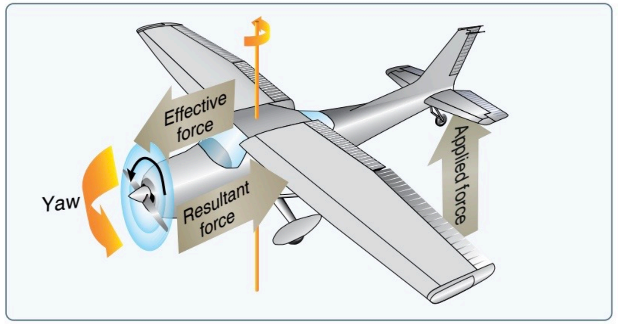

Figure 5-50. *Raising tail produces gyroscopic precession.*

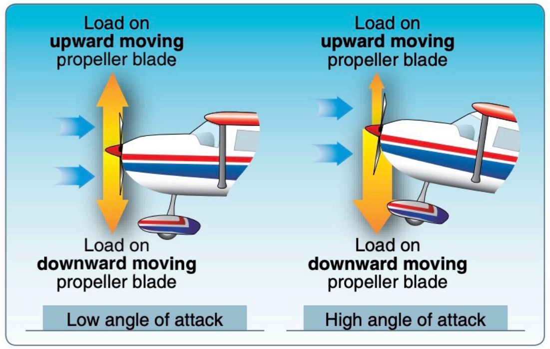

Figure 5-51. *Asymmetrical loading of propeller (P-factor).*

Torque – Propeller spins clockwise, plane rotates counterclockwise (left)

Spiraling Slipstream – Air flow over airframe spirals and strikes the left vertical stabilizer

Gyroscopic Precession – When the propeller's plane of rotation is changed, a force is felt 90° ahead, raising the tail creates a left turning tendency

P – Factor – At a high AOA, the right, downward propeller is taking a bigger bite of air, this creates a left turning tendency

Powerplant

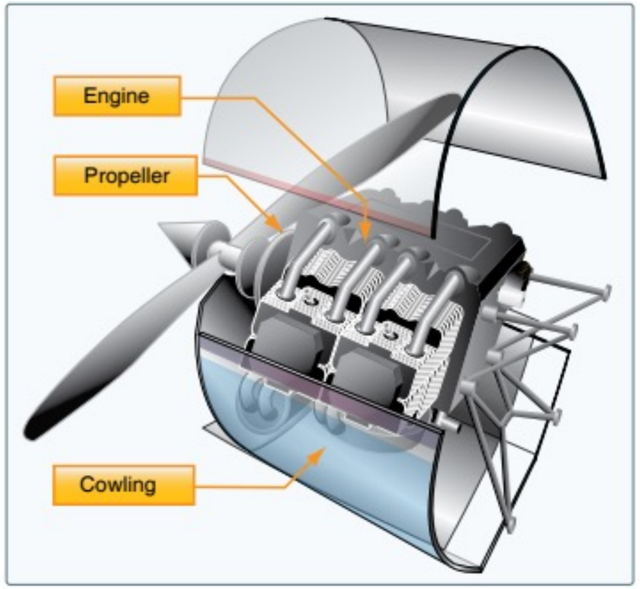

Figure 3-13. *Engine compartment.*

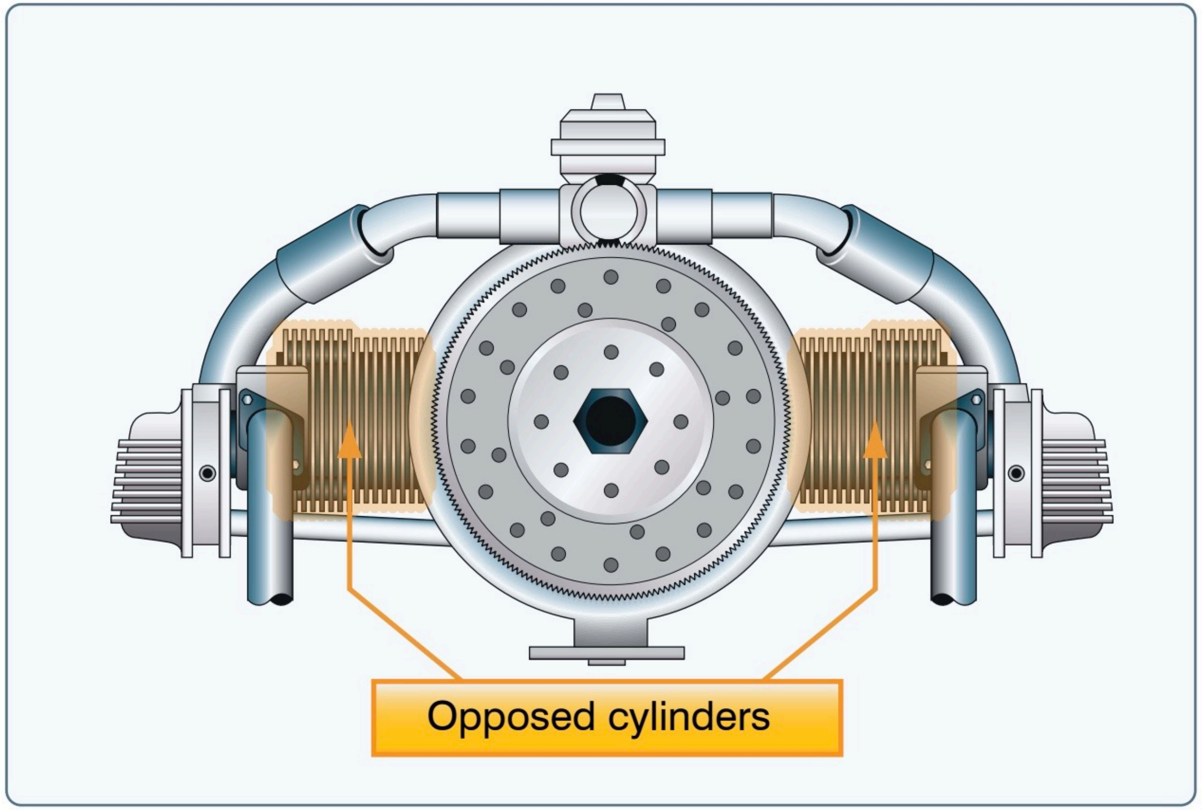

Figure 7-2. *Horizontally opposed engine.*

Most engines in trainers (like in a 172 or PA-28-180) are 4-cylinder, air-cooled, horizontally opposed piston engines.

