Aviation Program - Intro

- The program follows the Federal Aviation Administration (FAA) syllabus and prepare you to take the FAA Private Pilot knowledge test.
- The FAA only allows cadets that are at least 15 years old to sit for the test.
- This will be a fast paced training, pay attention, work hard and ASK QUESTIONS.
- **Pay close attention to terminology and definitions:** Statue Miles (SM), Nautical Miles (NM), Magnetic heading, Geographic heading, Bearing to/bearing from etc…
- **Temperature:** the Celsius scale is used (freezing point is 0^o).
- **Time:** we will use the Universal Coordinated Time (UTC) on a 24 hour format. UTC it's the same time across the globe. EST is UTC - 4 hours (Daylight Savings Time) and UTC - 5 hours (Standard Time)
- **PIC** = Pilot in Command
- **Heading**: is where the nose of the plane is pointing towards.
- **Course**: is the ground track that the plane is following on the ground.

Basic Aerodynamics

Basic Aerodynamics

In this section we will be covering:

Key definitions

The four forces of flight

How lift is generated and how planes turns

Ground effect and wake turbulences

Aerodynamics Terms

- **Airfoil** = a structure with curved surfaces designed to generate lift.
- **Chord line** = an imaginary straight line from edge to edge of an airfoil.
- **Relative wind** = is the direction of the wind in relation to the airfoil.
- **Angle of attack** = angle between the chord line and the relative wind.
- **Angle of incidence** = angle at which the wing is attached to the fuselage.

A wing always stall at the same angle of attack, regardless of speed/weight.

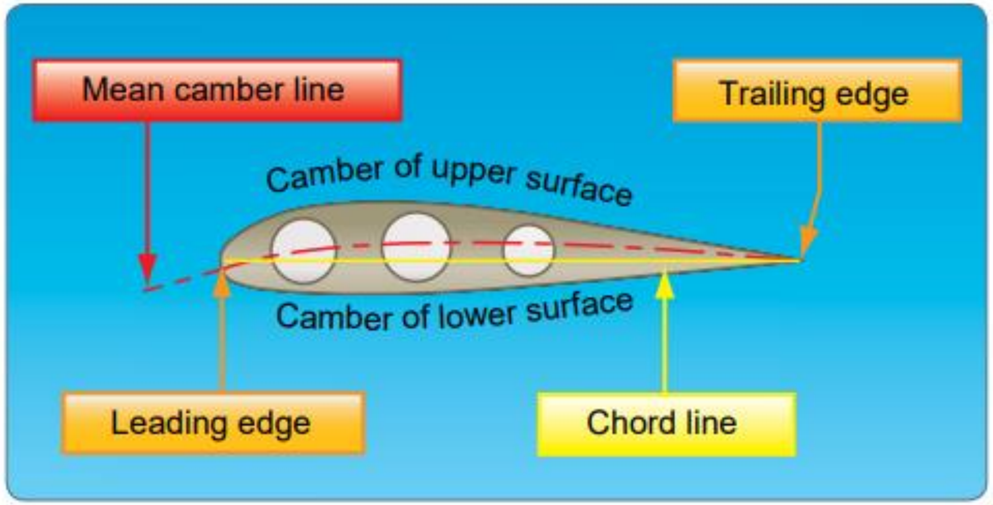
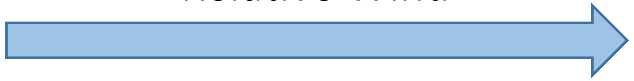


Figure 4-5. *Typical airfoil section.*

Relative Wind



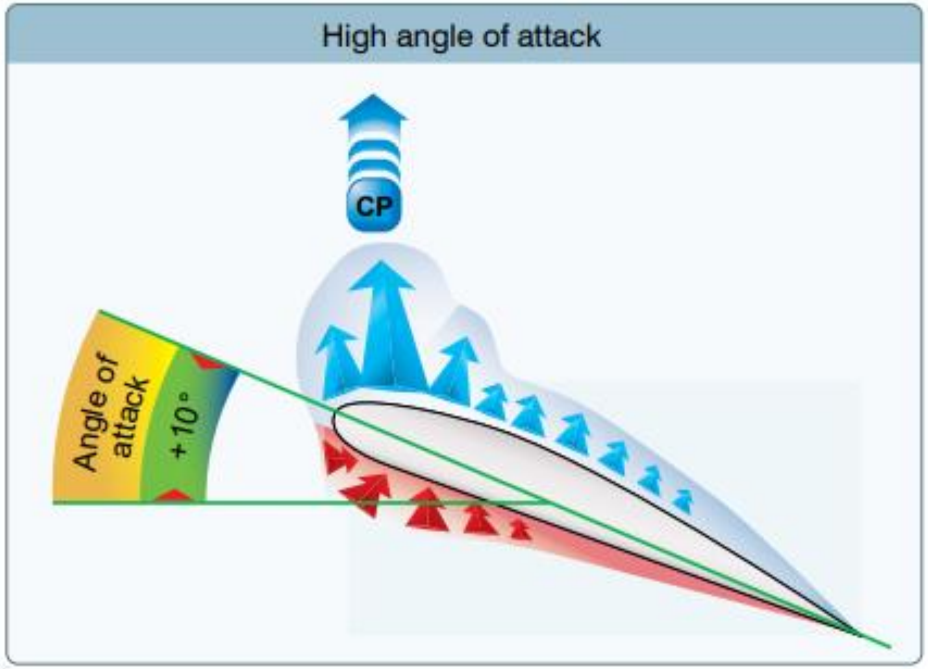


Figure 4-7. *Pressure distribution on an airfoil and CP changes with AOA.*

Aerodynamics Terms

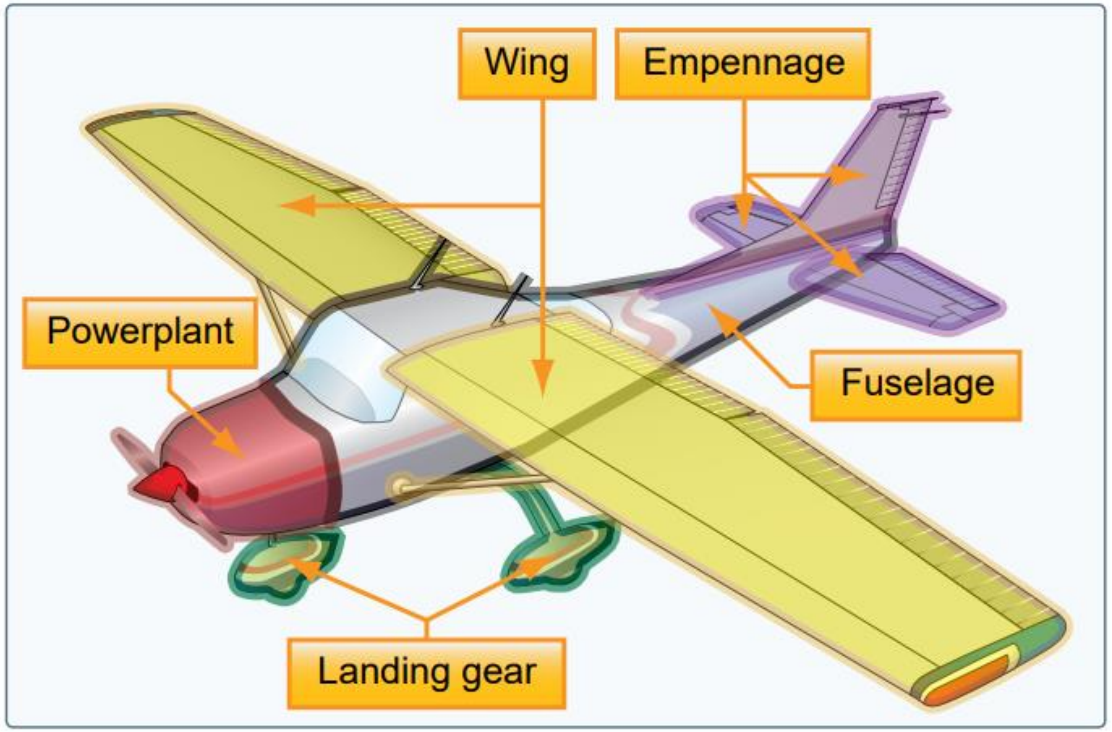


Figure 3-4. *Airplane components.*

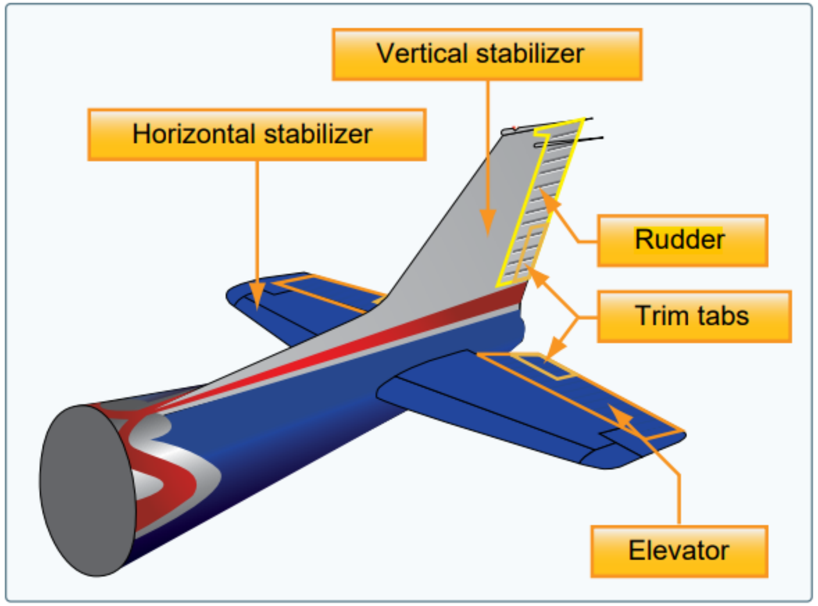


Figure 3-10. *Empennage components.*

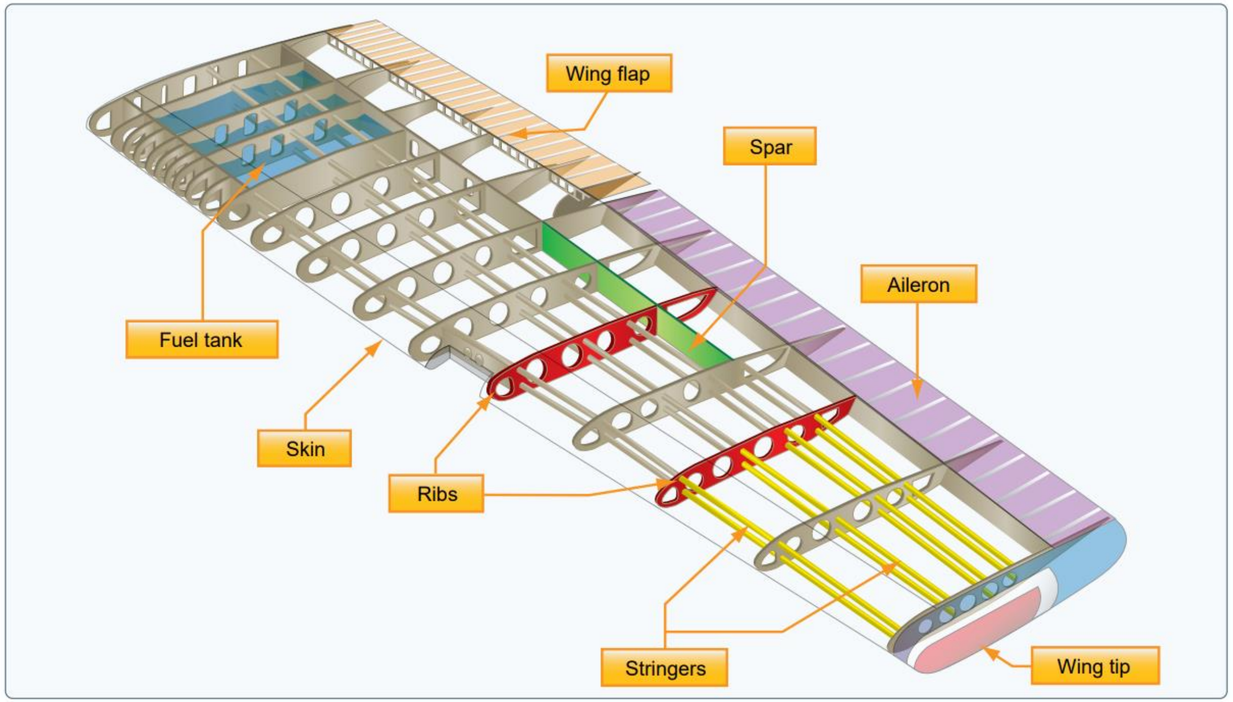


Figure 3-7. *Wing components.*

The Four Forces Acting in Flight

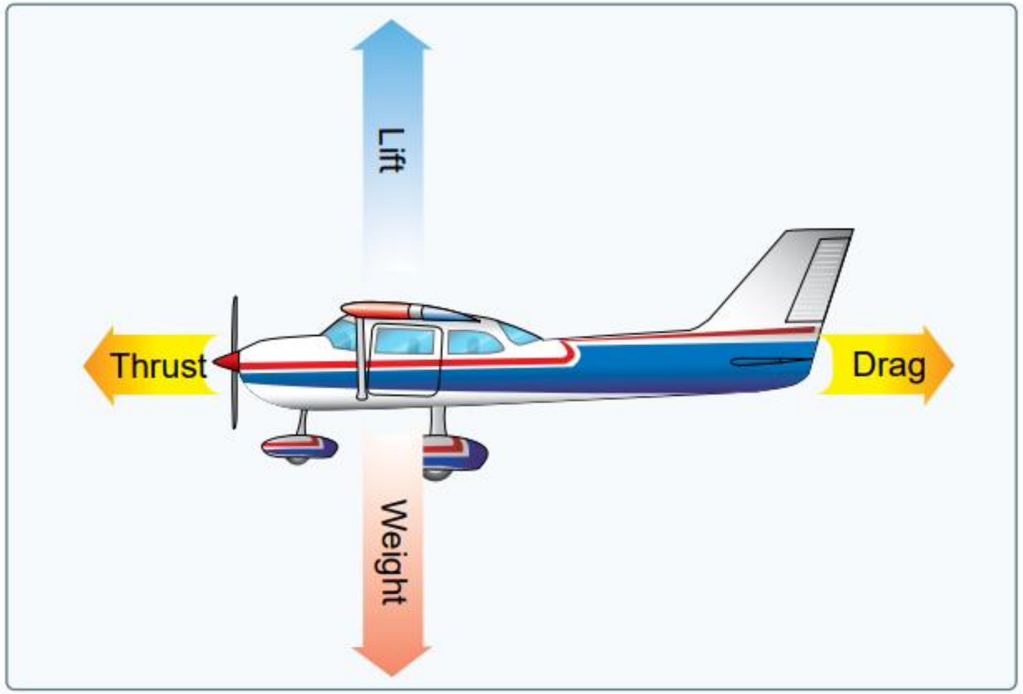
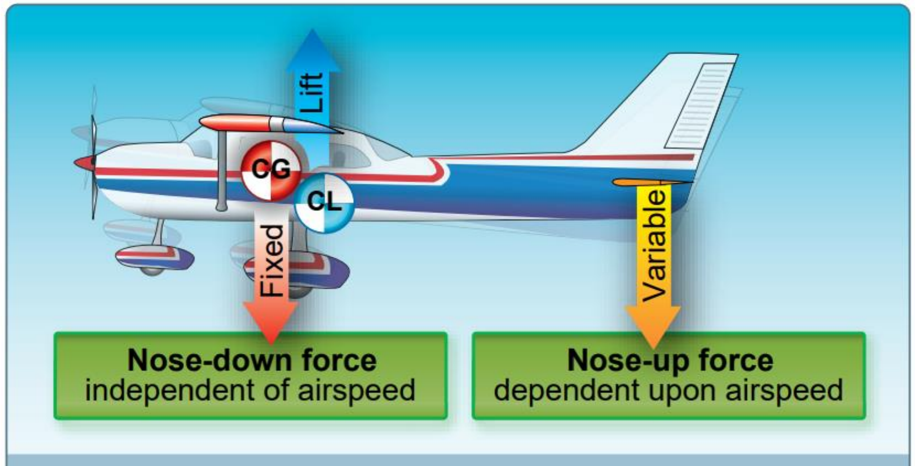


Figure 5-1. *Relationship of forces acting on an aircraft.*

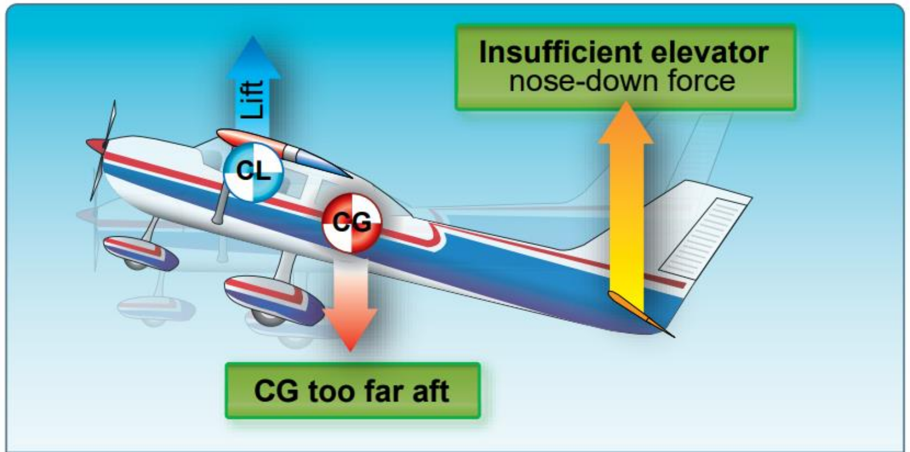
- While **thrust** is created by spinning the propeller, **lift** is created by the pressure differential between the air flowing below and above the airfoil according to the Bernoulli's' principle.
- When the lift and weight are equal and the thrust and drag are equal then the plane travels at a constant velocity.
- **The center of gravity (CG)** = an imaginary point where all the weight is concentrated (the plane would balance if suspended at that point).
- **The center of lift (CL)** = A point along the wing chord line where lift is considered to be concentrated (aka center of pressure).

