Lesson 2 – Airplane Components and Flight Surfaces

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Category, Class, and Type – Aircraft

- **Understanding the different organizations of aircraft can be confusing.**
  - **Airmen are classified differently than Aircraft. Why?!?!**

1. **Category – Broadest grouping, based on use and environment.**
2. **Class – Narrows the category by design and performance.**
3. **Type – Refers to a specific make and model.**

Aircraft Category

- A general grouping of aircraft with similar characteristics and intended uses.
- Includes:
  - Aerobatic
  - Commuter
  - Normal
  - Transport
  - Utility
  - Limited
  - Restricted
  - Provisional

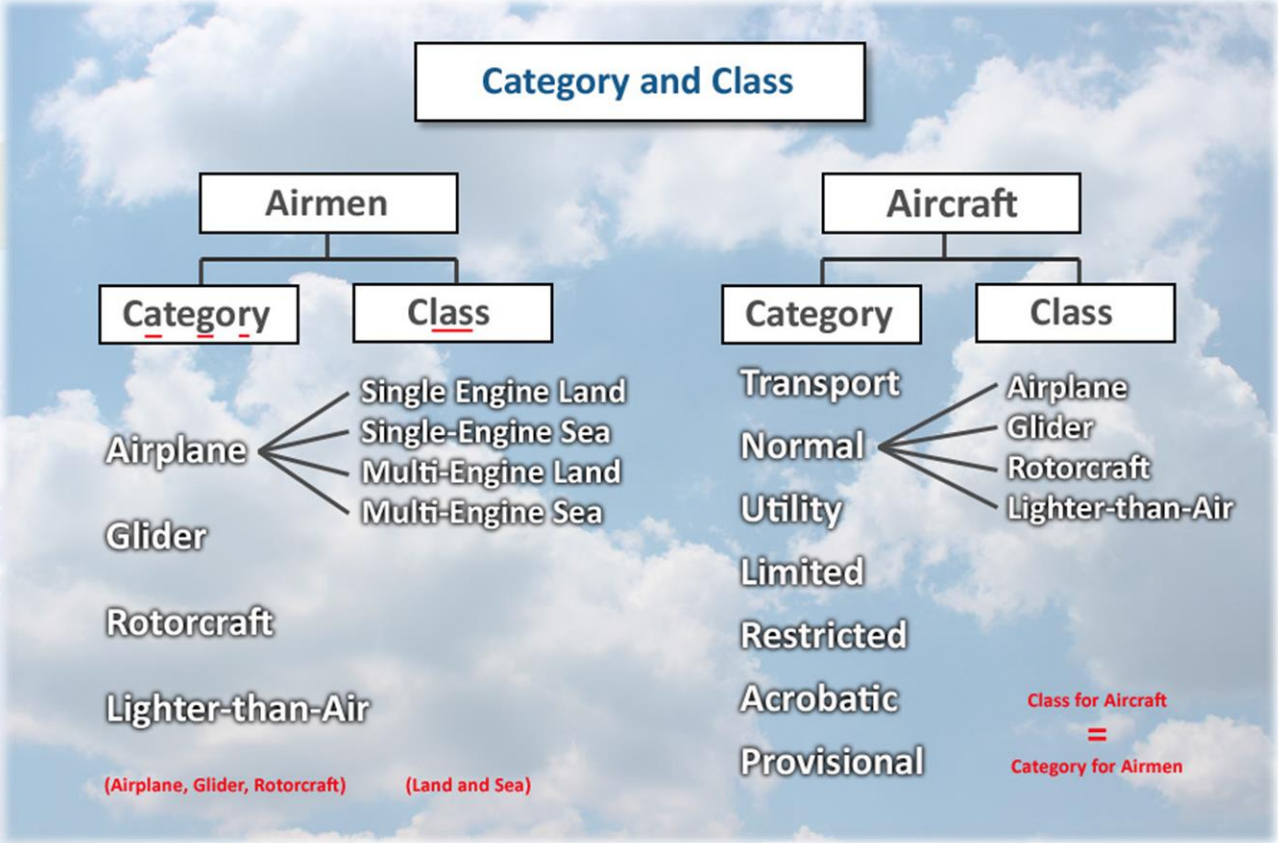
Aircraft Class

- Refers to a more specific division within a category based on design and performance characteristics.
- For example, regarding the Normal Category only, there are four classes:
  1. Airplane
  2. Glider
  3. Rotorcraft
  4. Lighter-than-air

Aircraft Type

- Refers to a specific make and model of an aircraft.
- Examples: Cessna 172, Boeing 737, or Airbus A320.
- The FAA uses type definitions to identify the specific qualifications and certifications required to pilot a certain type of aircraft – an *endorsement*.
  - Examples:
    - High Powered.
    - Complex.

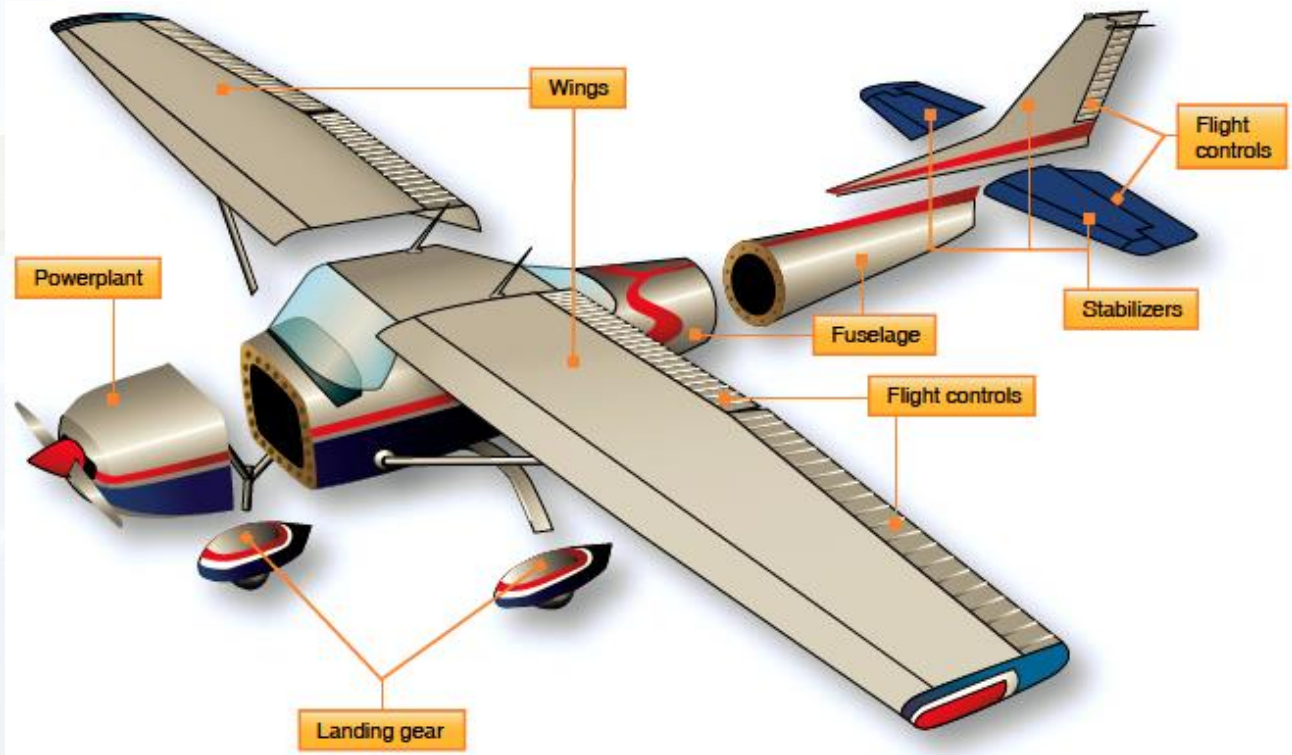
Summary: Aircraft Category, Class, and Type (for Airmen and Aircraft)