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Example

Click to add text

Lycoming IO-360 180 HP

Fuel injected (vs. “O” for carbureted)

361-cubic-inch cylinders

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Four Strokes of an Engine

Four Strokes

1. Intake (”suck”) – Fuel and air are brought into the cylinder
2. Compression (“squeeze”) – The air/fuel mixture is compressed
3. Power (“bang”) – The compressed air/fuel mixture is ignited by the spark plugs
4. Exhaust (“blow”) – The exhaust is released from the piston

Notes:

- The timing of the valves is controlled by a cam shaft
- The spark plugs are independent of the electric system, they are grounded by turning the ignition to “off”; this is why the master switch can be off and the engine still can run
- The two spark plugs are for a more complete fuel burn and for redundancy, there is an indepent left and right magneto system

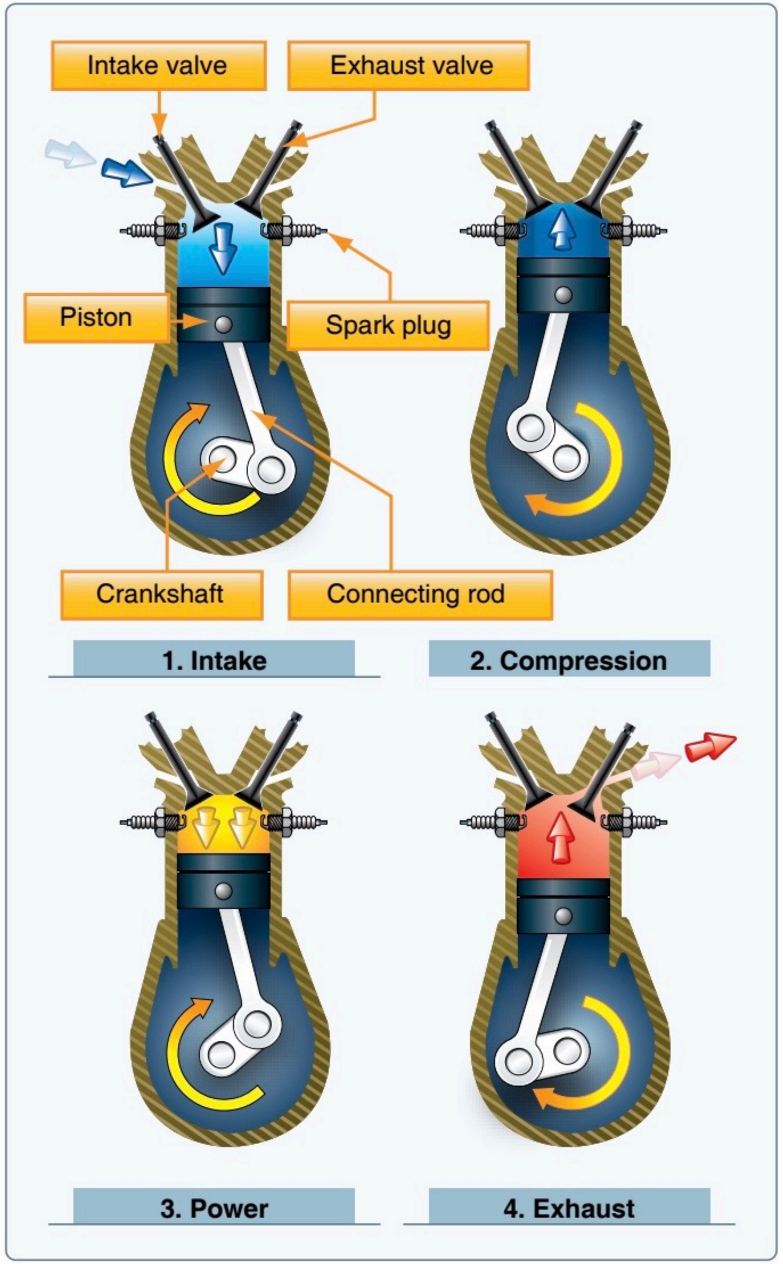

Figure 7-5. *The arrows in this illustration indicate the direction of motion of the crankshaft and piston during the four-stroke cycle.*

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Fuel Injection vs. Carburetor

