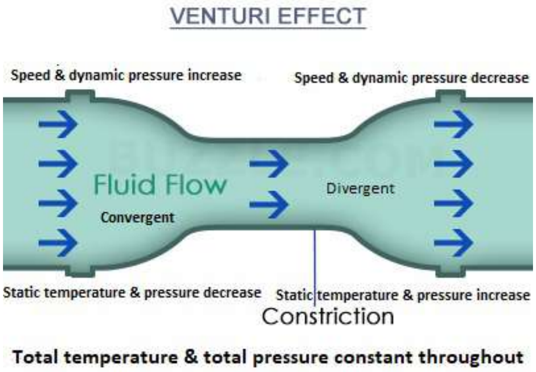
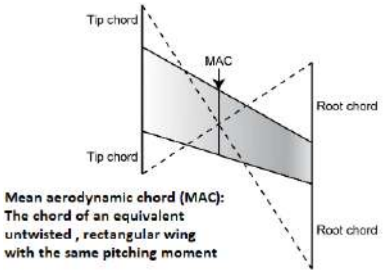
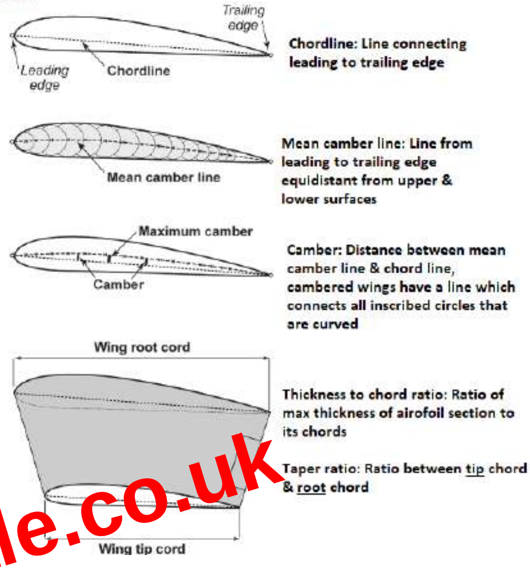
POF

General:

Bernoulli: Sum of all energy constant
Temperature ~ density(rho)[kg/m^3]
Density ∝ mass
Density ∝ pressure
Density does not vary in venturi
Density decrease as humidity increase
Temp ↑ mass flow ↓
Dynamic pressure [q](N/m^2)
= $^1/_2$**ρV(TAS)^2**
Dynamic press = 0 when speed = 0
Static + dynamic = constant
p/(rho*T) = Constant







- SI units:
  - Weight (Newton) = Force = Mass(kg) x acceleration
  - Power (Nm/s) = Watts (W) Force x distance ÷ time (J/s) [There is time]
  - Work = Joule
  - Force [kg.m/s^2]= m x a
  - Wing loading[W/S](N/m^2): Weight of aircraft ÷ area of the wings
- Density decrease with increase in humidity (Dry air = better performance)
- Mean geometric chord: Wing area ÷ wing span
  Difference between **MAC** & **mean camber line**
  Relative thickness: Expressed in % chord
  Symmetrical airfoil: 0 camber, mean camber line = chord line
  & lift characteristics as the actual wing
- **Aeroplane** AOA: Angle between speed vector & longitudinal axis
  Wing AOA: Angle between longitudinal axis & wing root chord line
  Angle of incidence: Angle between wing root chord line & longitudinal axis
  Dihedral angle:
  - Angle between wing plane & the horizontal with aeroplane in an unbanked level condition
  - Angle between the 0.25 chord line of the wing and the lateral axis
- Lift & drag forces depend on the pressure distribuition around the aerofoil cross section
- Lift = Component of total aerodynamic force perpendicular to the **undisturbed** airflow

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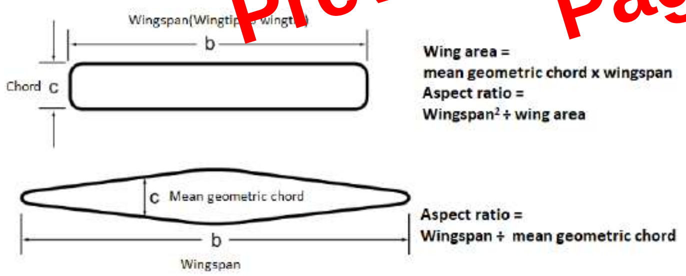
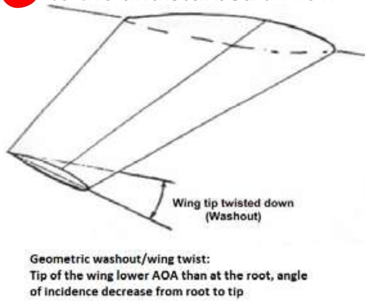
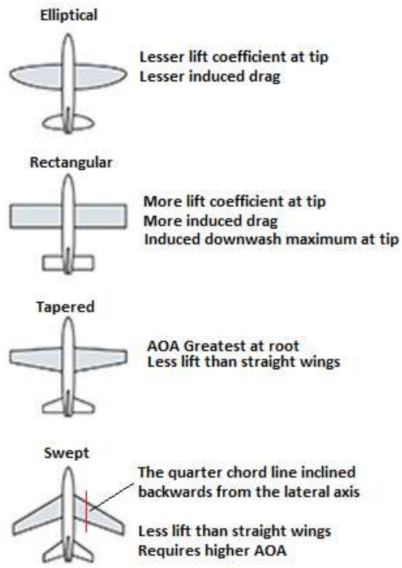