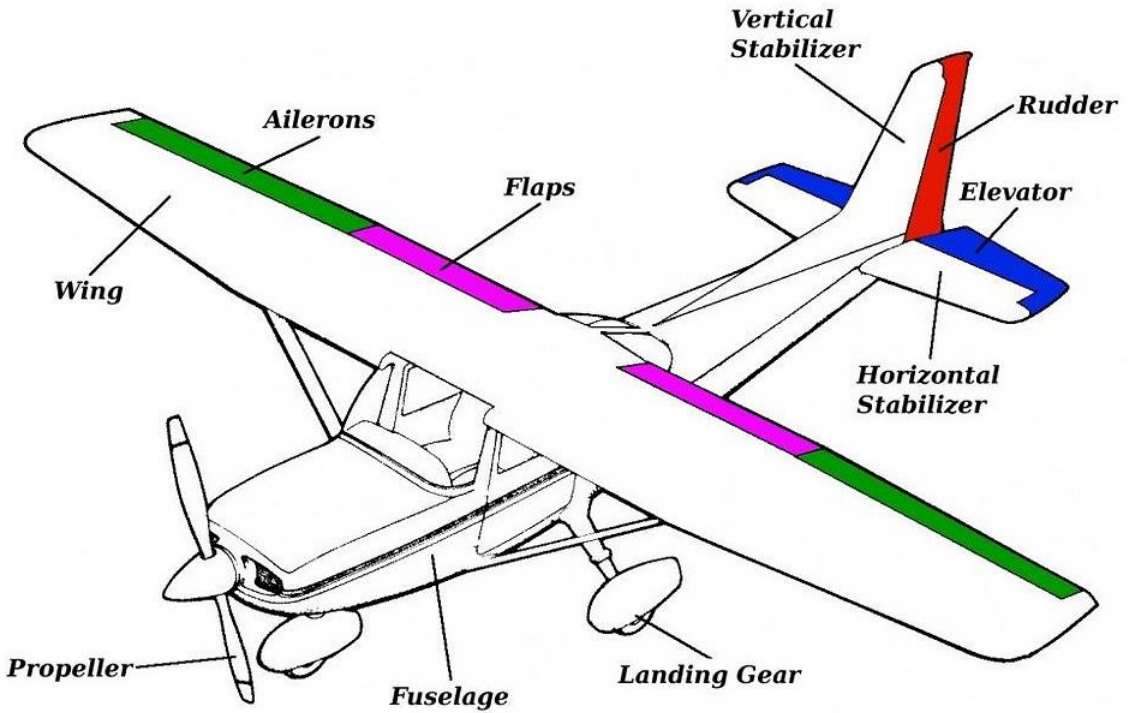
Airplane Components and Control

- Airplanes range from simple home-built machines to complex fight jets.
- All airplanes have common structural and control components.

