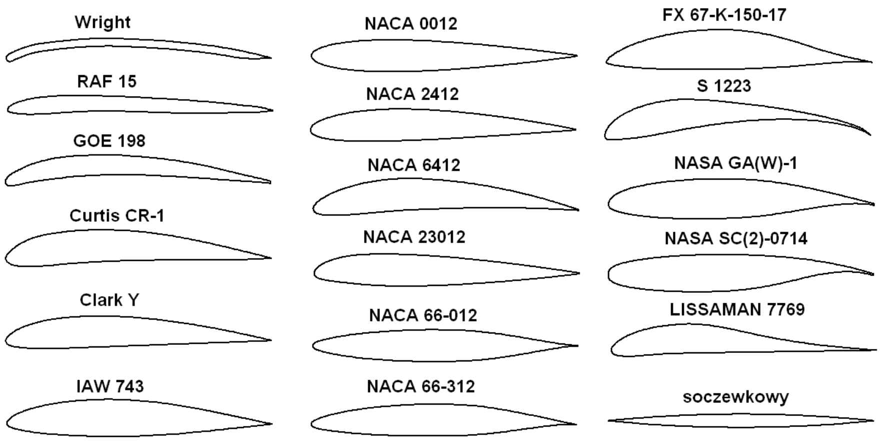
Wing

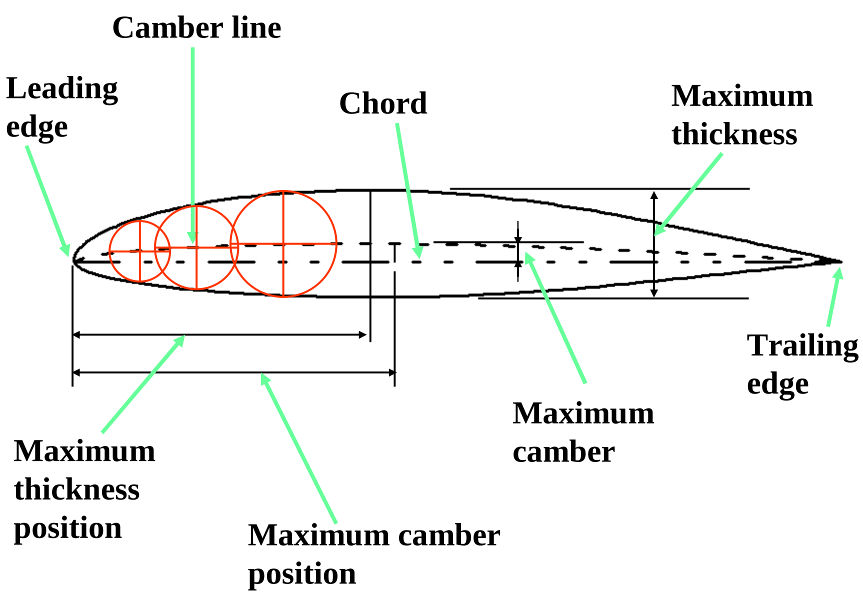
Airfoil selection

- Aerodynamic characteristics (K_{max}, C_{Lmax}, stall characteristics)
- Structural reasons;

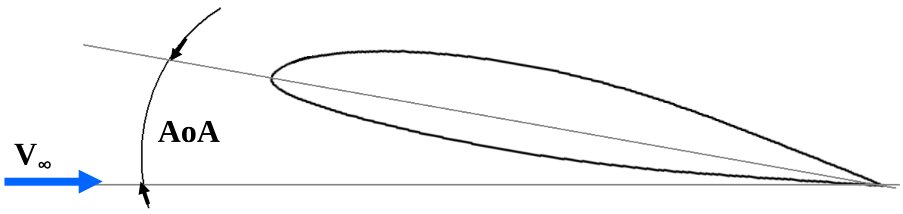
Airfoil geometry



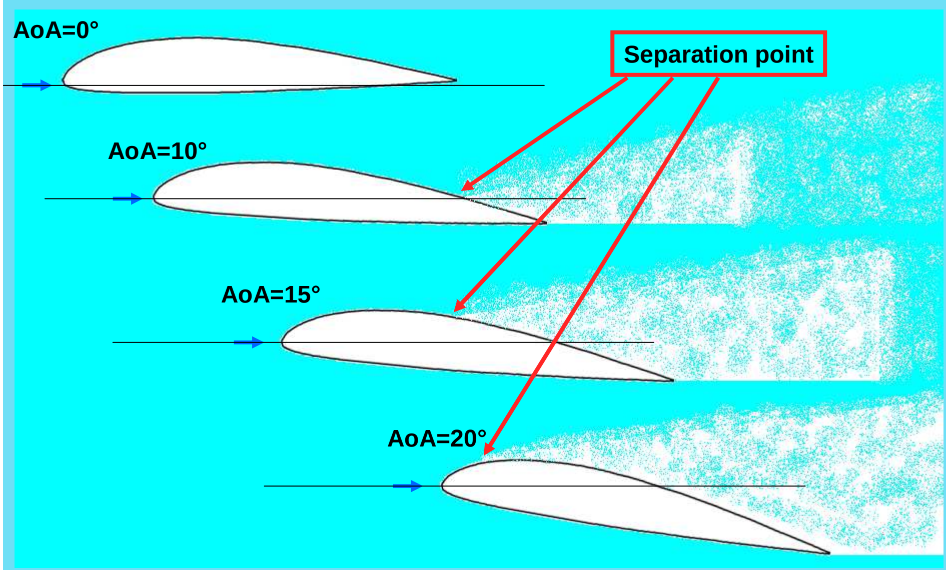
Airfoil geometry



Angle of attack definition

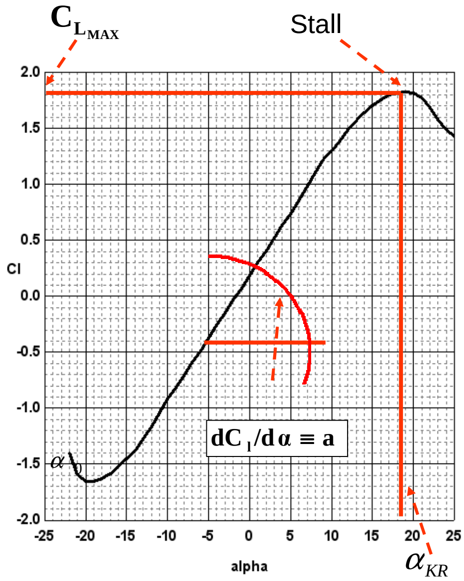


Stall

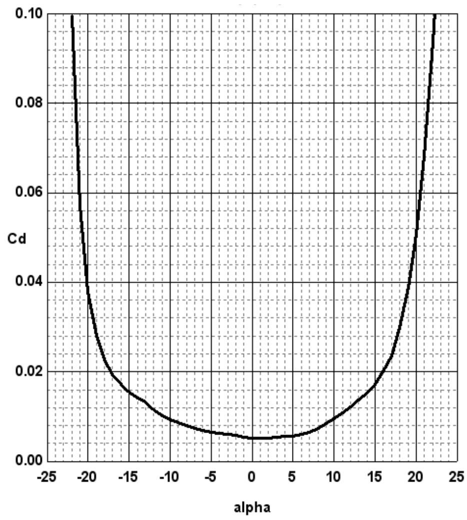


Airfoil aerodynamic characteristics

Lift coefficient (C_z or C_L)

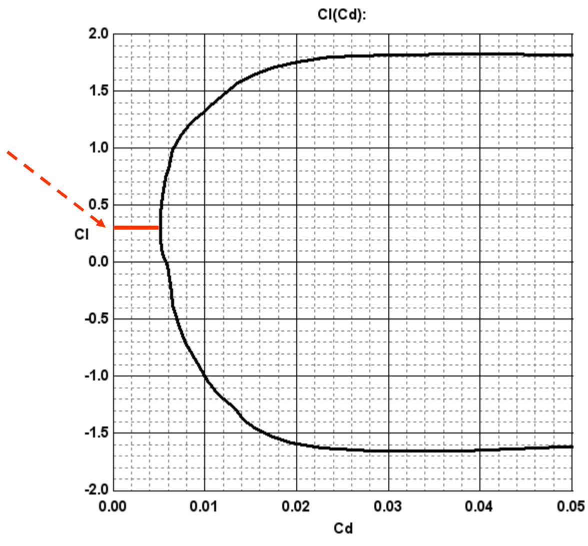


Drag coefficient (C_x or C_D)



