LEVEL 4
COMBINED AVIATION REVIEW

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PO 431 – EXPLAIN PRINCIPLES OF FLIGHT
- M431.01 – EXPLAIN FEATURES OF WING DESIGN
- M431.02 – DESCRIBE FLIGHT INSTRUMENTS

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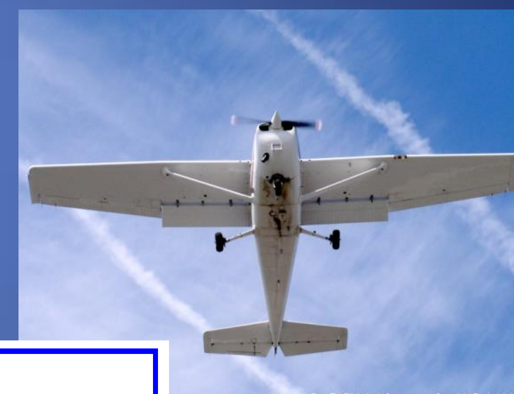
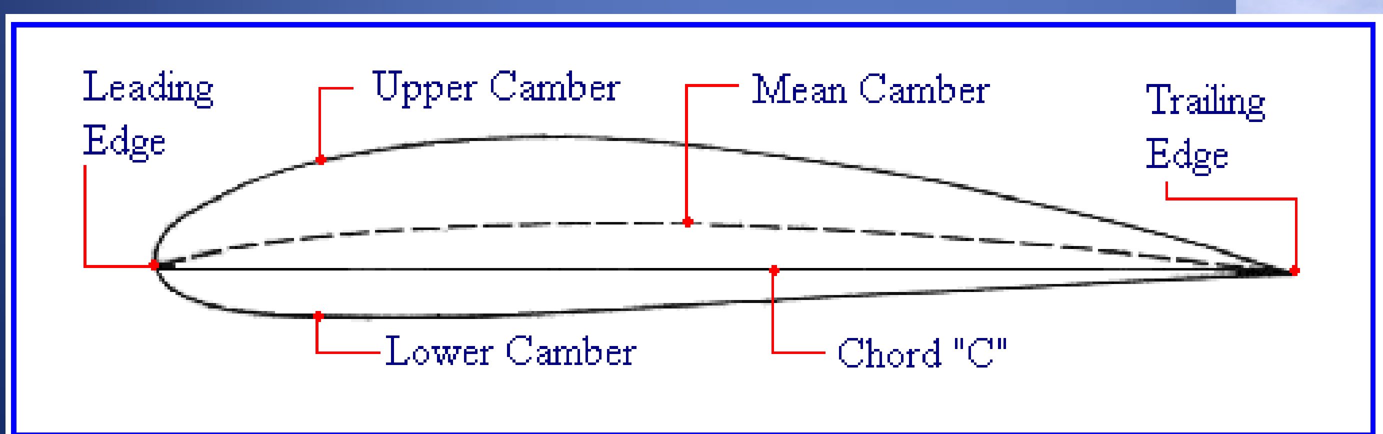
M431.01 – EXPLAIN FEATURES OF WING DESIGN

CHAMBER & CHORD

- **Chamber** is a measure of the curvature of an airfoil
- **Chord** is the imaginary line between the leading edge and the trailing edge of the wing
- Conventional airfoils are generally thickest at 25% chord.

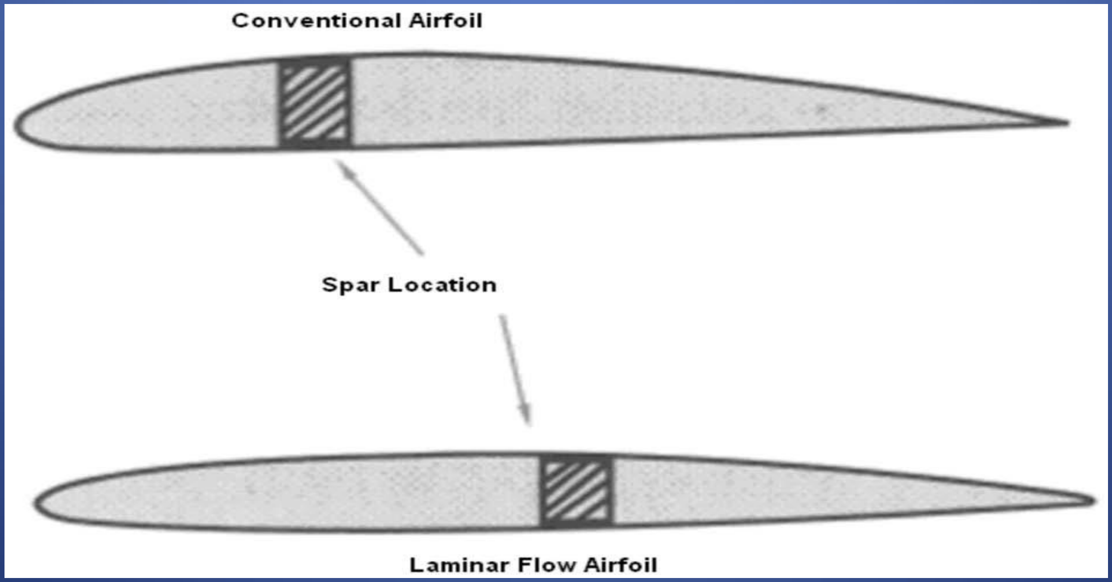




AIRFOILS

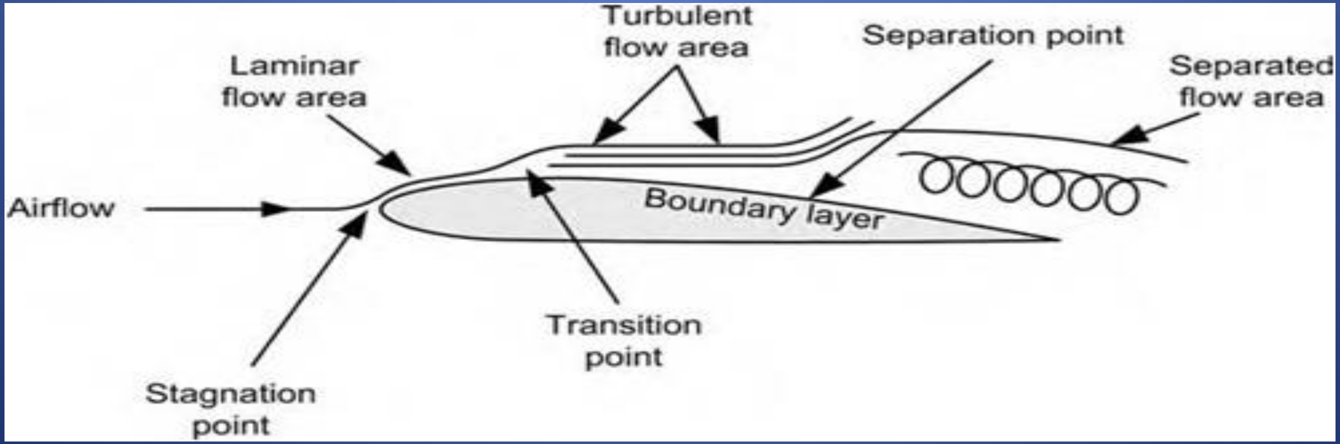
- **Conventional airfoils** generally are the thickest at **25** percent of the chord and can be found in a variety of shapes and designs.

- **Laminar flow airfoils** have their thickest point at **50** percent of the chord, a leading edge that is more pointed and upper and lower surfaces that are nearly symmetrical. Originally developed to make aircraft fly faster, they can be found on many different aircraft types.



AIRFOILS

- **Boundary Layer –** The very thin layer of air over the surface of the wing.
- **Laminar Layer –** Smooth portion of the boundary layer nearest the leading edge of the wing
- **Transition/Separation Point** – Point on wing where the boundary layer becomes turbulent
- **Turbulent layer** – Turbulent portion of the boundary layer at the trailing edge of the wing