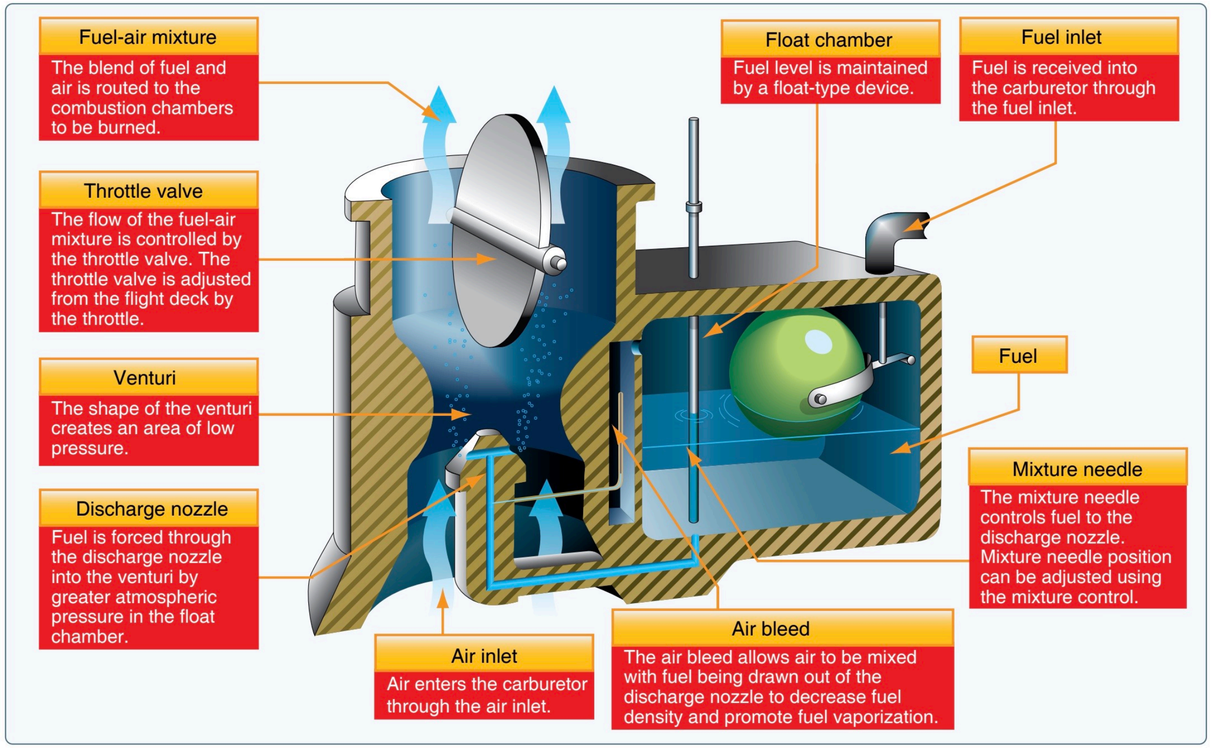

Figure 7-10. *Float-type carburetor.*

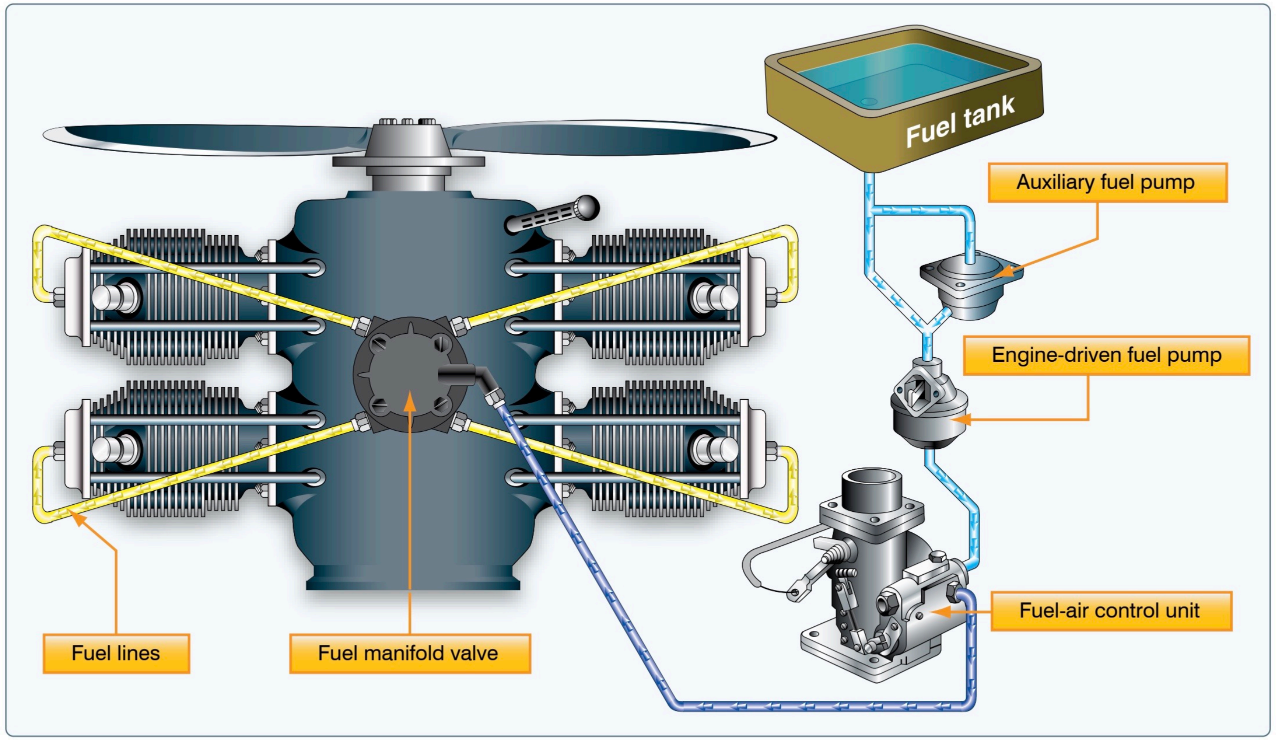

Figure 7-13. *Fuel injection system.*

A venturi is used to bring the fuel air mixture to the engine, because of the fast moving air this is subject to carburator icing. This is why carb heat must be used in some airplanes when operating out of the green arc on the tachometer.

Fuel injected engines use fuel pumps to deliver fuel-air control unit that then delivers the fuel/air mixture to the cylinders

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Propeller

The propeller is also creating lift.

Notice the propeller has a greater angle of attack (AOA) near the hub because this part of the propeller is spinning more slowly and need the greater AOA to create the same amount of lift as the faster-spinner outside part of the propeller. This allows for a uniform lift production across the length of the propeller blade.