Airfoil aerodynamic characteristics

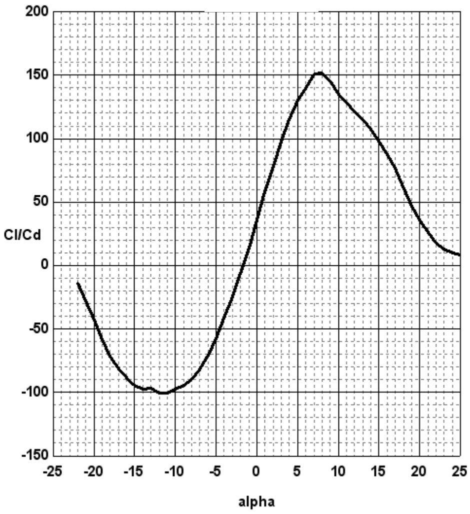
Design C_z

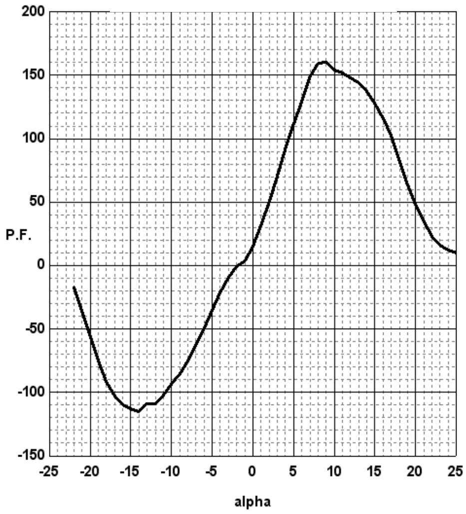


Airfoil aerodynamic characteristics

Gliding ratio (C_z / C_x)

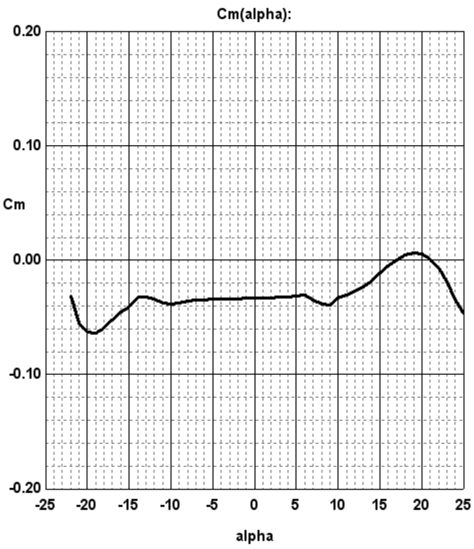
Power factor (C_z^3 / C_x^2 lub $C_z^{1,5}$ /Cx)





Airfoil aerodynamic characteristics

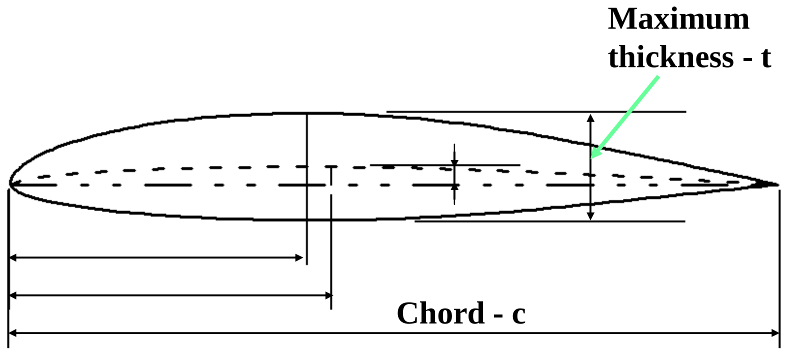
Pitching moment coefficient C_m



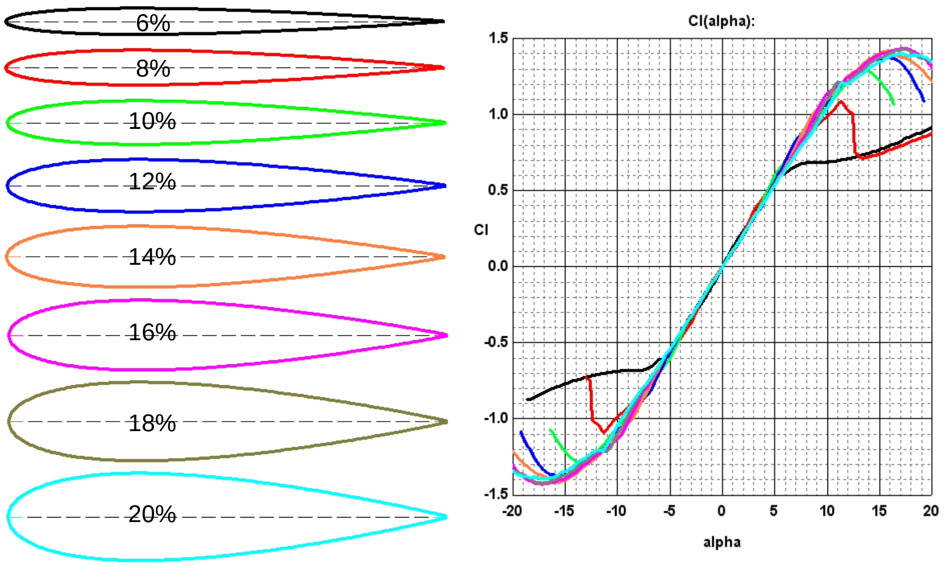
Derivative dCm/dCz is an indicator of stability.

It is negative for stable aeroplanes and positive for unstable aeroplanes.

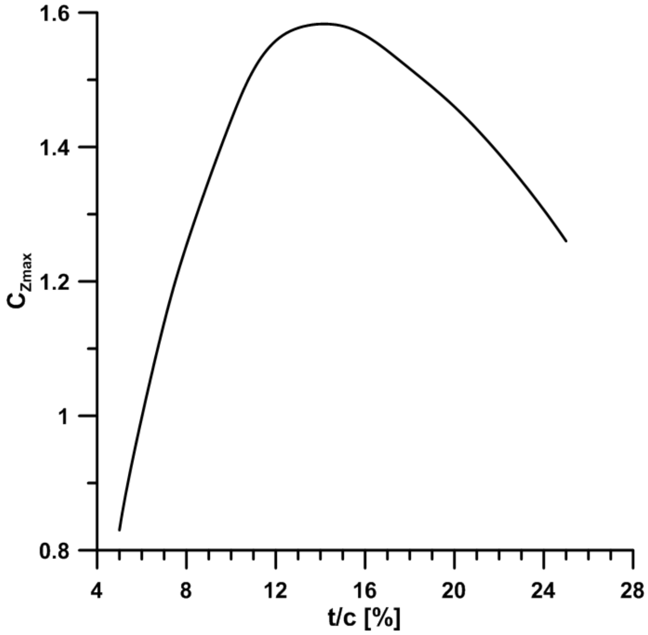
Maximum thickness – t/c



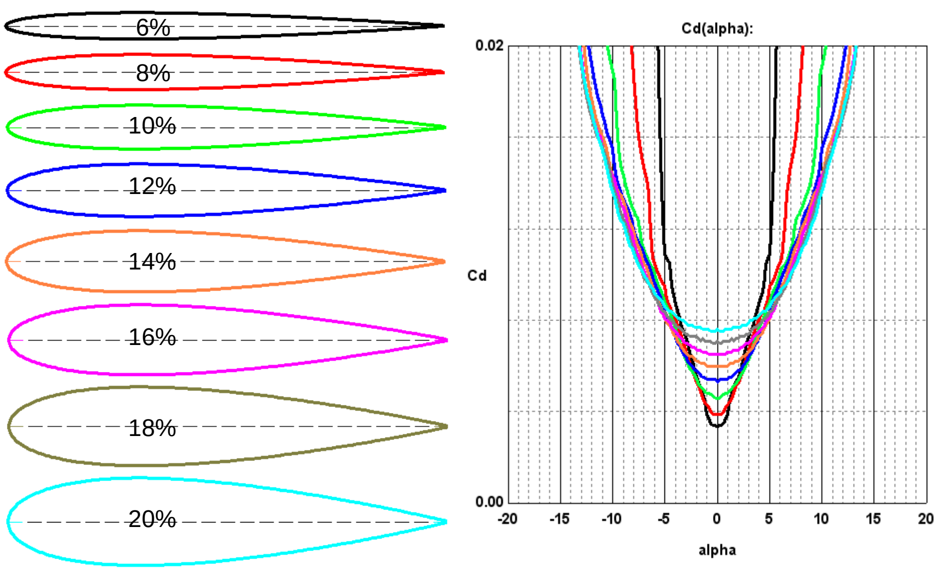
Effect of airfoil thickness on lift coefficient