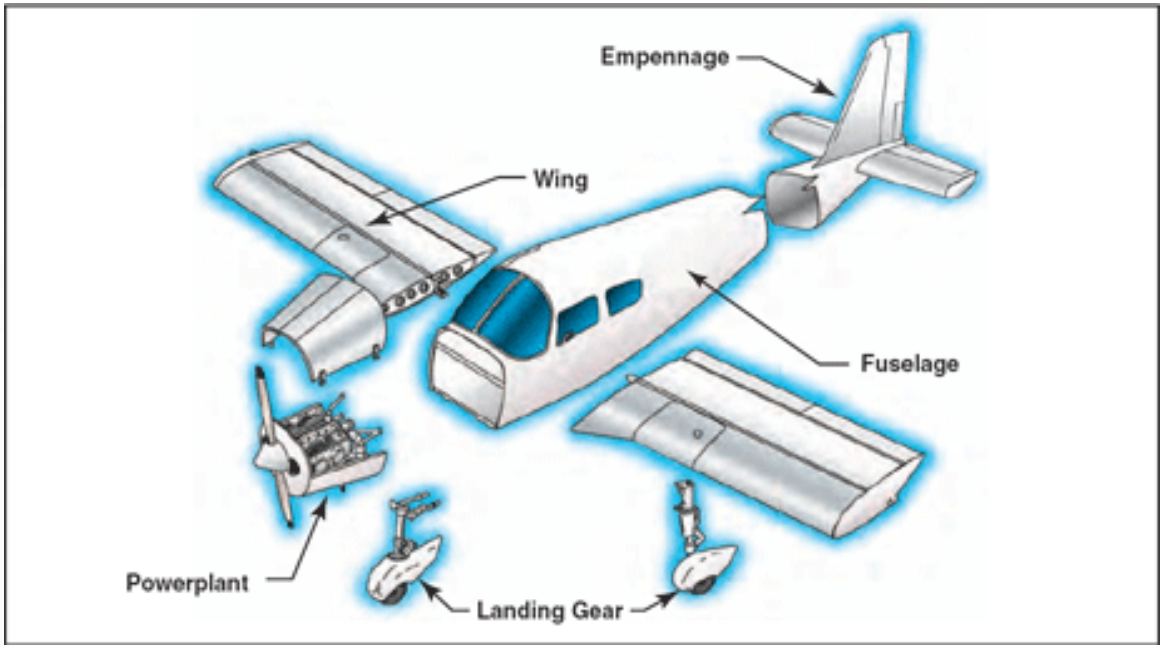
Basic Airplane Components



Airplane Components: Flight Surfaces



Basic Airplane Components: Sections

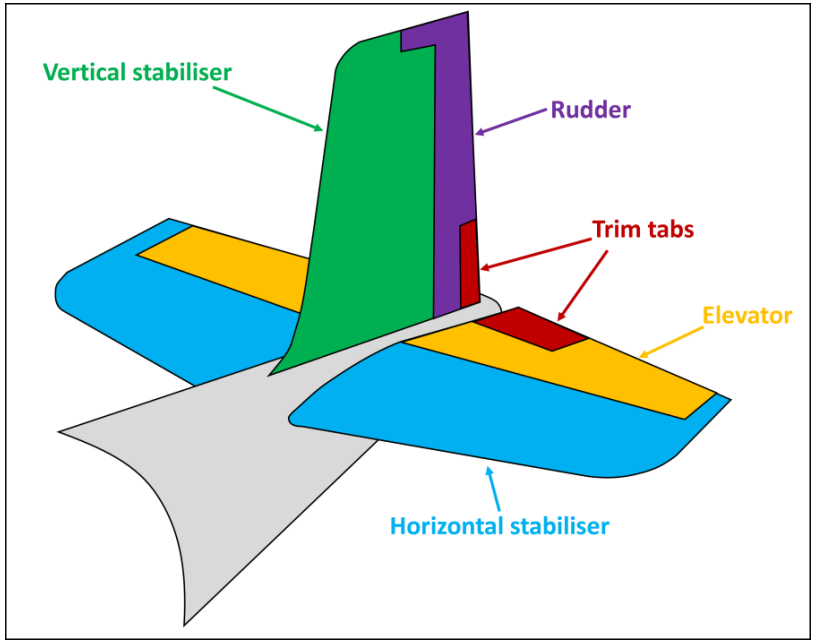


Airplane Components: Fuselage

The fuselage is the central, body-like structure to which all other components are attached.

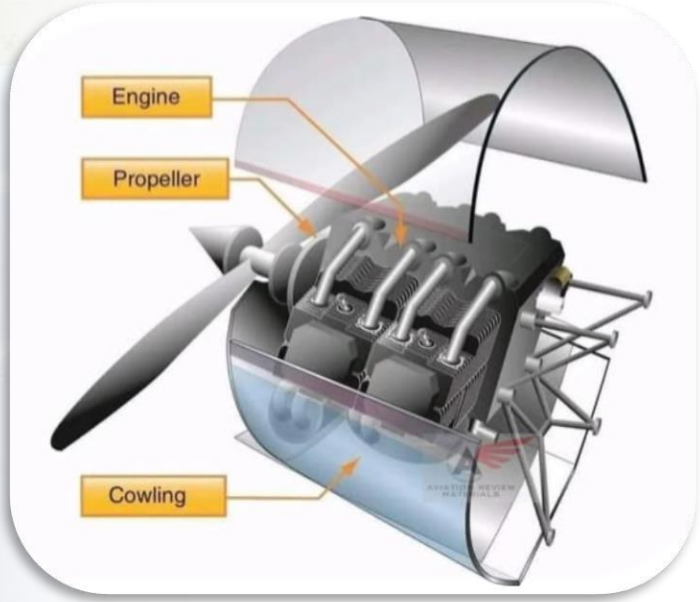
Airplane Components: Empennage

The empennage is the tail section of an airplane, comprising the vertical stabilizer, rudder, horizontal stabilizer, and elevator.



Airplane Components: Powerplant

The engine system, and cavity in which it sits, that generates the power and thrust for the airplane.



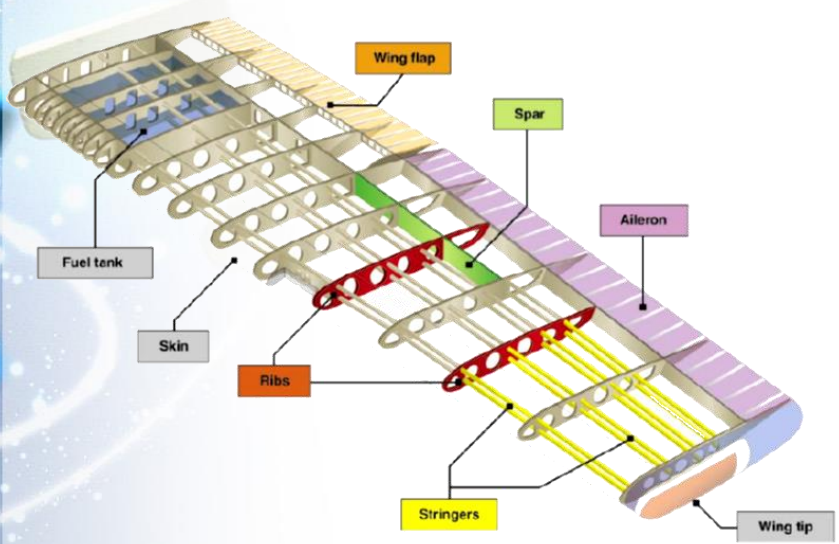
What's the difference…

There are two terms often confused with each other:

1. Nacelle – the entire housing that attaches the engine to the aircraft.
2. Cowling – the outer shell of the nacelle.

Airplane Components: Wings

The horizontal structure that projects from both sides of the fuselage that is the main source of lift.

