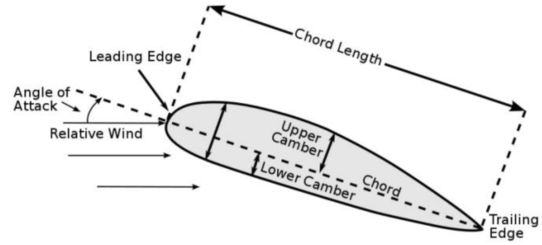
135 Bell-Irving Squadron

Level Four Aviation Subject Review Book

Aviation Subjects – Combined Assessment Proficiency Check Review

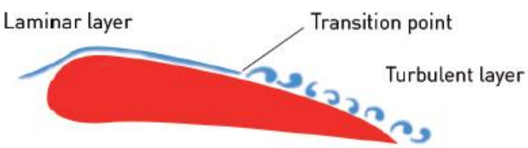
M431.01 – FEATURES OF WING DESIGN

Chord: An imaginary straight line joining the leading and trailing edges of the wing.

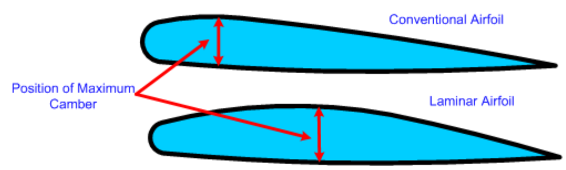


Boundary Layer

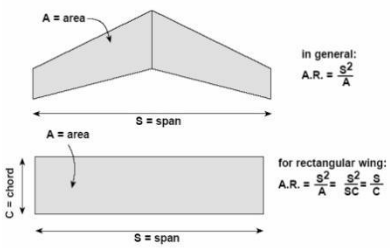
The very thin layer of air lying over the surface of the wing is called the boundary layer. At the front of the wing, the boundary layer flows smoothly over the surface and this area is called the laminar layer. As the air flows further along the wing, it slows down due to skin friction, the layer becomes thicker, and it becomes turbulent. The turbulent area is called the turbulent layer. The transition point between the laminar and turbulent areas tends to move forward as airspeed and the angle of attack increase.



Conventional Airfoils: Generally are the thickest at 25% of the chord and can be found in a variety of shapes and designs.



Laminar Flow Airfoils: Have their thickest point at 50% of the chord, a leading edge that is more pointed and upper and lower surfaces that are nearly symmetrical. The design of the laminar flow airfoil reduces drag by maintaining the laminar flow of air throughout a greater percentage of the chord.

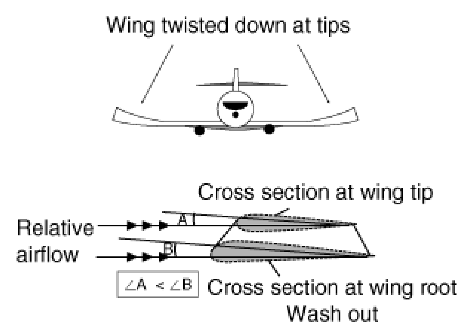


Aspect ratio: The relationship between the length of the wing and its width (chord). It is calculated by dividing the span by the average chord.

Angle of Incidence: The angle at which the wing is permanently inclined to the longitudinal axis of the aircraft.

Wash-Out and Wash-In

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 the angle of incidence at the wing root. If the wing root stalls before the wing tip, the ailerons, located closer to the wing tip, can still be effective during the early part of the stall.



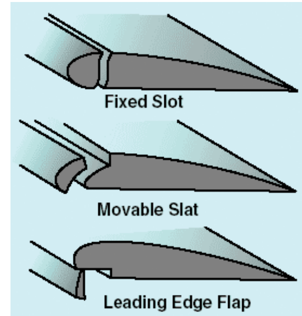
Decreasing the angle of incidence at the wing tip is called wash-out and increasing the angle is called wash-in.