Boundary Layer

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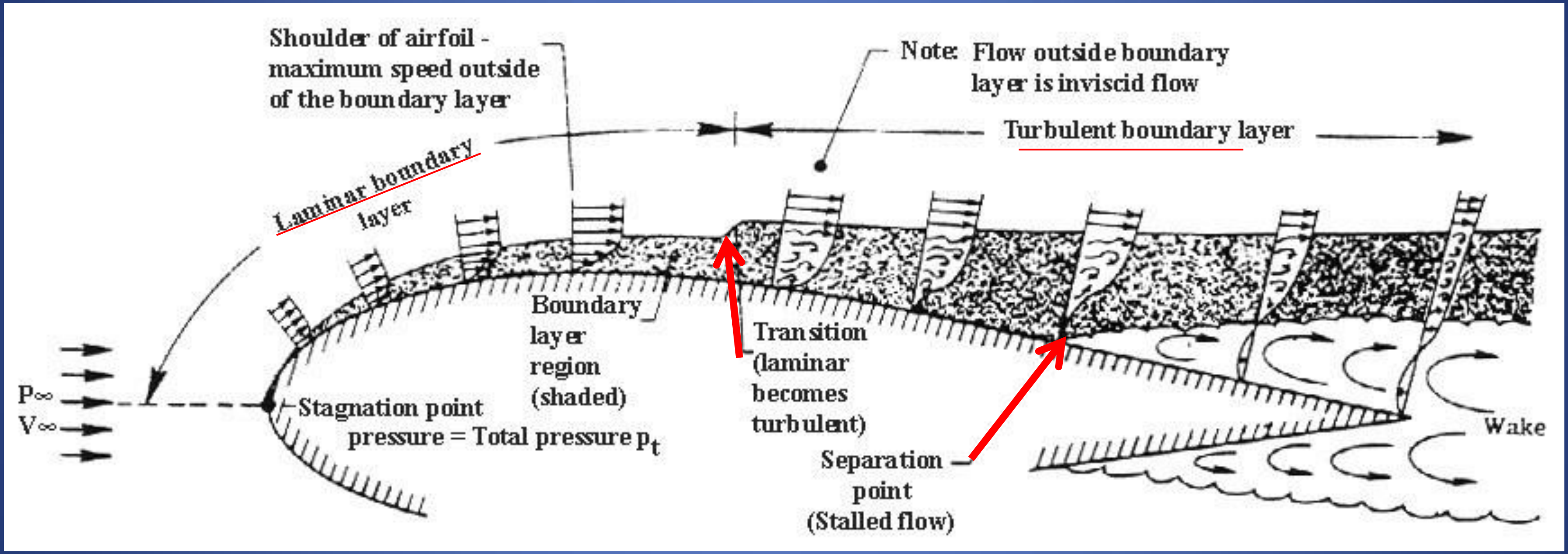
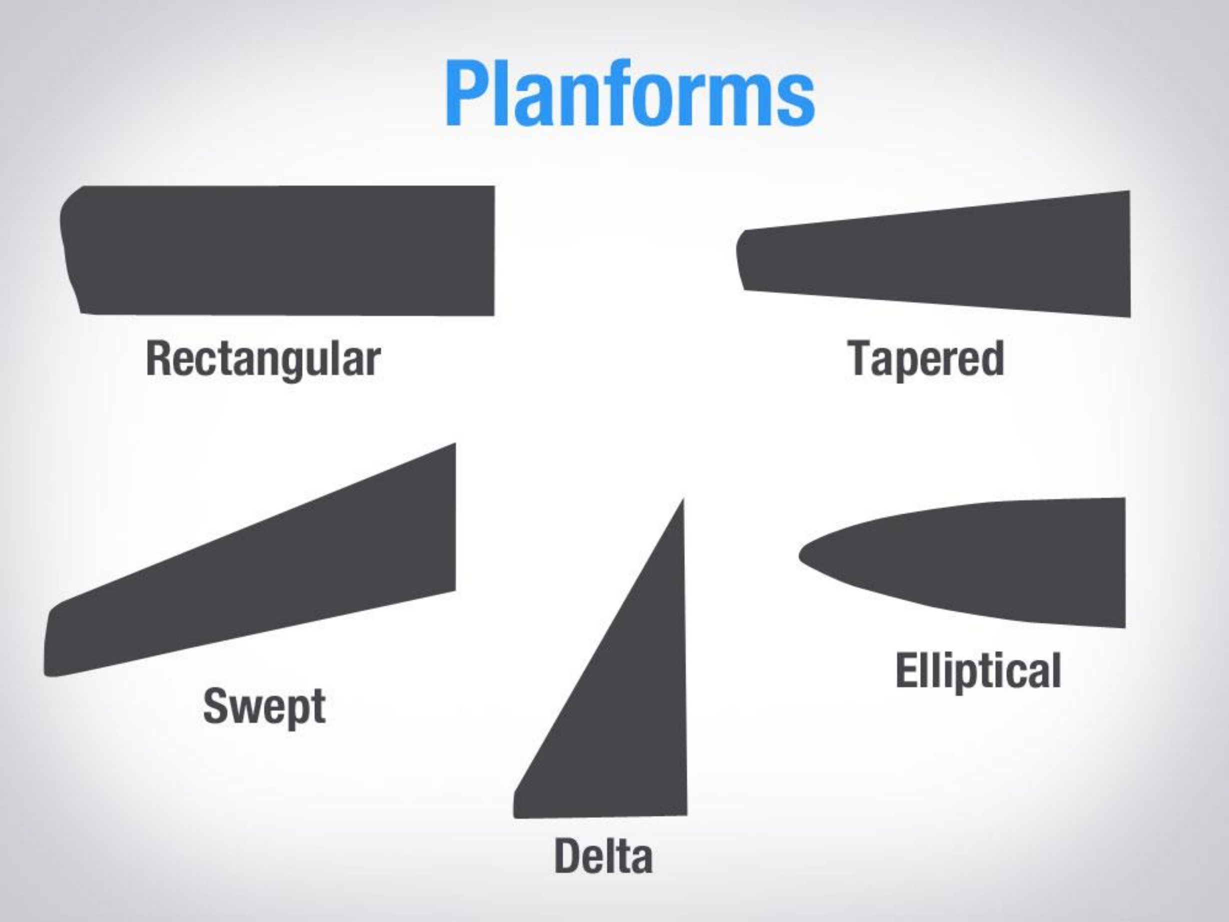
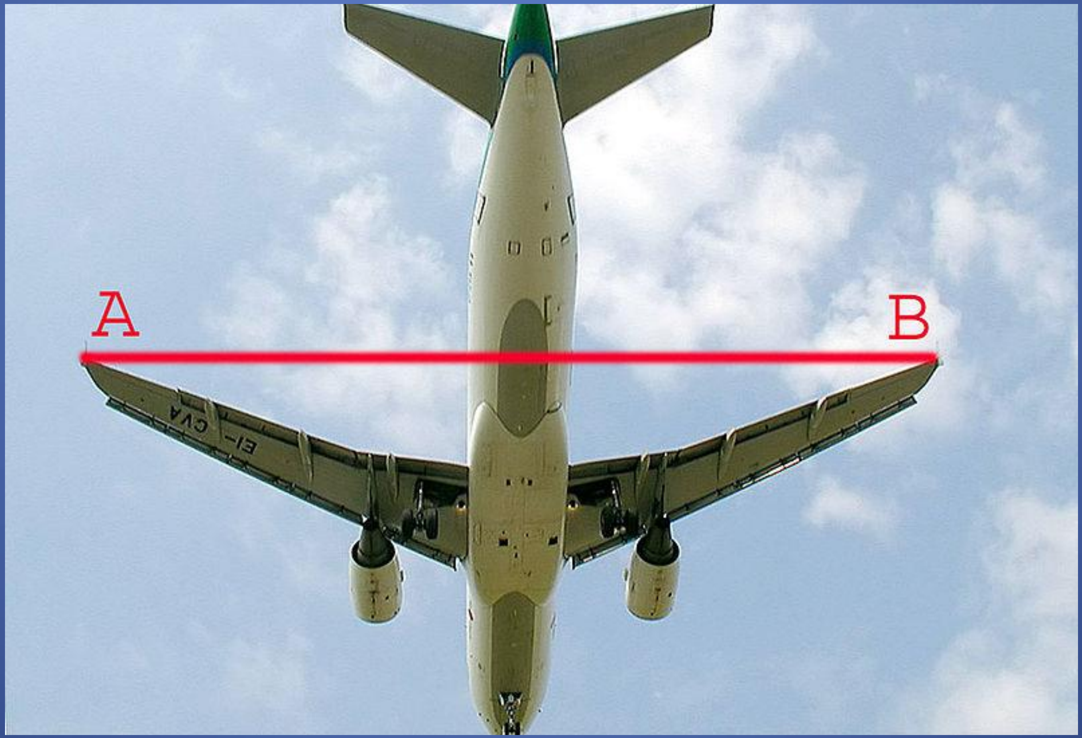


AIRFOILS



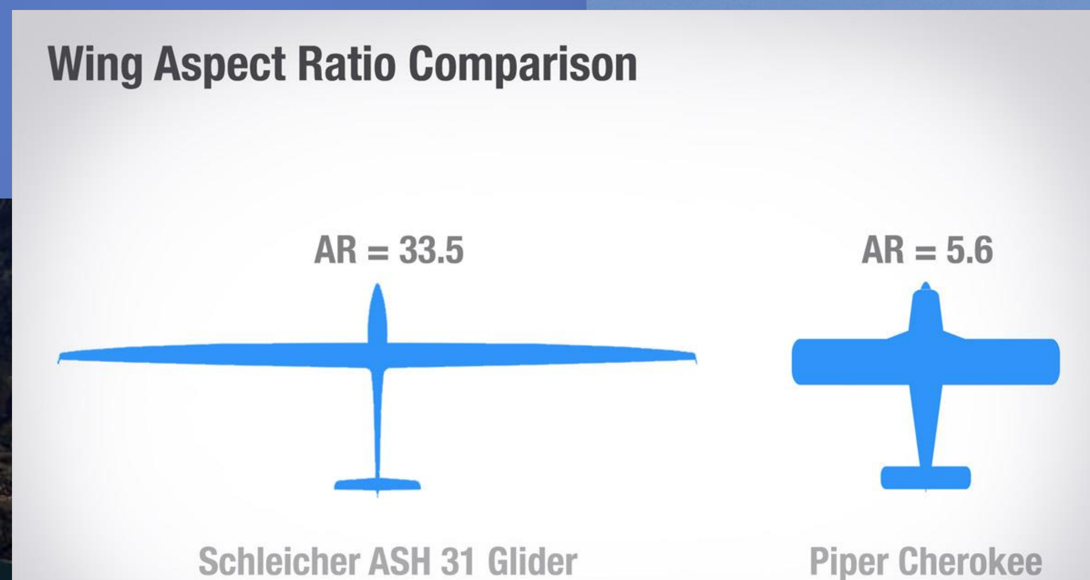
Wing Span

- **Wingspan** is the maximum distance from **wing tip** to **wing tip**



ASPECT RATIO

- Ratio of the **span** to **chord** of the wing
- A measure of how SLENDER the wing is
- Calculated by dividing the span by the average chord
- Induced drag can be reduced with a high aspect ratio



ASH 31 Glider 21m / 1.6 m = 33.5 AR

Angle of Attack

– The angle at which…

Angle of Attack

– The angle at which the airfoil meets the ***relative*** airflow

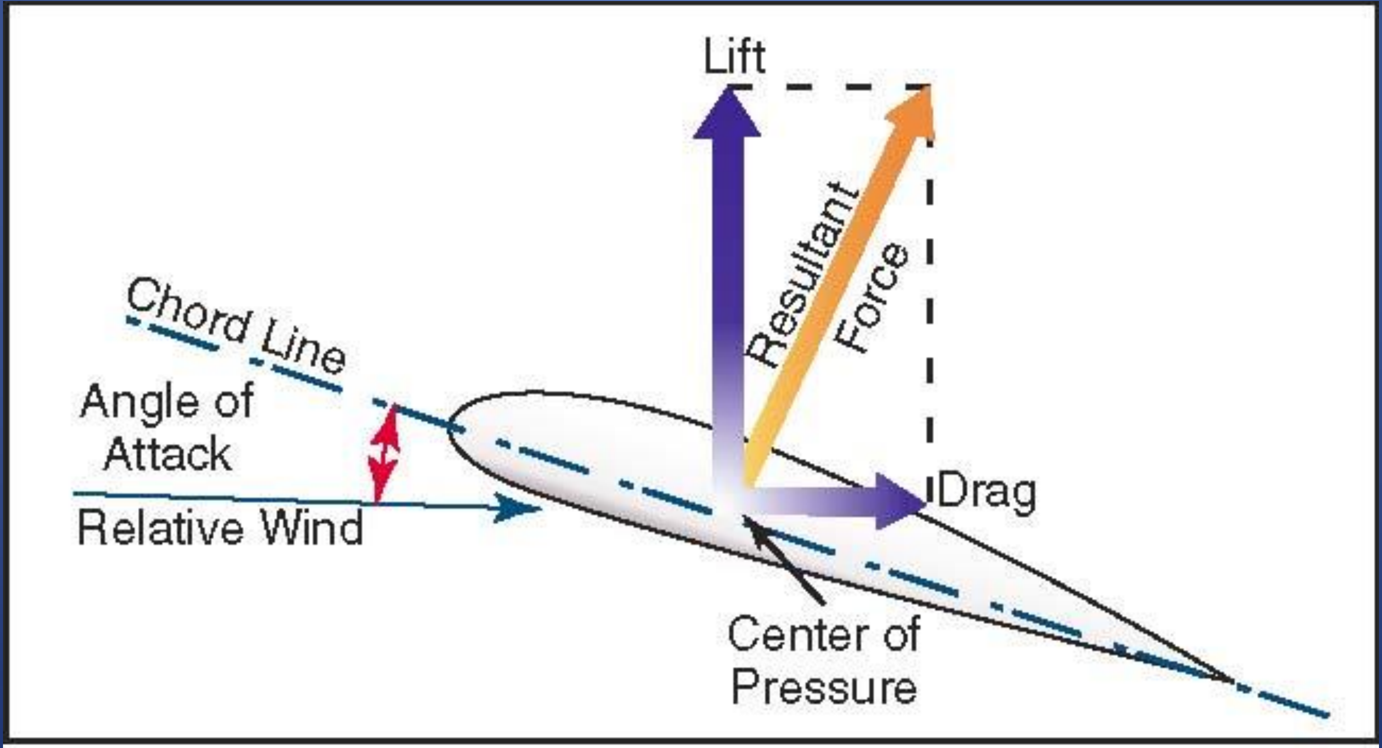


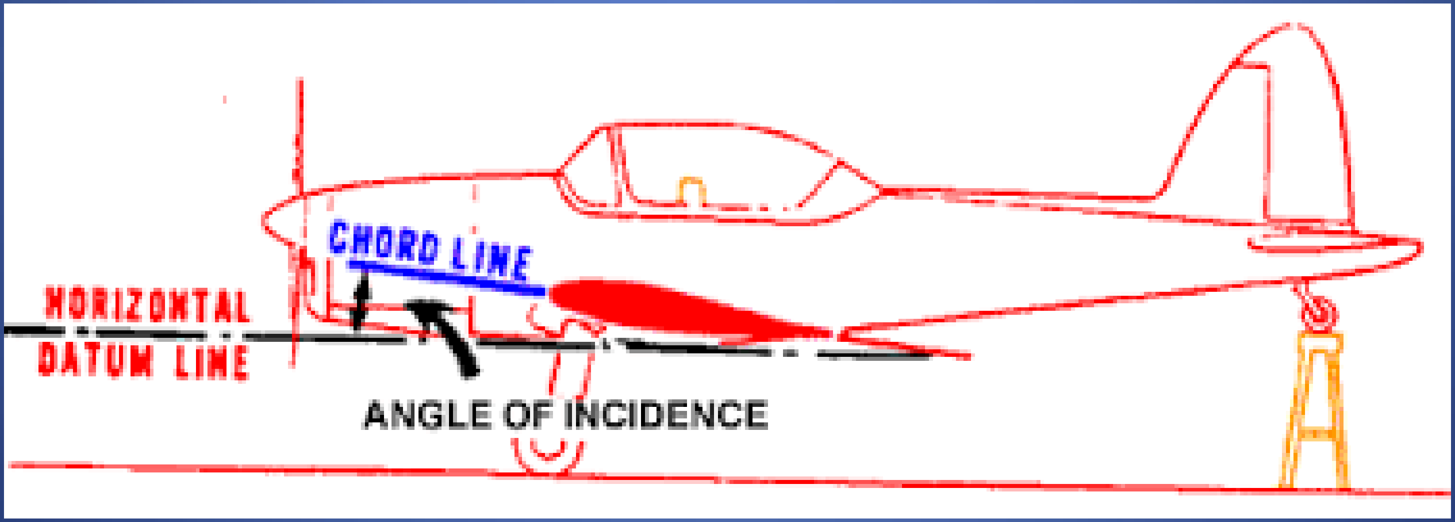
Figure 2-9. Force vectors on an airfoil.