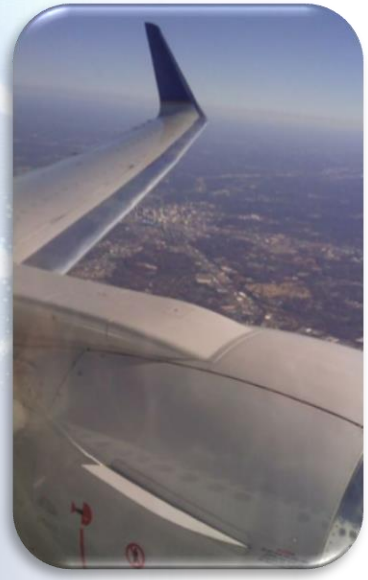


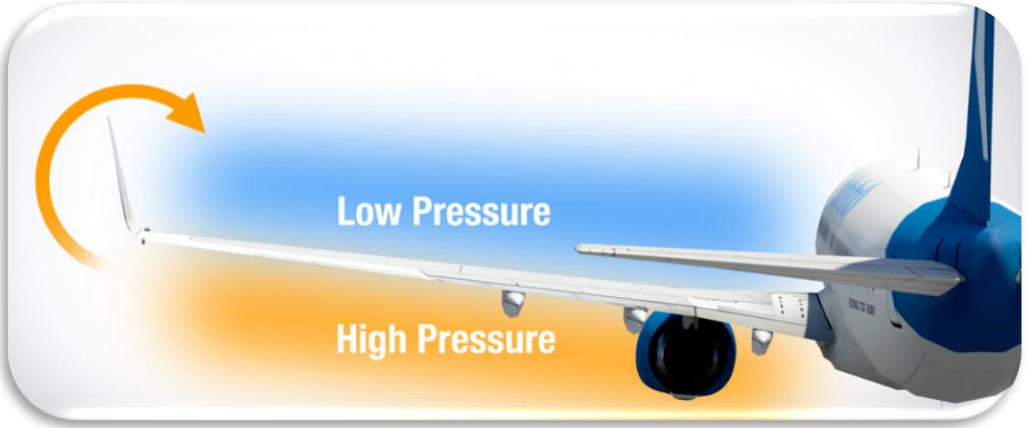
In general:

- **Spar** – the primary structural component providing the overall strength and rigidity.
- **Rib** – perpendicular to the spars, the ribs provide the shape of the wing and provide connection points for other components and the skin.
- **Stringer** – runs the length of the wing and are responsible for transferring the aerodynamic load acting on the skin to the frame.
- **Skin** – the outer covering of the wing that provides the aerodynamic shape and structural strength.
- Note: The wing also contains the
    1. Fuel tank(s)
    2. Flaps
    3. Ailerons

Airplane Components: Wings

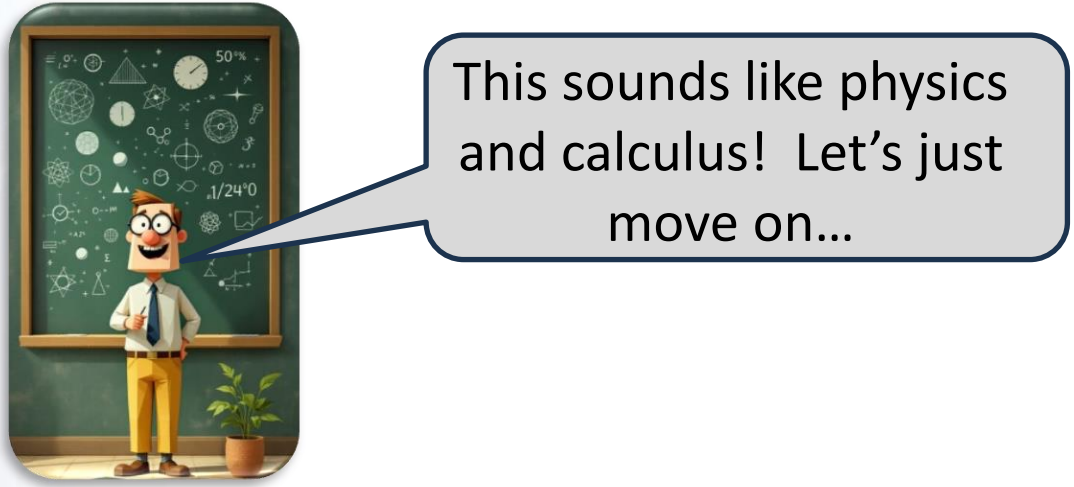
- Winglets are upward extensions on wingtips found on some airplanes.
- They do not act to increase roll performance.
- However, winglets do manage airflow at the tip of the wings, reducing wingtip vortices and induced drag.
- This improves the airplane's stability and aerodynamic efficiency.





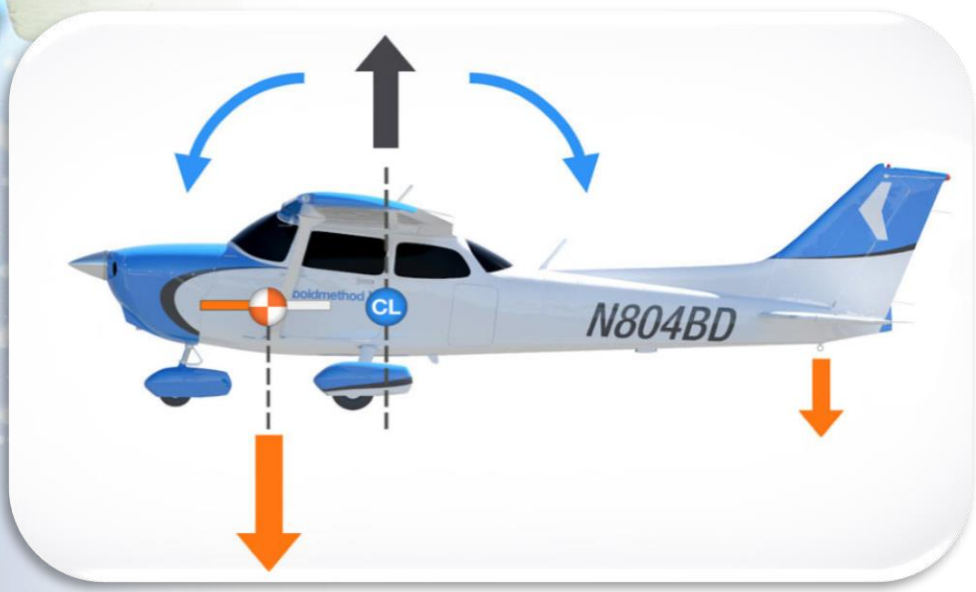
Center of Gravity and Center of Lift

- **Center of Lift** is a point where the entire lift force generated by the wings, control surfaces, and fuselage are said to act.
- **Center of Gravity** is a point where the entire weight of the airplane may be considered.



Center of Gravity and Center of Lift: Stability

Typically, the more forward the Center of Gravity (CG), the more stable an airplane is.



Note: The horizontal stabilizer acts as an inverted wing, generating lift downward, balancing the torque between the CG and CL.