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:

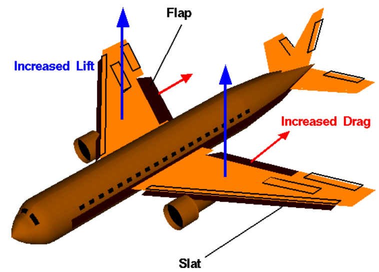
- installing wing tip fuel tanks,
- using wing tip plates or winglets, and
- drooping the wing tips.

Wing Fences: Vertical surfaces attached to the upper surface of the wing. They act as guides and control the direction of airflow over the wing, especially at high angles of attack. This improves low-speed handling and stall characteristics.



Slats: Auxiliary airfoils that automatically move out in front of the leading edge at high angles of attack. The resulting opening changes the airflow over the leading edge, smoothing out eddies that form on the top of the wing.

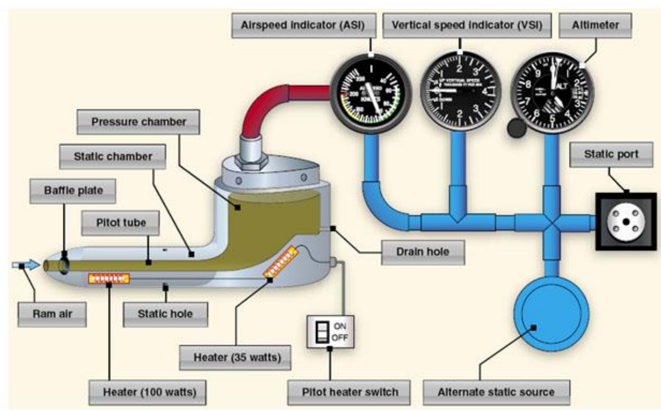
Slots: Affect the airflow in the same way as slats, except that they are passageways built into the wing.



Flaps: The most common high-lift device found on a wing. Located at the trailing edge, their primary purpose is to increase lift by changing the camber of the wing. Some styles of flaps also increase the effective wing area. The increased lift causes a lower stall speed and allows the aircraft to approach at a slower airspeed.

Spoilers: Devices on a wing that are used to decrease the lift and increase the drag being produced. They are used to increase the rate of descent during the landing approach

M431.02 – FLIGHT INSTRUMENTS



Instruments connected to the pitot static system work on air pressure. There are 2 types of air pressure:

- **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.

The airspeed indicator (ASI) is connected to both the pitot pressure source and the static pressure port(s). The altimeter and the vertical speed indicator (VSI) are connected only to the static pressure port.

AIRSPEED INDICATOR (ASI)

The ASI is connected to both the pitot tube and static ports and displays the difference between the 2 pressures as the speed of the aircraft moving through the air (not over the ground).

ASI Markings

- **Red:** Indicates never exceed speed (VNE)
- **Yellow:** Starts at the maximum structural cruise (VNO) and extends to the VNE. This area is called the caution range.
- **Green:** The normal operating range. Starts at the power-off stall speed (VSI) and extends to the VNO.
- **White:** Range in which fully extended flaps may be used. Starts at the power-off stall speed with flaps and gear extended (VSO) and extends to the maximum flaps extended speed (VFE)

ASI Errors

- **Density Error:** ASI is calibrated for normal sea level pressure of 29.92”Hg at a temperature of 15°C. 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 tube. 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.

Airspeed Definitions

- **Indicated Airspeed (IAS):** Uncorrected airspeed read from the instrument dial.
- **Calibrated Airspeed (CAS):** IAS corrected for instrument (lag) error and installation (position) error.
- **Equivalent Airspeed (EAS):** CAS corrected for compressibility factor. This is very significant to aircraft operating above 10,000 feet and 250 knots.
- **True Airspeed (TAS):** CAS (or EAS) corrected for density (pressure and temperature)

ALTIMETER

The altimeter is connected only to the static pressure port(s) and measures the pressure of the outside air.

Altimeter Error – 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 4000 feet, while the actual altitude may be 3000 feet.

