Aerodynamics Brainstorm File
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Atmosphere consists of 78% Nitrogen, 21% Oxygen, 1% other gases
`Troposphere` is where temperature decreases with altitude (1.98^oC 1000ft) and where the weather takes place.
Lapse Rate ISA International Standard Atmosphere = Temperature decreases 1.98^oC per 1000ft
Temperature Unit conversion F = 9C/5+32 C = 5/9(F-32) K=C+273
`Temperature Variation in the Troposphere` is
above the Equator -80^oC , above $45^oN/S$ -56^oC , above the poles -45^oC
At Sealevel the atmosphere pressure is normally 950 - 1050mb or hpa (1013 hpa is standard)hpa = hecto pascal = `Static Pressure`. With increase in altitude atmospheric pressure drops e.g. at 30,000ft the pressure is 300.9 hpa = `Pressure Altitude` = the ISA pressure given for a certain altitude (also `density altitude`). In reality this varies with the ambient temperature. `Density` = $\frac{Mass}{Volume}$ in kilogram per cubic meter . `Factors affecting density` when considering a gas are $Density = \frac{Pressure}{GasConstant \cdot Absolutetemperature}$

Reduced air density above 10,000 ft affects the human body and leads to hypoxia, lack of judgement to sleepiness or collapse according to altitude.
The greater the `humidity`, the lower the air — humidity decreases the total pressure
`Performance Ceilings` Info from www.EASA66.com
`Service Ceiling` is the altitude where the rate of climb of an aircraft falls below 100 ft per minute
`Absolute Ceiling` is the altitude where the rate of climb of an aircraft falls to zero

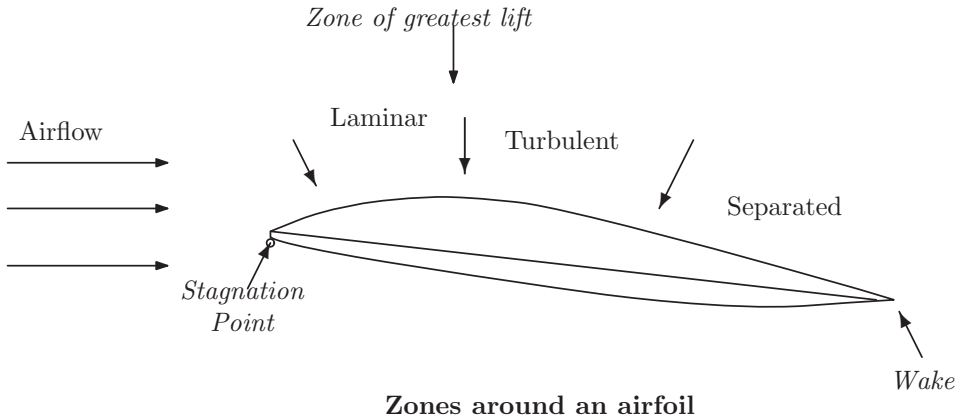
Gas Laws `Boyle's Law` = P_1 x V_1 = P_2 x V_2 V= Volume , P= Pressure

`Charles' Law` = $\frac{V_1}{K_1} = \frac{V_2}{K_2}$ V= Volume , K= Constant — Volume increases by 1/273 per every ^oC

`Combined Boyle's and Charles' Law Equation` $\frac{P_1 \cdot V_1}{K_1} = \frac{P_2 \cdot V_2}{K_2}$
Speeds
`Indicated Airspeed` IAS = dynamic air pressure of air against a vehicle = $\frac{1}{2}\rho V^2$ = `Dynamic Pressure`
`Rectified Airspeed` RAS is IAS corrected for instrument position errors
`Equivalent Airspeed` EAS = Rectified Air Speed corrected for compressibility (as subtracted quantity)
`True Airspeed` TAS = the Equivalent Air Speed corrected for Density
`Calibrated Air Speed` CAS for mean sea level compressibility corrected indicators also corrected for instrument and position errors
`Mach Number` is the ratio of TAS to the local speed of sound

Info from www.EASA-66.com

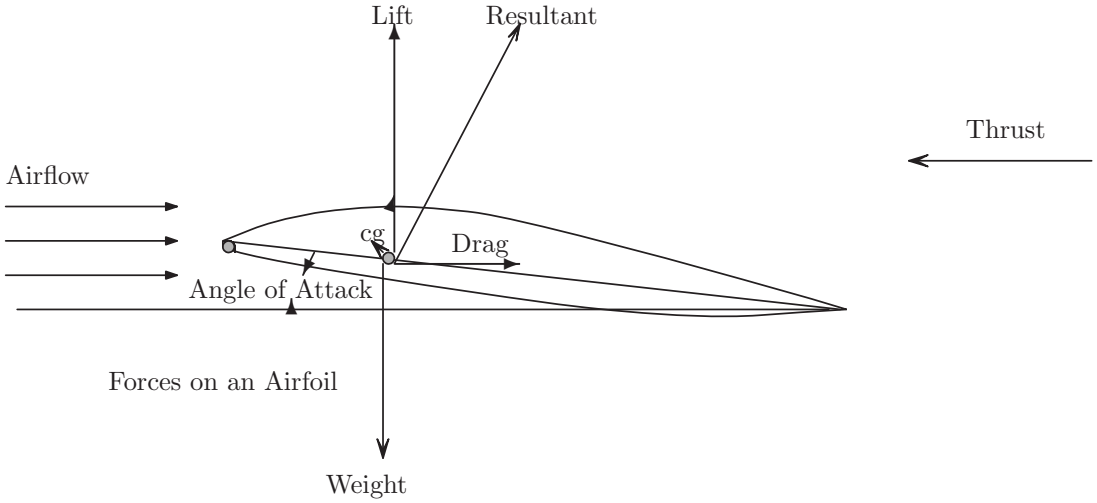
Principles of Airflow
Dynamic pressure at 400kts is about 4 psi (1013.25 hpa = 14.69 psi)
Moving air passes and airfoil quicker than a cube, therefore the shape is very important. In a venturi or on an airfoil $A_1 \cdot V_1 = A_2 \cdot V_2$, which means the mass of air being at the leading edge is meeting again at the trailing edge. Therefore it must flow faster over the curved area and therefore reduces its pressure, which gives the lift on the airfoil.