Center of Gravity and Center of Lift

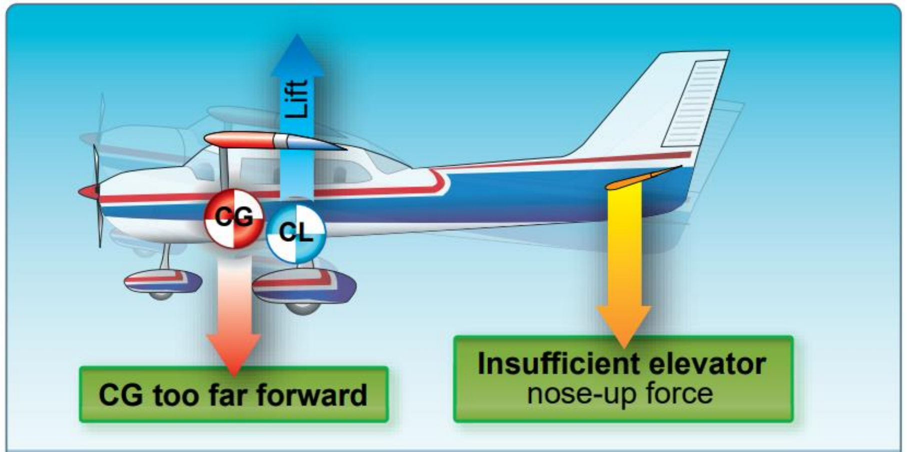


Vertical forces acting on an airplane in flight.

- To allow a pilot to control the plane, CG and CL should be close enough to each other.
- CG and CL being too far apart will affect the aircraft balance and controllability.



If the CG is too far aft, there might not be enough elevator nose-down force at the low stall airspeed to get the nose down for recovery.



If the CG is too far forward, there will not be enough elevator nose-up force to flare the airplane for landing.

Figure 3-3. *Center of gravity (CG).*

Axes of Rotation

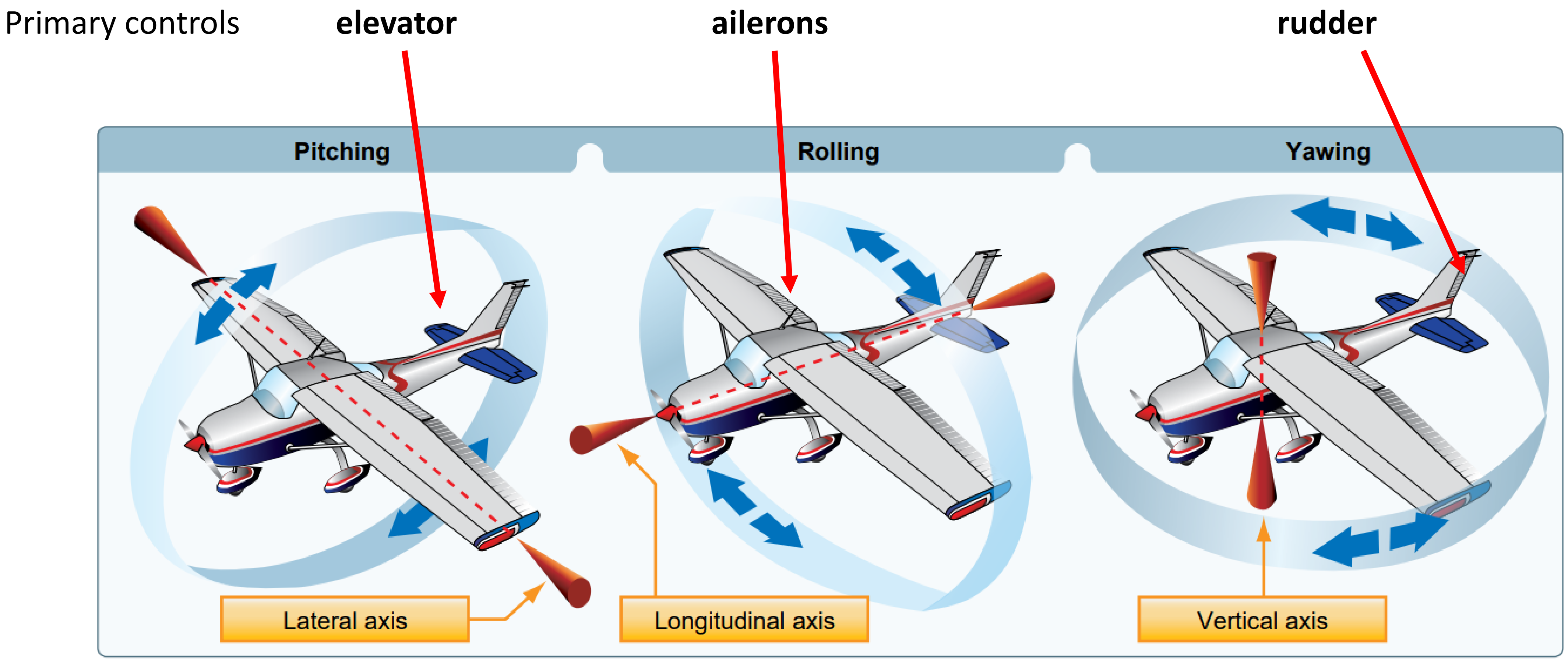


Figure 5-18. *Axes of an airplane.*

- The three axis intersect at the center of gravity.

The Bernoulli's Principle

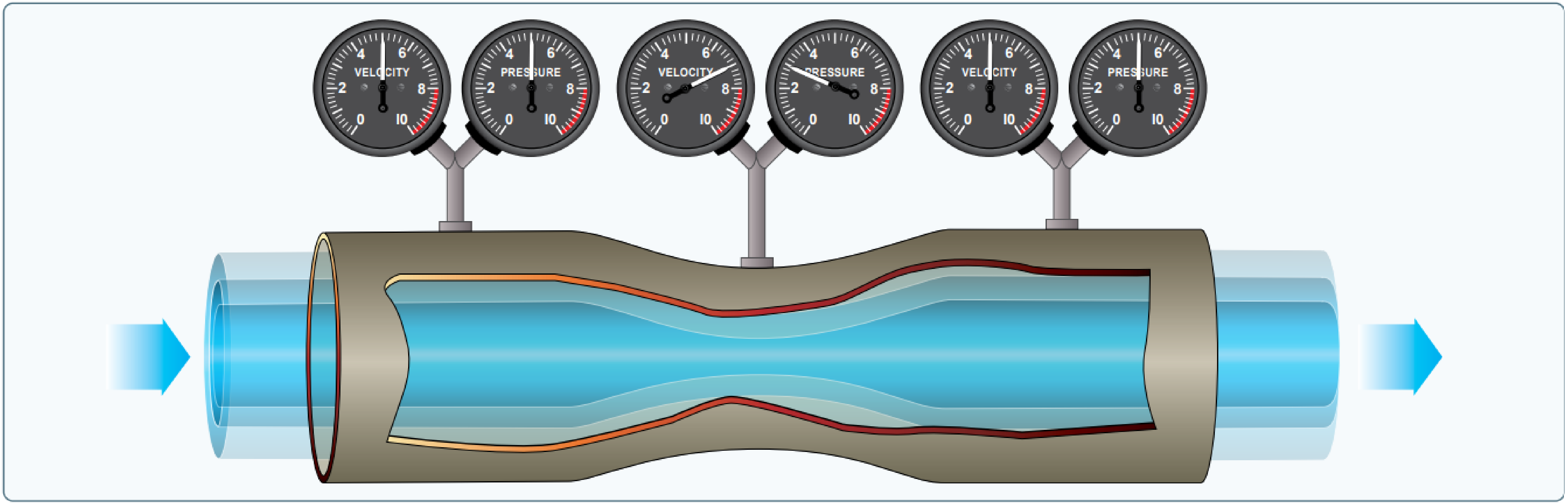
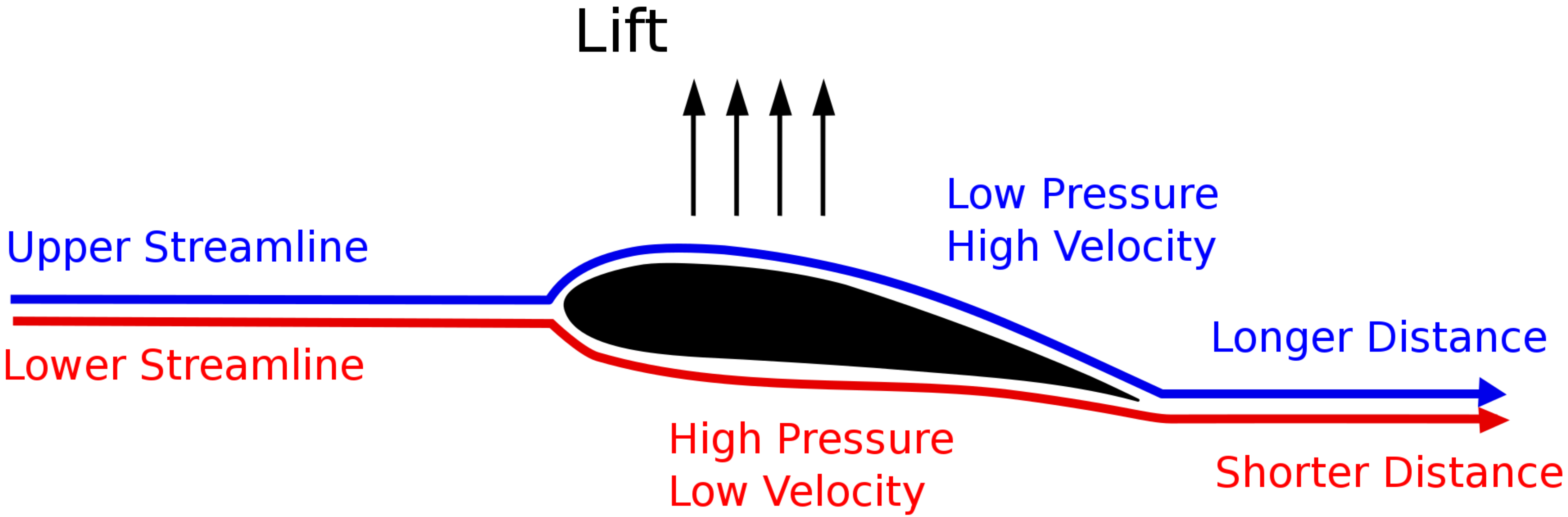


Figure 4-4. *Air pressure decreases in a venturi tube.*

The Bernoulli's Principle



- Pressure differential between the upper and lower surface of the wing, due to the Bernouilli principle, creates lift.

Drag

- **Drag** is the force that resists movement of an aircraft through the air.
- **Parasite drag** is the resistance of the air produced by any part of an airplane such as wing screws, rivets, frost, paint etc.; it increases as airspeed increases.
- **Induced drag** is the by product of lift; the high pressure air beneath cause a cortes inducing; it increases as airspeed decreases.

Stability

- Stability is the inherent ability of an airplane to return to its original flight condition after being disturbed by an outside force.
- Positive static stability => ability to return to the original condition.
- Positive dynamic stability => ability to return to the original condition over time (ex. a pendulum).

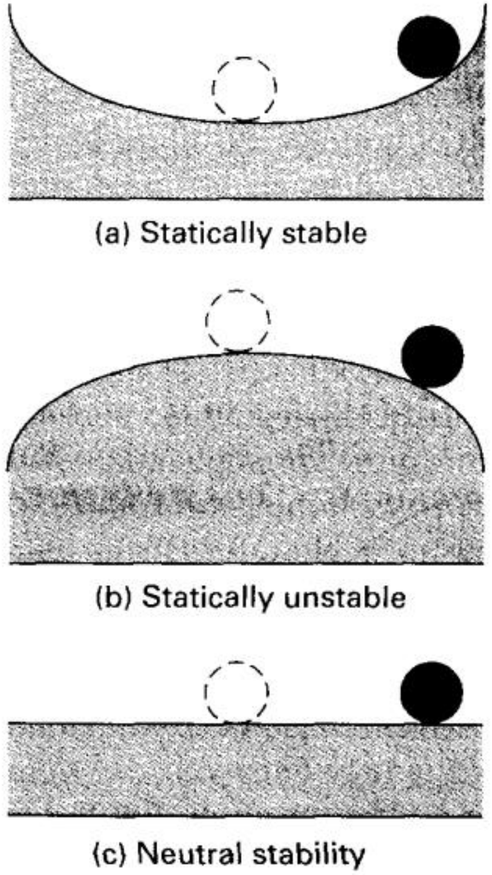


FIGURE 2.3
Sketches illustrating various conditions of static stability.

Source: https://home.engineering.iastate.edu/~shermanp/AERE355/lectures/Nelson%20Chapter%202.pdf

Turns, Loads, and Load Factors

- During turns a portion of the lift is diverted into an horizontal component.
- Increasing the bank angle requires more lift to be generated to compensate for the portion of vertical lift diverted horizontally increasing the load on the wings.
- This load increases the stall speed.
- Load factor = the additional weight carried by the wings divided by the aircraft weight.