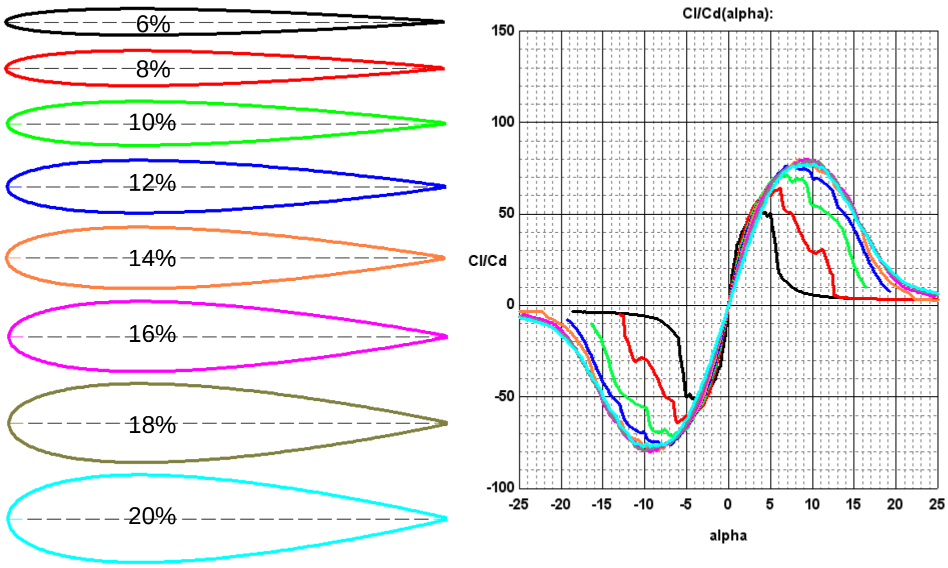
Effect of airfoil thickness on lift coefficient



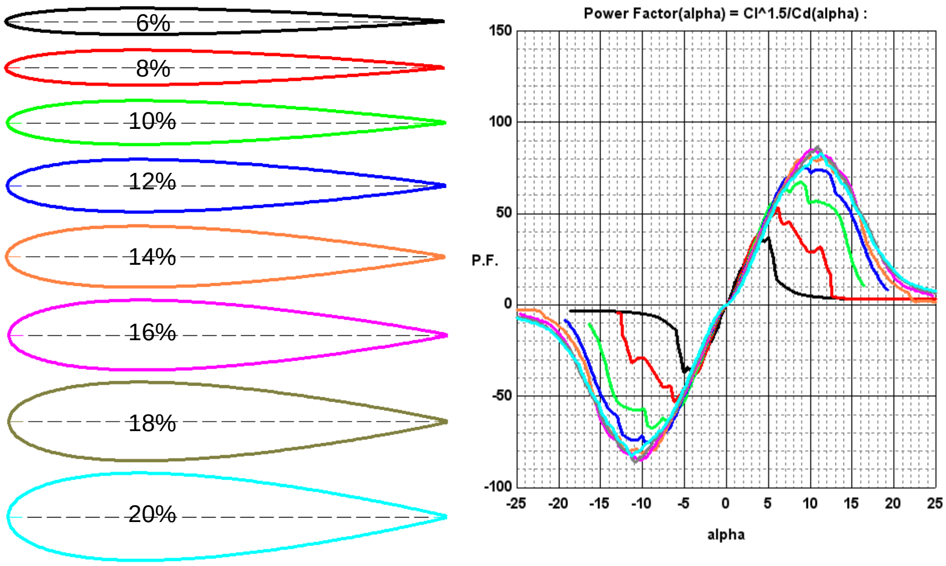
Effect of airfoil thickness on drag coefficient



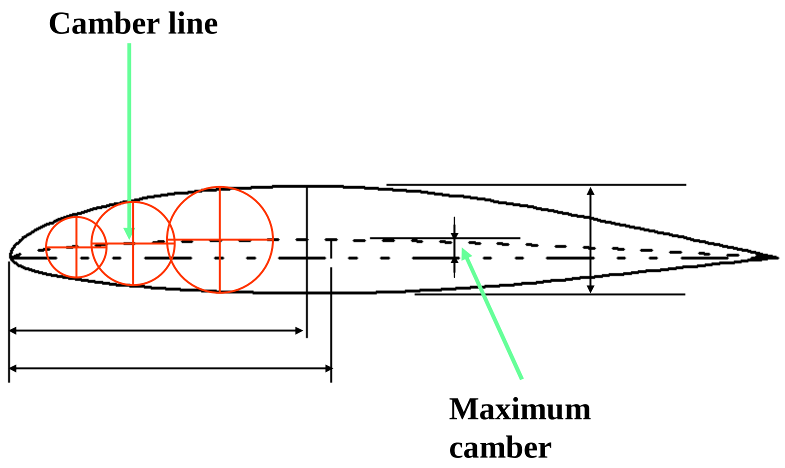
Effect of airfoil thickness on gliding ratio



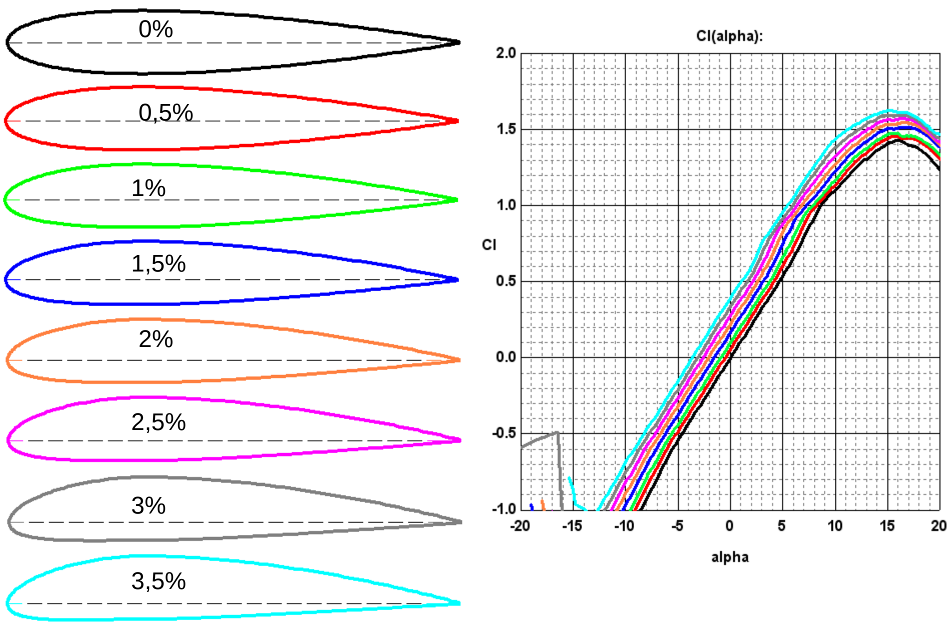
Effect of airfoil thickness on power factor