Altitude Definitions

- **Indicated Altitude:** Altitude displayed on the altimeter when set to the current barometric pressure.
- **Pressure Altitude:** Altitude displayed on the altimeter when it is set to the standard barometric pressure (29.92”Hg)
- **Density Altitude:** Pressure altitude corrected for temperature.
- **Absolute Altitude:** Actual height above the Earth’s surface (altimeter set to field level pressure).

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. Even though the VSI will quickly indicate a climb or descent, it may take several seconds before the correct rate of descent is displayed. This delay is known as lag.

GYROSCOPE

The gyroscope is a spinning wheel (rotor) in a universal mounting (gimbal) that allows its axle to be pointed in any direction

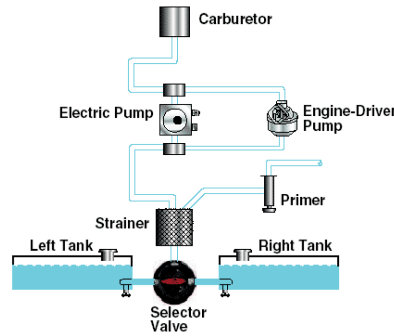
Gyroscopic Inertia: Also known as rigidity in space, gyroscopic inertia is the tendency of a rotating object to remain in its plane of rotation. This allows the spinning rotor to remain in place regardless of how the gimbal is moved around it.

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° to its axis and take up a new plane of rotation parallel to the force applied.

M432.01 – FUEL SYSTEMS

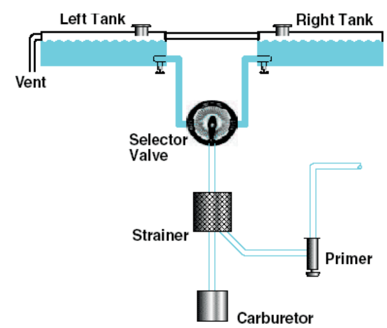
THE FUEL SYSTEM

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.



FUEL-PUMP SYSTEM

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.



GRAVITY-FEED SYSTEM

Fuel Selector Valve: The fuel selector valve is used by the pilot to select the desired fuel tank to draw fuel. The selector valve may also be used to shut off the flow of fuel from the tanks.

FUEL TYPES

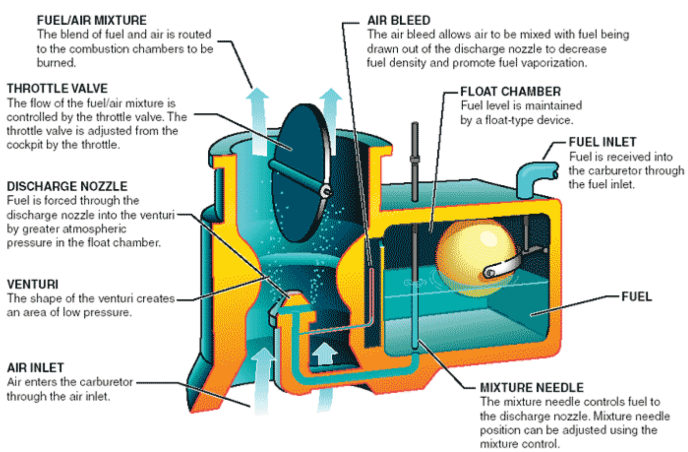
High octane fuel burns slowly and expands evenly rather than explode quickly (detonation). The octane rating of fuels is calculated by the ratio of octane and heptane.

- **Octane.** A substance which possesses minimum detonating qualities.
- **Heptane.** A substance which possesses maximum detonating qualities.

Proportion of octane to heptane is expressed as a percentage. For example 73 octane means 73 percent octane and 27 percent heptane.

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.

FLOAT CARBURETOR



Throttle Valve

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.

Mixture Control

The correct fuel / air mixture will be obtained at sea level as carburetors are normally calibrated for sea level operation.

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 that 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.

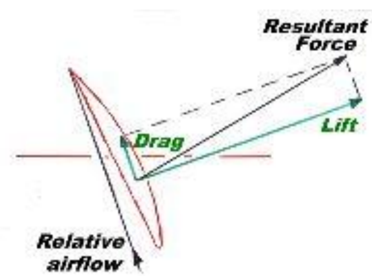
Carburetor Icing
With temperatures ranging from minus 5 degrees Celsius to plus 30 degrees Celsius and under certain moist atmospheric conditions, ice can form in the induction system closing off the flow of fuel to the engine. Ice can form on various surfaces of the carburetor especially on the throttle.