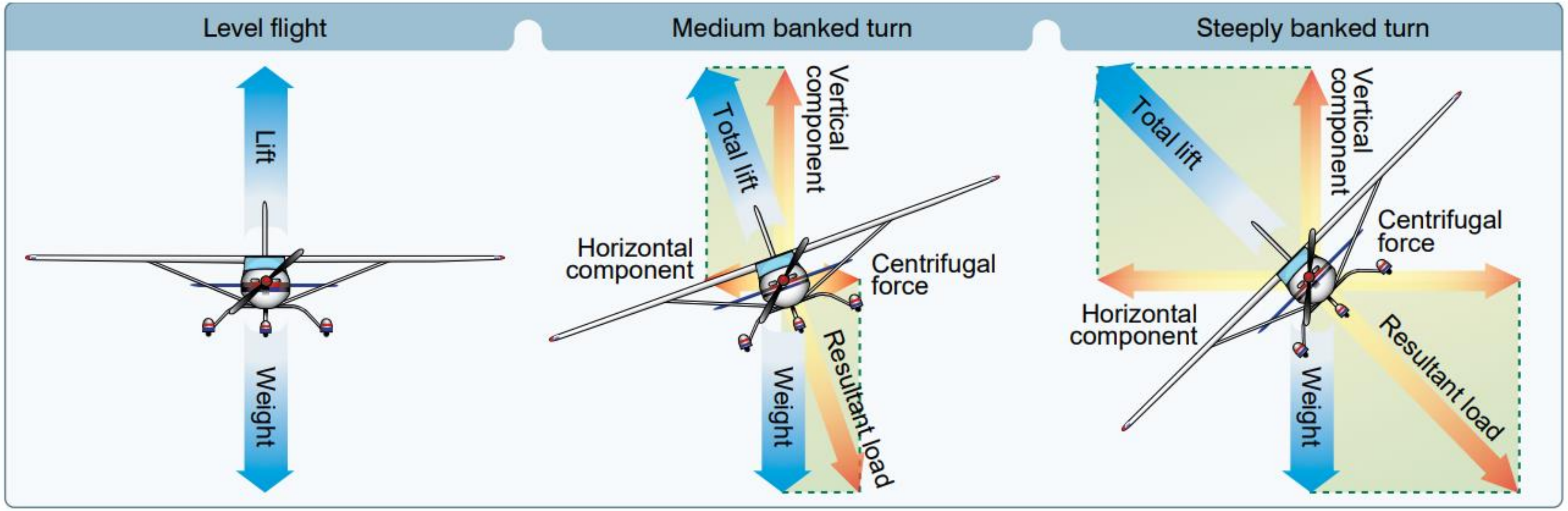


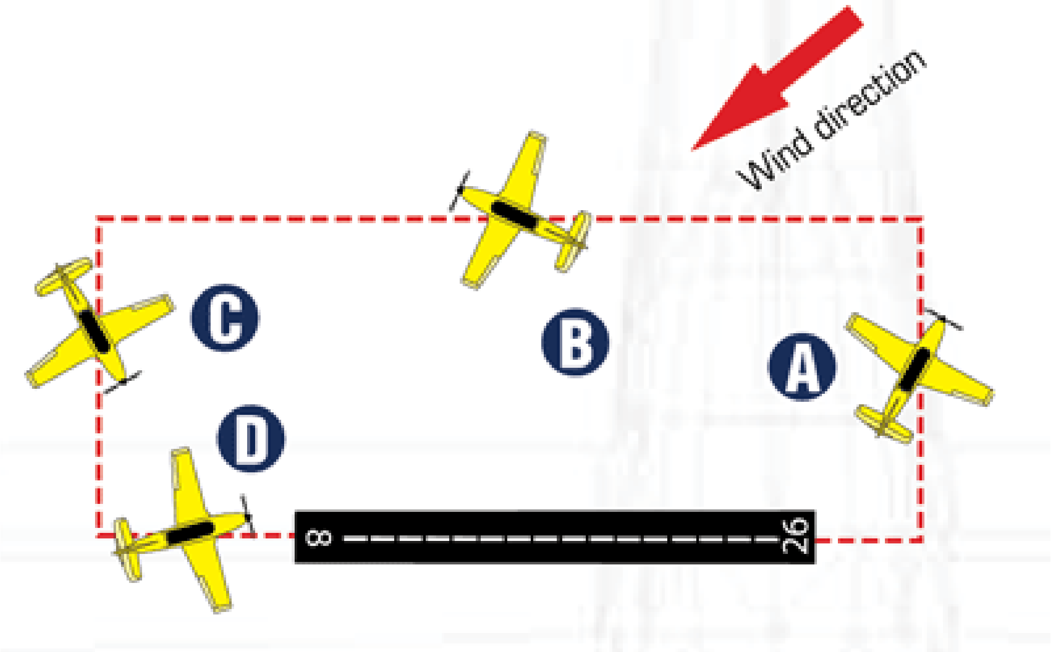
Figure 5-34. *Forces during normal, coordinated turn at constant altitude.*

Manoeuvers

- The four fundamentals involved in maneuvering an aircraft are:

  Straight and level, turns, climbs and descents.

- The wind will affect how you perform those maneuvers following a ground track.



Becasue of the wind direction, the airplane must be crabbed in all positions, (A, B, C & D), to maintain a rectangular traffic pattern.

Adapted from Rod Machado's Private Pilot Handbook

Stalls and Spins

- Stall is a condition during which the wing experiences a rapid decrease in lift.
- When the wing angle increases to a “critical angle of attack”, the air over the wing will become to “burble”; a plane always stalls at the same angle of attack.
- An aircraft will enter into spin only after both wings are stalled.
- It will continue to spin as long as the outside wing continues to provide more life the inside wing.
- Note: a stalled wing continue to provide some lift but not enough to sustain the plane weight.

Attached flow

Separated (stalled) flow

Source: https://eaglepubs.erau.edu/introductiontoaerospaceflightvehicles/chapter/maximum-lift-stalling-spinning/

Flaps

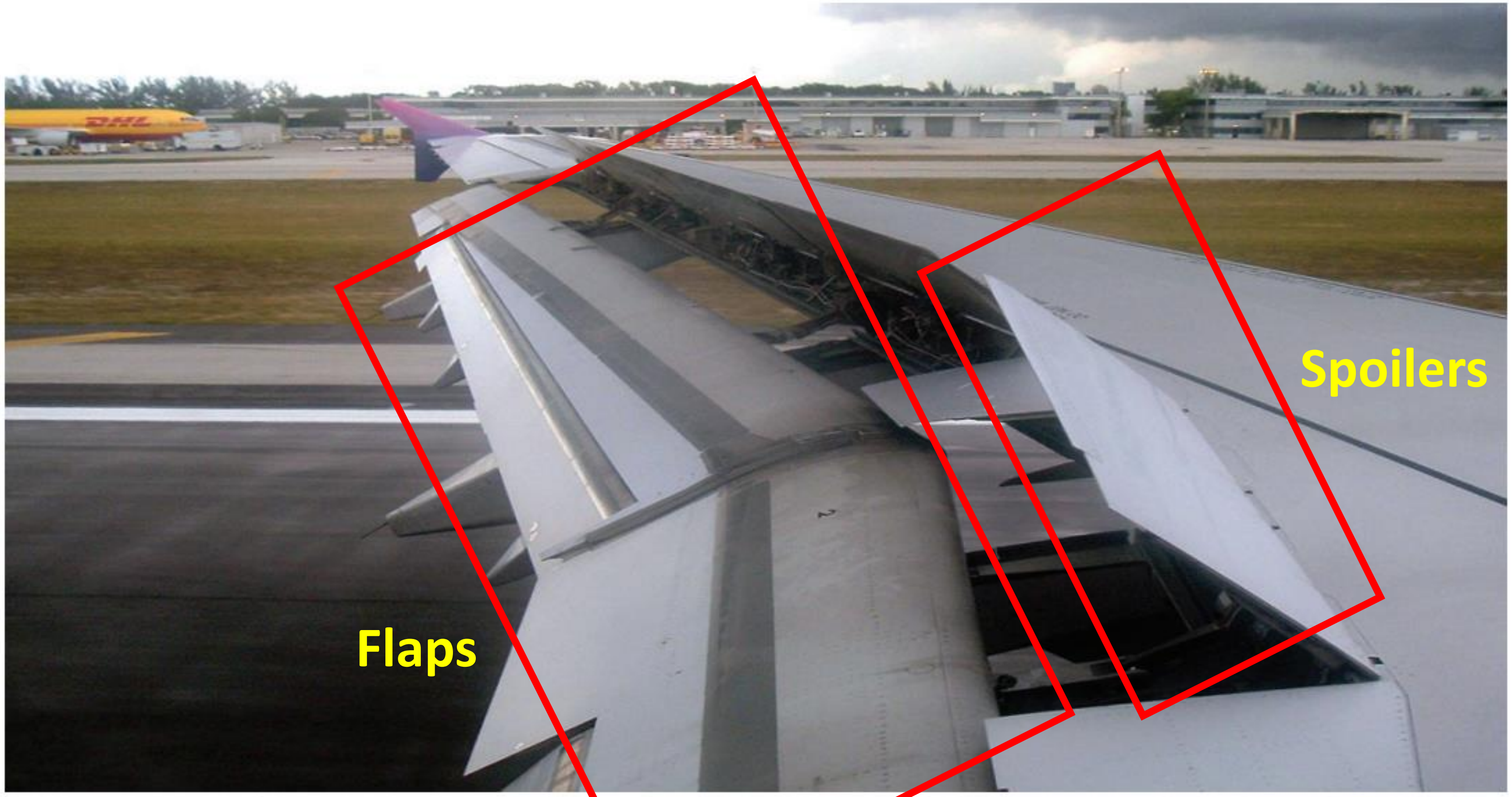


Figure 16-10. *Spoilers.*

- Flaps are wing devices allowing to increase the wing camber, the angle of attack and lift.
- They enable a steeper landing approach to a lading without an increase in airspeed.

Ground Effect

- It is an <u>air cushion</u> created by the air trapped between the wing and the landing surface.

Figure 5-16. *Ground effect changes airflow.*

- Occurs when flying within one wingspan or less above the surface.
- Ground effect causes the plane to “float”.
- Ground effect risks: (1) delayed landing (running out of runway) or
  (2) taking off before reaching safe take off speed.

Wake Turbulences

- Aircrafts create two types of wake turbulences: propeller/jetblast and wingtip vortices.
- Wingtip vortices occur when the upper airstream on the wing meets the lower air stream and spin from the wing tip.
- Vortices tend to move laterally and below the flight path of the generating aircraft.
- Are stronger when the plane is heavy, slow and "clean" (landing gear and flaps up).
- They represent a serious hazard especially for small aircrafts.

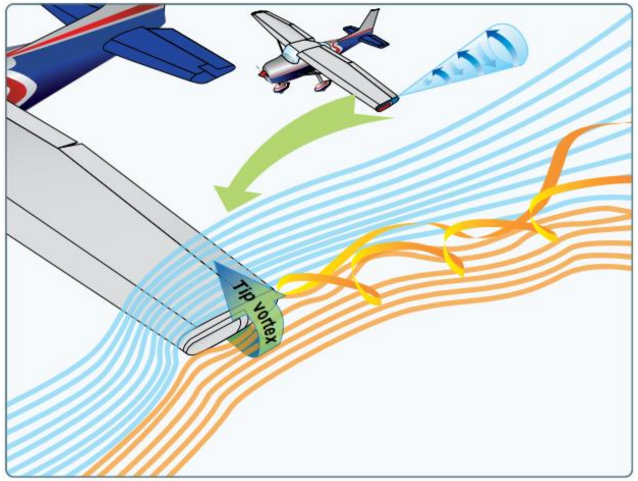
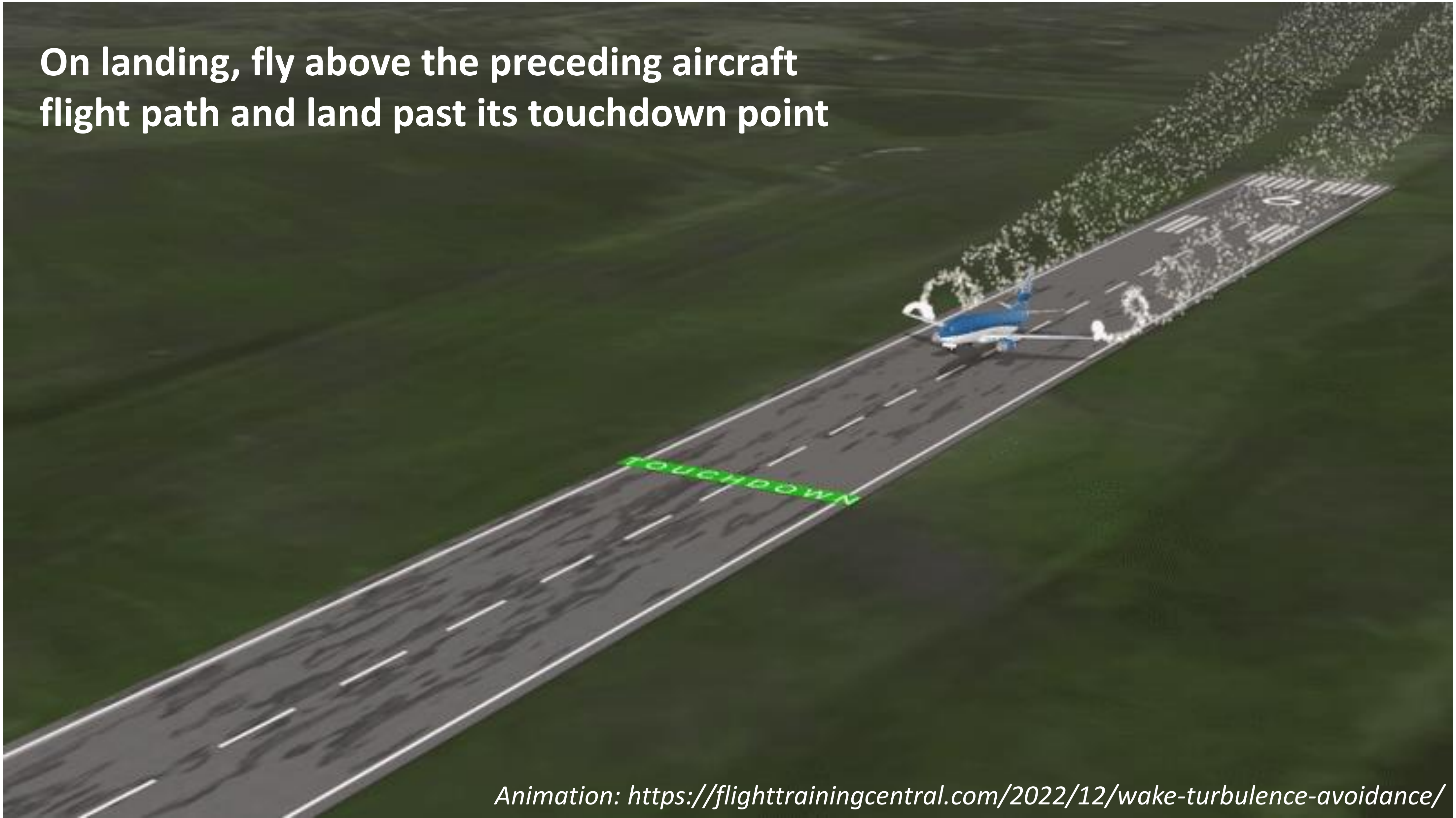


Figure 4-8. *Tip vortex.*

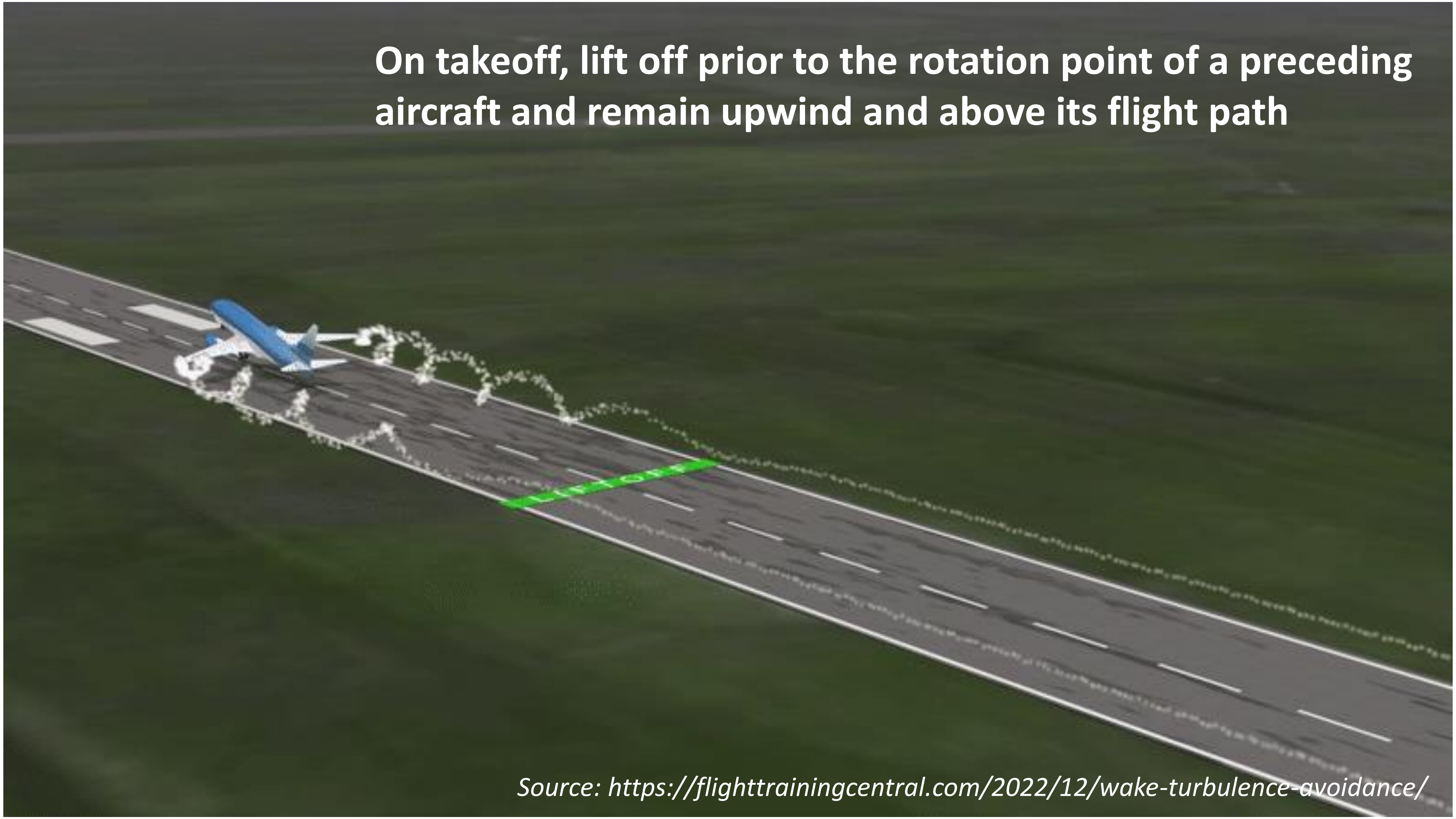
Source: https://i0.wp.com/nats.aero/blog/wpcontent/uploads/2014/02/featureVortex.jpg?w=507&ssl=1

How to Avoid Wake Turbulences



Animation: https://flighttrainingcentral.com/2022/12/wake-turbulence-avoidance/

How to Avoid Wake Turbulences



Source: https://flighttrainingcentral.com/2022/12/wake-turbulence-avoidance/

Aircraft Systems I

Powerplant

Aircraft Systems

- In this lesson we will covering two key aircraft systems:

    The engine (aka powerplant)

    The flight instruments

Reciprocating Engines

- Most small aircraft are designed with reciprocating engines.
- Reciprocating = back-and-forth movement of the pistons.