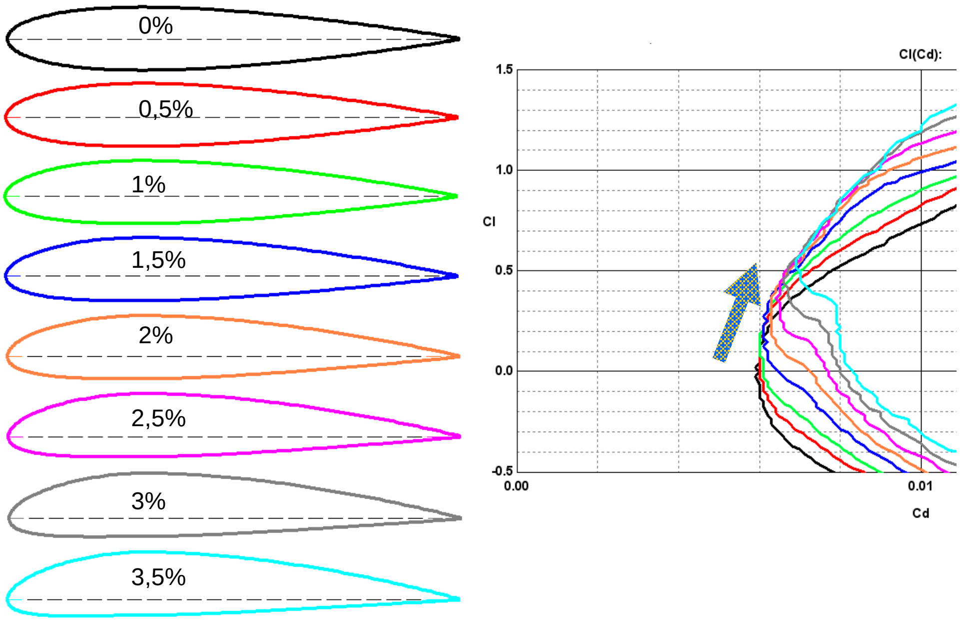
Camber



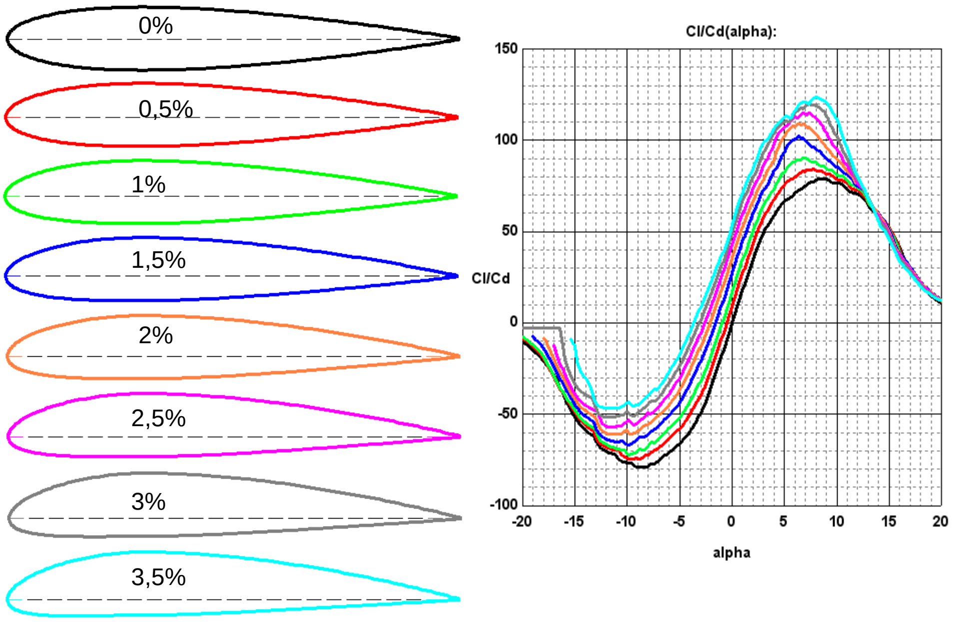
Effect of airfoil camber on lift coefficient



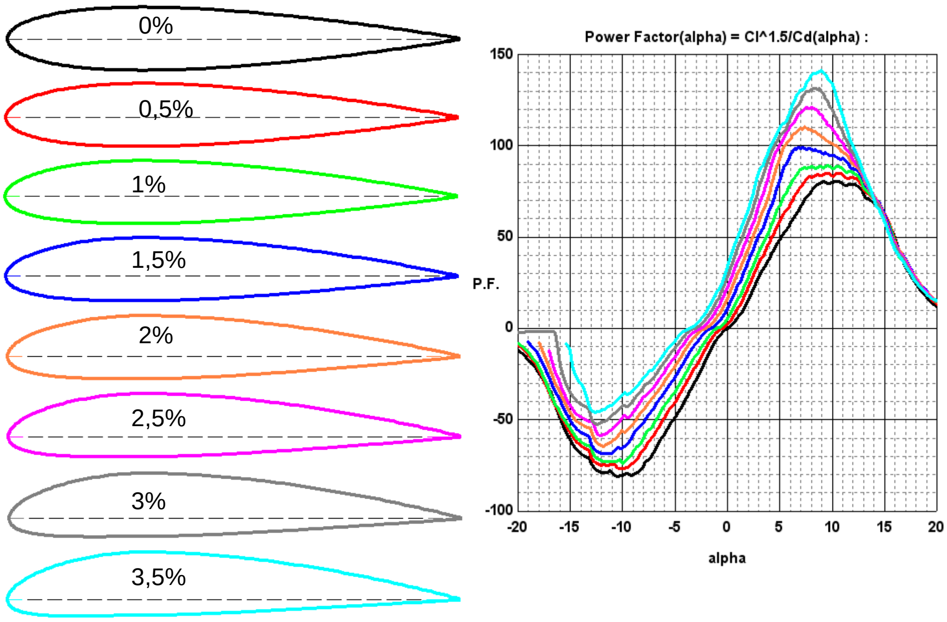
Effect of airfoil camber on drag coefficient



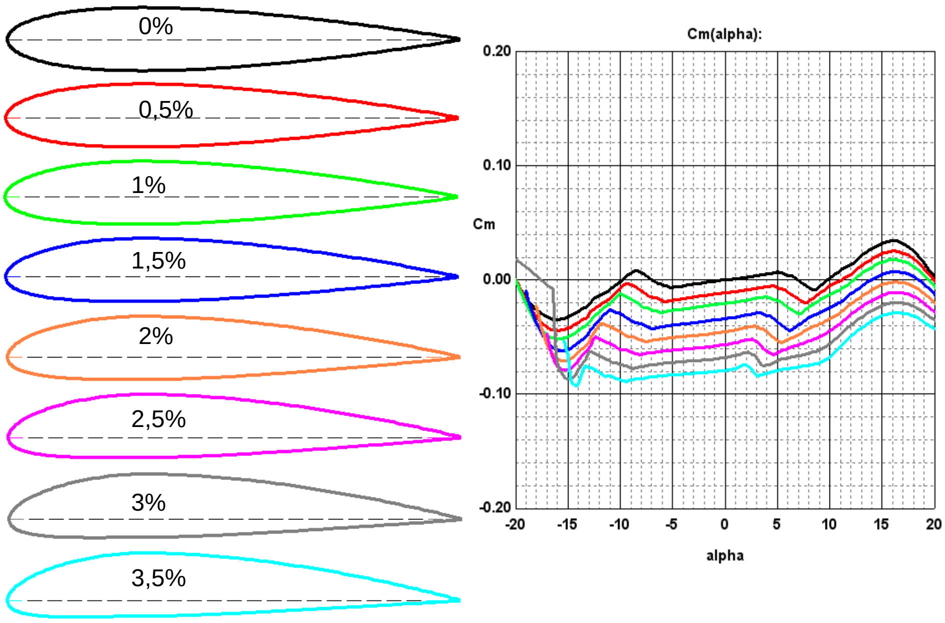
Effect of airfoil camber on gliding ratio



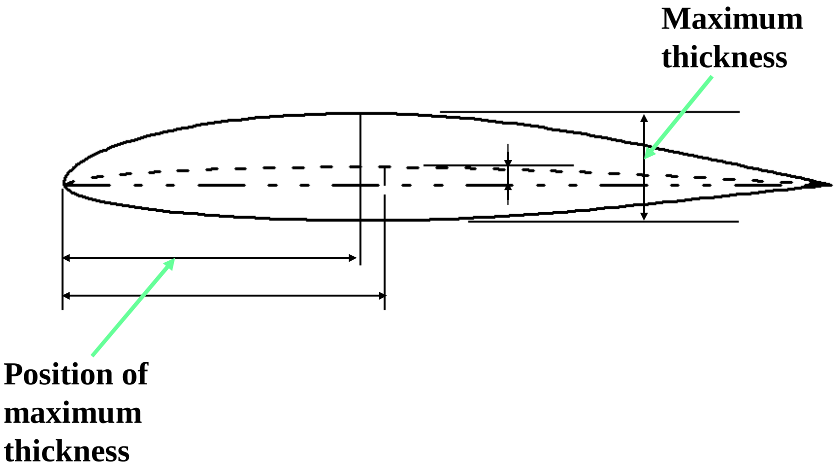
Effect of airfoil camber on power factor