Angle if Incidence

– The angle at which…

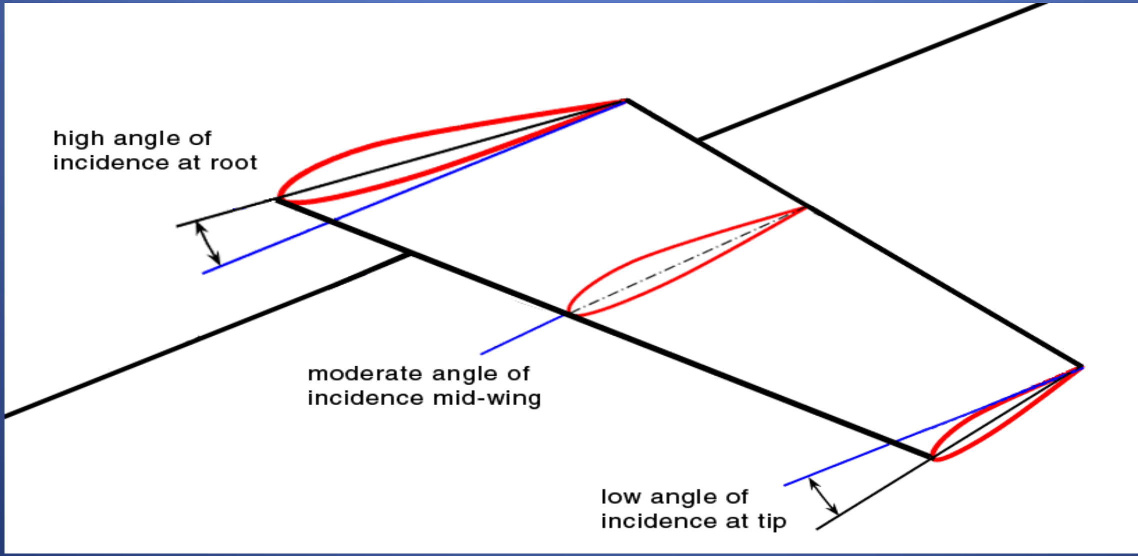
Angle if Incidence

– The angle of incidence is the angle between the mean aerodynamic chord of the wing and the longitudinal axis of the aircraft



Angle if Incidence

– The angle of incidence impacts forward visibility, take-off and landing characteristics, and drag in level flight
– To reduce the tendency of the wing to stall suddenly, the wing can be designed so that the angle of incidence at the wing tip is different than at the wing root.
– Decreasing the angle of incidence at the wing tip is called **wash-out** and increasing the angle is called **wash-in**.



High Lift Devices

- **Wing Tip Design**

  Wing tip fuel tanks, plates, winglets, drooping
- **Wing Fences**

  Control airflow direction over wing
- **Slots**

  Air passageways built into the wing
- **Slats**

  Auxiliary airfoils that move in front of the leading edge of the wing at high angles of attack
- **Flaps**

  Located at the trailing edge of the wing, increase lift by changing the wing’s camber (curvature)

High Lift Devices

➢ Wing Tip Design

Induced drag can be reduced by limiting the formation of wing tip vortices. This is done by preventing air from spilling over the wing tip by modifying the wing tips in one of the following ways:

- installing wing tip fuel tanks,
- using wing tip plates or winglets, and
- drooping the wing tips.

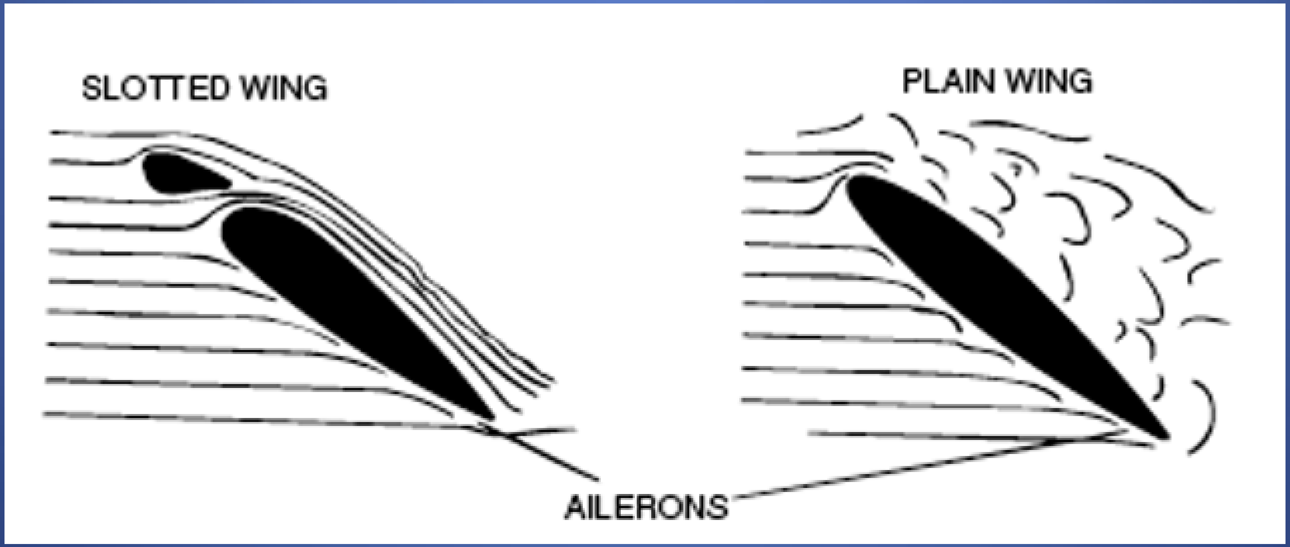
High Lift Devices

- **Wing Fences**
  - Control airflow direction over wing

High Lift Devices

- **Slots**

  - Air passageways built into the wing



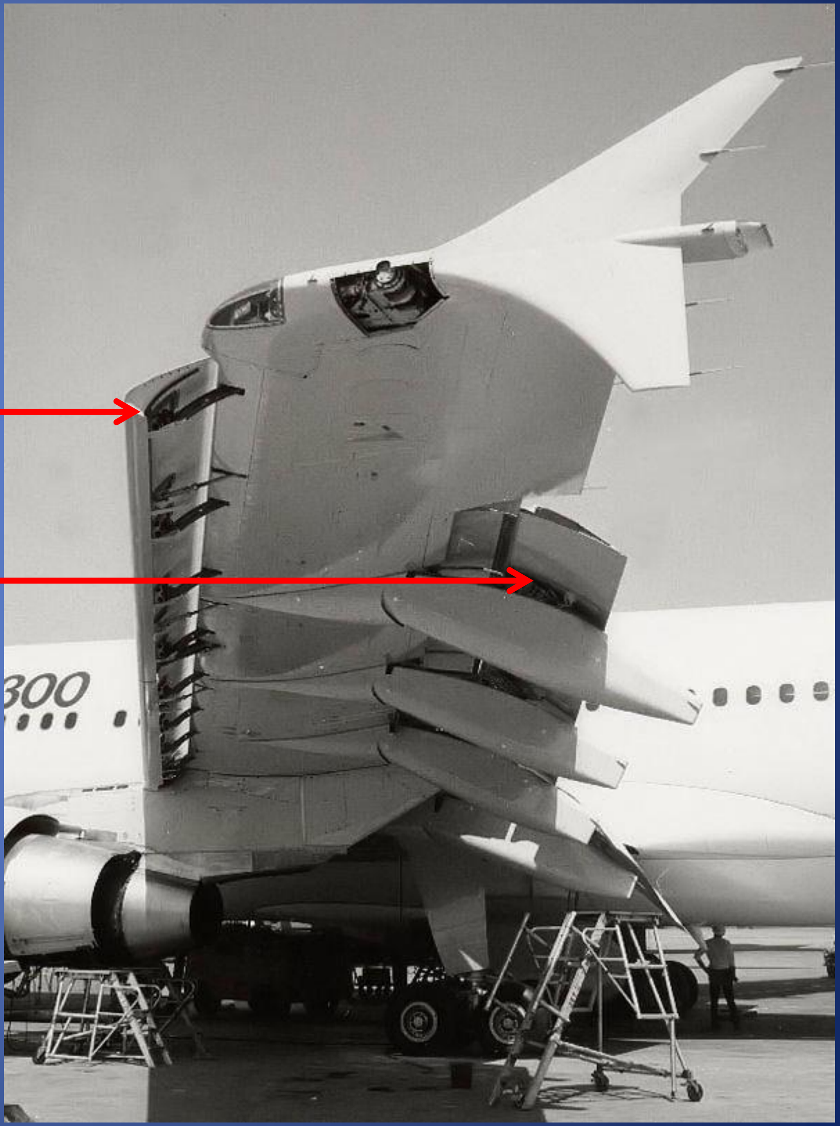
High Lift Devices

- **Slats**

  Auxiliary airfoils that move in front of the leading edge of the wing at high angles of attack

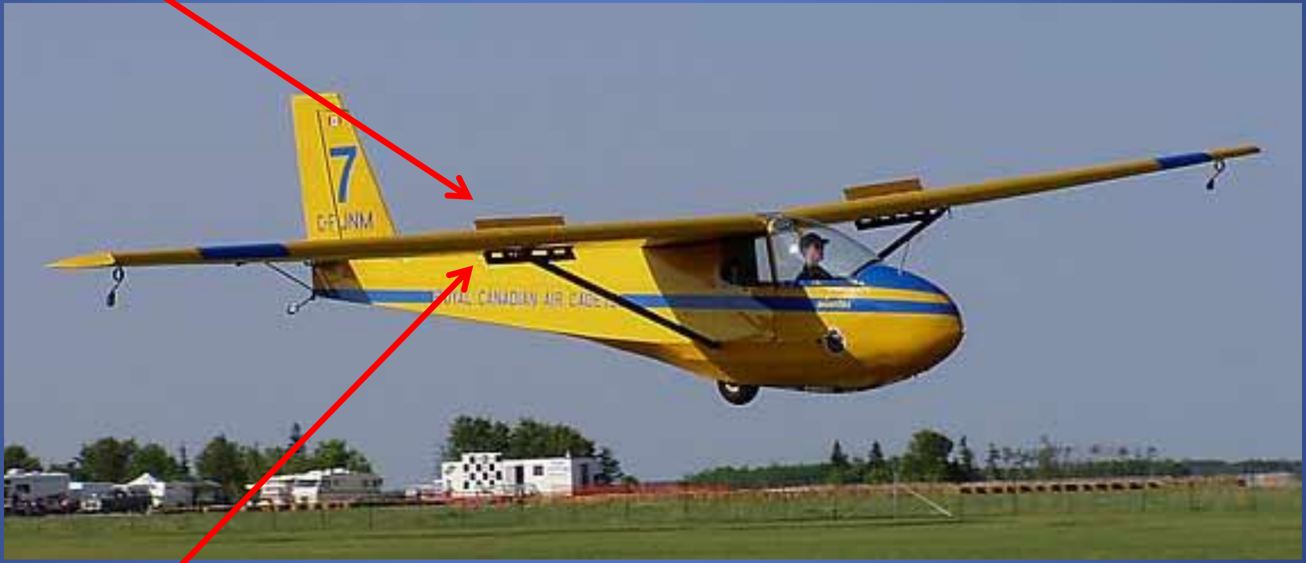
- **Flaps**

  Located at the trailing edge of the wing, increase lift by changing the wing's camber (curvature)



Airfoils

Spoilers decrease (spoil) lift and increase drag



Speed Brakes (Dive brakes) create drag with minimal effect on lift being produced.