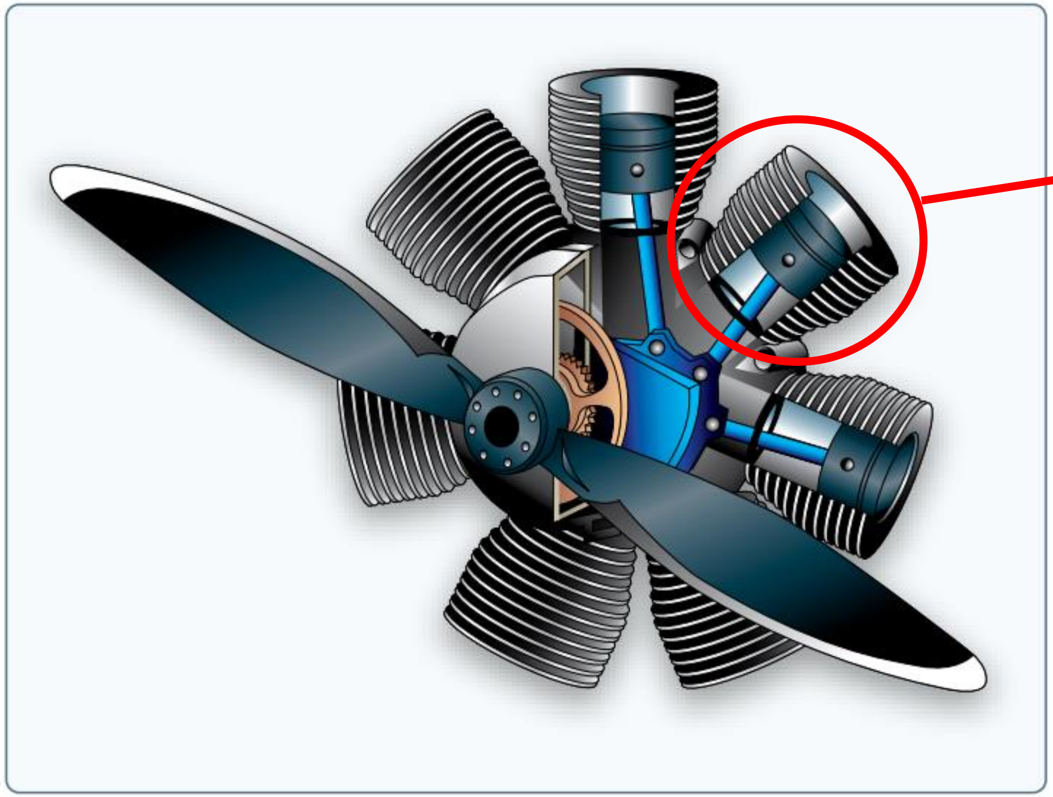


Figure 7-1. *Radial engine.*

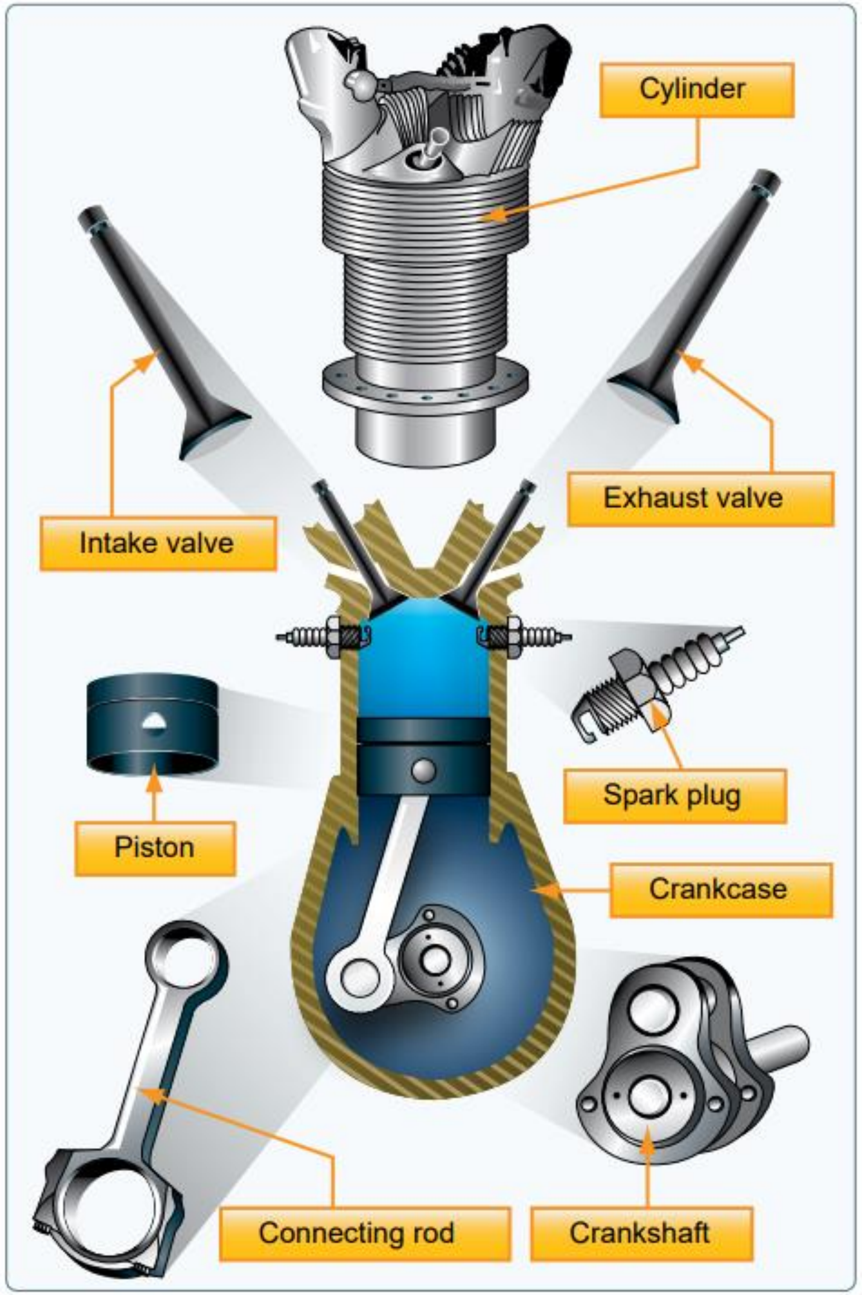
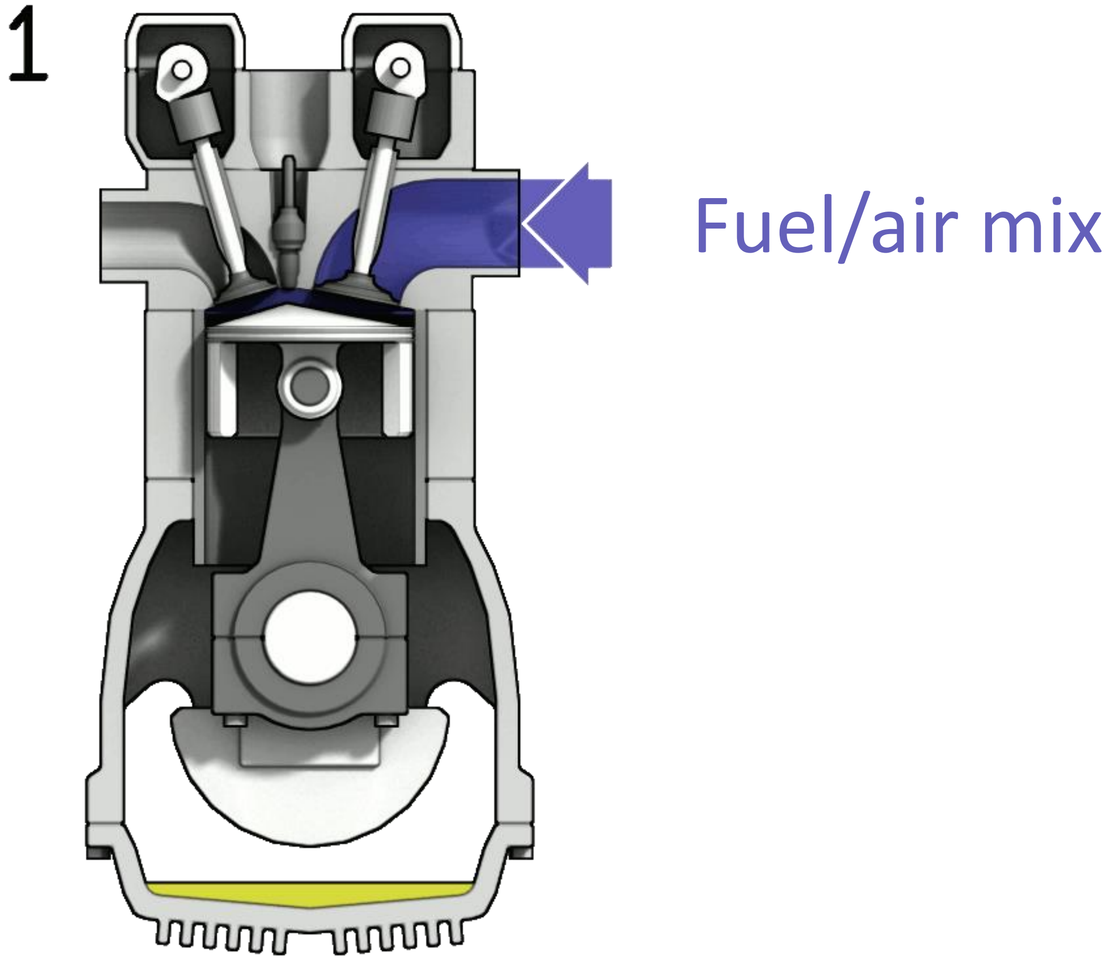


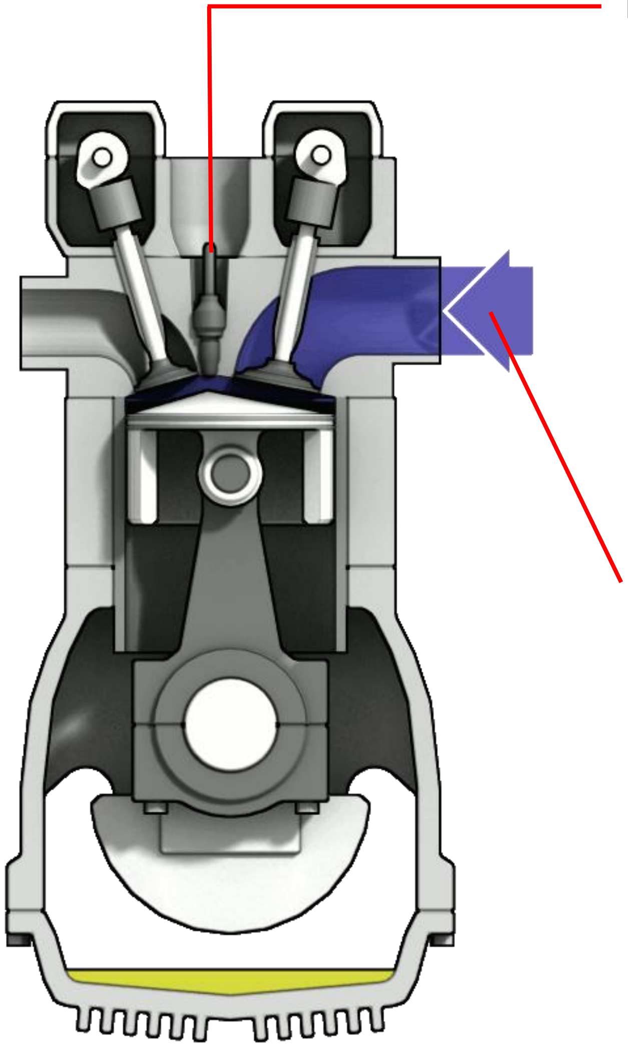
Figure 7-4. *Main components of a spark ignition reciprocating engine.*

Reciprocating Engines In Action

1. Intake
2. Compression
3. Power
4. Exhaust



Supporting Systems



Ignition and electrical system

- Electricity is provided by an alternator and a dual (for safety) magnetos system
- Magnetos can continue to provide electricity the event of a total loss of power
- Alternator generate more power than magnetos

Fuel induction system

- Fuel/air are mixed using a carburetor or an injection system
- With a carburetor system, the fuel/air mix changes as altitude changes (air gets less dense at altitude)
- Less dense air => reduce fuel to maintain the right fuel/mix proportions