Center of Gravity and Center of Lift: Stability

Positive Static Stability

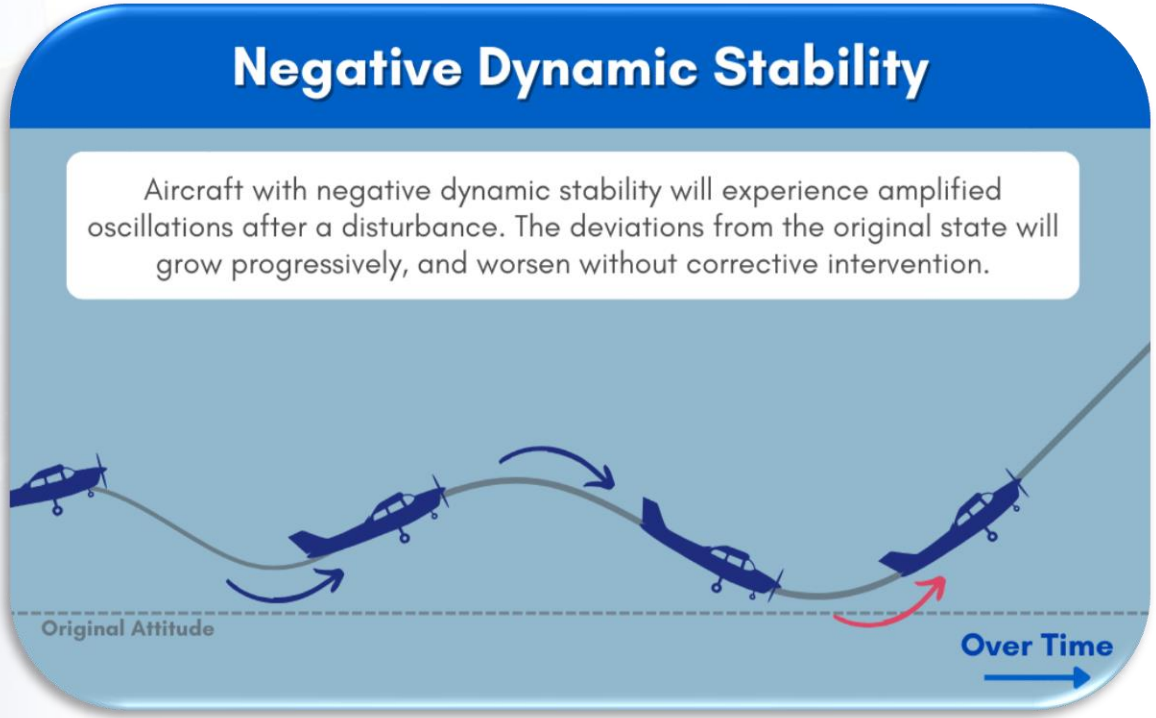
Positive static stability allows an aircraft to naturally return to its original position when disturbed.

Trimmed Straight and Level

Disturbance causing nose-up

Restoring stability with nose-down

Center of Gravity and Center of Lift: Stability



Airplane Components: Landing Gear

The assembly of struts, wheels, and brakes that support the airplane's weight and provide mobility on the ground.

Airplane Components: Landing Gear

<u>Two general types of landing gear to consider in GA airplanes:</u>

1. Fixed – the landing gear assembly does not move. It is cheaper to maintain but does reduce the aerodynamics of the airplane.
2. Retractable – the landing gear is mechanized and can be pulled up to the fuselage or enter cavities in the belly of the airplane. This makes the airplane more streamlined and fuel efficient. However, it is "one more thing" for a GA pilot to worry about and a source of maintenance and repair.

Airplane Components: Landing Gear

Ooooooppppppssss…

Either a forgetful pilot or a mechanical failure.

Airplane Components: Landing Gear

There are two types of landing gear arrangements in GA aircraft:

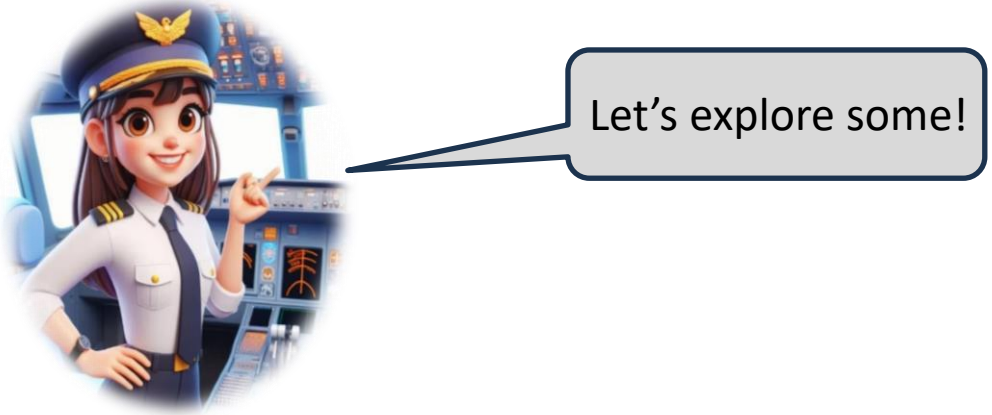
1. Tricycle
2. Taildragger

Airplane Components: Landing Gear

Some airplanes have floats in conjunction with or instead of wheeled landing gear.

Airplane Designs

- There are many…many!...different overall designs for airplanes.
- Pilots are often very passionate about this.
- These design differences are not frivolous nor “just for looks.”
- These design differences affect lift, drag, speed, performance, acrobatic abilities, and efficiency.



Airplane Designs: High Wing Aircraft

- The wings are mounted on top of the fuselage.
- Some examples are the Cessna 150, 172, 177, and 182.

Airplane Designs: Low Wing Aircraft

- The wings are mounted on bottom of or below the fuselage.
- Often have to climb onto the wing to enter the cockpit.
- Some examples are the Piper Cherokee or the Cirrus SR20.

Airplane Designs: Mid-Wing Aircraft

- The wings are attached to the fuselage at the midpoint.
- Often seen in military aircraft.
- Some examples are the Dassault Rafale, the F4-U Corsair, and the F4F Wildcat.