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FLIGHT INSTRUMENTS

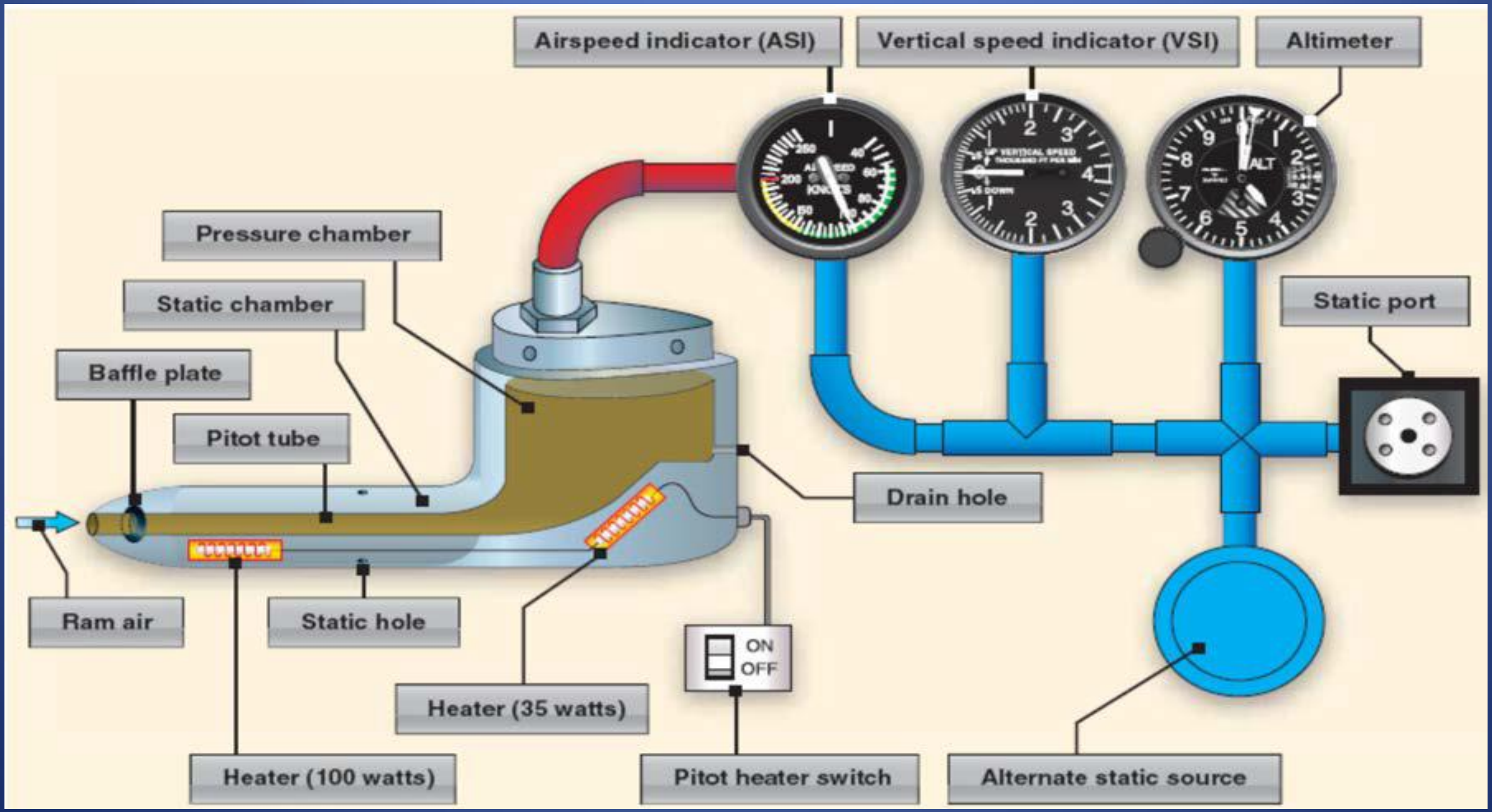
PITOT STATIC SYSTEM
Instruments connected to the pitot static system work on air pressure. There are two types of air pressure in the pitot static system:

Pitot pressure. The increase in air pressure caused by the forward motion of the aircraft through the air.

Static pressure. The atmospheric pressure outside the aircraft, not affected by turbulence or motion.

FLIGHT INSTRUMENTS

The airspeed indicator (ASI) is connected to both the pitot pressure source (usually a tube attached to the nose or wing) and the static pressure port(s) (usually a small vent on the side of the aircraft). The altimeter and the vertical speed indicator (VSI) are connected only to the static pressure port.



FLIGHT INSTRUMENTS

AIRSPEED INDICATOR (ASI)

The ASI is connected to ***both*** the pitot pressure source and static pressure port and displays the difference between the two pressures as the speed of the aircraft moving through the air (not over the ground).

ASI Markings

The ASI has colour-coded markings to indicate operating ranges and speeds.

FLIGHT INSTRUMENTS

ASI Markings

Red. A red line indicates the never exceed speed (VNE).

Yellow. A yellow arc starts at the maximum structural cruise (VNO) and extends to the VNE. This area is typically known as the caution range.

Green. The normal operating range. It starts at the power-off stalling speed (VSL) and extends to the VNO.

White. The range in which fully extended flaps may be used. It starts at the power-off stalling speed with flaps and gear extended (VSO) and extends to the maximum flaps extended speed (VFE).

FLIGHT INSTRUMENTS

ASI Errors

Density error. The ASI is calibrated for normal sea level pressure of 29.92 inches of mercury (Hg) at a temperature of 15 degrees Celsius. **Temperature and pressure normally decrease with an increase in altitude, decreasing the density of the air and causing the ASI to read less than the true airspeed**.

Position error. Results from the position of the pitot pressure source. Eddies formed by air moving over the aircraft and the angle of the pitot source to the airflow cause position error.

Lag error. A mechanical error that is the result of friction between the working parts of the instrument. This error is responsible for a slight delay between a change in airspeed occurring and the change being shown on the instrument.

Icing error. The error caused by a complete or partial blockage of the pitot pressure by ice. This error can be prevented or corrected by turning on the pitot heat (if equipped) or descending to a lower altitude where the outside air temperature (OAT) is higher.

FLIGHT INSTRUMENTS

Airspeed Definitions and Corrections

- **Indicated airspeed (IAS).** The uncorrected airspeed read from the instrument dial.

- **Calibrated airspeed (CAS).** The IAS **corrected for instrument (lag) error and installation (position) error.**

- **Equivalent airspeed (EAS).** The **CAS corrected for the compressibility** factor. This is very significant to aircraft operating above 10 000 feet and 250 knots (kt).

- **True airspeed (TAS).** The **CAS** (or EAS) **corrected for density** (pressure and temperature).

FLIGHT INSTRUMENTS

ALTIMETER

The altimeter is connected ***only*** to the static pressure port(s) and measures the pressure of the outside air. A sealed aneroid capsule inside the instrument case expands or contracts due to changes in the static pressure.
The expansion or contraction is mechanically linked to the indicator's needles and causes them to rotate around the dial to show the altitude.

FLIGHT INSTRUMENTS

Altimeter Errors

- **Pressure error.** Barometric pressure varies from place to place and this error is corrected by using an altimeter setting obtained from the nearest aviation facility (flight service station, control tower, etc). All aircraft flying in the same area should be using the same altimeter setting.

"From high to low—look out below".

When an aircraft flies into an area with a relatively lower pressure, if the altimeter setting is not corrected, the altimeter will read higher than the actual altitude. For example, the altimeter may be indicating 4 000 feet, while the actual altitude may be closer to 3000 feet. This could cause a conflict with other aircraft, or even worse, cause the aircraft to come into contact with the ground.

FLIGHT INSTRUMENTS

Altitude Definitions

- **Indicated altitude.** The altitude displayed on the altimeter when it is set to the current barometric pressure.

- **Pressure altitude.** The altitude displayed on the altimeter when it is set to the standard barometric pressure (29.92 inches of Hg).

- **Density altitude.** The pressure altitude **corrected for temperature**.

- **Absolute altitude.** The actual height above the Earth's surface (the altimeter set to field level pressure).

FLIGHT INSTRUMENTS

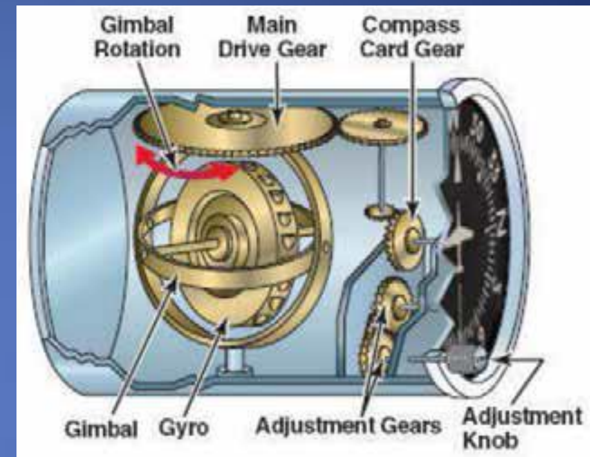
VERTICAL SPEED INDICATOR (VSI)

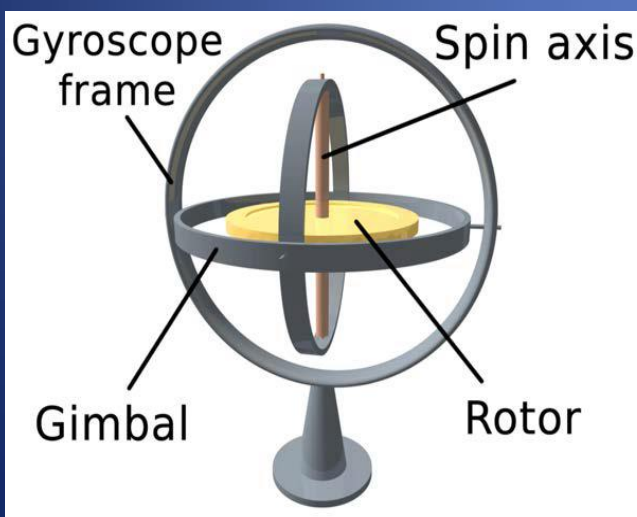
The VSI is connected ***only*** to the static pressure port(s).
The rate of change of the static pressure is transmitted to the needle to indicate if the altitude is increasing or decreasing.