Carburetor

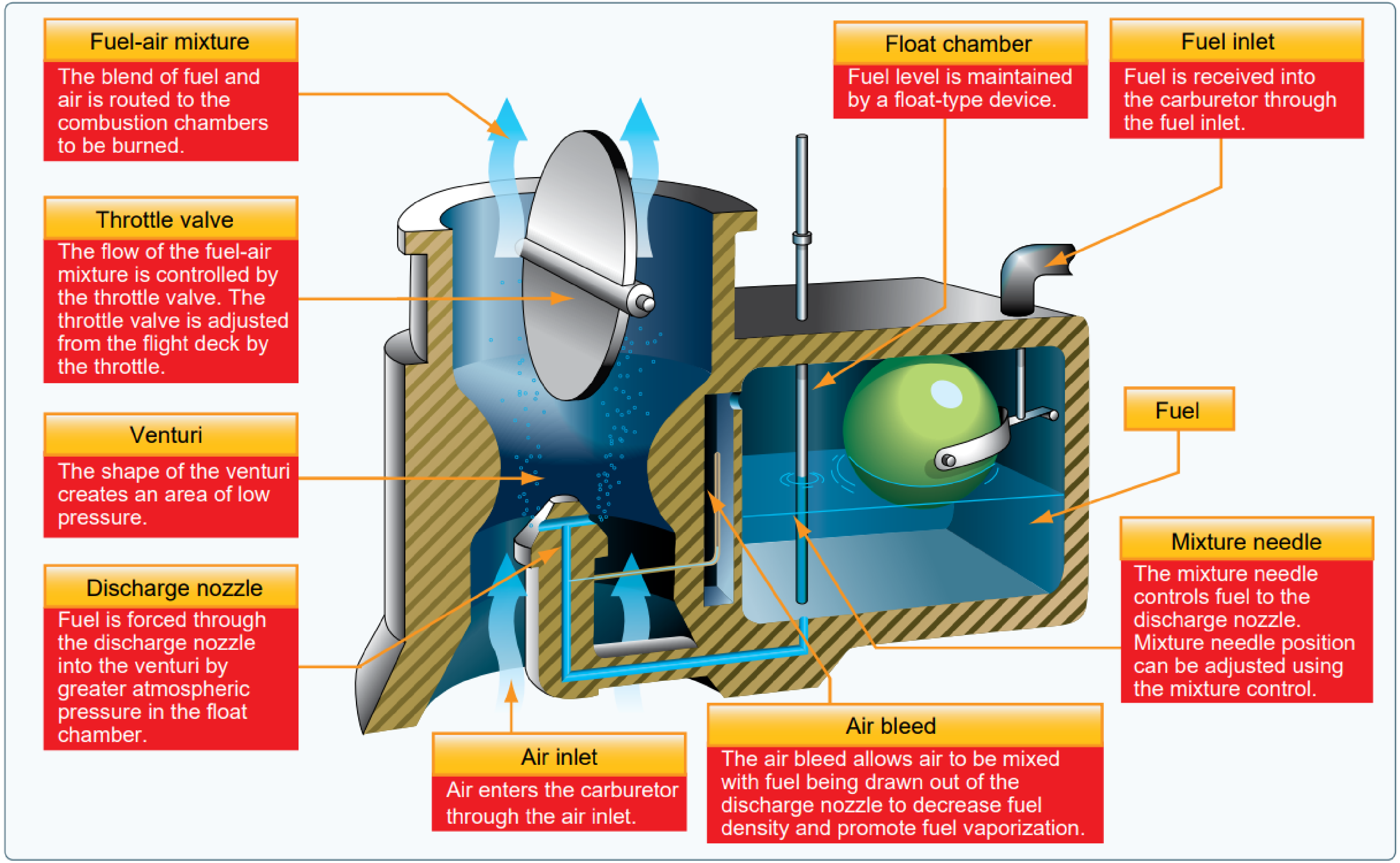


Figure 7-10. *Float-type carburetor.*

Carburetor Icing

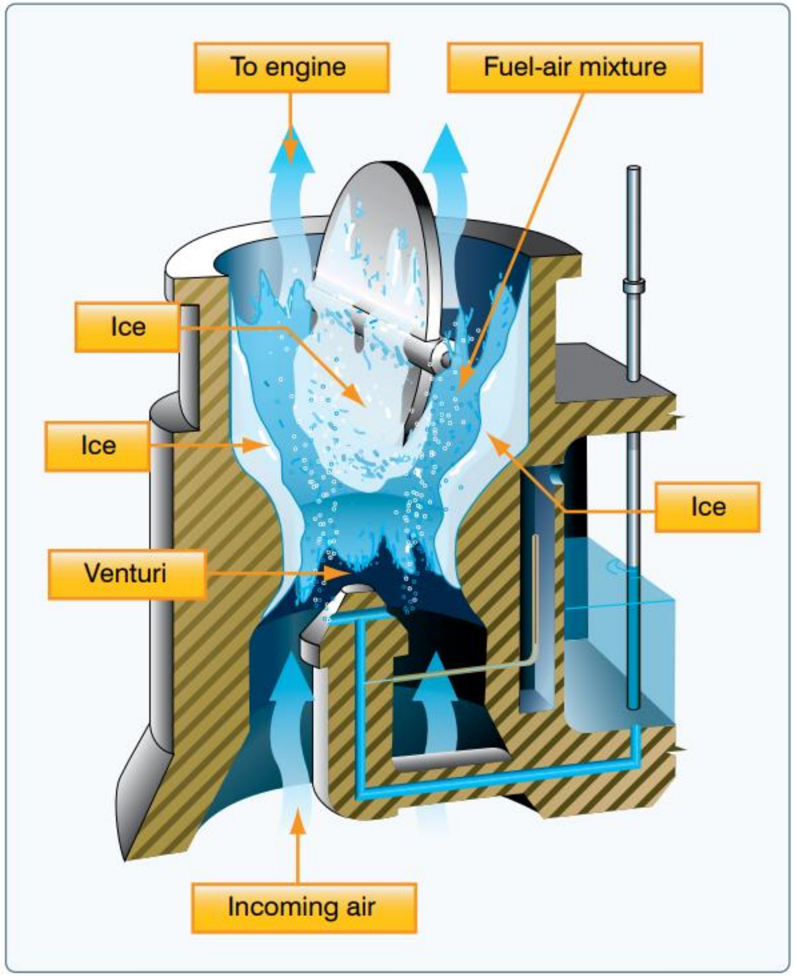


Figure 7-11. *The formation of carburetor ice may reduce or block fuel-air flow to the engine.*

- Rapid expansion of air and vaporization of fuel causes a sudden cooling => **ice could form in the carburetor.**
- This could lead to ice forming inside the carburetor.
- Signs of icing are engine roughness and a RPM drop.
- **Conditions conducive of icing** are temperatures of 20-70F + high relative humidity.
- **Carburetor heat** can warm air entering the carburetor and prevent/melt icing.

Fuel Flow

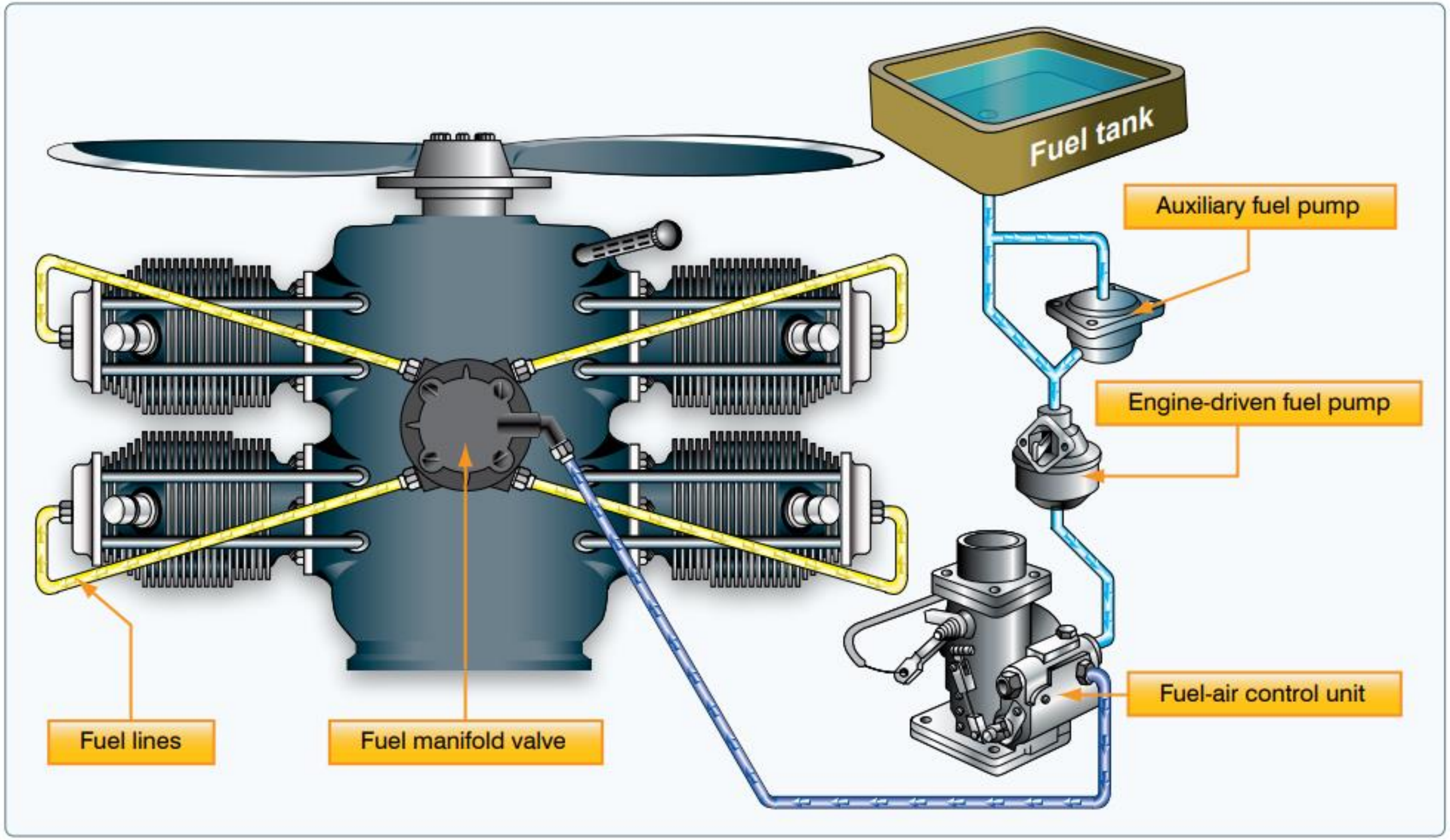


Figure 7-13. *Fuel injection system.*

Aviation Fuel

- Fuel must be free of contaminants (water/impurities) and of the proper grade (if unavailable use the next higher grade).
- To avoid water condensation forming at night, <u>fill up</u> the tanks after a flight.
- Remove/check for impurities before each flight by draining the <u>tank sumps</u>.
- **Most planes** have both a main and auxiliary fuel pumps (startup and backup).
- **Fuel detonation** occurs when <u>low grade</u> fuel is used or fuel/air mix is too lean.
- **Fuel preignition** is caused by residual hot spot in the combustion chamber.

Engine Temperature

- Lubricating oil prevents metal to metal contact, absorbs and dissipates heat.
- **High engine temperature** can result in higher oil consumption, power loss and permanent internal engine damage.
- **Causes of high engine temperature:** high power settings and too lean fuel/air mixture, low fuel grade, or low level of oil.
- **To lower the temperature:** reduce the rate of climb, increase airspeed, enrich the mixture, retard the throttle.
- **In the event of a power failure:** immediately establish best glide & airspeed.

Propellers & Torque

- Propellers provide thrust and act like a wing taking a “bite” out of the air.
- Propeller can be fixed pitch (fixed blade angle) or variable-pitch.
- With a variable pitch propeller
  (aka constant-speed propeller)
  a pilot can change the blade angle.

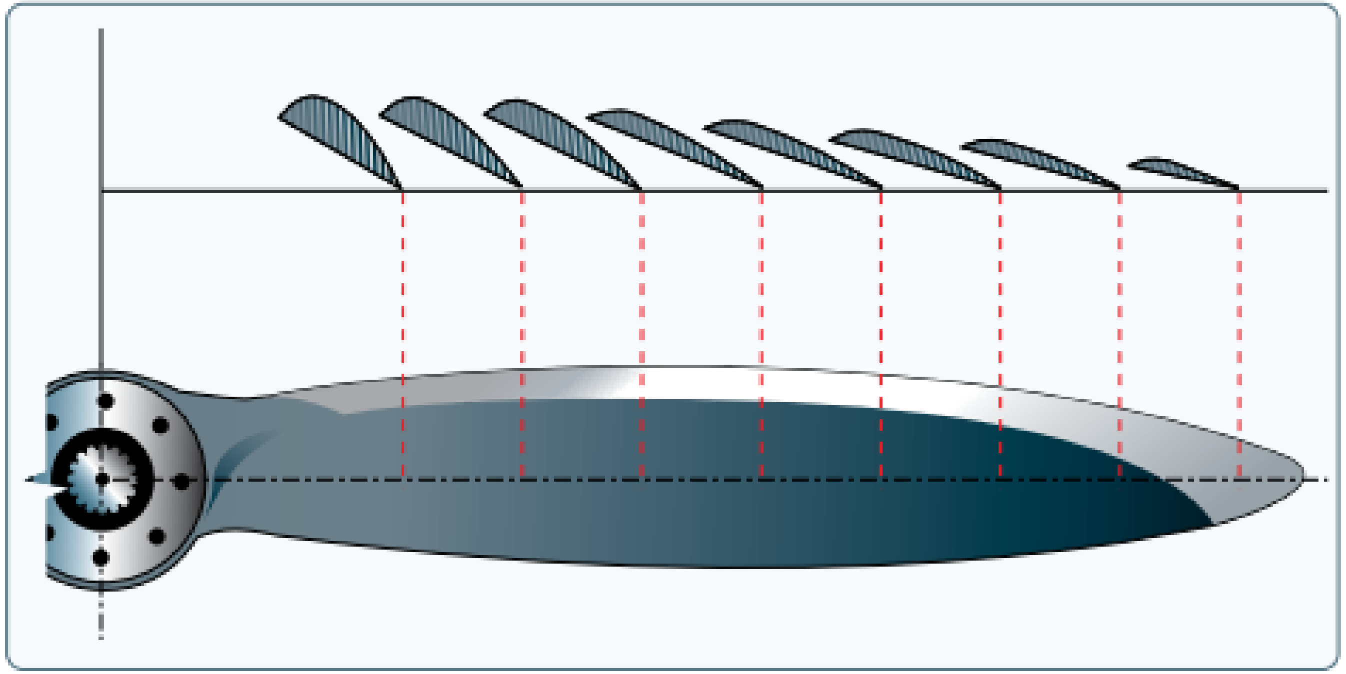


Figure 5-43. *Airfoil sections of propeller blade.*

Constant-Speed Propeller

- Here, the throttle controls the power output and the propeller regulates the RPM.
- With constant-speed propeller, avoid high manifold pressure with low RPM.

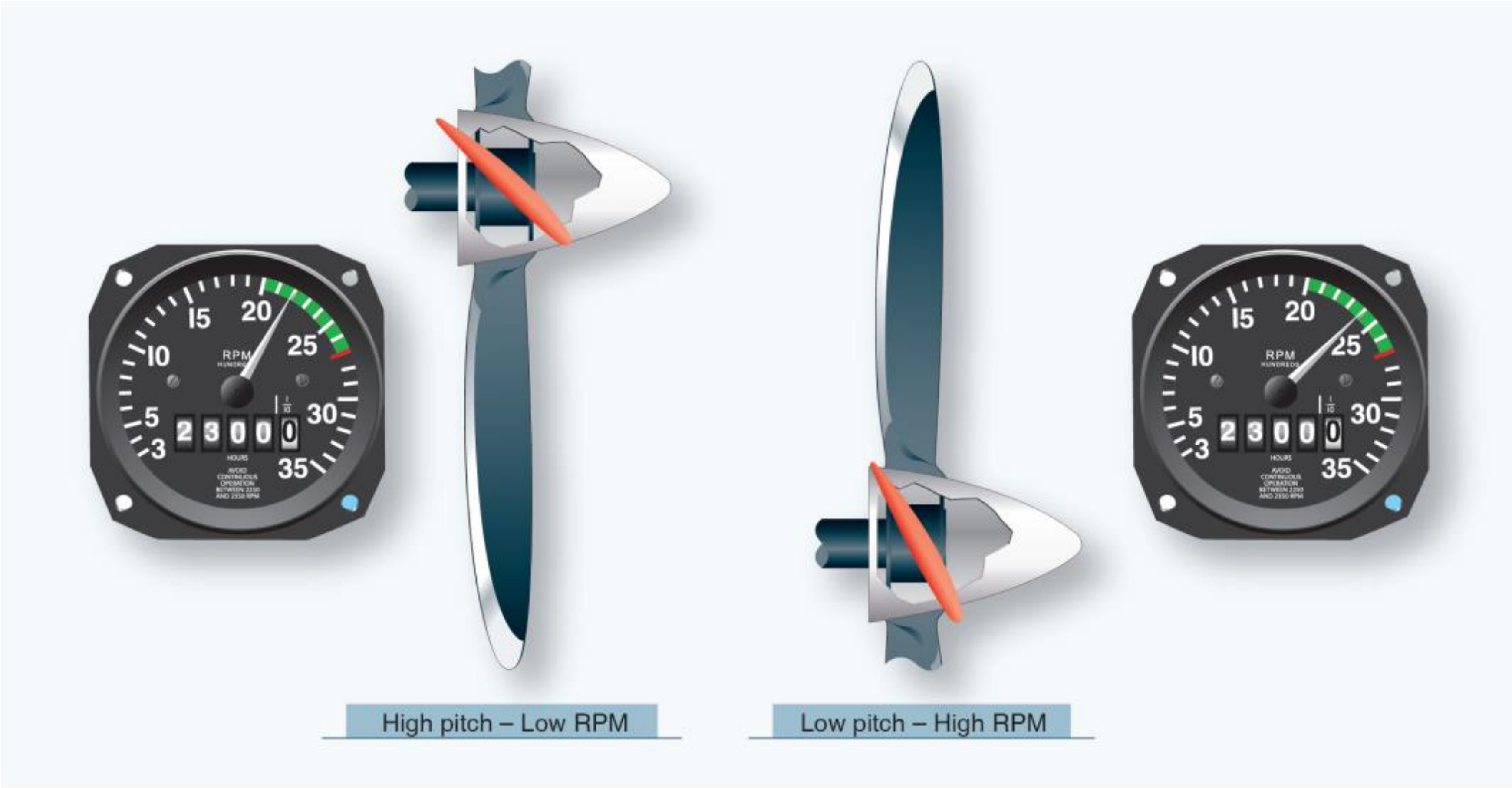


Figure 12-6. *Controllable-pitch propeller pitch angles.*

Left Turning Tendencies

- For some reasons, some airplanes want to turn to the left…
- This tendency is related to four forces related to the engine and the spinning propeller:

    1. Torque reaction
    2. Spiraling slipstream (corkscrew effect)
    3. Gyro precession
    4. P-factor

Left Turning Tendencies

Torque reaction

Spiraling slipstream

P-factor

Gyro precession

- The engine spinning action creates an opposite reaction (Newton law).
- As the engine spins the propeller to the right, the airplane turns to the left.
- Torque is stronger at low airspeed, high power settings and high of attack.