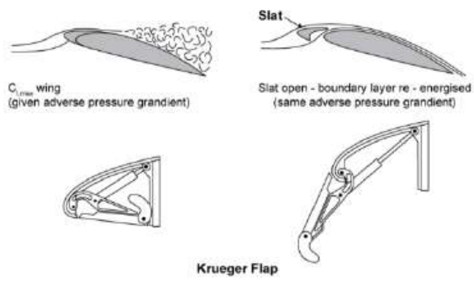


2D airflow over an aerofoil

- Typical C_L/C_D ratio: Max at angle of attack of 4°
- Lift:
  - Upwash ahead of the wing & downwash behind
  - Downwash increase: Lift generated by the aerofoil increases
  - Upper surface produces greatest proportion of lift at all speeds
  - Generated when the flow direction of a certain mass of air is changed
- Stagnation point:
  - Static pressure maximum value
  - Relative velocity = 0
- AOA
  - Decrease: Stagnation point moves forward /up, lowest pressure(CP) moves aft, COP moves aft
  - Increase: Stagnation point moves down, lowest pressure(CP) moves forward, COP moves forward until crit AOA
- Aerodynamic centre of an aerofoil:
  - Approx 25% chord irrespective/**independent of AOA**
  - Assume no flow separation, pitching moment coefficient does not change with carying angle of attack

- Moves aft then turns down
- Increase wing area & camber

3. Slotted flaps:
   - Increasing camber & re-energize flow through slots



- Krueger leading edge flap:
  - Part of the lower surface of the leading edge, hinged at its forward edge
- Slat:
  - Critical AOA increases when slat is deployed
  - Increases C_{LMAX} more than it causes yawing moment
  - Large decrease in stall speed with relatively less drag
  - Slats are installed outboard (Near tips)
  - Higher contribuition to C_{LMAX} than flaps at any position, greater effect on stall speed than flaps
  - Increase boundary layer energy at the suction peak (fixed point), postponing stall to higher AOA using venturi effect
  - An auxiliary leading edge device cambered aerofoil positioned forward of the main aerofoil so as to form a slot
  - Automatically operated by aerodynamic forces acting on the leading edge, when a certain AOA is reached
- Vortex generators:
  - Delays stall by reducing boundary layer separation, installed near wing **leading** edge
  - Re-energize boundary layer
  - Transfer energy from the free airflow into the boundary layer
- Tailplane:
  - Increased downwash at tailplane = Increased negative lift (Downward lift of tailplane), producing a pitch up moment (Which opposes wing pitch down moment at wings upon flap deployment), and increasing effectiveness of the tailplane (More airflow over the tailplane & control surfaces)
- Asymmetric flaps:
  - Flap asymmetry causes rolling, slat asymmetry causes difference in C_{LMAX} or yawing moment
  - Slightly asymmetric flaps: Causes a steady rate of roll which may be correctable with ailerons

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- Spoilers:
  - Roll spoilers: Reduces lift on a part of wing, generating the desired rolling moment. There is a local increase in drag which supresses adverse yaw
  - Spoiler extension **increases the stall speed**, the **min rate of descent** (ROD) & **min angle of descent**
  - Symmetrically deflected spoilers: Decelerate aeroplane/decrease ROD, may be used as speed brakes during flight
  - Speed brakes increase drag in order to maintain a steeper gradient of descent, spoilers may be used as speed brakes
  - **AOA constant**, spoilers deployed: C_D **increases** & **C_L decreases**
  - Flight level & **speed constant**: C_D increases & **C_L unaffected (More correct)**
  - Air brakes reduce **min drag speed**
  - Wing spoiler extension causes an increase in drag & decrease in lift
- Boundary layers:
  - Laminar:
    - Less change in velocity close to surface
    - Lesser mean speed
    - Friction drag lower
    - Thinner
    - More tendency to separate from the surface
    - Less kinetic energy than turbulent layer
    - No velocity components exist normal to surface
  - Turbulent:
    - More change in velocity close to surface
    - More mean speed
    - Friction drag higher
    - Thicker
    - Less tendency to separate from the surface
    - More kinetic energy than laminer layer
    - Compared with laminar layer, a turbulent boundary layer is better able to resist a positive pressure gradient before it separates
- Skin friction drag:
  - Increases with age
  - Ageing causes the transition point to move forward & larger part is turbulent
- Icing:
  - Frost: Decrease in lift & an increase in drag
  - Increases landing distance up to 40 – 50%
  - Most critical during rotation
  - Ice accretion causes reduction in C_{LMAX}, increase of drag