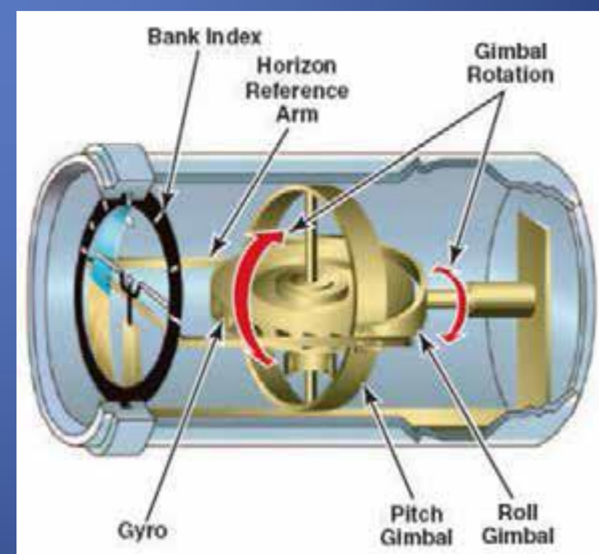
FLIGHT INSTRUMENTS

GYROSCOPE OPERATION

The gyroscope is a spinning wheel (rotor) in a universal mounting (gimbal) that allows its axle to be pointed in any direction. Aircraft use gyroscopes for navigation, with the gyroscope maintaining the orientation of the universe so that relative changes in the aircraft's orientation can be measured.



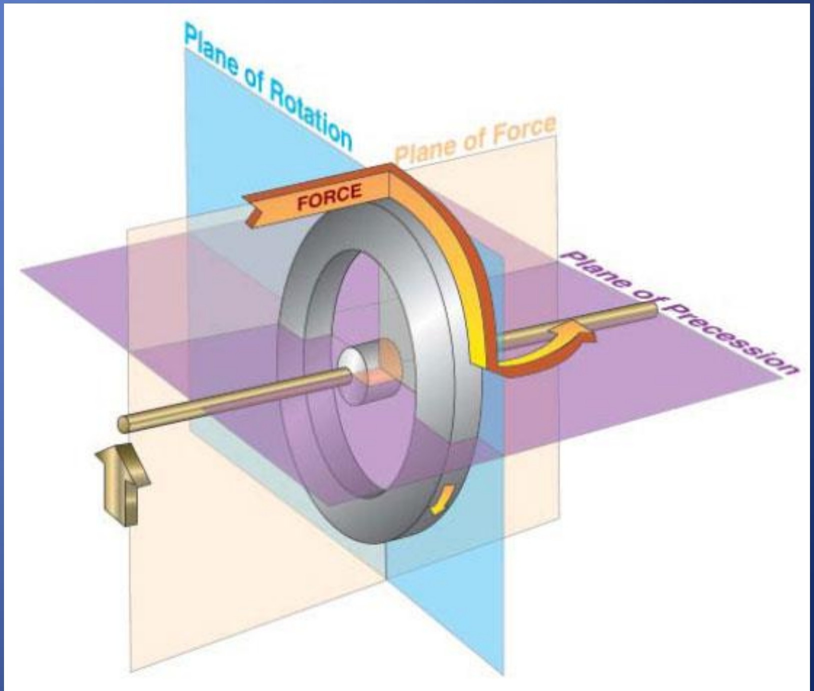




FLIGHT INSTRUMENTS

PRECESSION

Precession is the tendency of a rotating body, when a force is applied perpendicular to its plane of rotation, to turn in the direction of its rotation 90 degrees to its axis and take up a new plane of rotation parallel to the force applied.



FLIGHT INSTRUMENTS

MACH INDICATOR

The Mach indicator displays the ratio of its airspeed to the local speed of sound.

The Mach number is *calculated* by dividing the airspeed by the speed of sound.

The Mach indicator measures and correlates static and dynamic pressures.

FLIGHT INSTRUMENTS

Speed of Sound

At sea level, at a temperature of 15 degrees Celsius and under normal atmospheric conditions, the speed of sound is about 340 m/s or 1100 ft/sec (1,225 km/h or 761 mph). The speed varies depending on atmospheric conditions; the most important factor is the temperature.

https://www.youtube.com/watch?v=gWGLAAYdbbc

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FUEL SYSTEMS

CARBURETORS

The heat energy in an internal combustion engine is developed from the burning of a mixture of gasoline and air. The carburetor measures the correct quantity of gasoline, vaporizes fuel, mixes it with the air in the required proportion and delivers the mixture to the cylinder when the combustion occurs.

An engine will run hotter with a ***lean mixture*** than a rich mixture as the lean mixture will burn slower and the cylinder walls are exposed to high heat for a longer time.

A ***rich mixture*** burns quickly exposing the cylinder walls to high temperatures for a shorter time and the additional fuel in the fuel / air mix cools the engine.

FUEL SYSTEMS

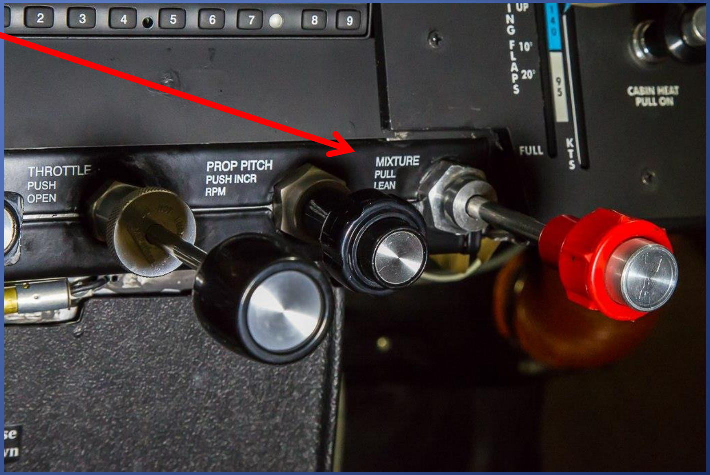
CARBURETORS

➢ **Mixture Control**

As altitude increases, the density of the air decreases and a given volume of air weighs less. The proportion of air by weight to that of fuel will become less although the volume remains the same.
The mixture at higher altitude becomes over-rich causing fuel waste and loss of power. A **mixture control** is fitted to the carburetor and is controlled from the cockpit. It adjusts the amount of fuel being drawn from the nozzle, restoring the proper fuel / air mix.

The general rules when using a manual mixture control are:

Rich mixtures—high power settings, and
Leaner mixtures—cruise power settings.



FUEL SYSTEMS

CARBURETORS

- **Throttle Control**

Forward movement of the throttle opens the throttle valve, which increases the fuel / air mixture, and increases the power being produced by the engine.

Aft movement of the throttle closes the throttle valve, which reduces the volume of fuel / air mixture, and decreases the power being produced by the engine.

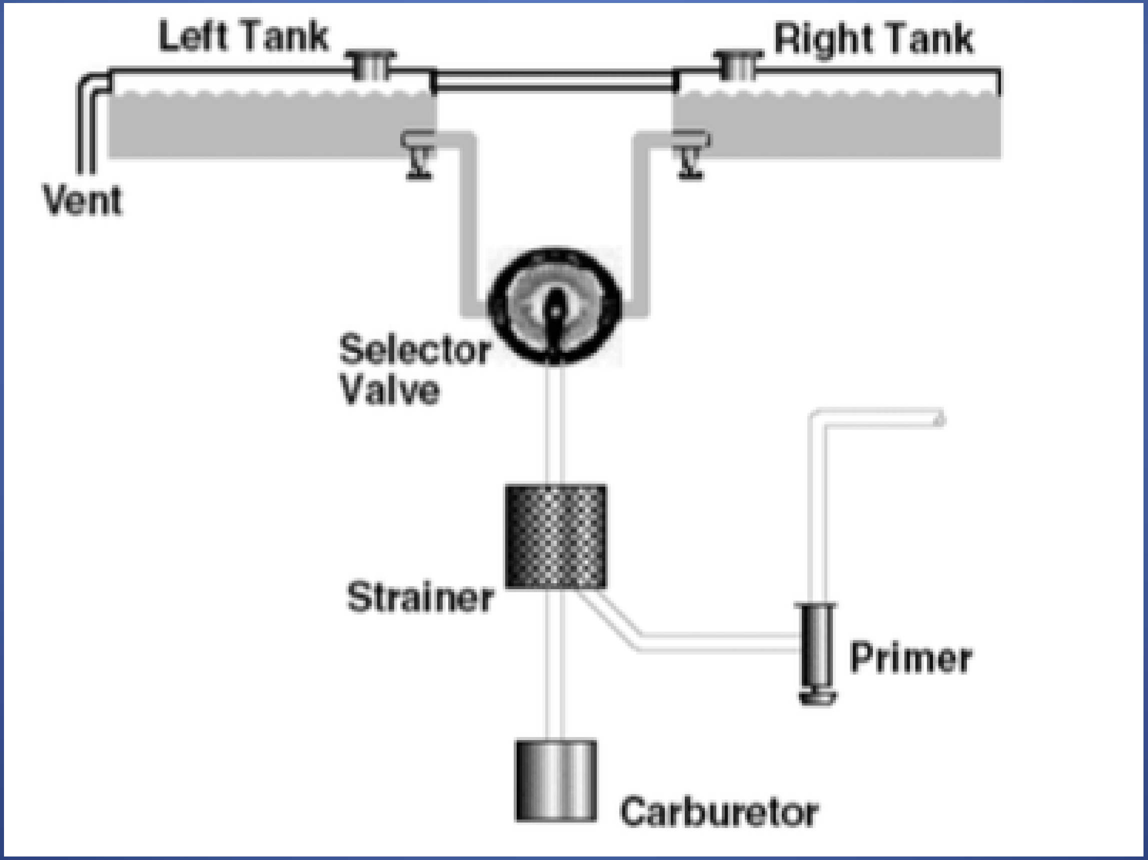
FUEL SYSTEMS

Pressure-Feed System
Aircraft with low-wing configurations and large aircraft with a large volume of fuel movement use an **engine driven fuel pump** to provide the pressure to keep fuel flowing.

Gravity-Feed System
High-wing, low-powered light aircraft use the gravity-feed system. The bottom of the fuel tank in the wing must be high enough to provide pressure for the fuel to travel past the fuel selector to the carburetor.

FUEL SYSTEMS

Components of a Gravity Feed Fuel System



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PROPELLER SYSTEMS

- **Pitch**

The distance in feet a propeller travels forward in one revolution. Propeller pitch is the difference between theoretical pitch (geometric pitch) and practical pitch (effective pitch).

PROPELLER SYSTEMS

The propeller is a rotating airfoil designed to push air backward as it moves forward along a corkscrew (helical) path. It meets the air at an angle of attack as it rotates, producing thrust (lift) and torque (drag).

A typical propeller is twisted so the blade angles and tapers from the hub to the tip. The highest angle of incidence (pitch) is at the hub and the smallest pitch is at the tip.

By means of the variation in airfoil sections and the angle of attack, uniform ***thrust*** is maintained throughout most of the diameter of the propeller.