FUEL INJECTION
With a fuel injection system, a control valve supplies pressurized fuel continuously to the induction system near the intake valve. The fuel is vaporized and sucked into the cylinder during the intake stroke.

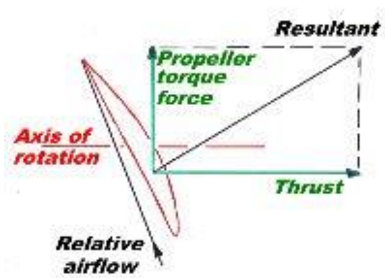
Advantages of fuel injection include:
- more uniform distribution of fuel to all cylinders,
- better cooling, through the elimination of lean hot mixtures to some of the more distant cylinders,
- fuel saving through uniform distribution,
- increased power since the heat carburetor air is eliminated, and
- elimination of the hazard of carburetor icing.

M432.02 – PROPELLER SYSTEMS

Propeller: 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).



Propeller torque is drag. It is the resistance to the blades as they rotate, resulting in a tendency in the aircraft to roll in a direction opposite to the rotation of the propeller. **Engine crankshaft torque** is the turning moment produced at the crankshaft. When the propeller is revolving at a constant rpm, propeller torque and engine torque will be exactly equal and opposite.



PITCH
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.

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).

Theoretical pitch.
The distance travelled forward in one revolution if the propeller was working in a perfect fluid. This depends on the blade angle and diameter of the propeller.

Practical pitch.
The distance the propeller travels in air in one revolution. The forward motion is less than theoretical pitch.

TYPES OF PROPELLERS
Fixed pitch propeller: The blade angle cannot 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.

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.

Mechanical variable pitch propeller.
The pilot adjusts this type of propeller by a control on the instrument panel. The control is directly linked to the propeller which has stop sets to govern the blade angle and travel.

Hydraulic variable pitch propellers.
A hydraulically operated cylinder pushes or pulls on a cam connected to gears on the propeller blade. The mechanism can be a counterweight or hydromatic.

M432.03 – ENGINE INSTRUMENTS

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: It 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.

Cylinder Head Temperature: It shows the temperature of one or all engine cylinder heads. This reading shows the pilot the effectiveness of the engine cooling system.

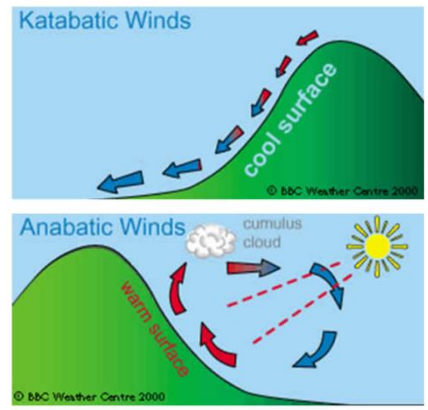
Tachometer: It shows the speed at which the engine crankshaft is turning in hundreds of revolutions per minute (rpm). The tachometer records the engine hours of operation. The tachometer is marked with colour-coded arcs to indicate the proper range of engine operation, including:

- green indicating normal range of operation;
- yellow indicating the caution range and possible problems; and
- red indicating the maximum limit.

Manifold Pressure Gauge: It 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.

M436.01 – WINDS

Surface Friction: Plays an important role in the speed and direction of surface winds. The friction between the air and the ground slows the air down causing a lower wind speed than would be expected from the pressure gradient. The friction also changes the direction causing the wind to blow across the isobars toward the centre of a low pressure area and away from the centre of a high pressure area.



Katabatic Winds: At night, the sides of hills cool by radiation. The air in contact with them becomes cooler and denser, and blows down the slope into the valley. A katabatic wind is the term for down slope winds flowing from high elevations down the slopes to valleys below. If the slopes are covered with ice and snow, the katabatic wind can also carry the cold dense air into the warmer valleys during the day.