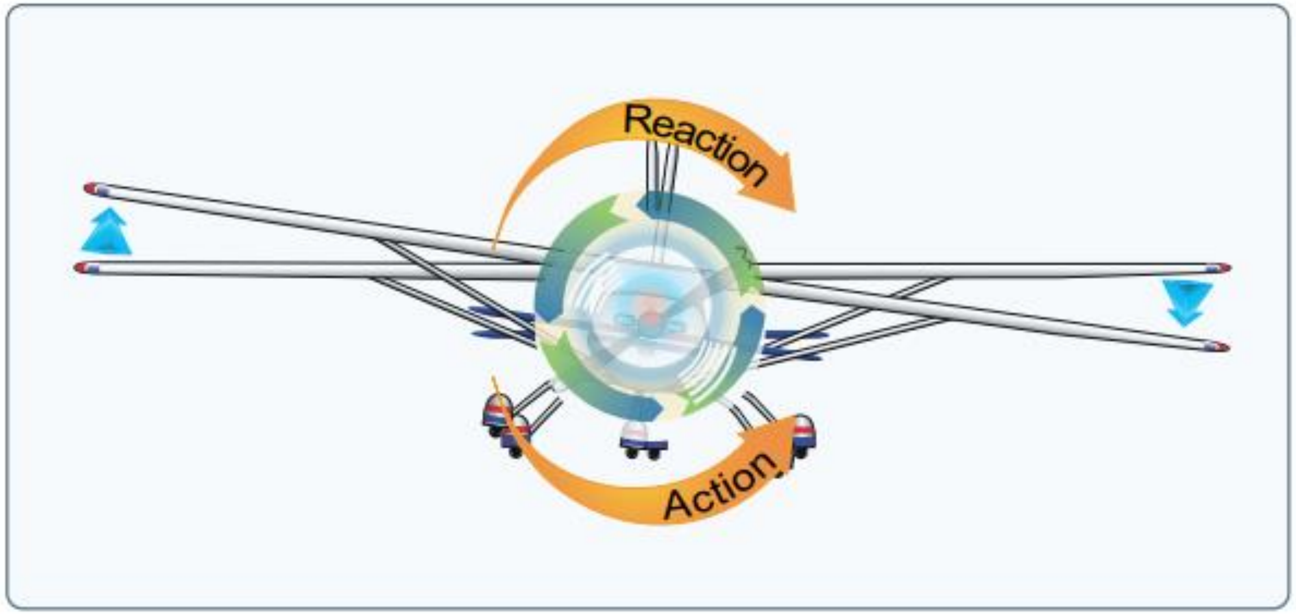


Figure 5-47. *Torque reaction.*

Left Turning Tendencies

Torque reaction

Spiraling slipstream

P-factor

Gyro precession

- As the propeller spins some of the wind spirals around the airplane.
- The air hits the left side of the fin turning the plane to the left.
- Higher at slow airspeed and high power settings.

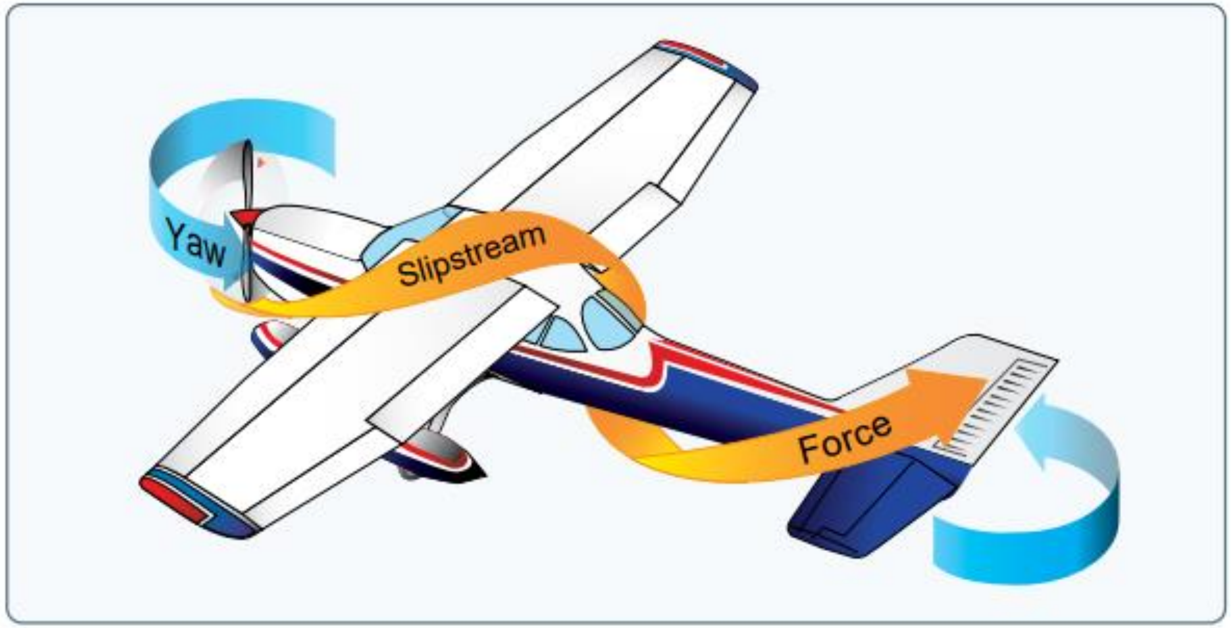


Figure 5-48. *Corkscrewing slipstream.*

Left Turning Tendencies

Torque reaction

Spiraling slipstream

P-factor

Gyro precession

- Occurs when the propeller creates an asymmetrical thrust causing it the plane to yaw slightly to one side.
- The left turning tendency is created when the propeller disc tilts upward and increases the angle of attack of the descending blade.
- P-factor is strongest at high angle of attack.

Note: The angle between the propeller chord line and the relative wind for the propeller is the propeller's angle of attack.
Note: Since the propeller is a rotating airfoil approximately 90° to the aircraft motion, the relative wind it experiences is not the same as the relative wind for the wings.

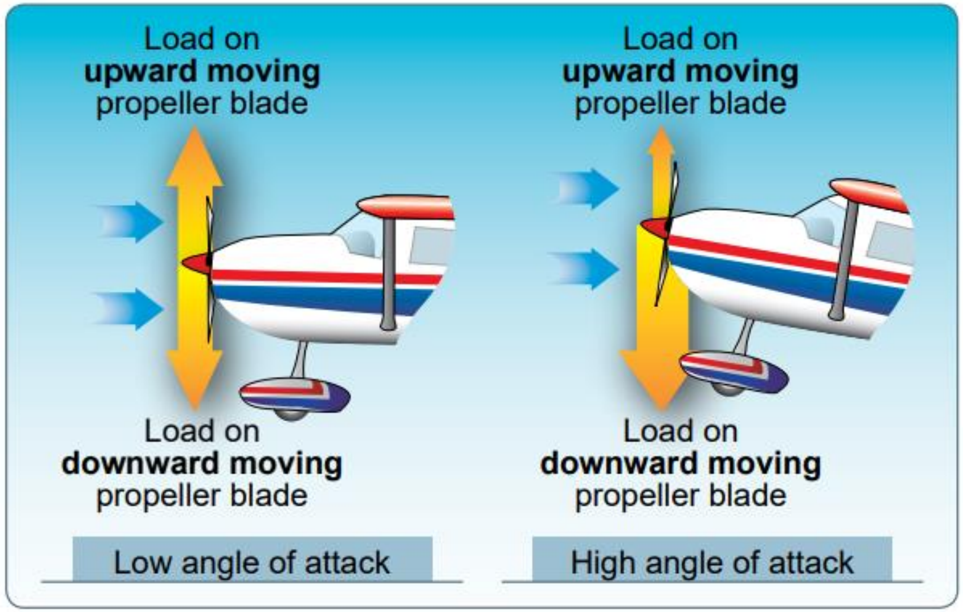


Figure 5-51. *Asymmetrical loading of propeller (P-factor).*

Left Turning Tendencies

Torque reaction

Spiraling slipstream

P-factor

Gyro precession

- A fast spinning propeller acts as a gyroscope.
- When an outside force acts on a gyroscope we get a resulting a force that is 90^{o} ahead of the applied force.
- As the plane pitches down and the propeller turns to the right, the resulting force pushes the plane to the left.

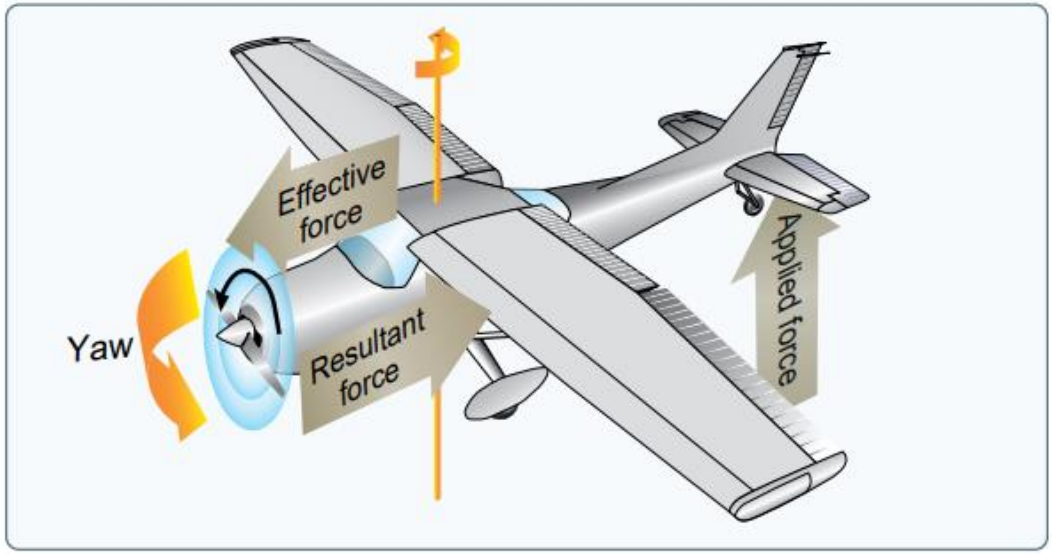
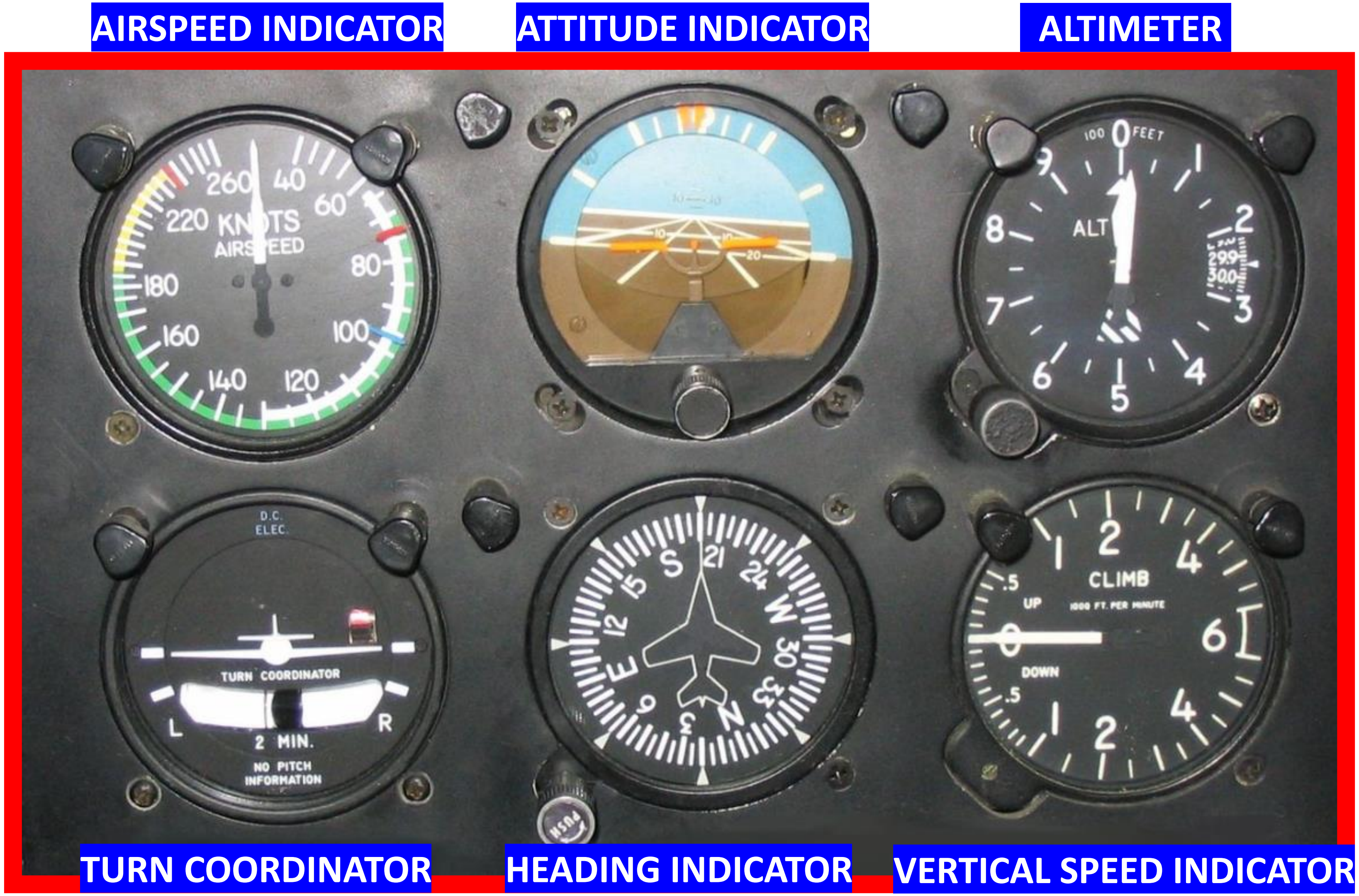


Figure 5-50. *Raising tail produces gyroscopic precession.*

Aircraft Systems II

Flight Instruments

A Typical Instrument Panel



The Instrument Panel (EFD)