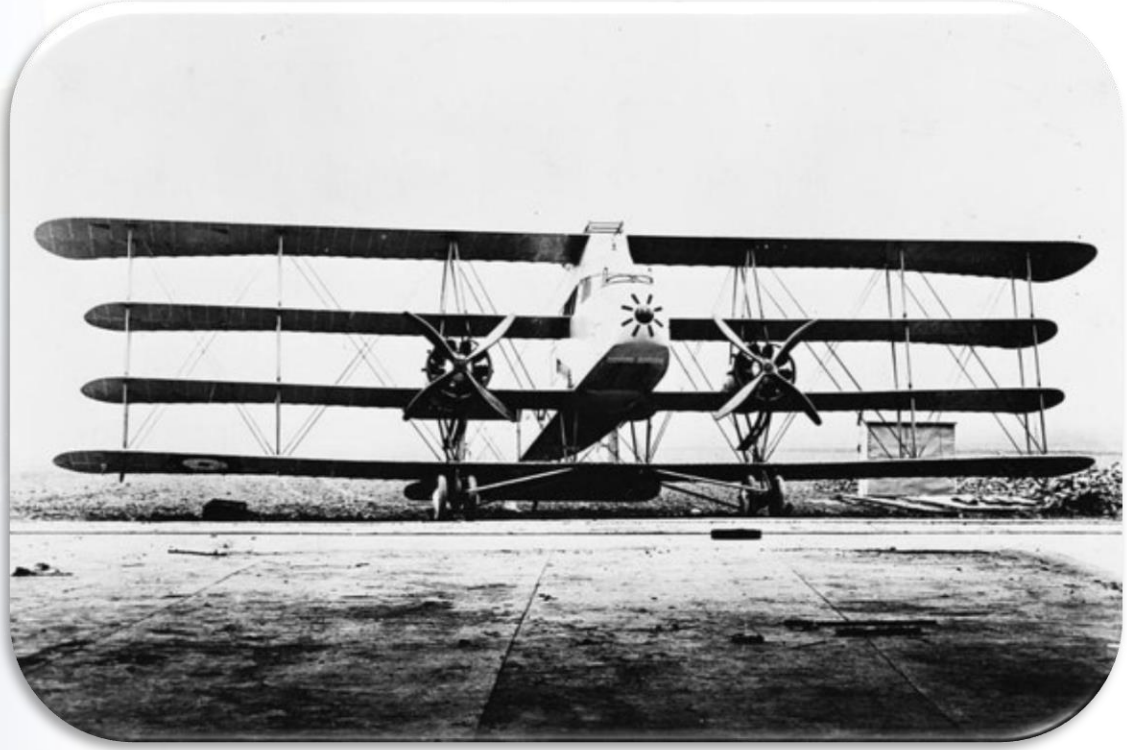
Airplane Designs: Multi-Wing Aircraft

- These airplanes have two (or more) wings attached to the fuselage.
- Examples include: The Wright Flyer (!), the Fokker DR-1, and the Beechcraft Staggerwing.

Airplane Designs: Canard Wings

- A canard wing is a small wing mounted on the fuselage in front of the main wing.
- It increases lift and maneuverability and acts as a horizontal stabilizer.
- Examples include the Saab 37 Viggen and the Beechcraft Starship.

Airplane Designs: Do what…?



Airplane Designs: Twin Vertical Stabilizers

- Having two vertical stabilizers enhances control and stability, especially at high angles of attack.
- Examples include the B-25 Mitchell, the F-35, and the Cessna 337.

Airplane Designs: Multiple Vertical Stabilizers

- Some airplanes have three vertical stabilizers!
- This is the Lockheed Constellation:

Airplane Designs: V-Tail

- A few airplanes have twin stabilizers, with their cosine components acting together to act as the vertical stabilizer.
- An example is the Beechcraft Bonanza:

Airplane Powerplants

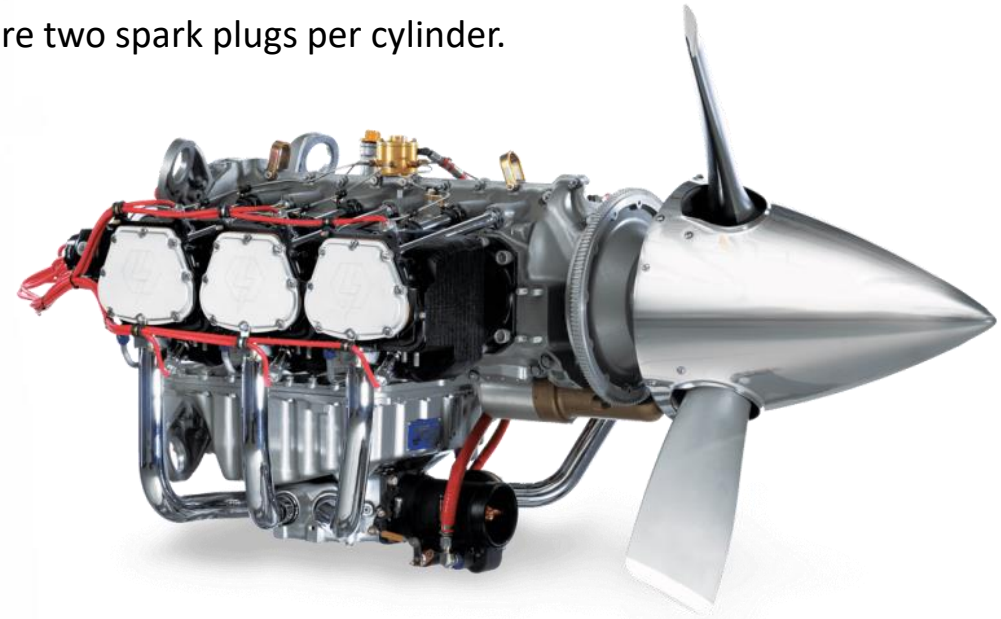
What makes an airplane go, “Vroooooom?”

Airplane Engines

- We will limit our discussion to prop-driven airplanes.
- There are many types of engines (“powerplants”) used in GA airplanes.
  - Think of the many engines that are available for cars.
- This will be a brief summary.
  - Engine Mechanics is a discussion for another time.