Anabatic Winds: It occurs during the day when the slopes of hills, not covered by snow, are warmed. The air in contact with them becomes warmer and less dense, therefore flowing up the slope.

Gusts: A gust is a rapid and irregular change of wind speed and may be associated with a rapid change in wind direction. Gusts are caused by mechanical turbulence that results from friction between the air and the ground and by the unequal heating of the earth's surface, particularly during hot summer afternoons.

Squalls: A squall is a sudden increase in the strength of the wind of longer duration than a gust and like a gust, may be accompanied by a rapid change of wind direction.

M436.02 – AIR MASSES & FRONTS

AIR MASSES

Air Mass: A large section of the troposphere with uniform properties of temperature and moisture in the horizontal.

Three main factors that determine weather in an air mass:

1. Moisture content
2. Cooling process
3. Stability of the air

Characteristics of Cold Air Mass (Arctic and Polar):

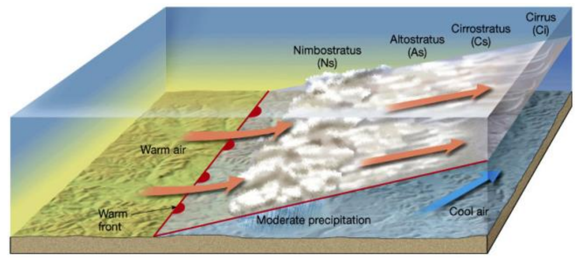
- Instability
- Turbulence
- Good visibility
- Cumuliform clouds
- Precipitation in the form of showers, hail, and thunderstorms

Characteristics of Warm Air Mass (Tropical):

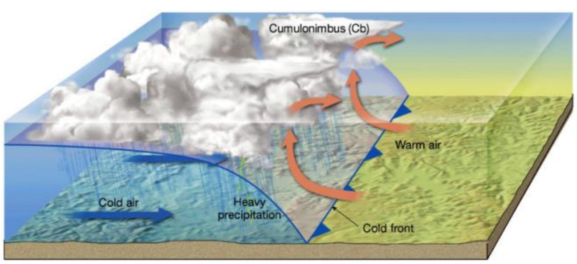
- Stability
- Smooth air
- Poor visibility
- Stratiform clouds and fog
- Precipitation in the form of drizzle

FRONTS
Front: The transition zone between 2 air masses.

Cold Front: A frontal system along which cold air is advancing. When a mass of cold air overtakes a mass of warm air, the cold air, being denser, stays on the surface and undercuts the warm air violently. The slope of the advancing cold front is quite steep as surface friction slows the air at the surface, allowing the upper air to catch up. The rapid ascent of warm air gives rise to a relatively narrow band of cumulus clouds.



Warm Front: Part of a frontal system along which cold air is retreating. As a mass of warm air advances on a retreating mass of cold air, the warm air, being lighter, ascends over the cold air in a long gentle slope. As a result of this long gentle slope and the relatively slow speed of warm fronts, the cloud formation associated with them may extend for 500 or more nautical miles in advance. These clouds develop in a distinctive sequence:

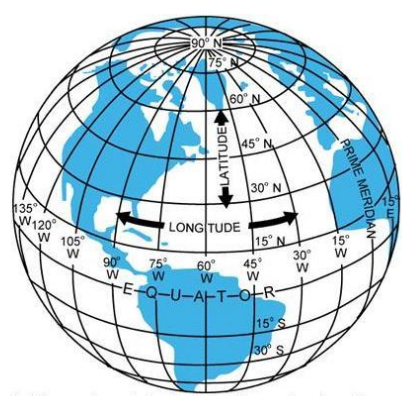


- Cirrus,
- Cirrostratus,
- Altostratus,
- Nimbostratus, and
- Stratus.

M437.01 – AIR NAVIGATION TERMS
MERIDIANS OF LONGITUDE
Meridians of Longitude: Semicircles joining the true / geographic poles of the Earth. Longitude is measured from 0 – 180° east and west of the prime meridian. Longitude is measured in degrees (°), minutes ('), and seconds ("). There are 60 minutes in a degree and 60 seconds in a minute.