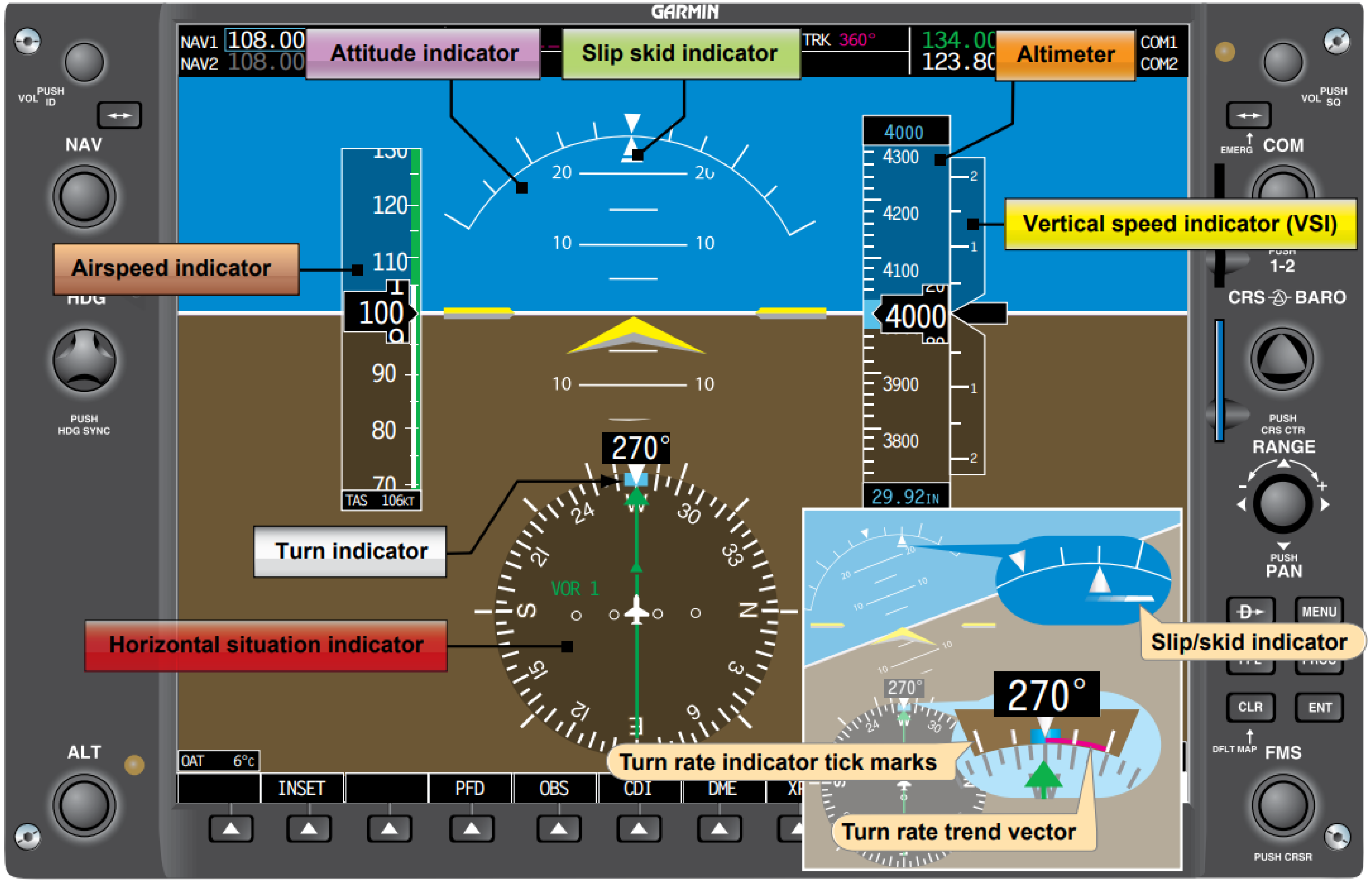
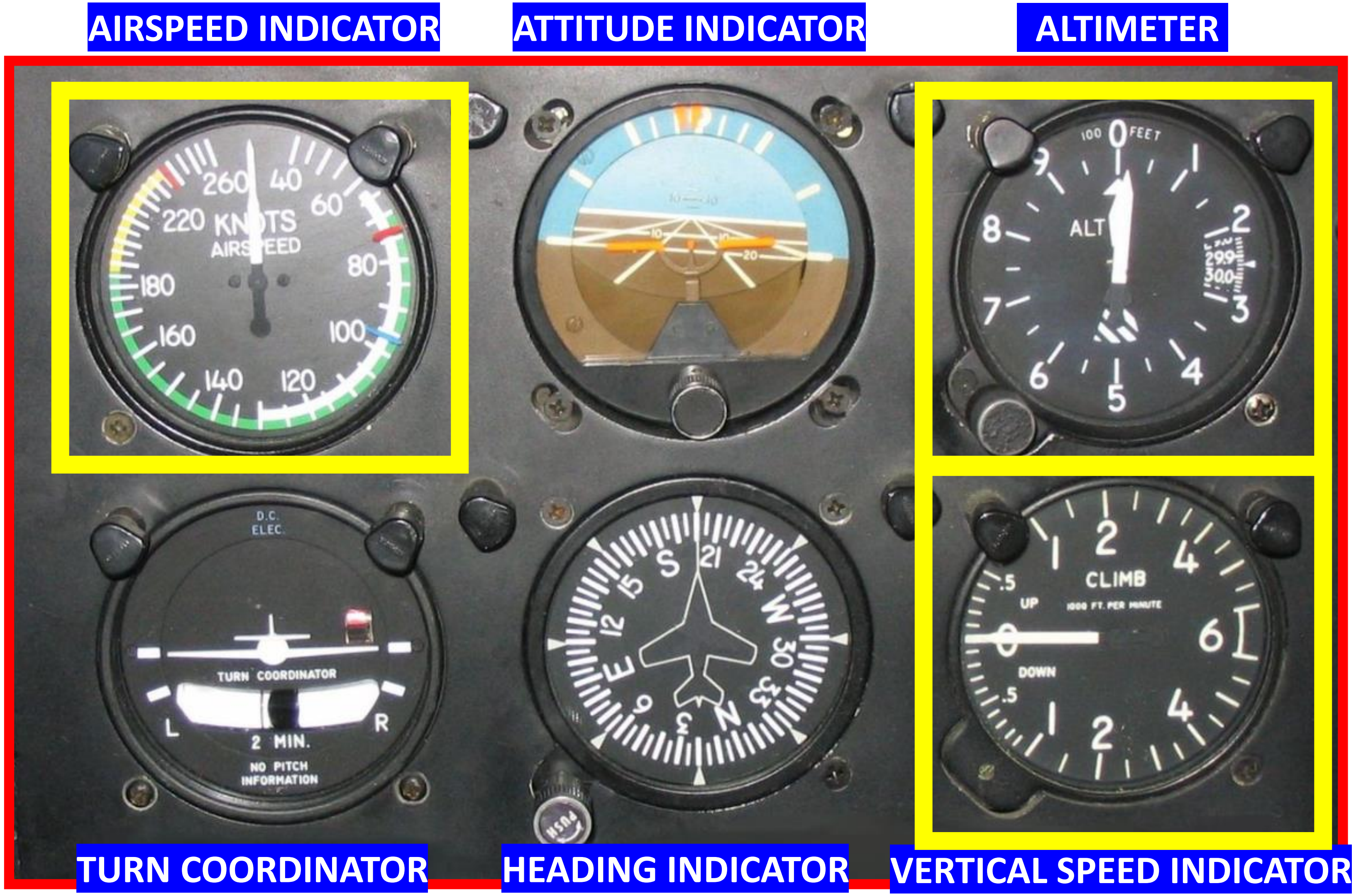
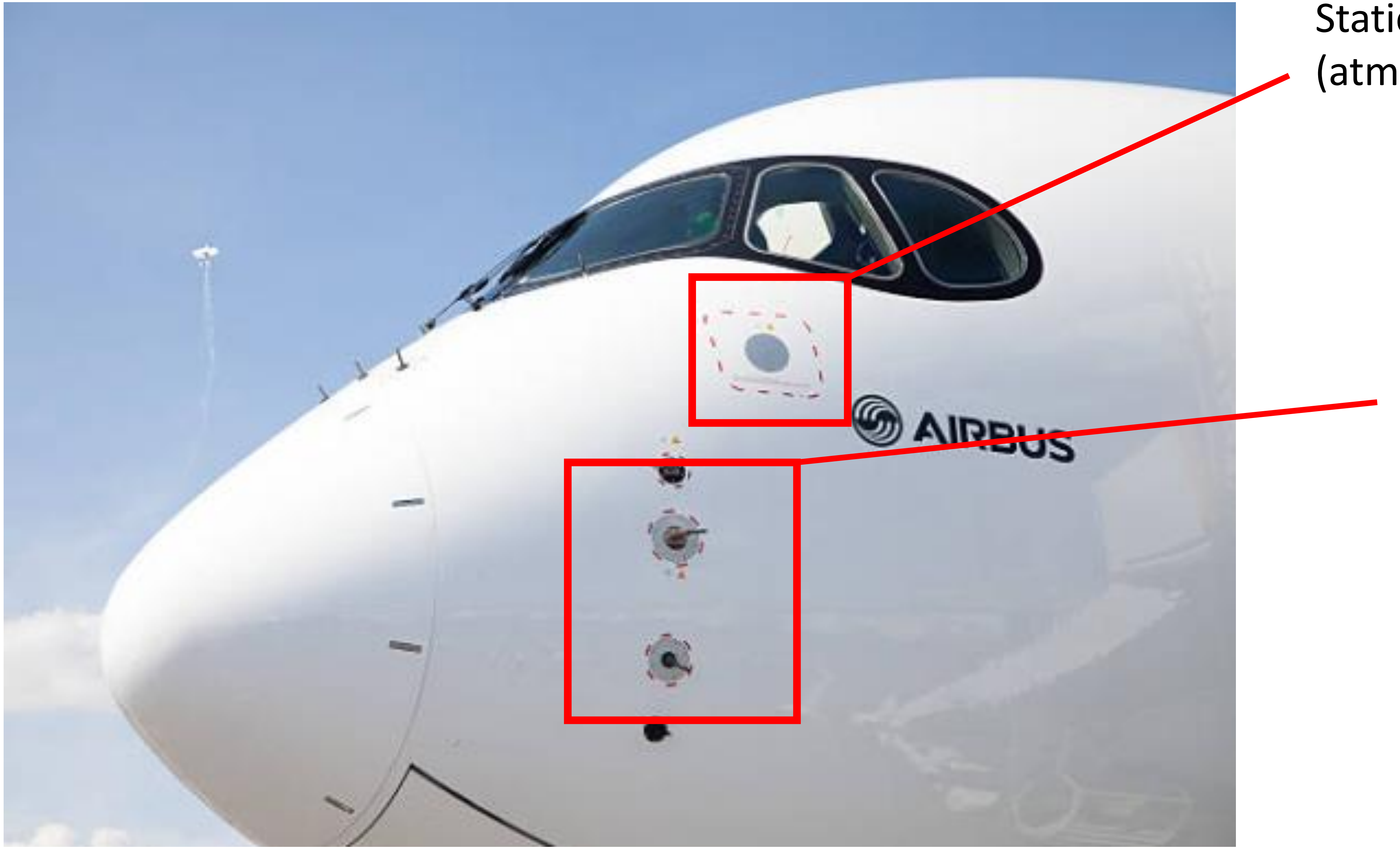


Figure 8-12. *Primary flight display (PFD). Note that the actual location of indications vary depending on manufacturers.*

Pitot-Static Instruments



Pitot-Static Instruments



Static port
(atmospheric pressure)

Pitot tube
(impact pressure)

Pitot-Static Instruments

Affected instruments

The Pitot tube uses impact pressure

Uses atmospheric pressure

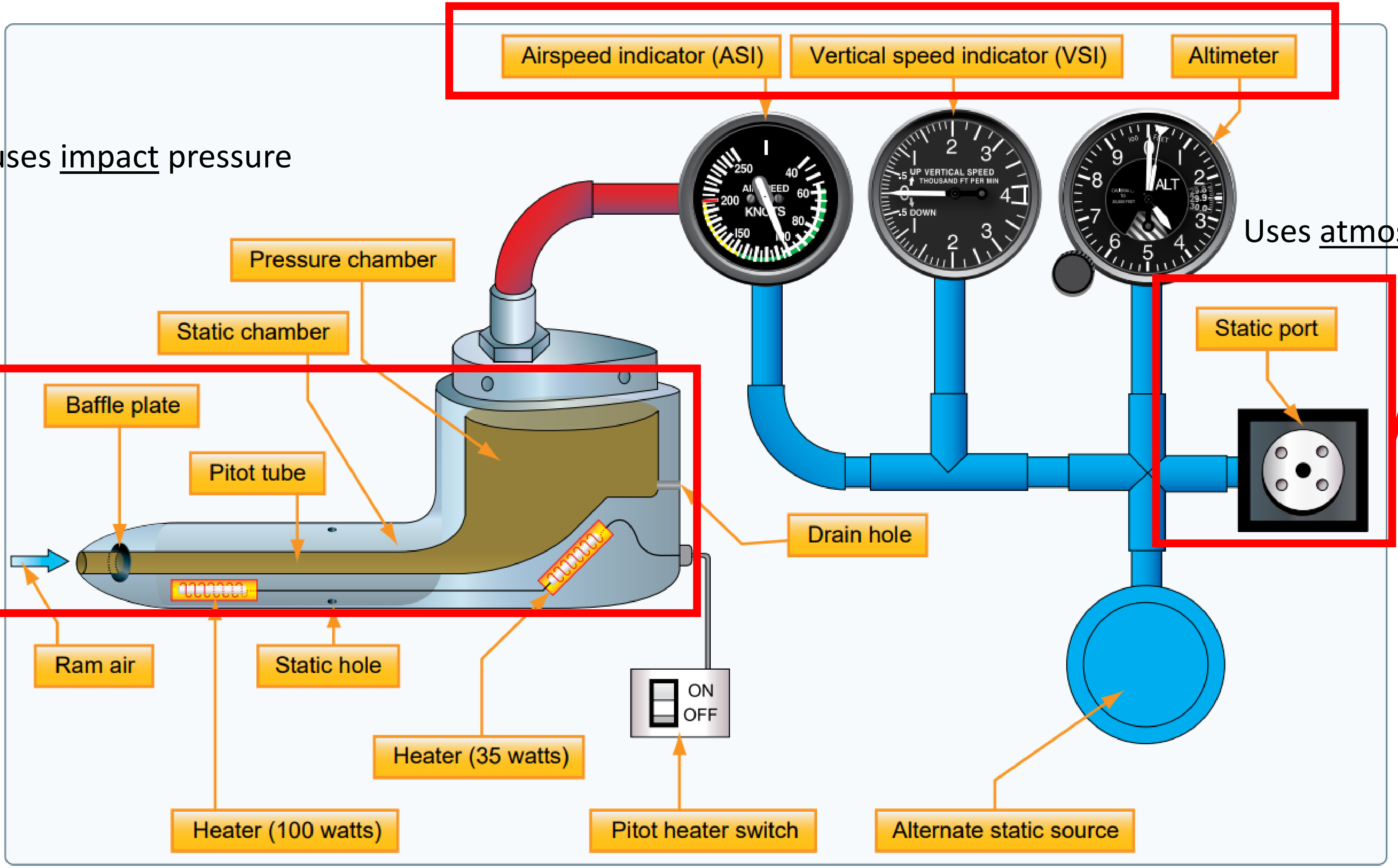


Figure 8-1. *Pitot-static system and instruments.*

Airspeeds and Airspeed Indicators

Caution range (avoided unless in smooth air)