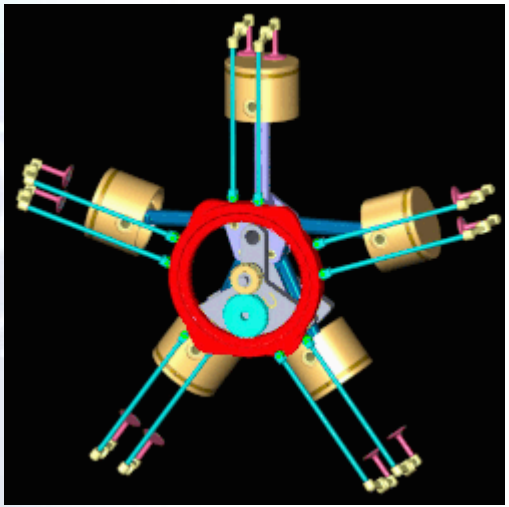
Airplane Engines - Straight 6

- Many GA airplanes (Cessna, Beechcraft, Piper) use a straight, inline 6-cylinder engine.
- The prop is attached directly to the crankshaft and simply rotates 1:1 (until 200 hp).
- These engines may be carbureted, have turbo, or be fuel-injected.
- By being in a straight line (not a “V” design), it runs smoother due to the balance.
- Note: There are two spark plugs per cylinder.



Airplane Engines - Radial Engine

- In a radial design, the cylinders radiate out from a central crankcase.
- The radial engine was used a lot in early aviation.
- Today, they are difficult to service and parts are hard to locate.



Airplane Engines – Tractors & Pushers

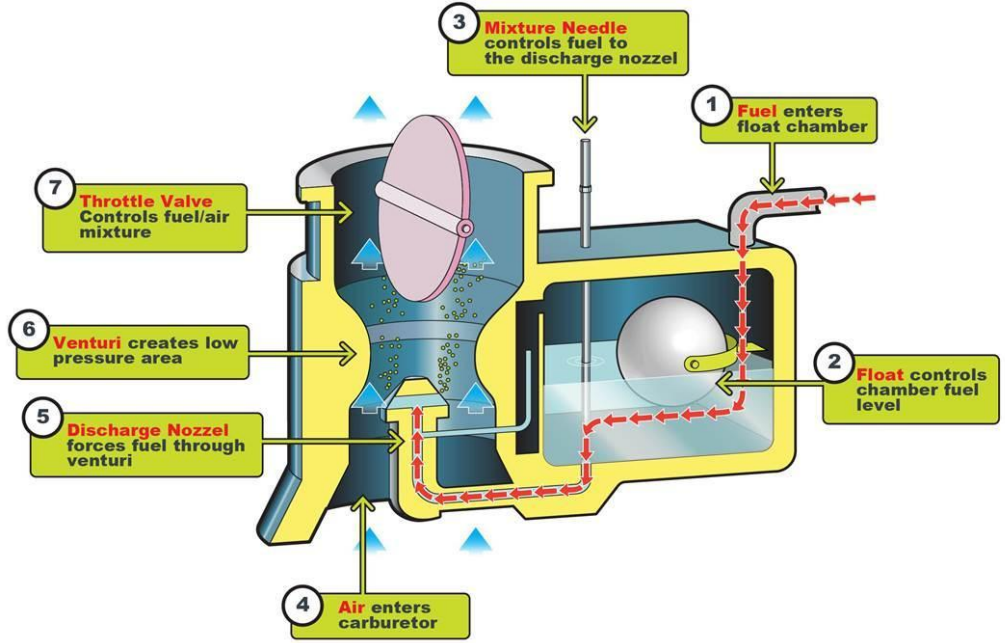
- Engines that face forward and pull the airplane are called, “tractors.”
- Engines the face backwards and push the aircraft are called, “pushers.”
- Some airplanes have both! The Cessna 337:

Airplane Engines – Multiple Engines

- Some GA airplanes have two engines.
- They require a special endorsement to operate.
- They are more expensive and have higher maintenance costs.
- Some examples are the Cessna 414 and the Piper Seminole:

Airplane Engines – Mixture

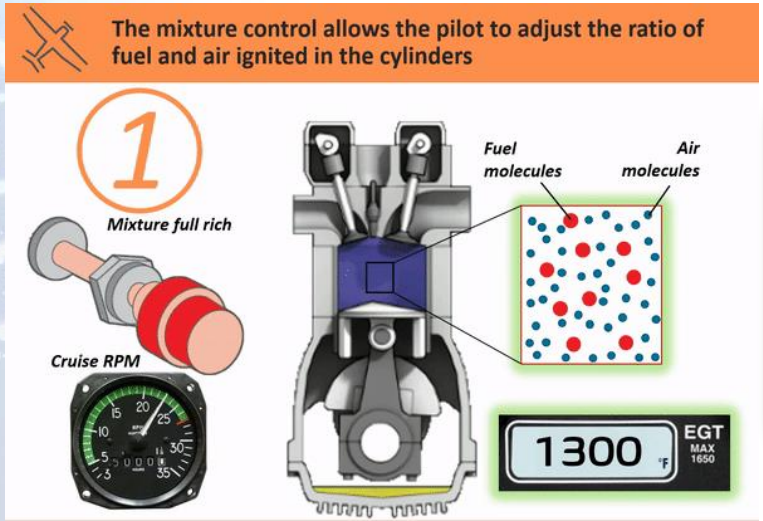
- In an airplane, the throttle controls the total amount of the fuel-air mixture that enters the engine, via the carburetor,controlling the power output.
  - The ratio of fuel to air has already been set and is fixed.
  - As the throttle is increased, so is the engine rpm, just like pushing the accelerator on a car.



Airplane Engines – Mixture

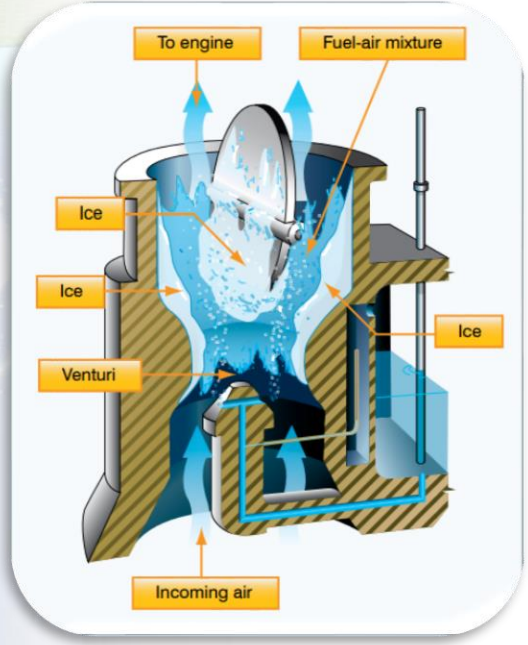
Mixture is the ratio of air to fuel.