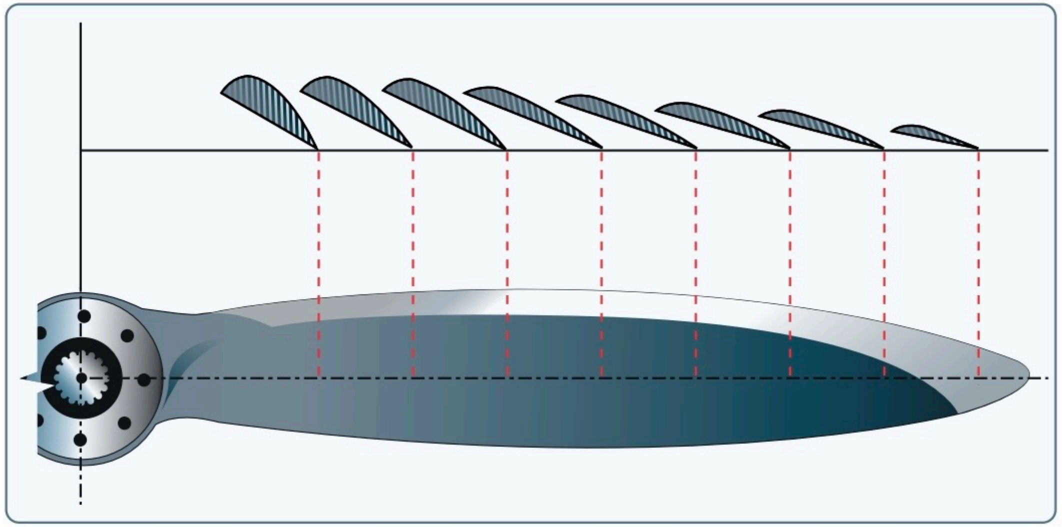

Figure 7-6. *Changes in propeller blade angle from hub to tip.*

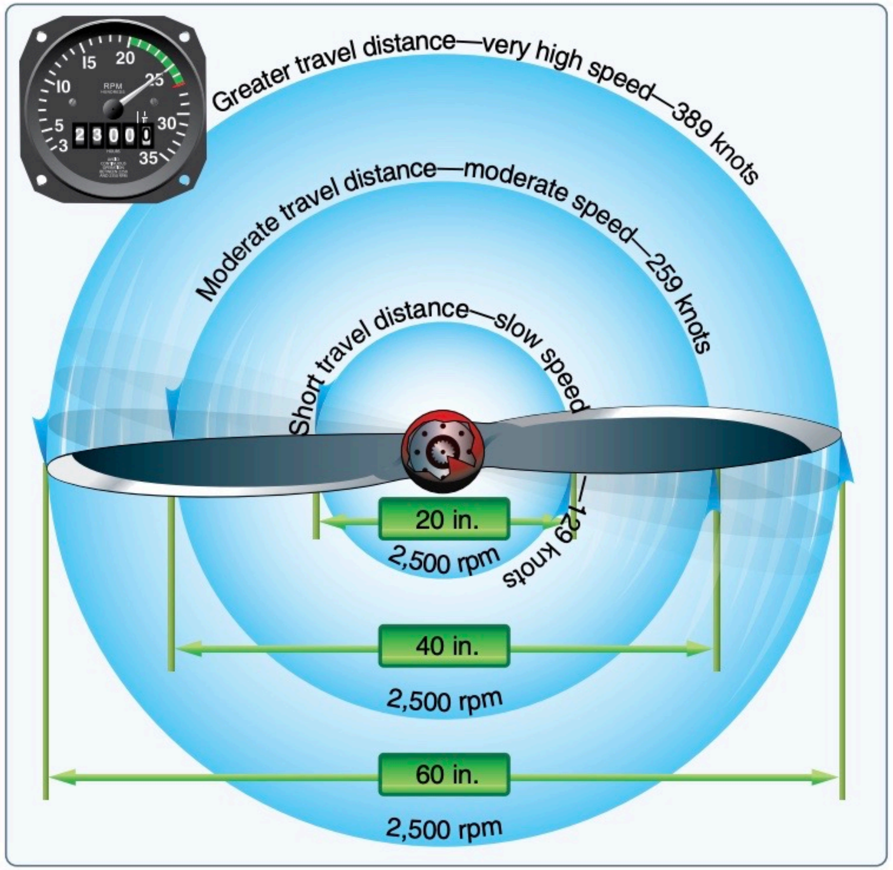

Figure 7-7. *Relationship of travel distance and speed of various portions of propeller blade.*

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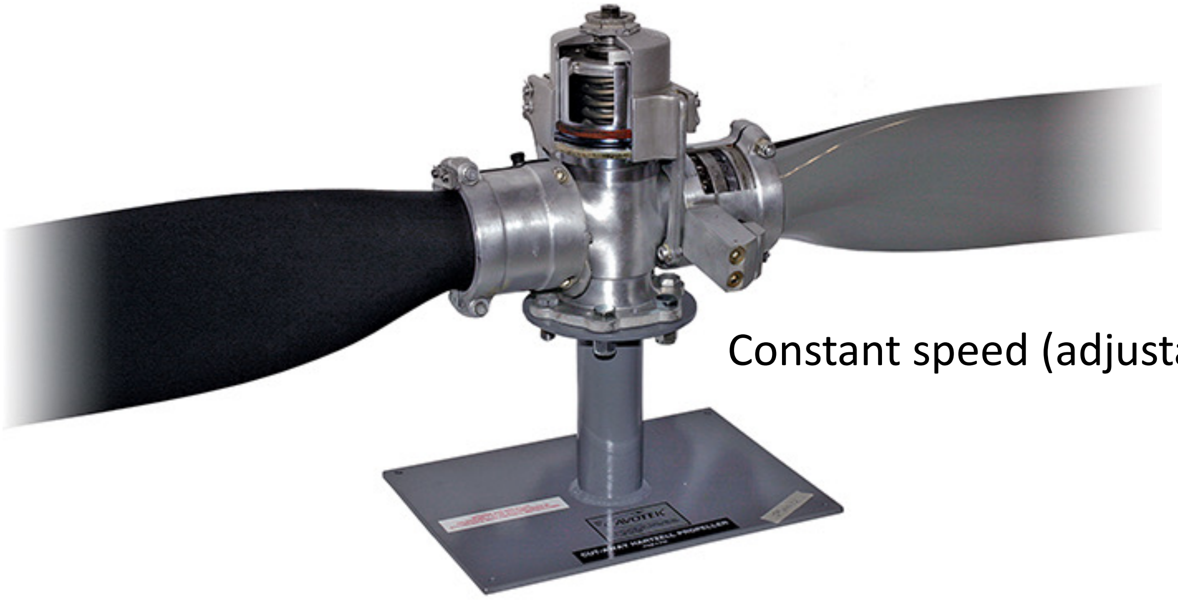
Fixed-Pitch vs. Constant Speed

Fixed pitch – The propeller is not adjustable in the air and the RPM is directly controlled by the throttle (most trainers)

Constant Speed – The pitch of the propeller is adjustable in the air and throttle and RPM are controlled independently

Fixed pitch



Constant speed (adjustable pitch)

Instruments – Pitot-Static System

This system is comprised of the pitot tube (usually under the wing) and a static port (usually near the cowling) to supply pressure data to the altimeter, airspeed indicator, and vertical speed indicator