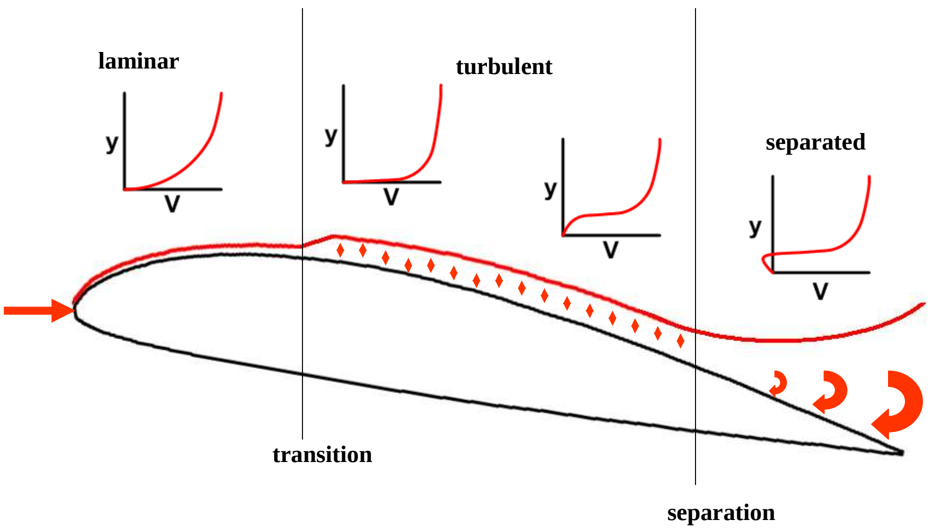
Effect of airfoil camber on moment coefficient



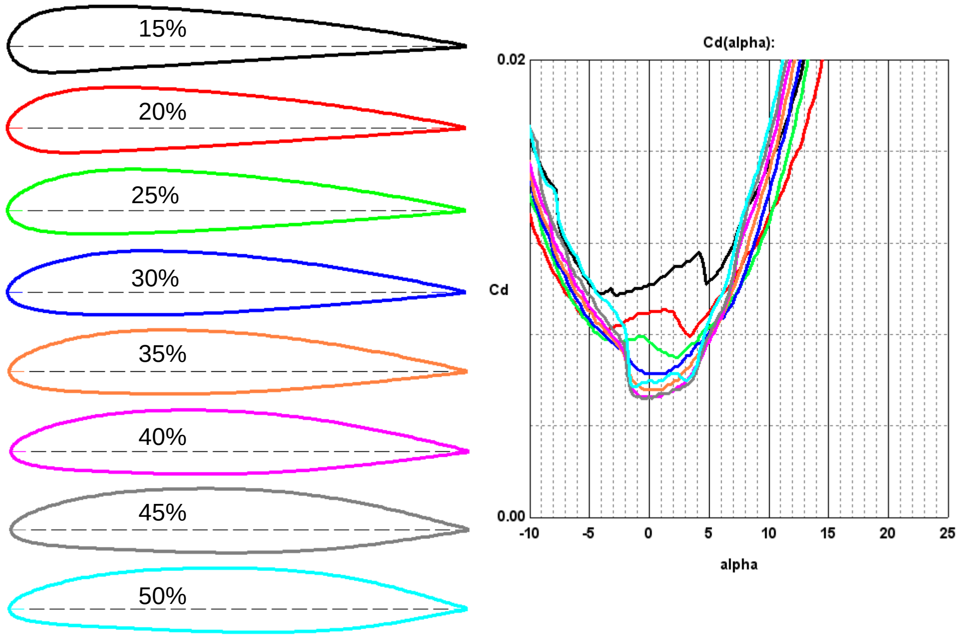
Position of maximum thickness



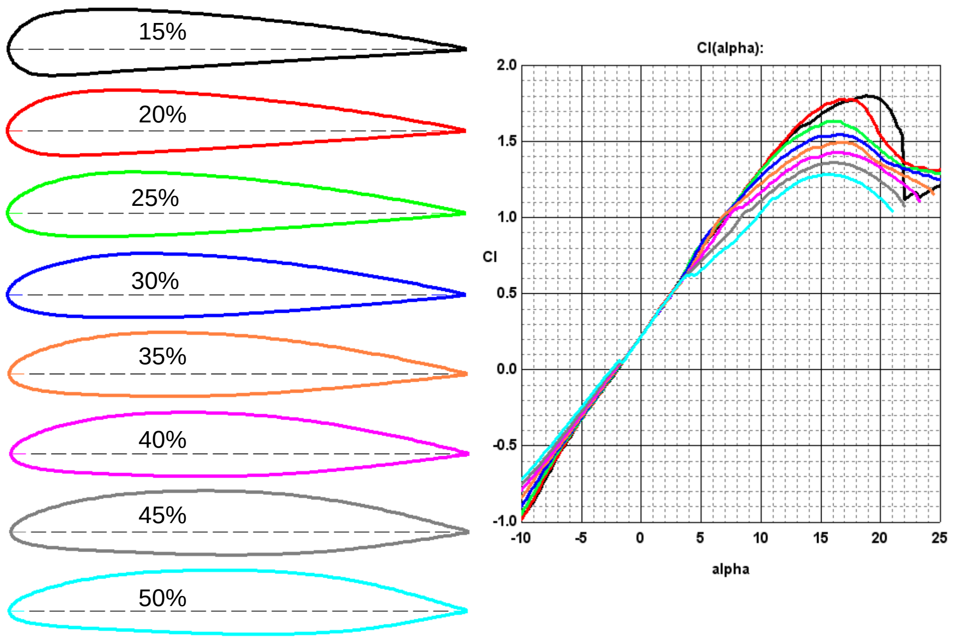
Boundary layer development



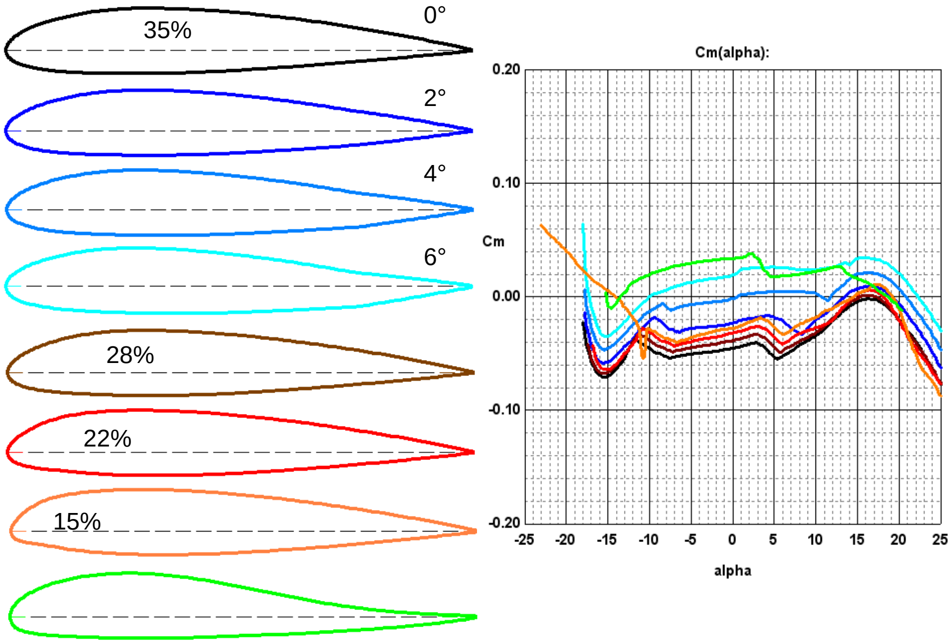
Effect of airfoil „laminarity” on drag coefficient



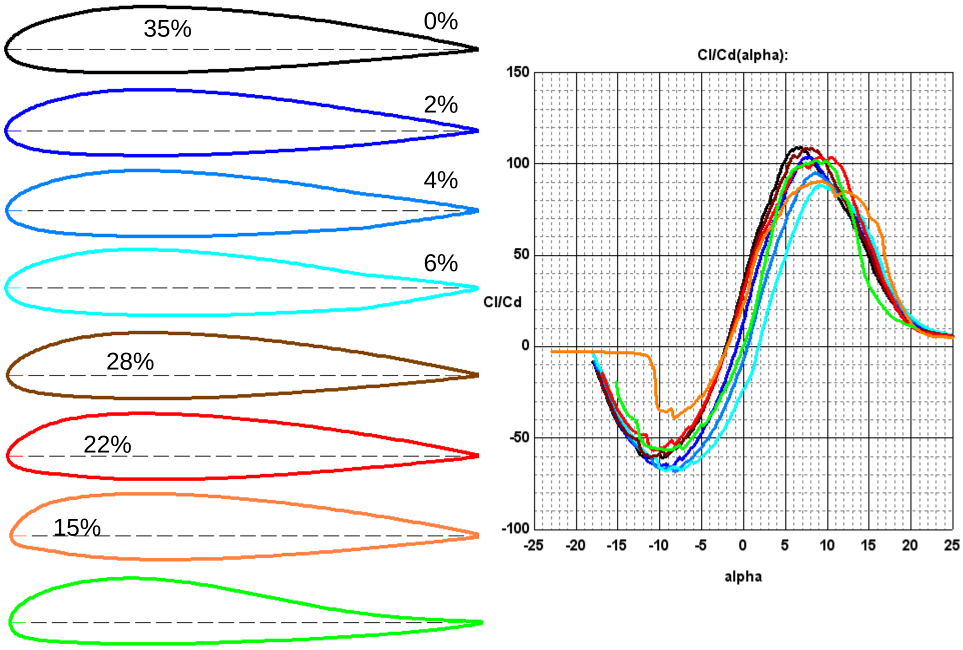
Effect of airfoil „laminarity” on lift coefficient