Zones around an airfoil

The **Stagnation Point** is the place where the air divides and so the full `Dynamic Pressure` will attack there.
The flow along the Boundary Layer may be laminar = parallel in streamline to the surface or turbulent. The highest lift coefficient is in the laminar zone. After the laminar area the airflow becomes turbulent until it separates and the wake begins.

LIFT



DRAG

Drag is divided in `Profile Drag` or `Zero Lift Drag` and `Induced Drag` or `Lift Dependent Drag`
Profile Drag = parasitic drag consists of:
Form or Pressure Drag
a part of Profile Drag depends on: Size, Fineness Ratio, Speed, Air Density, Separation Point.
Skin Friction Drag
depends on Wetted Area, Surface Roughness, Speed, Viscosity and Density, type of boundary layer flow.
Interference Drag occurs where two airflows meet e.g. wake.
Define chord line : a straight line joining leading edge and trailing edge, act as a reference line
Aircraft is ground by : bonding straps
Boundary layer definition : airflow passes over aerofoil and retard by skin
Define the centre of pressure : A point on the chord line, at which, the lift of the main planes acting vertically through this point
Stagnation point : the point on the leading edge of an aerofoil where the airflow separates, some going over along the surface and some going below along the surface

Print it out and learn it by heart!

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Bernoullis Principle: When a gas is accelerated, its pressure decreases.
Principles of Airflow
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All three axes of rotation intersect at the center of gravity; thus the aircraft maneuvers around the CG.
Angle of Attack: Angle between the relative wind and the chord.
Angle of Incidence: is the angle between the chord line of the wing and the longitudinal axis of the aircraft.
The **Stagnation Point** is the place where the air divides and so the full `Dynamic Pressure` will attack there.
The flow along the Boundary Layer may be laminar = parallel in streamline to the surface or turbulent. The highest lift coefficient is in the laminar zone. After the laminar area the airflow becomes turbulent until it separates and the wake begins.
Aspect Ratioratio of wingspan to the mean aerodynamic chord. High aspect ratio (long thin wings) have increased lift and decreased drag at high angles of attack. They have the disadvantage of increased drag at high airspeeds. Aircraft with low aspect ratios have poor drag characteristics at low speed, but are more efficient at higher airspeeds.
A wing will always **stall** at the same angle of attack. The load factor, weight and density altitude will cause the stalling true airspeed to vary but the stall angle of attack will always be the same.
Parasite drag increases with the square of the aircrafts airspeed. Includes form, skin friction, interference and wave.
Induced drag is a byproduct of lift and is proportional to the angle of attack of the wing.
The greatest change in airplane trim and stability will occur when power is added at slow speed.
As an aircraft burns fuel and becomes lighter, the optimum cruise altitude slowly increases and the speed that yields the optimum cruise performance slowly decreases.
Absolute Altitude: the altitude at which maximum climb power can just maintain level flight and zero rate of climb.
An airplane climbing at constant **Mach number** will experience a decrease in TAS as the temperature decreases.
Subsonic: below .75 Transonic: from .751.2 Supersonic: 1.25.0 Hypersonic: over 5.0
Critical Mach: the speed at which the first airflow over the wing reaches but does not exceed the speed of sound
Mach Tuck: as the critical Mach number is exceeded, part of the wing root is shock stalled. This causes loss of downwash on the tail as well as an aft movement of the wings center of pressure. The result is a pitch down tendency.
Swept wing greatly increases the critical Mach number, increases aspect ratio and effective camber, and reduces the maximum coefficient of lift. Also the wing tips have a strong tendency to stall first which gives early loss of aileron control with very little aerodynamic buffet on the tail surfaces.
Dutch Roll: a yaw causes the opposite swept wing to produce more lift and induced drag. This causes a roll in the direction of yaw and a corresponding yaw in the opposite direction. Usually dampened out by vertical stabilizer but a yaw damper may be required.
Temperature Lapse Rate: 2 C per 1,000 ft to 38,000 ft.
Pressure Altitude: height above standard datum plane.
Indicated Altitude: current local altimeter, approximates actual height above sea level.
True Altitude: actual height above sea level. Higher than indicated when warm. Lower than indicated when cold.
Density Altitude: pressure altitude corrected for non-standard temps. Higher than pressure alt when warm and lower than pressure alt when cold.
Air Density: airs thickness determined by pressure, temperature and humidity. Greater air density means more oxygen available for combustion. Increases with increasing pressure and decreases with increasing temp or humidity.
Tropopause separates Troposphere (Std lapse rate) and Stratosphere (Little change in Temp)
Surface Inversion: ground cools by radiation, cools the air near the surface. Lower air cooler than higher airwith small temp/dew point spread, fog or low clouds can develop.
Ice can form on an aircraft in flight when the temperature is below freezing and visible moisture is present. Highest accumulation is associated with freezing rain. Optimum temp for icing is 0^o to 15^o C. Almost no icing below 40^oC (-40^oF).
Extremely heavy rain can form a film of water over the wing that can be roughened by impact of raindrops and cause a loss of lift.