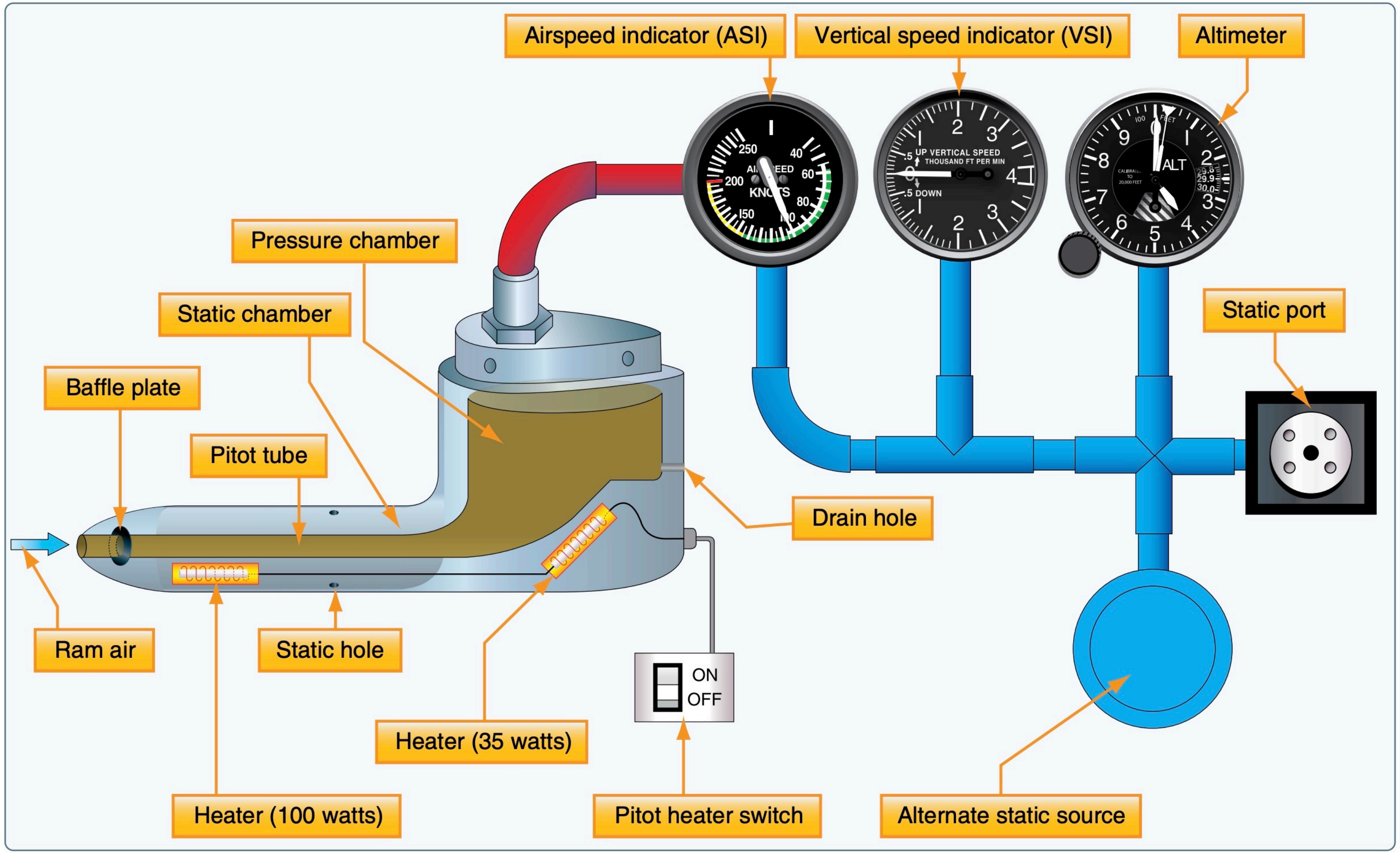


Figure 8-1. *Pitot-static system and instruments.*

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Instruments – Pitot-Static System