- Coffin corner: Stall speed = critical mach number, speed is too low & too high at the same time

<u>**M_{CRIT} influence**</u>
- Sweepback:
  - Appearance of shockwaves: Decreased velocity of air perpendicular to the leading edge
  - M_{CRIT} Increases with sweepback
  - M_{CDR}(Drag divergence mach number) increases with sweepback
  - Straight wing vs sweepback: 1.154 times increase of M_{CRIT} theoretically but half that value practically
  - Slower onset of transonic drag rise
  - **Higher C_D in-flight**
  - Lesser effectiveness of high life devices (Flaps etc.) as sweepback is increased
- Thickness/chord ratio:
  - **Reduced**: Delays onset of shock wave, reduces transonic variations in lift & drag coeffcients C_L/C_D
  - Thin aerofoils increases M_{CRIT}
  - Thick aerofoil & high AOA decreases/lowers M_{CRIT}
- Area ruling:
  - Gives aircraft smooth cross-sectional area distribuition
  - Decreases wave drag
  - Gives “waist” or “coke bottle” shape
- Camber: Larger camber gives lower M_{CRIT}
- Supercritical aerofoil:
  - Larger nose radius, flatter upper surface & with negative as well as positive camber
  - Allows a wing of relative thickness to be used for approximately the same cruise Mach number
  - Shows no noticeable shockwaves when flying just above M_{CRIT}
- Vortex generators
  - Decrease wave drag
  - Decrease shockwave induced separation
  - Reduce boundary layer separation drag when shockwaves form

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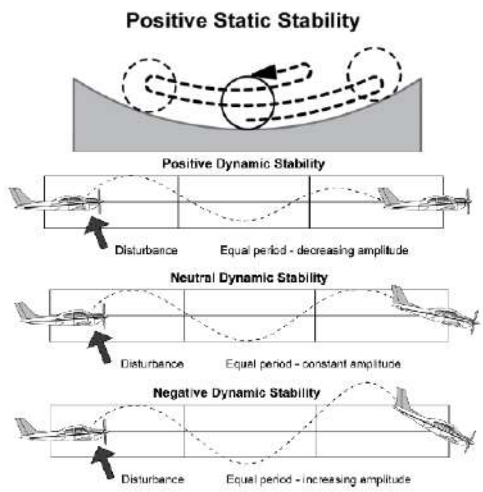
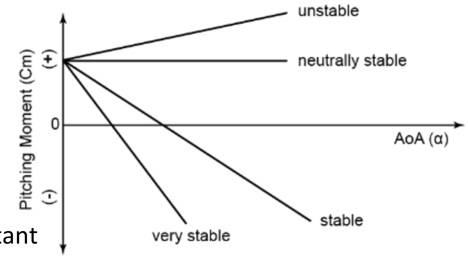
<u>**Stability:**</u>
- For there to be a condition of dynamic stability (Positive/neutral/negative) it must have positive static stability first
- For a plane to have dynamic stability it needs static stability & sufficient damping
- **Tends** to return: Positive static stability, initial **tendency** to return to equilibrium
- Returns: Positive dynamic stability
- Less stability = more manoeuvrability & vice versa
- Sum of moments about one axis is not = 0:
  - An angular acceleration about that axis exists
  - Aeroplane starts to rotate about its centre of gravity



<u>**Longitudinal stability(Around lateral axis):**</u>
- Transport aircraft load factor limit: 2.5G
- Positive static longitudinal stability: Nose down moment occurs after an upgust
- Phugoid:
  - Slow changes in speed & altitude
  - Dynamic longitudinal stability
  - Altitude varies significantly
  - Speed varies significantly
  - Can be easily controlled by the pilot
  - Long period of weak damping
- Short period oscillation:
  - Altitude remains approximately constant
  - Speed remains approximately constant
  - Should always be heavily dampened



- Directly influenced by centre of gravity (CG):
  - Aft CG limit: Determined by minimum acceptable static longitudinal stability, minimum value of the stick force per G
  - Fwd CG limit: Limited by insufficient flare capability & insufficient in-flight manouevrability, minimum control response
  - Neutral point: Aircraft become longitudinally unstable when CG is shifted beyond this point
  - CG static margin: Distance between CG datum & CG neutral point
  - Magnitude of stick force determined by distance the CG is forward of the neutral point
- Contribuitions to static longitudinal stability :
  - Engine nacelles aft of CG have **positive** contribution to static longitudinal stability
  - Wing contribuition depends on CG location relative to the wing aerodynamic centre
    May be negative, also with flaps