- In an airplane, the ideal mixture ratio is 14:1; that is 14 pounds of air for one pound of fuel (stochiometric).
- However, this ratio must be changed during different phases of flight.
- During takeoff, for example, a richer mixture (more fuel) is needed than what would be needed during cruise.
- Note that as an airplane gains altitude, the atmospheric air gets thinner. Therefore, the mixture must be leaned – less air entering the carburetor must be balanced with less fuel.
- The pilot controls the mixture with a second lever by the throttle. It is not automatically done and must be adjusted based on the "feel" of the airplane.



Airplane Engines – Carburetor Freezing

- There is one final consideration regarding airplane engines that we do not consider with cars: carb freezing.
- The carburetor of an airplane is a type of Venturi Tube – a narrowing of the path accelerates the airflow.
  - This drops the pressure and the temperature of the carburetor throat.
- To prevent the carburetor from freezing, a pilot must manually turn on a Carburetor Heater, usually below 2000 rpm at lower altitudes.
- (Definitely an argument for fuel injection!)



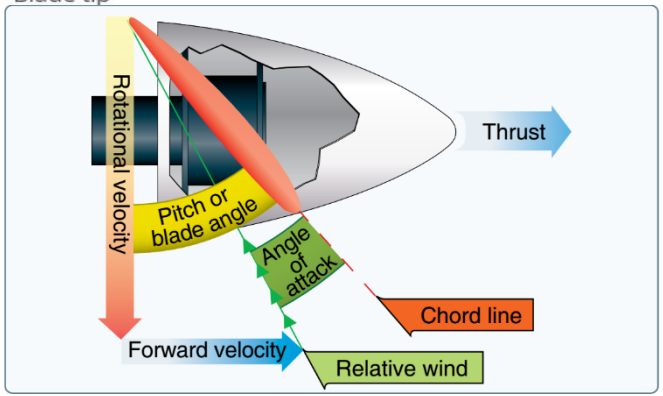
Propellers

- A propeller is a device that generates thrust by rotating blades, which pulls air from the front and pushes it backwards at high speed (Newton's Third Law).
- Propellers are a science all their own.
- Pilots/Owners of GA aircraft select a propeller based on their preferences or needs (speed, stability, efficiency).
- Most in GA have two or three blades.

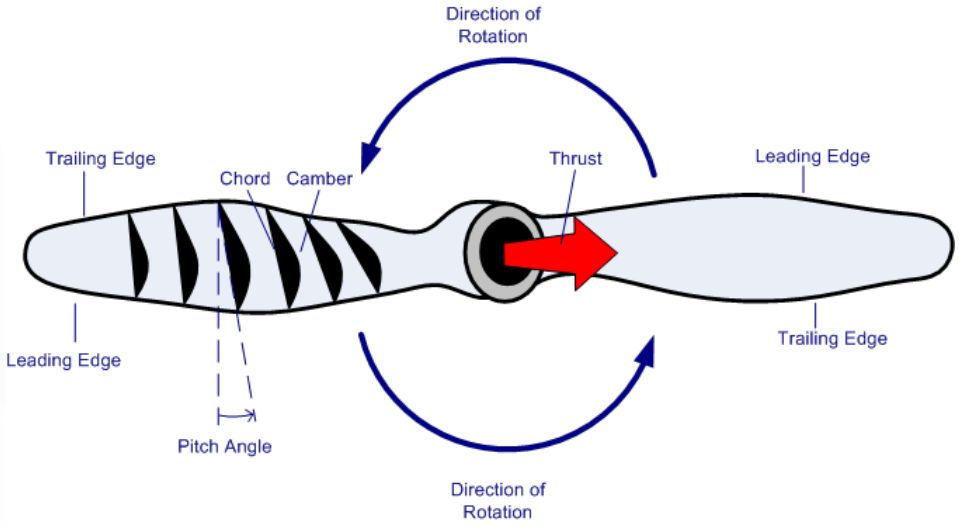
Propellers – Components

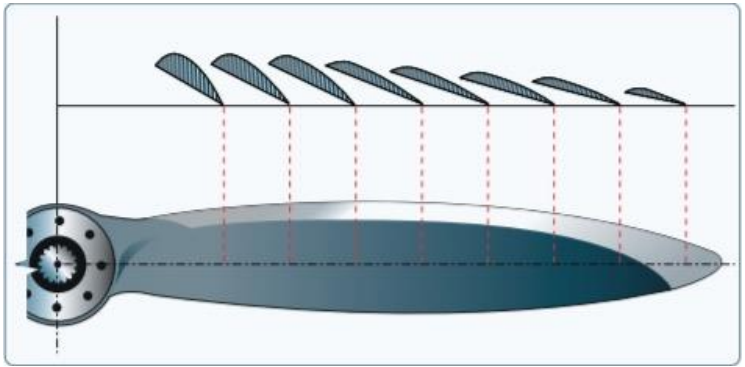
General Propeller Terms

- **Hub** – The central component where the blades are attached.
- **Blade Tip** – the extreme outer edge of the blade.
- **Leading Edge** – the forward-facing, thick edge of the blade that makes contact with the air.
- **Trailing Edge** – the rear edge of the blade where air flows away after being pushed by the propeller.
- **Chord** – A line that connects the leading edge to the trailing edge.
- **Camber** – the curvature of the blades that creates the pressure differential.
- **Pitch Angle** – the angle between the chord line and the plane of rotation.
- **Angle of Attack** – the angle between the chord line and the relative airflow.
- **Twist** – the gradual change in the propeller blade's angle from the hub to the blade tip.



Propellers – Components





The twist goes from course to fine as it moves from hub to tip.

Propellers – Fixed and Variable

With all their complexities and considerations, there are two different ways a propeller is attached/manipulated in GA airplanes.

1. Fixed-Pitch Propeller

- Often found in engines less than 200 hp.
- Here, the angle of the blades are fixed and the propeller is attached directly to the crankshaft.
- Thrust is controlled by engine rpm (through the throttle); that is, rpm and airspeed are directly correlated.

Propellers – Fixed and Variable

2. Variable-Pitch (constant speed) Propeller

- Often found in engines greater than 200 hp.
- Here, the blades can rotate along their long axis to change their pitch, improving efficiency.
- Airplanes so-equipped require a special endorsement and have an additional lever on the dash.
- With this configuration, throttle controls the manifold pressure (power), while the propeller lever controls the blade pitch and, consequently, the rpm.