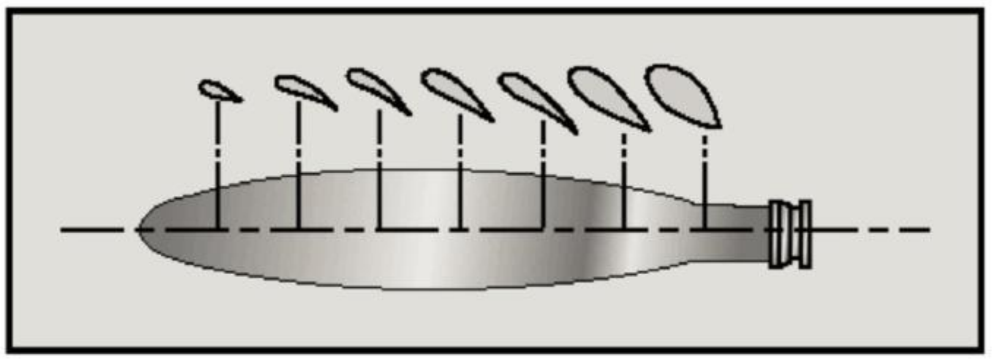


Figure A-1 Propeller Blade Shape

PROPELLER SYSTEMS

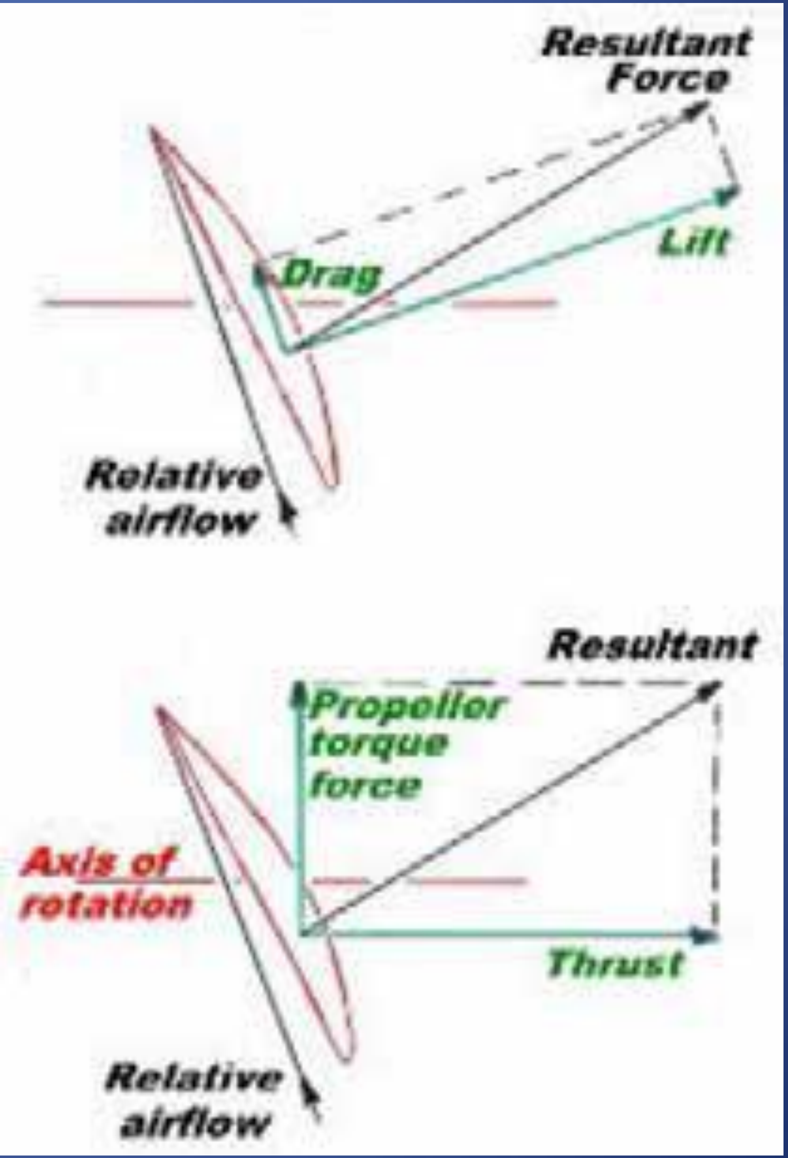
The angle of the blade, like the angle of incidence of a wing, governs the pitch. The propeller set in coarse pitch will travel a greater distance with each revolution. The aircraft will move forward at greater speed for a given rpm.

The propeller set in fine pitch will have less torque (drag) and will revolve at a higher speed around its axis. The engine will produce greater power. A fine pitch propeller will be good for taking off and climbing but a coarse pitch propeller will develop high cruise speed with comparatively low engine rpm giving good fuel economy.

PROPELLER SYSTEMS

Forces Acting on a Propeller Blade

- Propeller Torque Force
- Thrust
- Resultant Force



PROPELLER SYSTEMS

FIXED PITCH PROPELLERS

Fixed pitch propeller. The blade angle can not be adjusted by the pilot and is used on most training aircraft. The blade angle is set by the manufacturer to provide the best compromise for all flight conditions.

VARIABLE PITCH PROPELLERS

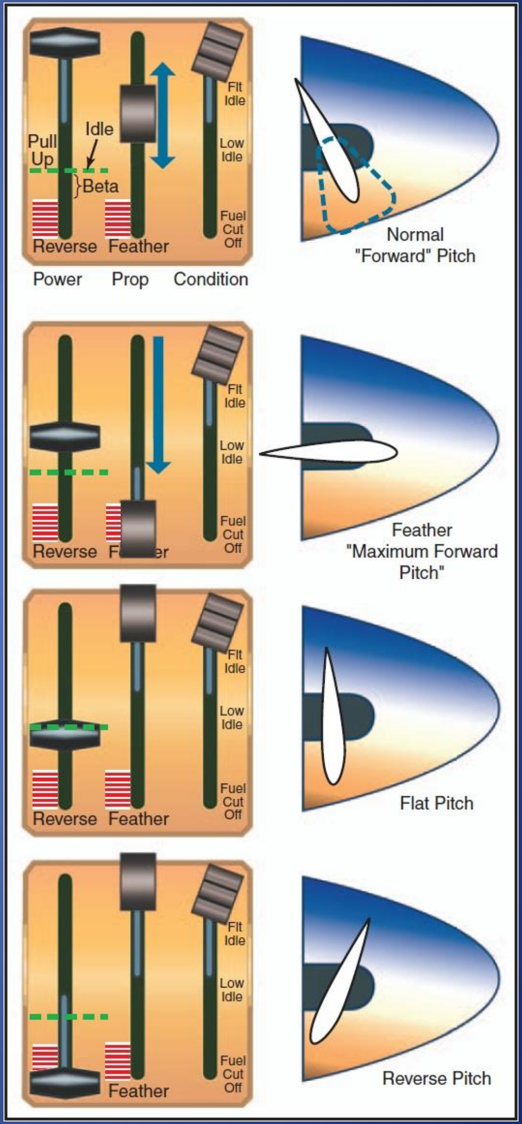
Adjustable pitch propeller. The blade angle can be changed on the ground to adjust for the varying flight situations such as changed takeoff and climb needs.

Controllable pitch propeller. The blade angles can be adjusted by the pilot during flight. The propeller set in a fine pitch for takeoff allows the engine to develop maximum power. The propeller is then adjusted to a coarse pitch to accelerate at a rapid rate to the desired cruise speed.

Constant speed propeller. The blade angles automatically adjust themselves to maintain a constant rpm as set by the pilot.

PROPELLER SYSTEMS

Variable Pitch Propellers



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ENGINE INSTRUMENTS

TACHOMETER

The tachometer shows the speed at which the engine crankshaft is turning in hundreds of revolutions per minute (rpm).
The tachometer records the engine hours of operation.

The tachometer is marked with colour-coded arcs to indicate the proper range of engine operation, including:

Green indicating normal range of operation;

Yellow indicating the caution range and possible problems; and

Red indicating the maximum limit.

ENGINE INSTRUMENTS

Oil Pressure Gauge

One of the principle engine instruments is the oil pressure gauge. It is usually positioned beside the oil temperature and fuel gauges. The instrument is calibrated in pounds per square inch (psi) and indicates the oil pressure supplied by the oil pump to lubricate the engine.

Oil Temperature Gauge

The oil temperature gauge records the temperature of the oil in degrees Fahrenheit or Celsius. As the oil warms during start-up, the pressure should read high and the temperature low. Both instruments should approach their normal readings as the oil warms.

An abnormal drop in oil pressure and rise in oil temperature indicates trouble. Also, no change in oil pressure but a change in oil temperature is a warning of excessive friction or overload in the engine.

ENGINE INSTRUMENTS

Manifold Pressure Gauge

The manifold pressure gauge also has colour-coded arcs displayed on the gauge to indicate the normal operating range and operation limits. The gauge indicates in inches of mercury the fuel / air pressure in the engine intake manifold at the point between the carburetor and the cylinders.

When the engine is not running, the reading on the manifold pressure gauge will be of the existing atmospheric pressure.

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WINDS

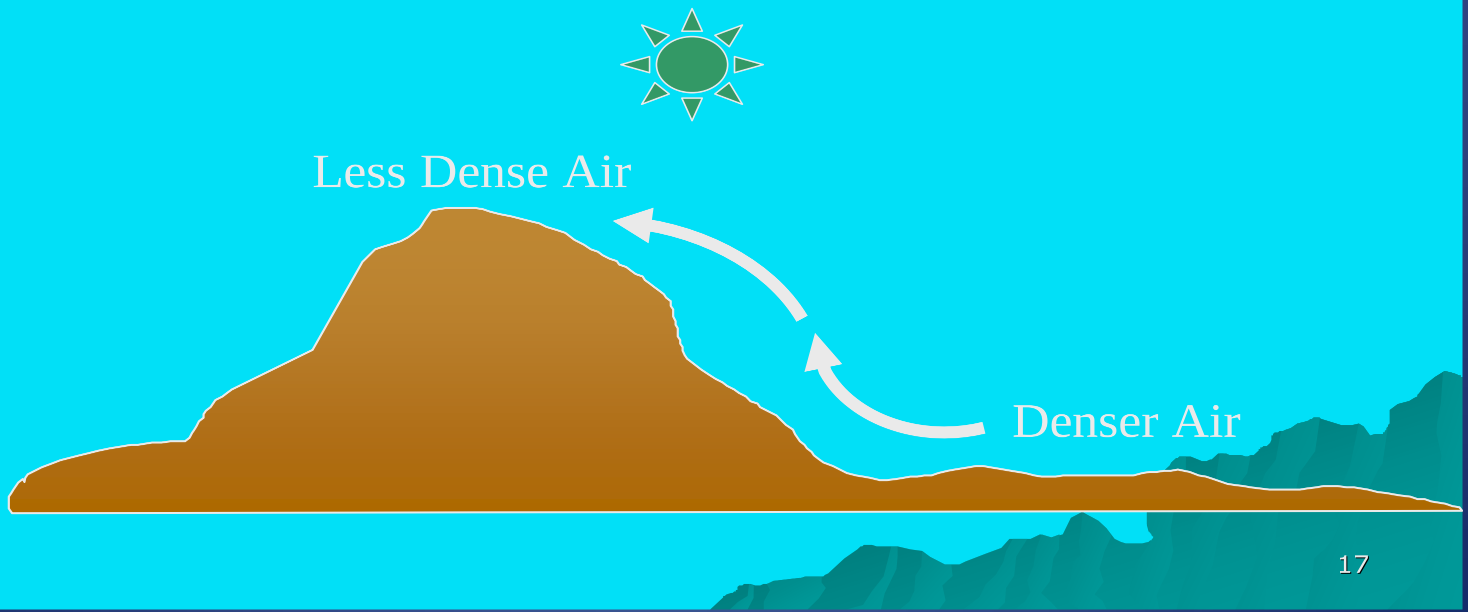
Katabatic Wind

At night, the slopes of hills cool. The air contact with them becomes cooler and therefore denser and it blows down the slope. Also known as a Mountain Breeze.

WINDS

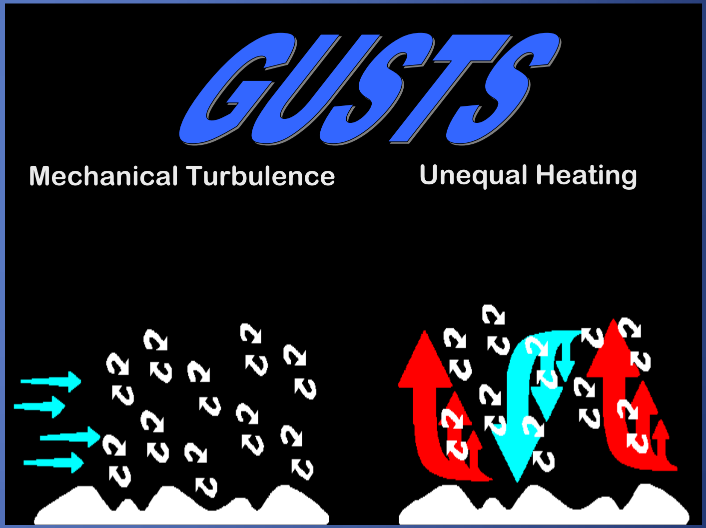
Anabatic Wind

Slopes of hills not covered by snow will be warmed during the day. The air in contact with them becomes warmer and less dense and therefore flows up the slope. Also known as a Valley Breeze.