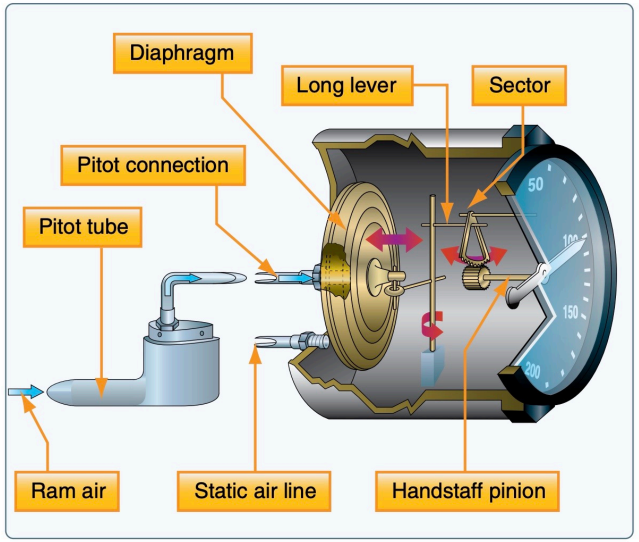

Figure 8-7. *Airspeed indicator (ASI).*

Airspeed indicator = pitot ram speed minus static pressure

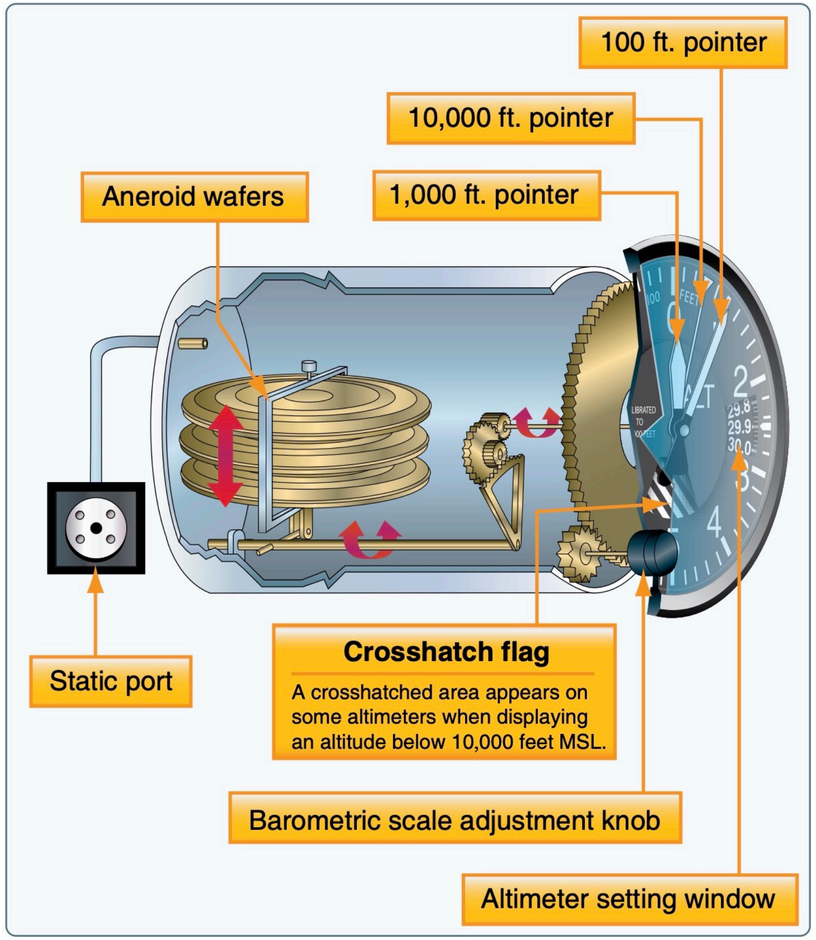

Figure 8-2. *Altimeter.*

Altimeter = static pressure

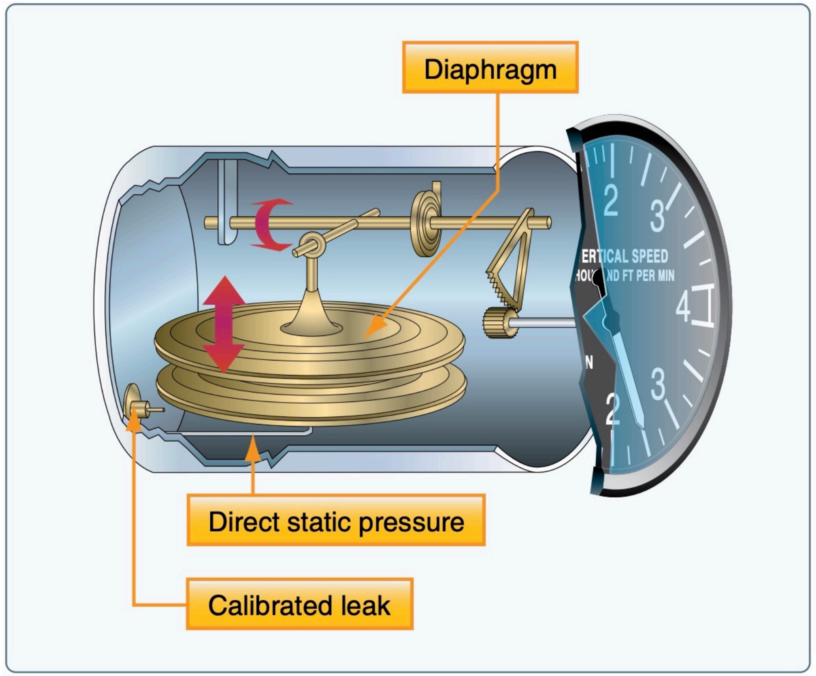

Figure 8-5. *Vertical speed indicator (VSI).*

Vertical speed indicator = internal wafer pressure minus static pressure with a calibrated leak

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Vacuum System

The vacuum system is driven by the engine and produces a flow of air for the gyroscopic instruments.

The turn coordinator/turn-slip indicator is usually driven by the electrical system.