The **Prime Meridian** is the meridian which passes through Greenwich, England and is numbered zero degrees.

The meridian on the opposite side of the Earth to the prime meridian is the 180th and is called the **International Date Line** (the time changes a day).



PARALLELS OF LATITUDE
Parallels of Latitude: Circles on the Earth's surface that lie parallel to the equator. Latitude is measured from 0 – 90° north and south of the equator, which is numbered 0°. Like longitude, latitude is measured in degrees, minutes, and seconds.

Equator is an imaginary line on the surface of the Earth equidistant from the poles.

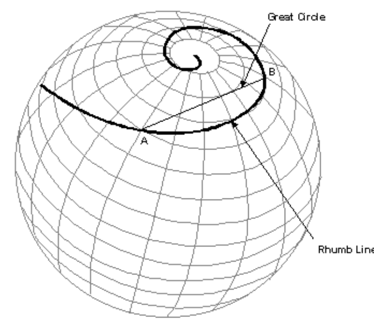
GREAT CIRCLES

Great circle: A circle on the surface of a sphere that passes through the centre of the sphere, cutting it into two equal parts.

The **equator** is a great circle. The **meridians of longitude** are semi-great circles as they run from pole to pole and do not completely encircle the Earth.

Only one great circle can be drawn through two places that are not diametrically opposite each other.

The shortest distance between these two points is the shorter arc of the great circle joining them. Therefore, most long-distance flights are flown over great circle routes.



The great circle is a straight line and the Rhumb line is a spiral curve

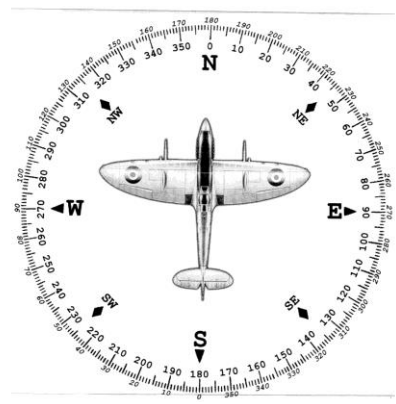
RHUMB LINE
Rhumb line: A curved line on the surface of the Earth, cutting all the meridians it meets at the same angle.

All **parallels of latitude** are rhumb lines. The **meridians of longitude** and the **equator** are rhumb lines as well as great circles.

When two places are not situated on the equator or on the same meridian of longitude, the distance measured along the rhumb lines joining them will not be the shortest distance between them. The advantage of the rhumb line route is that the direction is constant, allowing a navigator to follow a constant heading.

M437.02 – MAGNETIC COMPASS

MAIN PARTS OF THE MAGNETIC COMPASS



- **Lubber line.** The lubber line is a painted white line that indicates the direction the airplane is heading. It is in line with or parallel to the longitudinal axis of the airplane.
- **Compass card.** The compass card contains the numbers. It is attached to the pivot and moves within the compass bowl.
- **Compass bowl.** The compass bowl encompasses the entire compass assembly, including the liquid.
- **Pivot.** The pivot allows the compass card to rotate freely.
- **Magnetic needle.** The magnetic needle always points to magnetic north.
- **Liquid.** The compass bowl is filled with liquid to lubricate the pivot, reduce the weight of the compass card and magnets, and limit movement that may be caused by turbulence.

VARIATION
Variation: The angle between true north and magnetic north. It is also known as magnetic declination.

Agonic lines: Join places of zero magnetic variation.
Isogonic lines: Join places of equal magnetic variation.

COMPASS ERRORS
Northerly Turning Error
On turns from north, northerly turning error causes the compass to lag.
On turns from south, northerly turning error causes the compass to lead.
The amount of the error is greatest over the poles and the least over the equator.

Acceleration and Deceleration Errors

On east and west headings, acceleration causes the compass to register a turn toward north, and deceleration causes the compass to register a turn toward south.