WINDS

- *Gusts*
  - a brief rapid increase of wind speed.
  - may be associated with a rapid change in wind direction
  - Causes may be related to mechanical turbulence and unequal heating

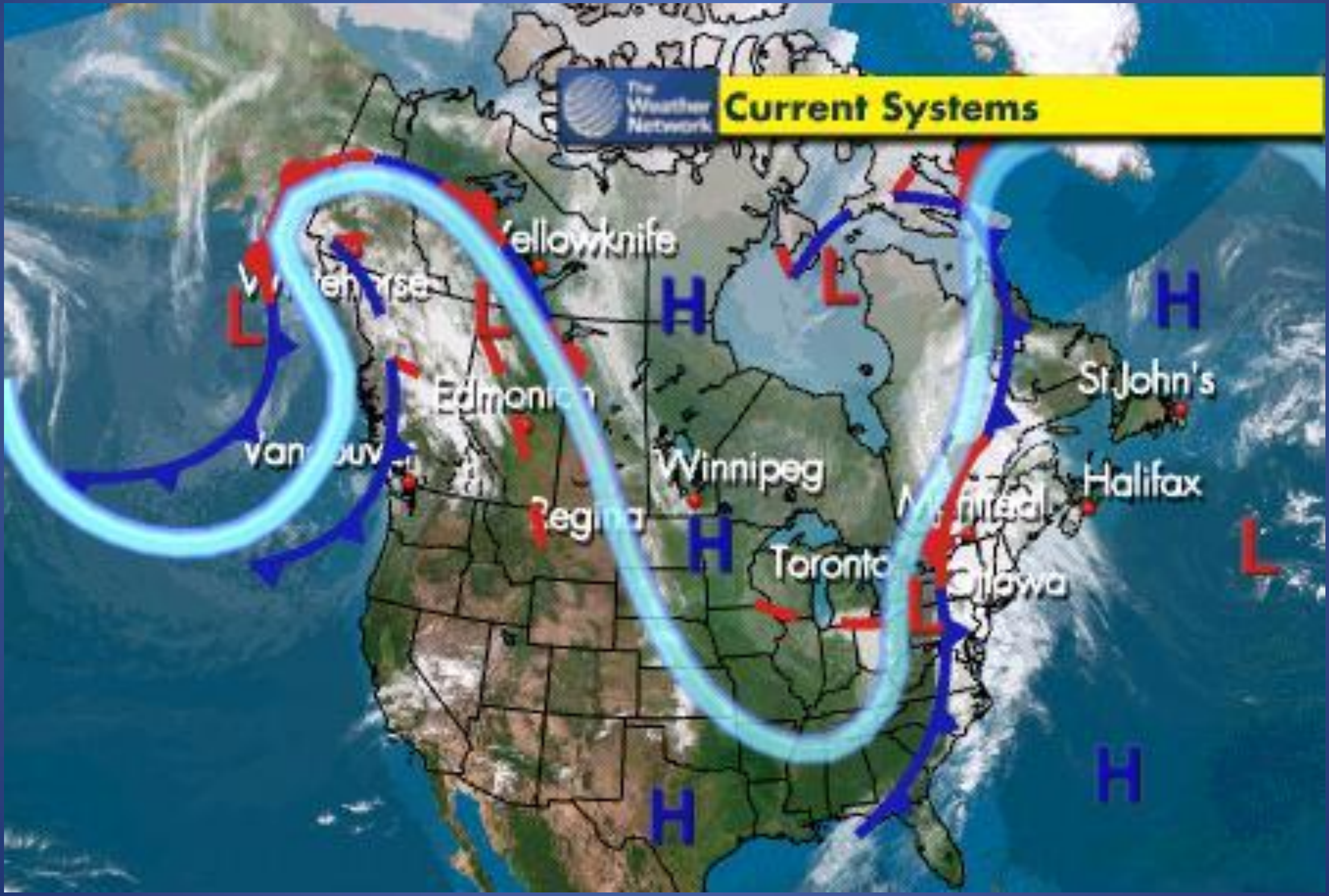


WINDS

JET STREAMS

- Jet streams are narrow bands of exceedingly high speed winds that exist in the higher levels of the atmosphere at altitudes ranging from 20 000 to 40 000 feet or more. They flow from west to east and are usually 300 nautical miles wide and 3 000 to
- 7 000 feet thick. Winds in the central core of a jet stream are generally between 100 and 150 knots, although they may reach speeds as great as 250 knots.

WINDS


The Weather Network
Current Systems
Yellowknife
Edmonton
Winnipeg
Toronto
St John's
Halifax

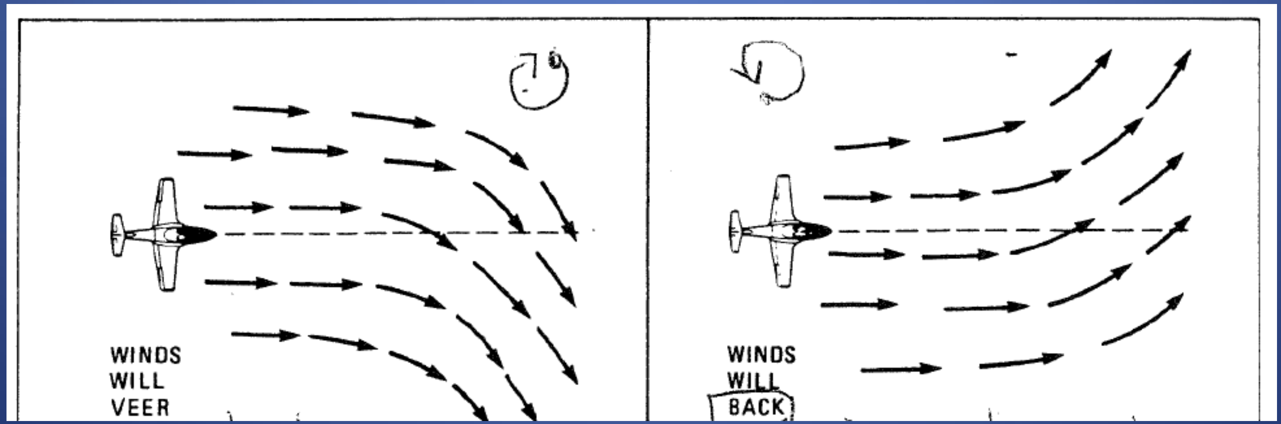
WINDS

Veering

- Wind changes direction clockwise
- Wind veers and increases during the day
- Wind veers and increases with increase in altitude

Backing

- Wind changes direction counter-clockwise
- Wind backs and decreases at night
- Wind backs and decreases with decrease in altitude



LEVEL 4
COMBINED AVIATION REVIEW

PO 431 – EXPLAIN PRINCIPLES OF FLIGHT
- M431.01 – EXPLAIN FEATURES OF WING DESIGN
- M431.02 – DESCRIBE FLIGHT INSTRUMENTS

PO 432 – DESCRIBE AERO ENGINE SYSTEMS
- M432.01 – DESCRIBE FUEL SYSTEMS
- M432.02 – DESCRIBE PROPELLER SYSTEMS
- M432.03 – DESCRIBE ENGINE INSTRUMENTS

PO 436 – EXPLAIN ASPECTS OF METEOROLOGY
- M436.01 – EXPLAIN WINDS
- M436.02 – DESCRIBE AIR MASSES AND FRONTS

PO 437 – EXPLAIN ASPECTS OF AIR NAVIGATION
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- M437.02 – DESCRIBE THE MAGNETIC COMPASS

Meteorology

- **Air Masses**

  Large sections of the troposphere with ***uniform properties of temperature and moisture in the horizontal direction***
- Weather in Air Masses

  Determined by moisture content, cooling process, and stability of the air
- Stability of Air

  Stable air - stratus clouds and poor visibility

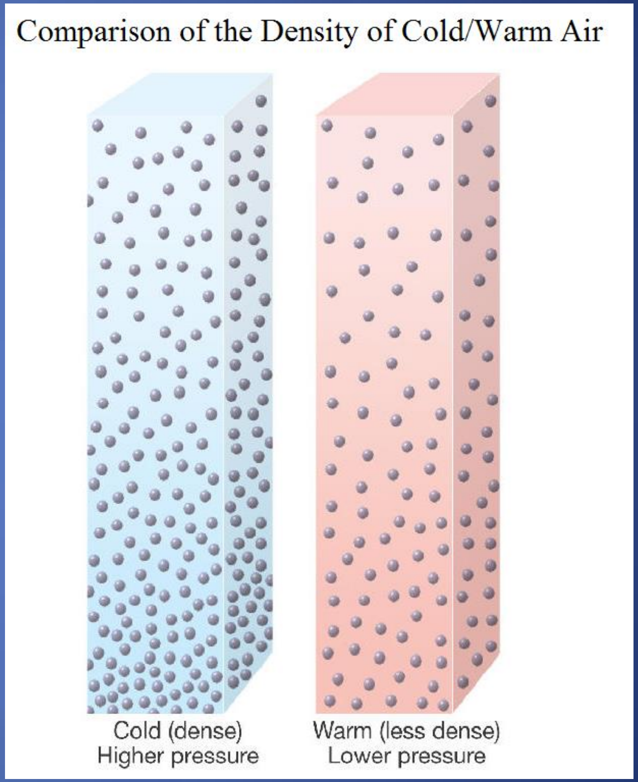
  Unstable air - cumulus clouds and good visibility

Stable and Unstable Air

Characteristic	Stable Air	Unstable Air
Lapse Rate	Shallow	Steep
Cloud Type	Stratus Type	Cumulus Type
Precipitation	Uniform Intensity including drizzle	Showers
Visibility	Poor low level (Fog may occur)	Good, except in precipitation
Wind	Steady winds which can change with height	Gusty
Turbulence	Generally smooth flying conditions	Turbulence may be moderate to severe

Meteorology

Density - mass per unit volume



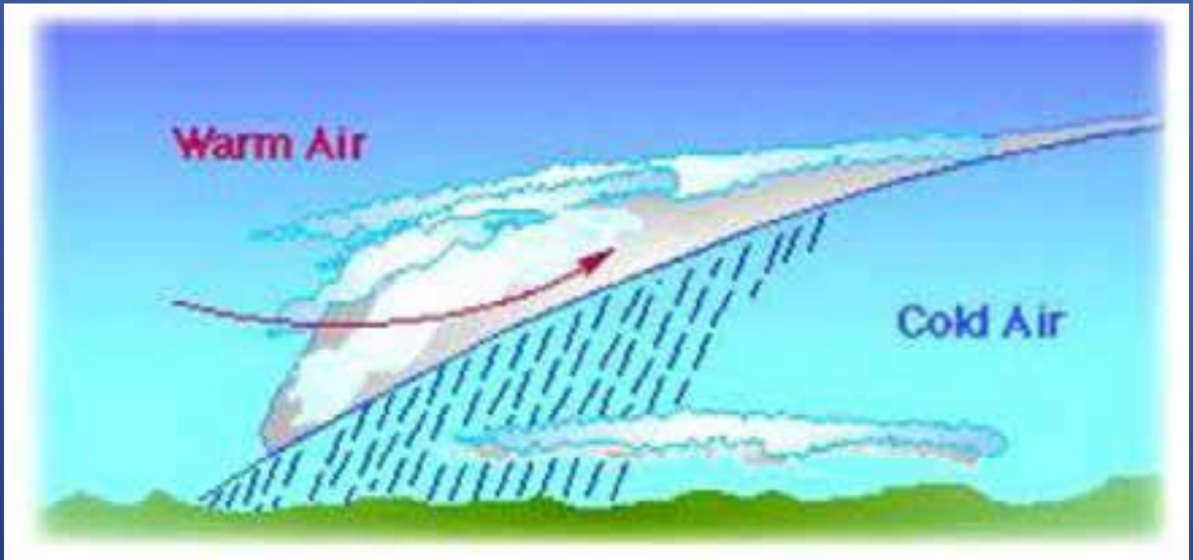
- Cold air is dense:
  - Molecules are move slowly and are packed close together
  - Heavier and tends to sink
- Warm is less dense:
  - Molecules are moving rapidly taking up more space (or less molecules in the same space)
  - Warm air is lighter and is pushed up by the cold air

FRONTS

Figure 1 Cold Front

FRONTS

A front is the transition zone between two air masses. The interaction of air masses along their frontal zones is responsible for **weather changes**.