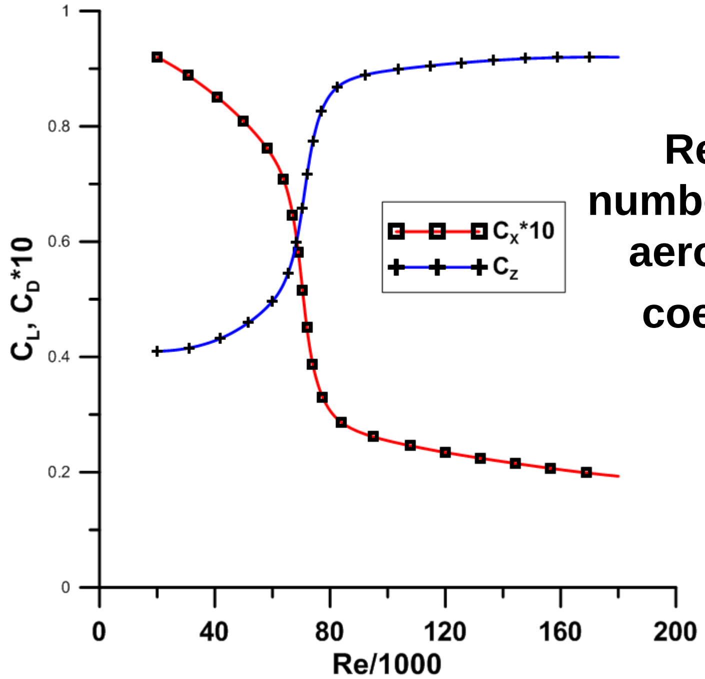


Effect of camber line shape on moment coefficient

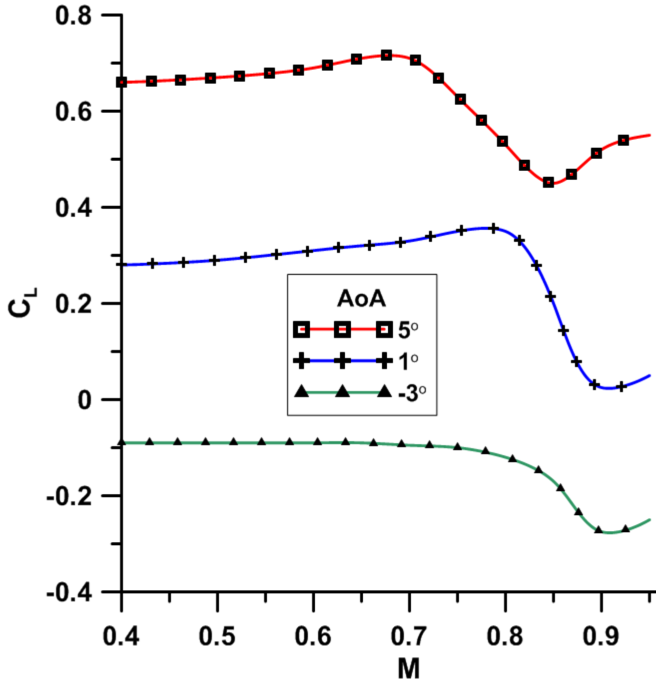


Effect of camber line shape on gliding ratio

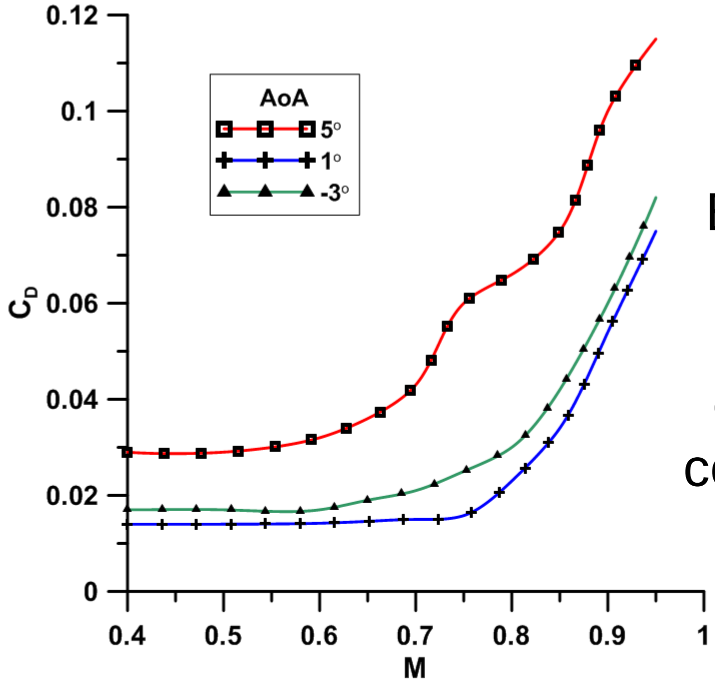




Reynolds number effect on aerodynamic coefficients

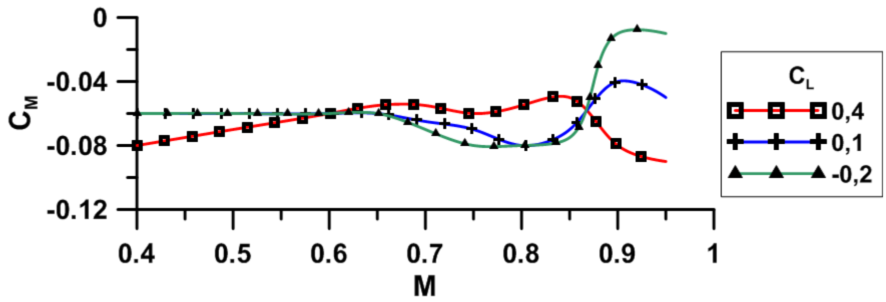


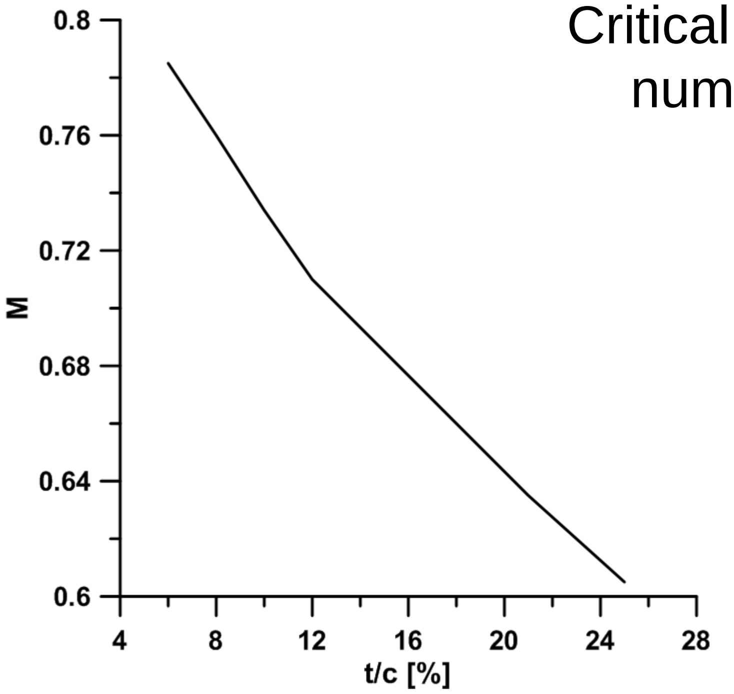
Effect of Mach number on lift coefficient