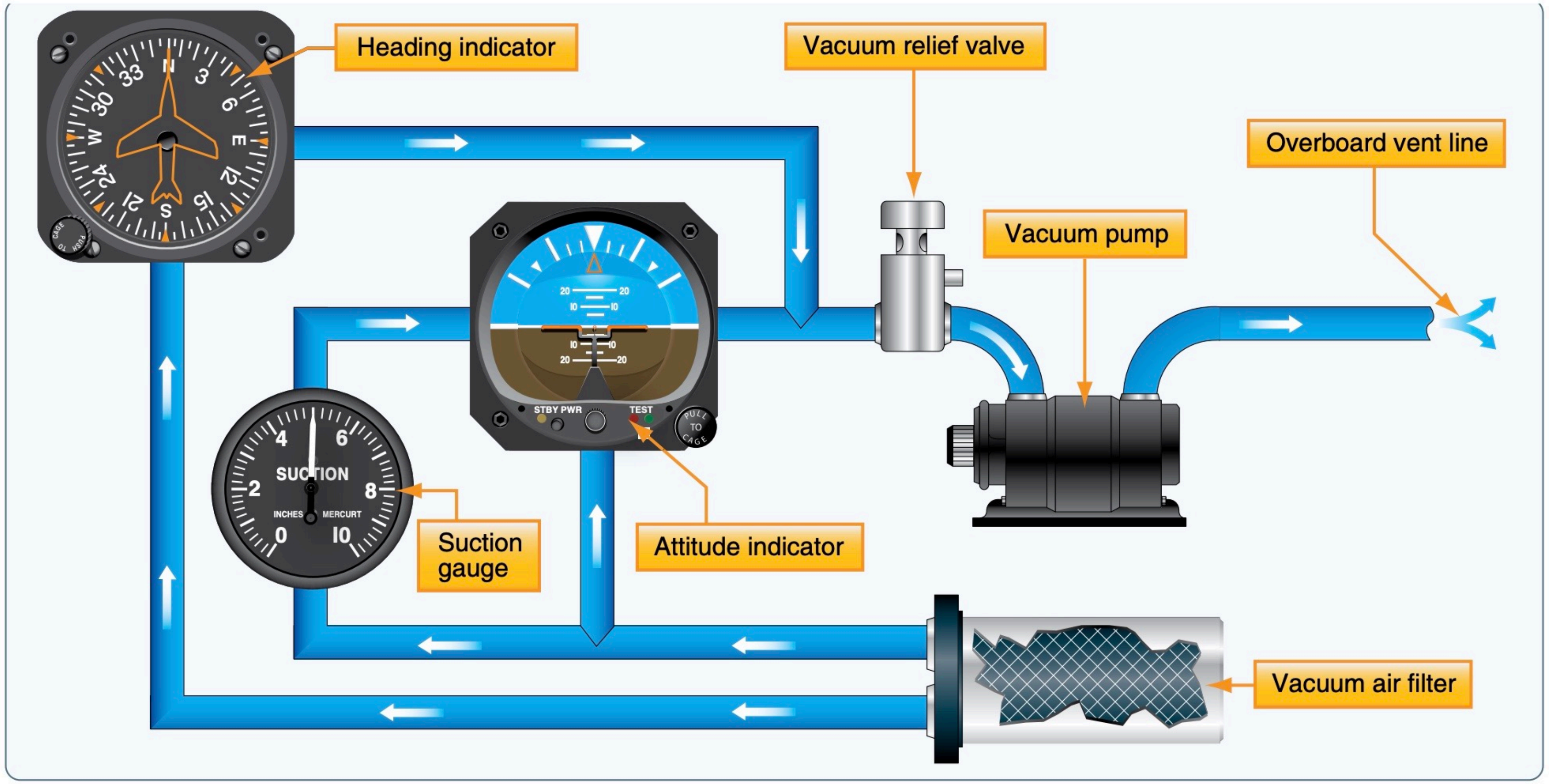

Figure 8-20. *Typical vacuum system.*

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Instruments

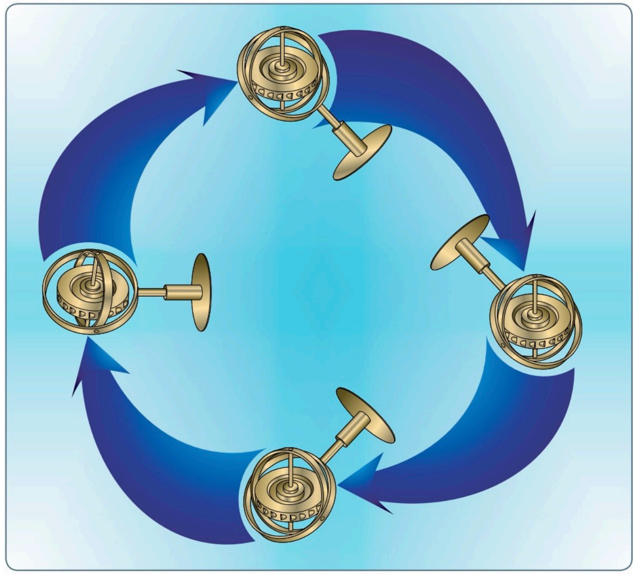

Figure 8-18. *Regardless of the position of its base, a gyro tends to remain rigid in space, with its axis of rotation pointed in a constant direction.*

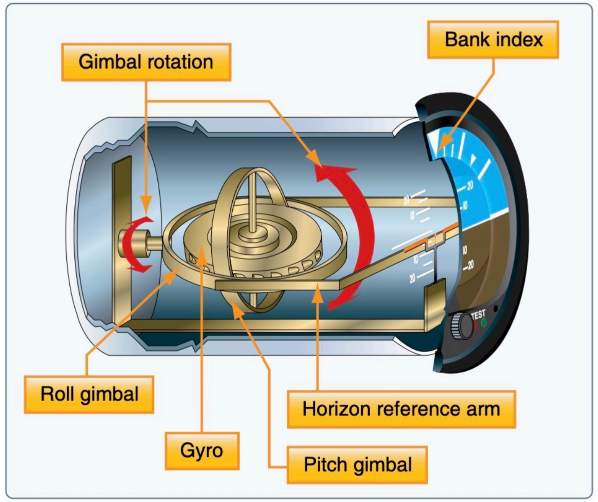

Figure 8-23. *Attitude indicator.*

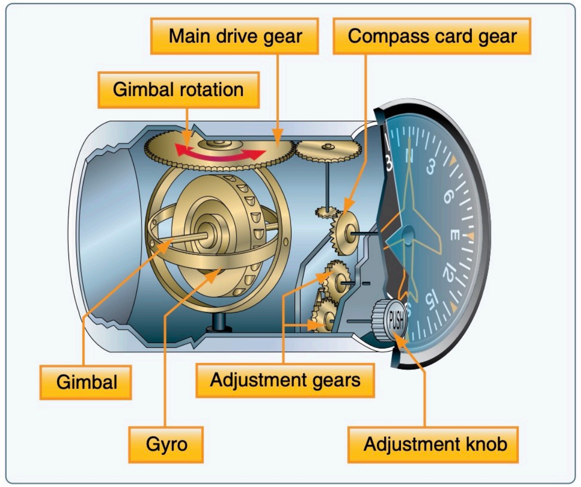

Figure 8-25. *A heading indicator displays headings based on a 360° azimuth, with the final zero omitted. For example, "6" represents 060°, while "21" indicates 210°. The adjustment knob is used to align the heading indicator with the magnetic compass.*

The attitude indicator and heading indicator use the gyroscopic principle of **Rigidity in Space**

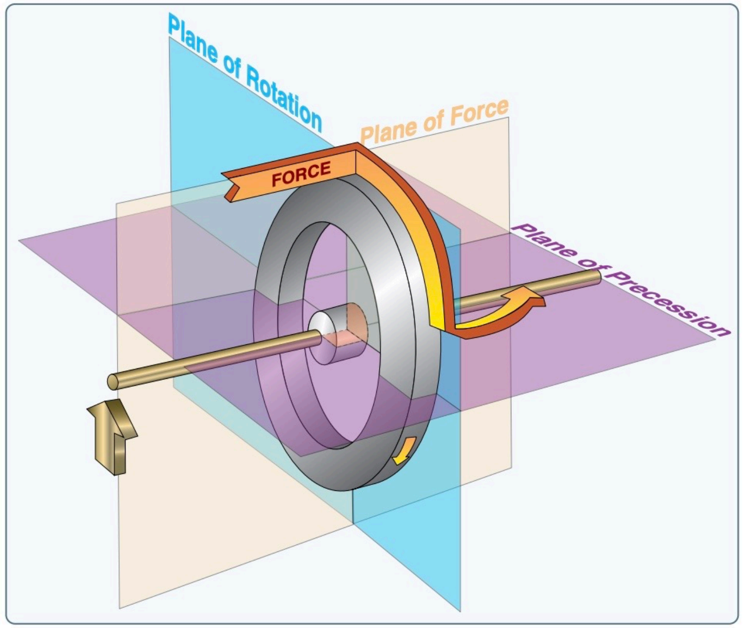

Figure 8-19. *Precession of a gyroscope resulting from an applied deflective force.*