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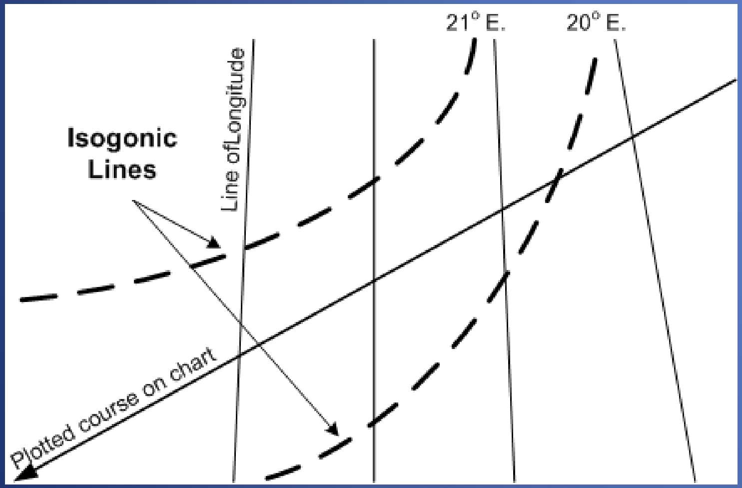
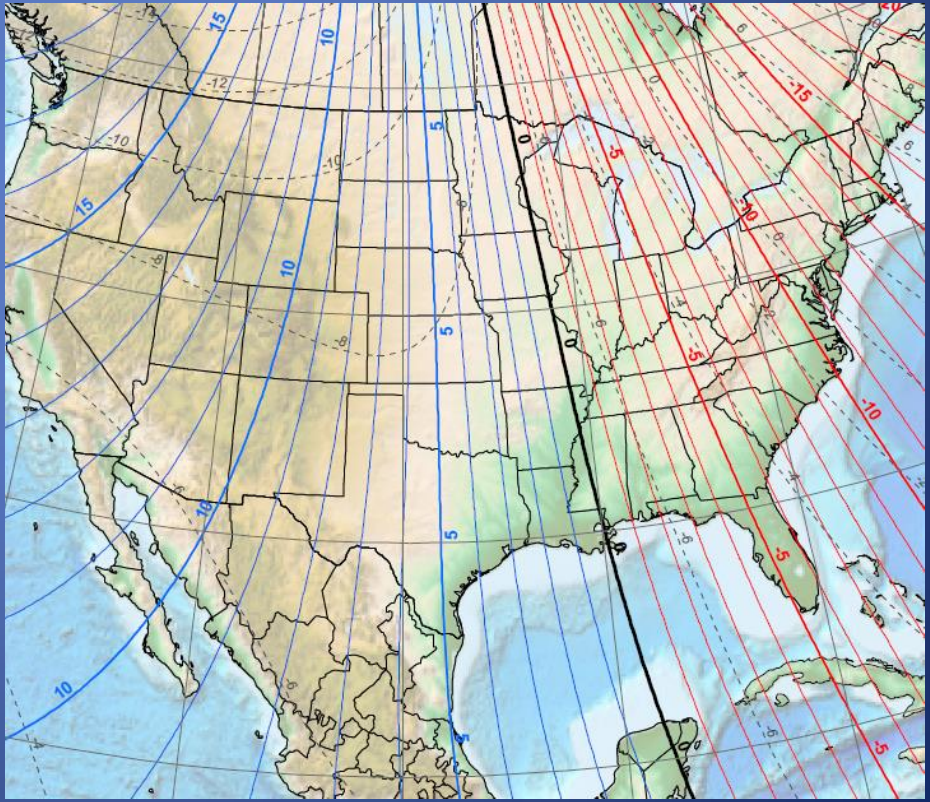
ISOGONIC / AGONIC

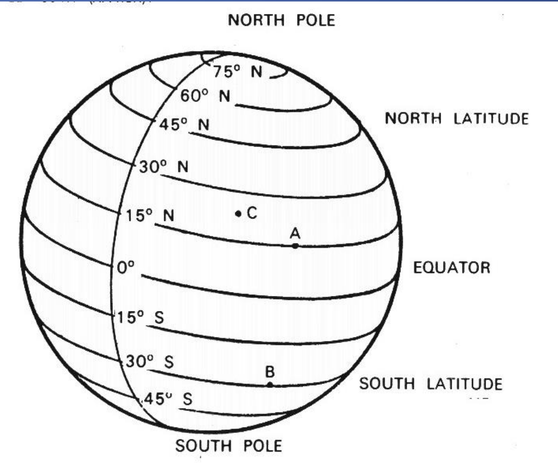
- Isogonic lines connect areas of equal variation
- Agonic lines connect areas of 0 variation



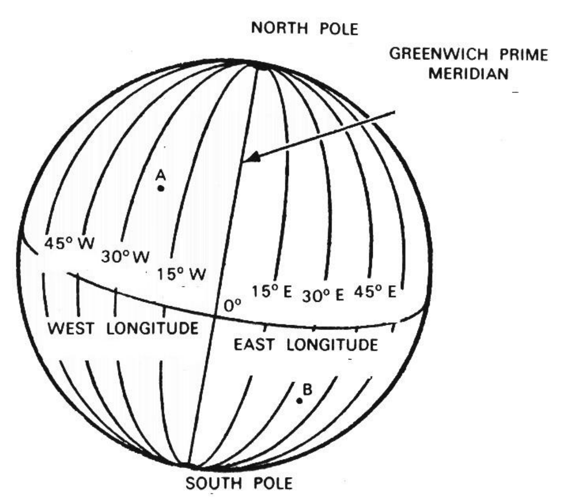


Longitude and Latitude

- Imaginary lines make up a grid on the surface of the earth.
- Parallels of Latitude run east to west (like the equator), and are numbered 0 to 90 degrees North and South from the equator.
- Meridians of Longitude run north to south and are numbered 0-180 degrees East and West from the Prime Meridian.



Parallels of Latitude



Meridians or Lines of Longitude

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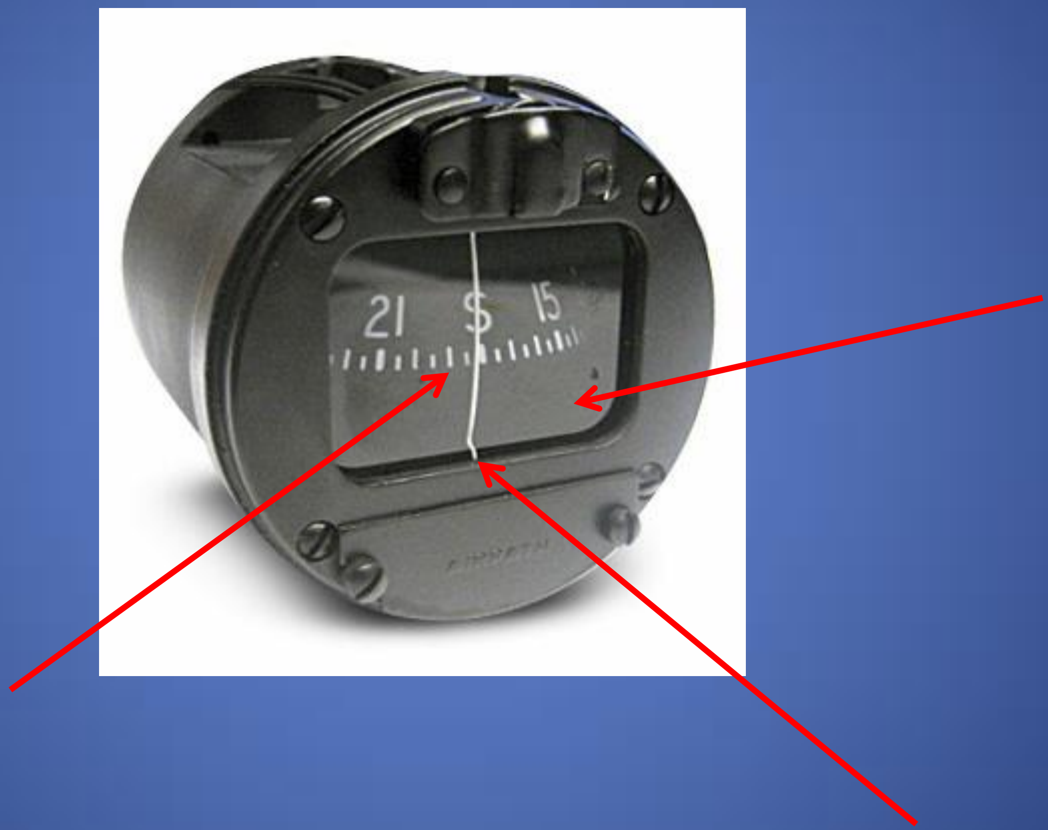


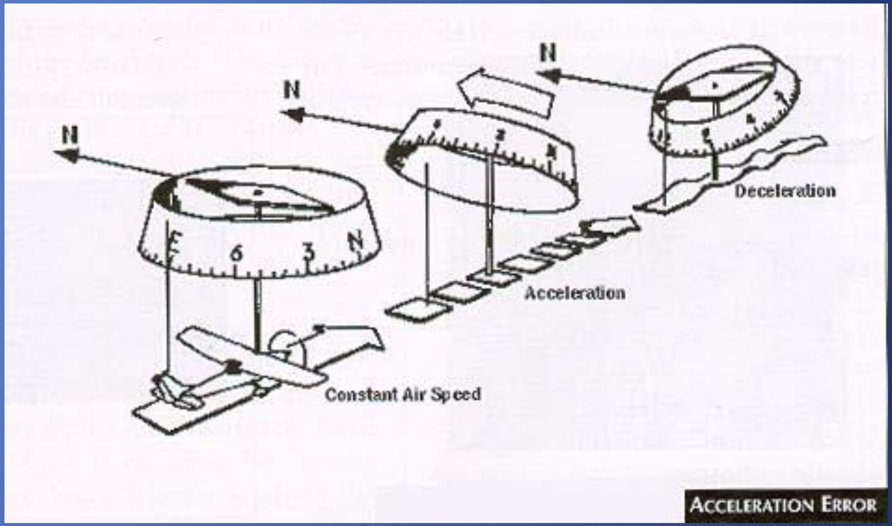
Acceleration and Deceleration Errors

When an airplane changes its speed, this affects the compass. This is most noticeable on east or west headings.

An acceleration will cause the compass to show (briefly) a turn north.

A deceleration will cause the compass to show (briefly) a turn south.

Acceleration North,
Deceleration South (ANDS)



DEVIATION

Deviation – the metal in the airplane (and the radios and other equipment) affect the compass so that it doesn't correctly point north. This is called deviation.

Compasses are "swung" which means the airplane is aligning on a marking on the ground that is known to be pointing north, south, etc, and the error (the deviation) is written on a compass correction card. The pilot takes this into account while planning flights.

FOR (MH)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
STEER (CH)	359°	30°	60°	88°	120°	152°	183°	212°	240°	268°	300°	329°
RADIO ON ☑					RADIO OFF ☐							

Calculating Compass Headings

When we fly, we generally use the compass to figure out what direction we are heading. This doesn't match the map though, because your map (chart) is in degrees true, while your compass uses degrees magnetic. So how do we figure out what direction to fly in?

Remember variation and deviation? We do some calculations to convert from degrees true to degrees magnetic (using variation) and the to our compass heading (using deviation).

True Heading ⟶Variation⟶Magnetic Heading ⟶Deviation ⟶Compass Heading

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QUESTIONS?