Effect of Mach number on drag coefficient

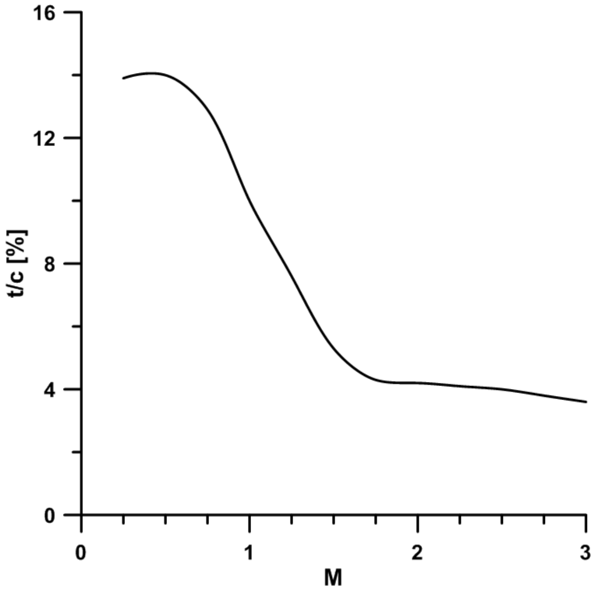
Effect of Mach number on moment coefficient



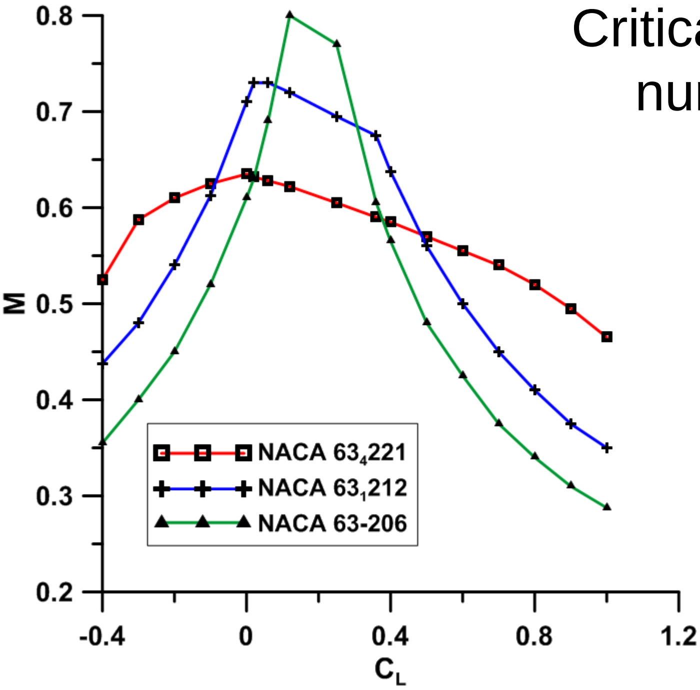


Critical Mach number

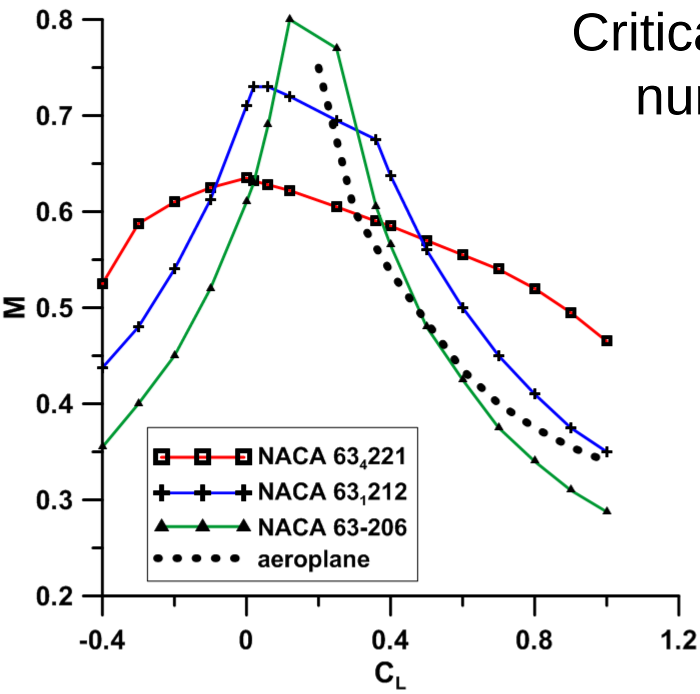
Historical values of an aeroplane airfoil thickness as a function of Mach number