Stall speed landing configuration

Stall speed in a specified configuration

Max structural cruising speed

Flap operating range

Green arc defines the normal operating range

Max flap extended speed

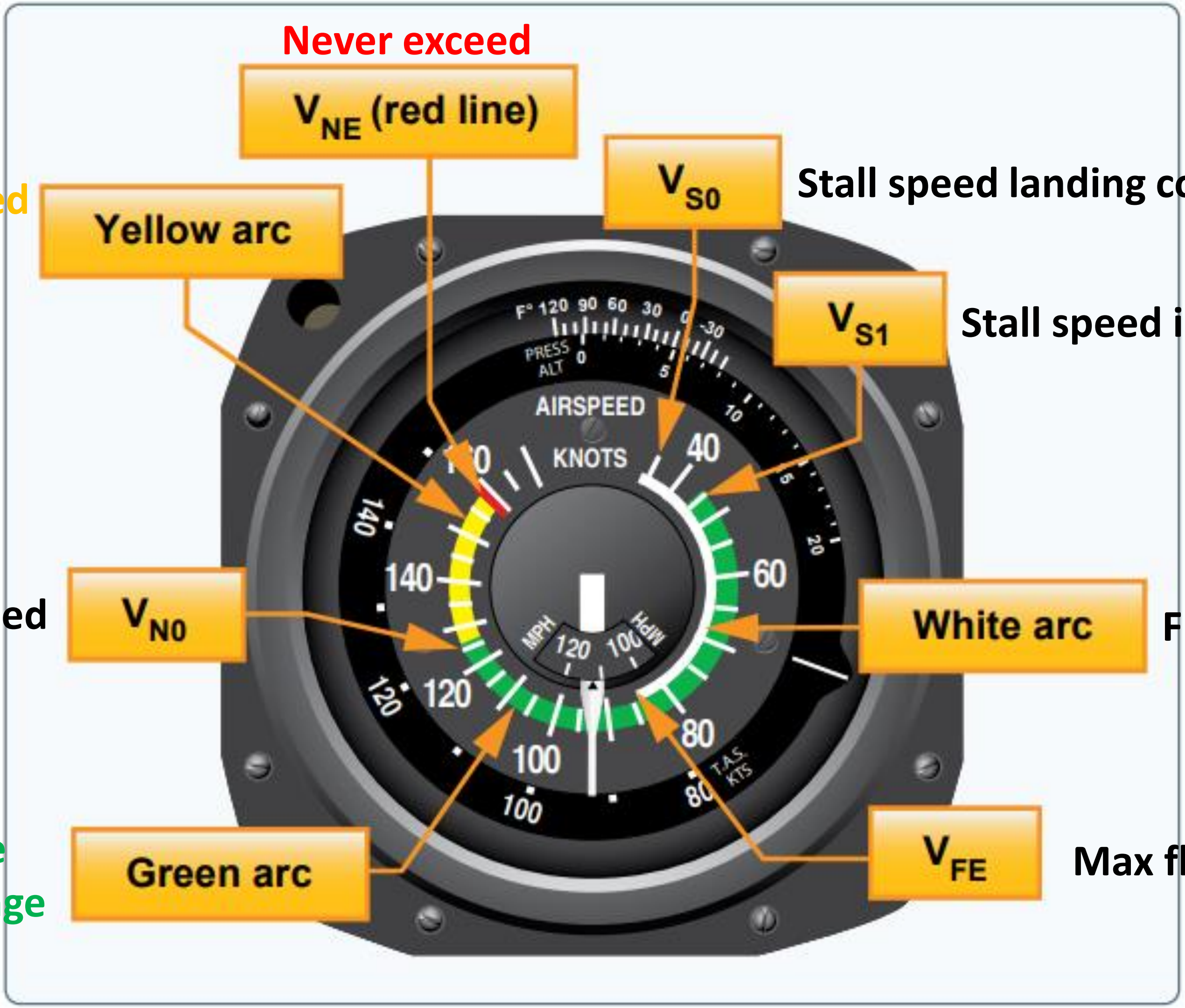


Figure 8-8. *Single engine airspeed indicator (ASI).*

Airspeeds

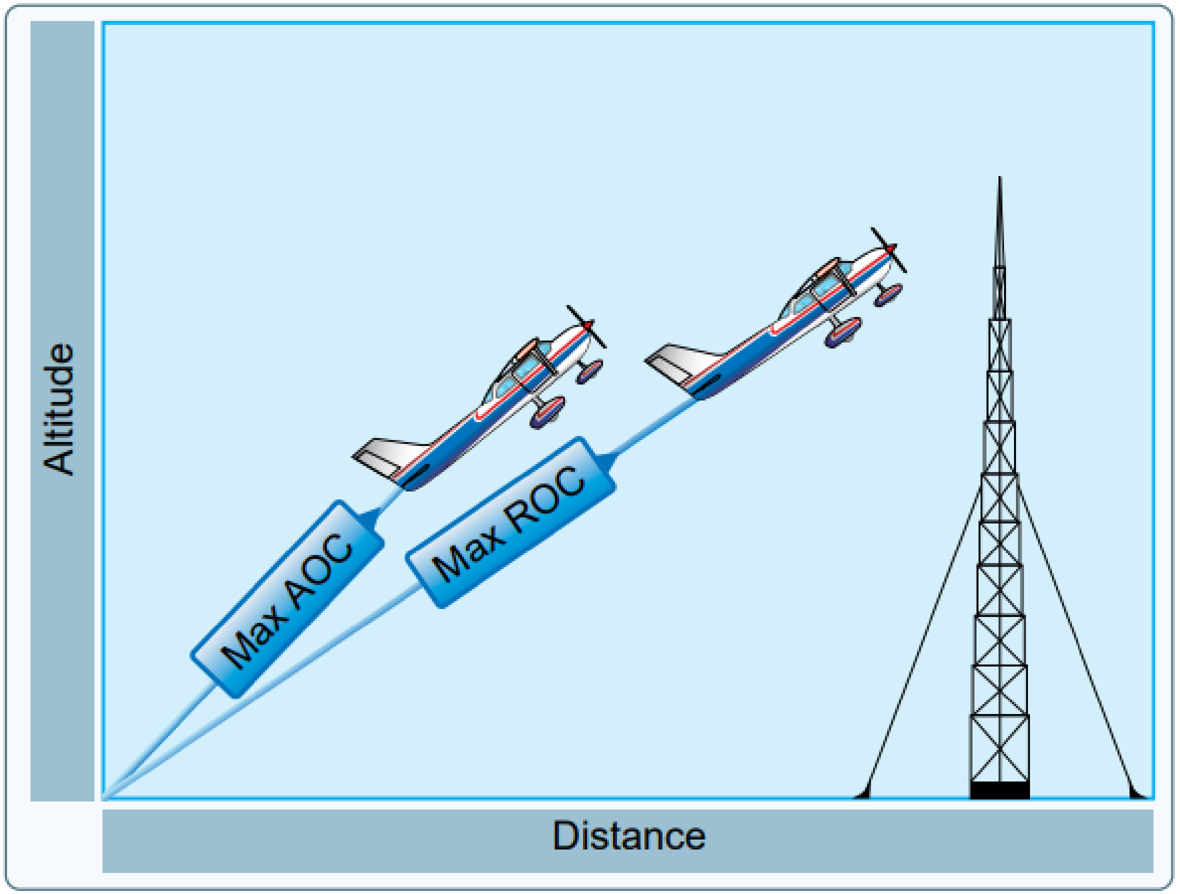


Figure 11-7. *Maximum angle of climb (AOC) versus maximum rate of climb (ROC).*

V_Y – best rate-of-climb (fastest gain in altitude).

V_X – best angle-of-climb (highest gain in altitude gain over a given distance).

V_{LE} – Max landing gear extended speed.

V_A – Design maneuvering speed.

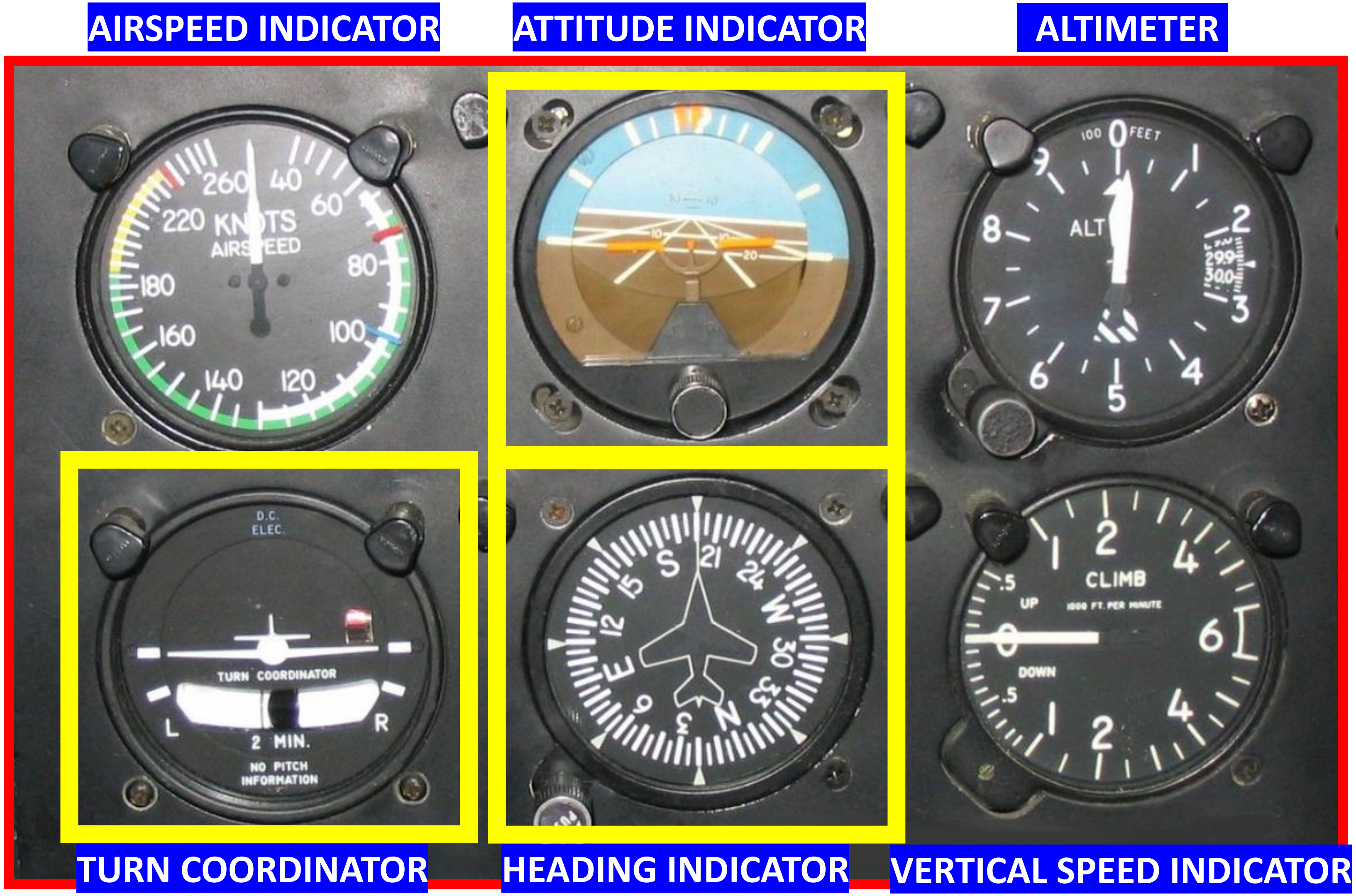
Altimeter and Altitudes

- Measures the altitude relative to atmospheric pressure.
- **Indicated altitude:** read on the altimeter after it is set to the current local altimeter settings.
- **Absolute altitude:** the height above the surface.
- **True altitude:** the true height above mean sea level.
- **Pressure altitude:** altitude indicated when the altimeter setting is adjusted to 29.92 Hg”.
- **Density altitude:** pressure altitude corrected for non standard temperature and/or pressure.

Altimeter Settings

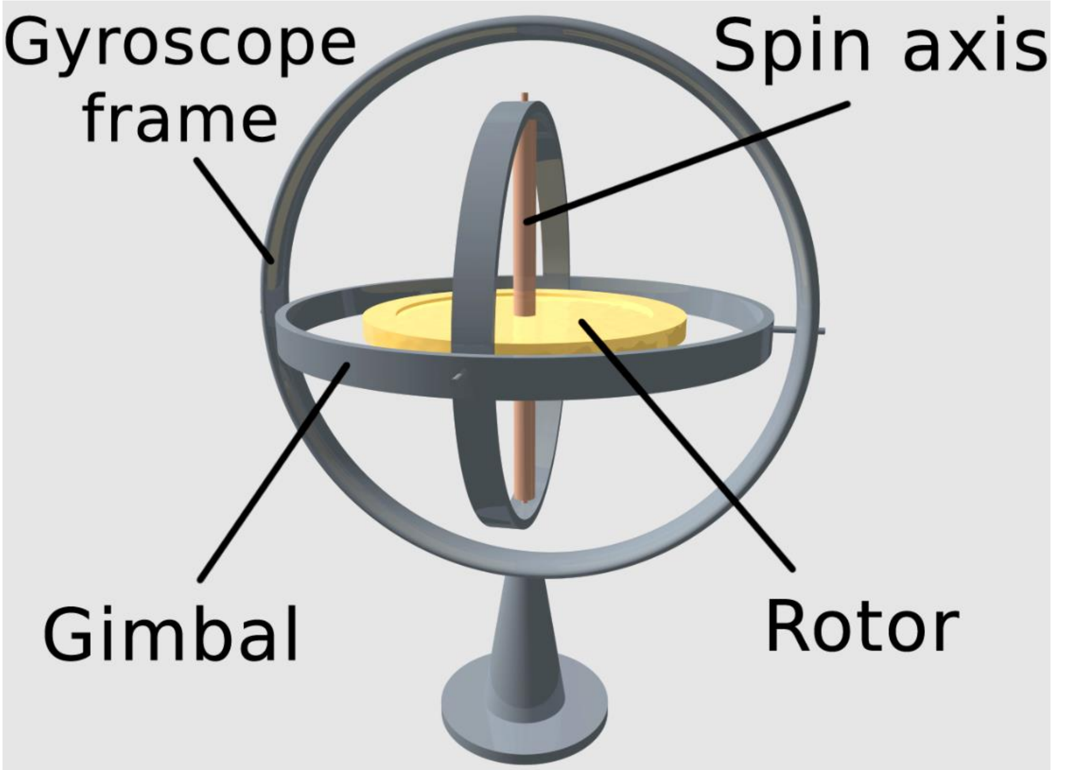
- An altimeter must be set using the correct pressure settings to reflect the correct true altitude (altitude above sea level).
- Altimeter settings are generally provided at the airport over an automated terminal information system (ATIS) that continuously transmit information on a radio frequency.
- When settings are not available, adjust the altimeter to the departure area elevation.
- At 18,000 ft, set the altimeter to 29.92 Hg
- **REMEMBER: Flying from a <u>high pressure</u> area to a <u>low pressure</u> area will indicate a higher than actual altitude above sea level (from high to low, lookout below!!)**

Gyroscopic Instruments



What are Gyroscopes?

- Gyroscopes are rapidly spinning wheels or disks which <u>resists any attempt to move them</u> from their plan of rotation.
- They are used for instruments requiring a certain stability even during minor airplane shakes.



Turn Coordinator

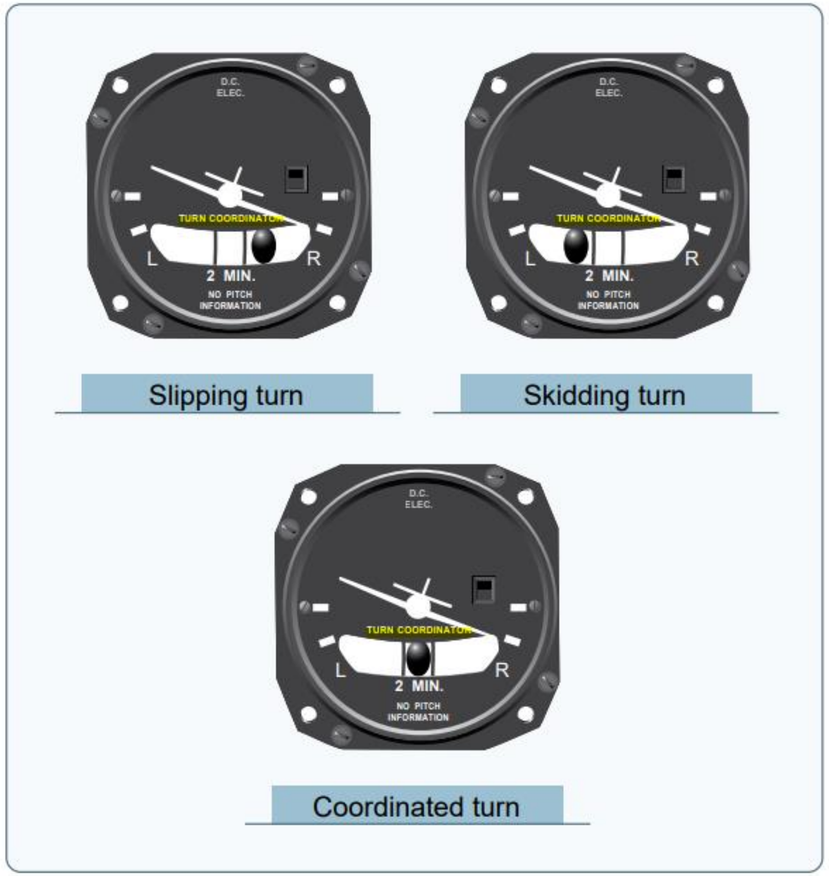


Figure 8-22. *If inadequate right rudder is applied in a right turn, a slip results. Too much right rudder causes the aircraft to skid through the turn. Centering the ball results in a coordinated turn.*

- It displays the rate of turn as well as roll information.
- It is used to determine:

  (1) the coordination of a turn (e.g., is the plane slipping or skidding?)

  (2) the bank angle required for a specific rate of turn (e.g., 2 minutes for 360 degrees).

The Magnetic Compass

Figure 8-32. *A magnetic compass. The vertical line is called the lubber line.*

The compass point towards and downwards (magnetic dip) the magnetic North. It is subject to errors:

1. Deviation: caused by aircraft electrical/metal elements

2. Variation: is the different between magnetic north and geographic north (the magnetic North shifts positions).

3. Laggings: occurs when turning toward N from E or W heading

4. Leading: occurs when turning S from E or W heading

5. Accelerating E or W, will indicate a turn to the N, **decelerating** a turn to the S.

UNOS: undershoot north, overshoot south

ANDS accelerate north, decelerate south