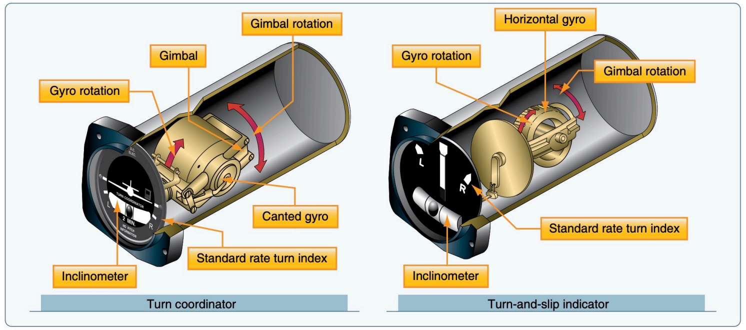

Figure 8-21. *Turn indicators rely on controlled precession for their operation.*

The turn coordinator uses the gyroscopic principle of **Precession**

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Electrical System

Most aircraft use either 14- or 28-volt DC electrical systems with 60-amp alternators and a 12- or 24-volt battery.

The alternator voltage is higher than the battery voltage to keep it charged.

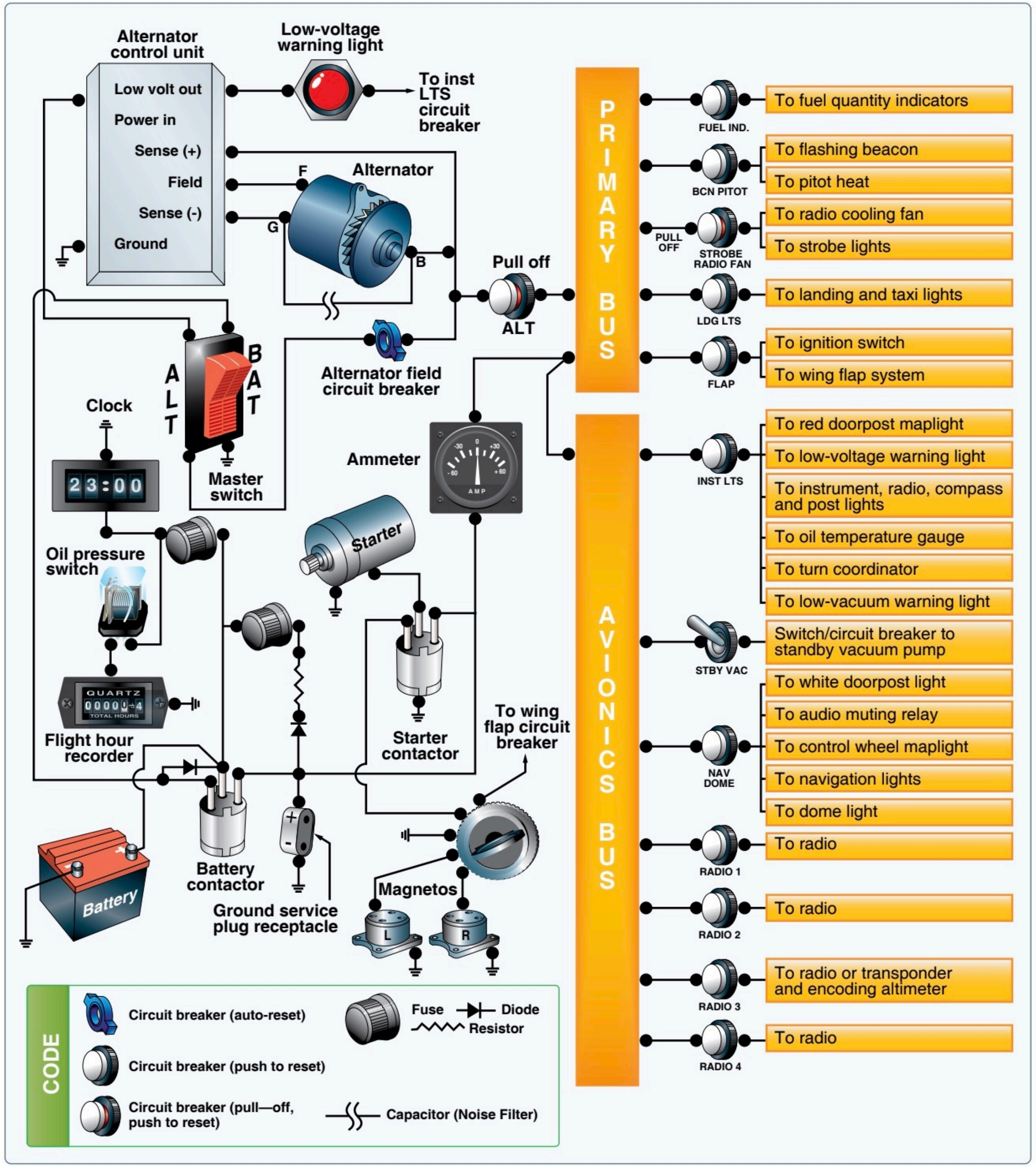

Figure 7-34. *Electrical system schematic.*

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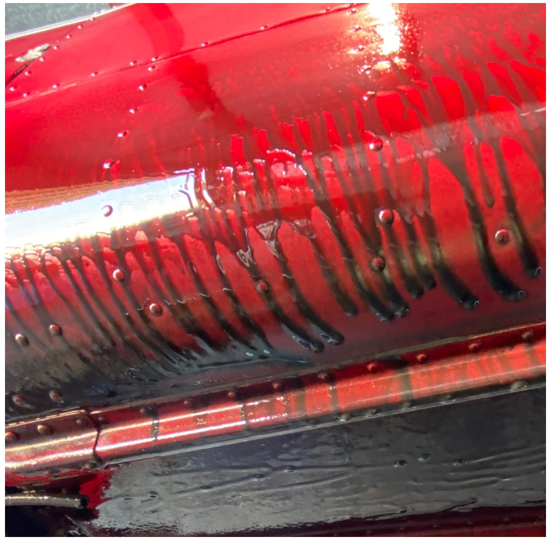
Fuel, Oil, and Hydraulic Fluid

Fuel

- 100LL is blue
- Check for contamination on preflight

Oil

- Lubricate moving parts and remove heat



Hydraulic Fluid

- Red
- Used in brake lines and to retract landing gear

Pint

Questions?

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