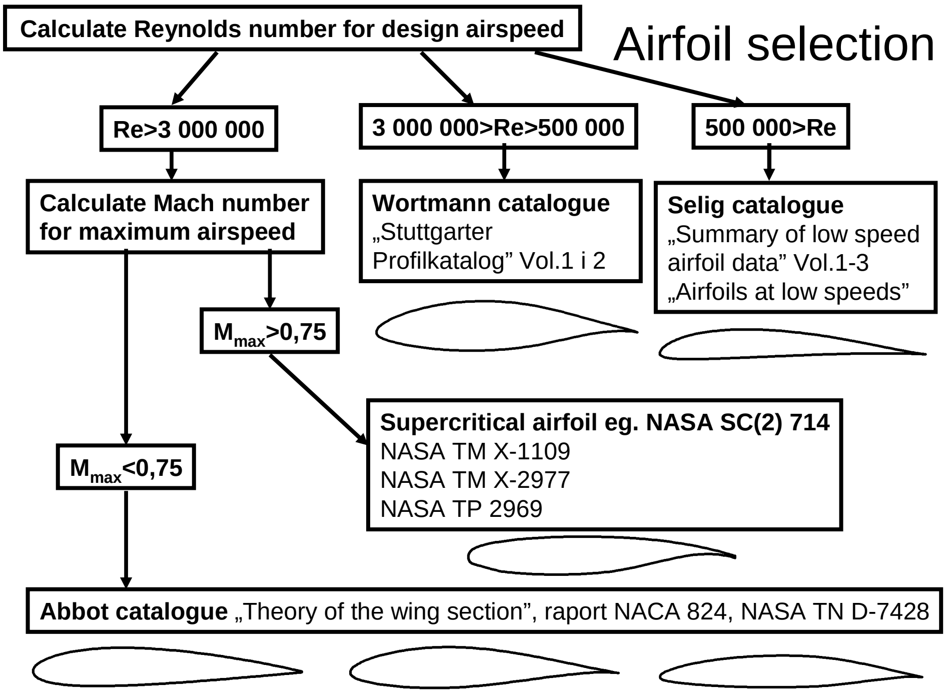
Critical Mach number



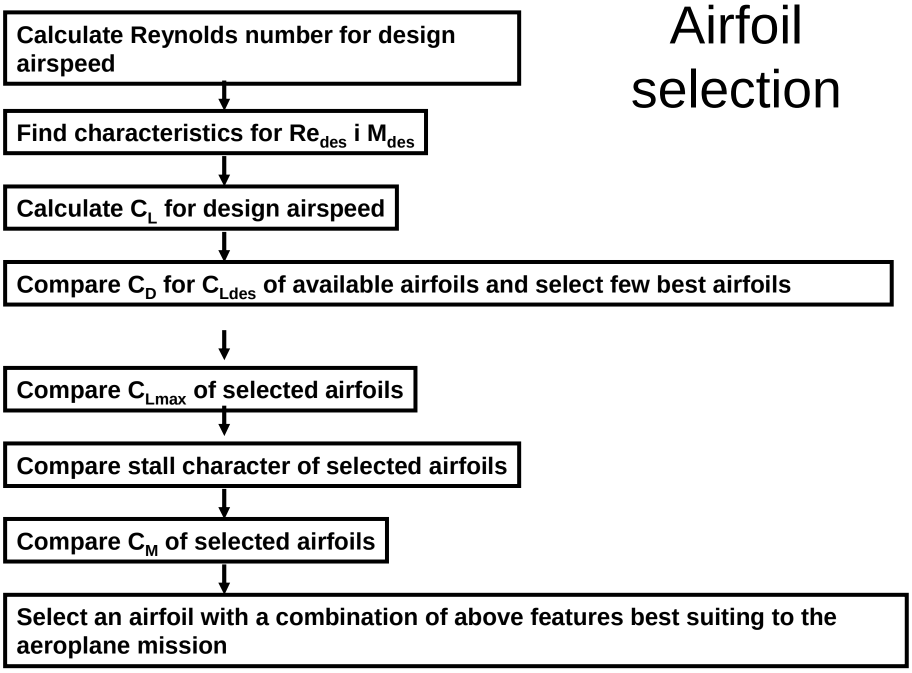
Critical Mach number



Airfoil selection



Airfoil selection

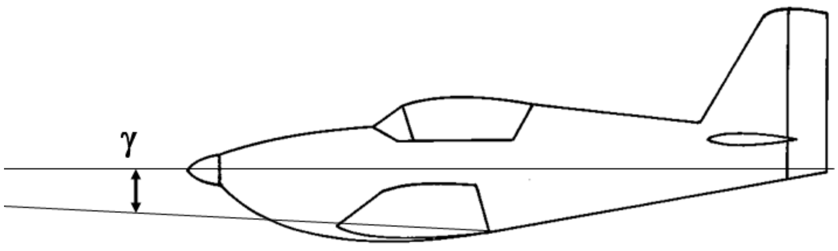


Remaining wing features

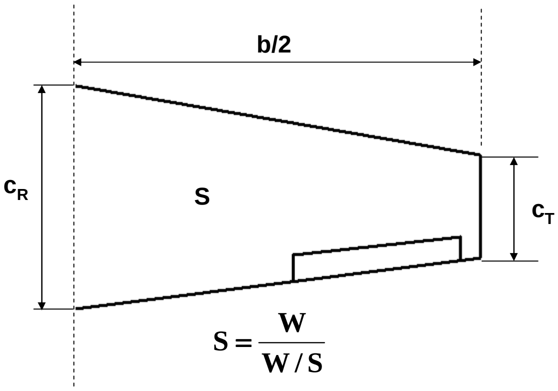
- Wing incidence;
- Mean aerodynamic chord mac, $\bar{c}$
- Wing area (reference area) S;
- Wing span b;
- Wing aspect ratio A;
- Wing dihedral;
- Wing sweep angle (leading edge Λ_{LE}, quarter chord $\Lambda_{c/4}$);
- Taper ratio λ;
- Geometrical and aerodynamic twist;
- Winglets
- Leading edges extensions;

Wing incidence angle

An angle between root chord and fuselage longitudinal axis



Taper ratio



$$S = \frac{W}{W/S}$$

$$b = \sqrt{A \cdot S}$$

$$c_R = \frac{2 \cdot S}{[b \cdot (1+\lambda)]}$$

$$c_T = \lambda \cdot c_R$$

$$\lambda = \frac{c_T}{c_R}$$

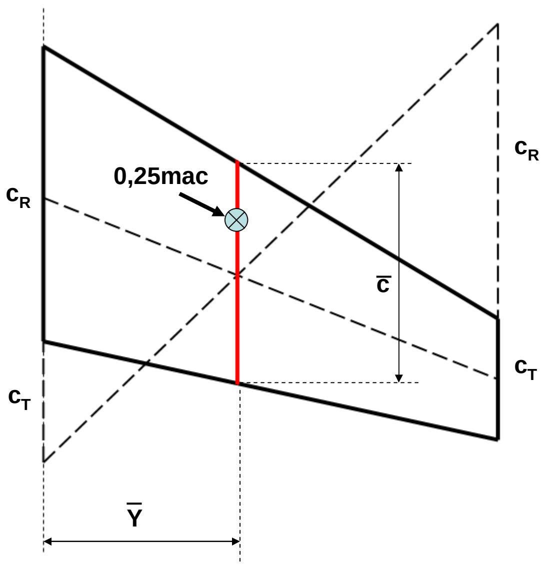
Straight wings:

λ=0.4÷0.5

Swept wings:

λ=0.2÷0.3

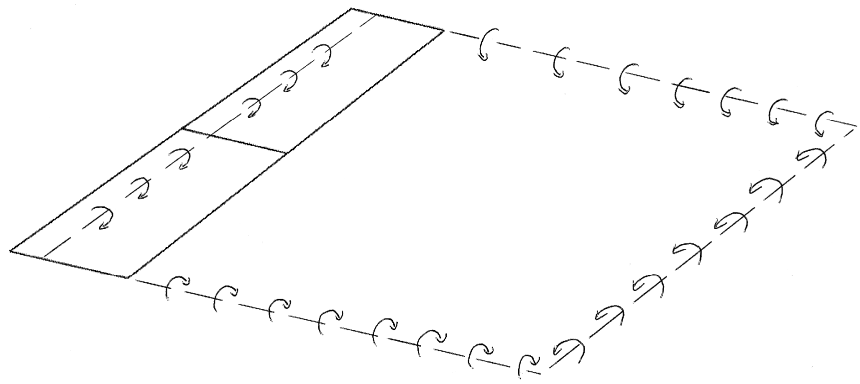
Mean aerodynamic chord mac, $\bar{c}$



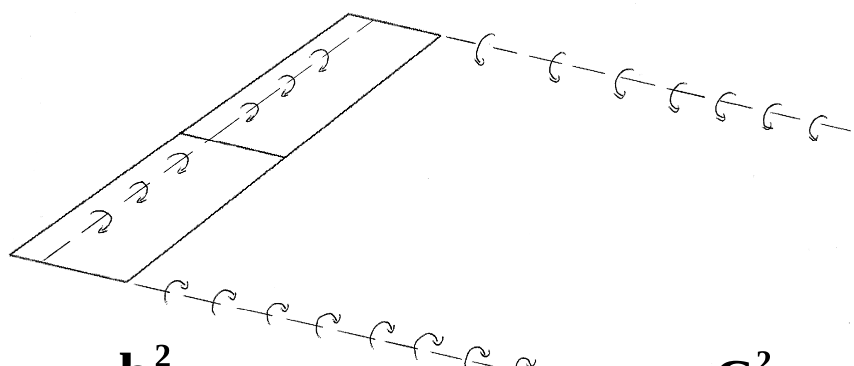
$$\bar{c} = \left(\frac{2}{3}\right) \cdot c_{ROOT} \cdot \frac{(1+\lambda+\lambda^2)}{(1+\lambda)};$$

$$\bar{Y} = \left(\frac{b}{6}\right) \cdot [(1+2\cdot\lambda)(1+\lambda)];$$

Vortices generated by a wing

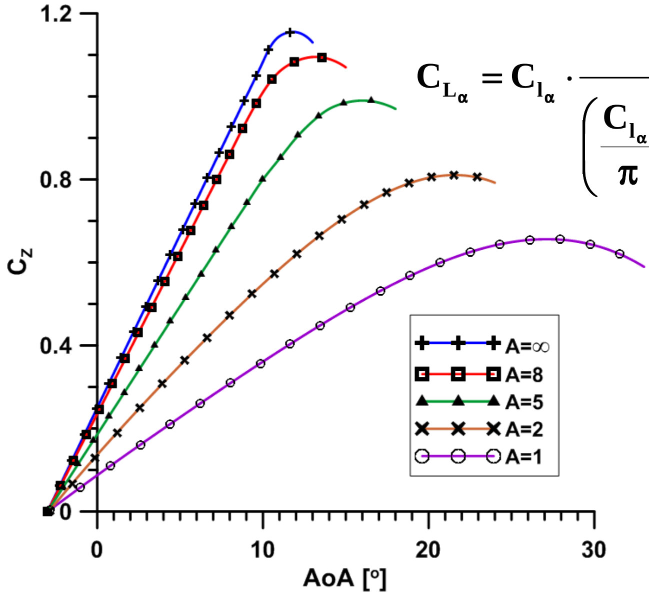


Vortices generated by a wing and effect of aspect ratio on drag coefficient



$$\mathbf{A} = \frac{\mathbf{b}^2}{\mathbf{S}} \qquad \mathbf{C_D} = \mathbf{C_{D0}} + \frac{\mathbf{C_L^2}}{\pi \cdot \mathbf{A} \cdot \mathbf{e}}$$

Effect of aspect ratio (A, AR) on lift coefficient

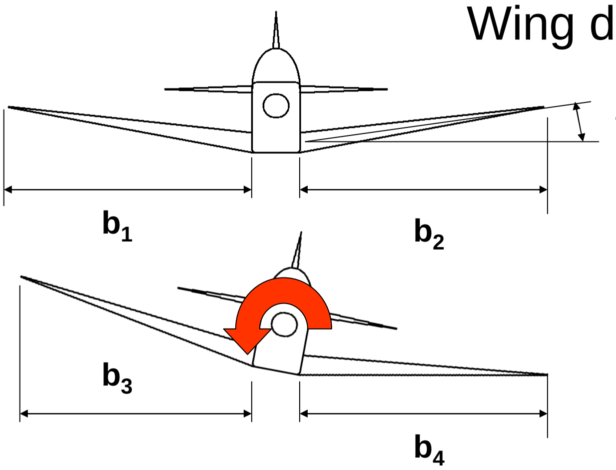


$$C_{L_\alpha} = C_{l_\alpha} \cdot \frac{A}{\left(\frac{C_{l_\alpha}}{\pi}\right) + \sqrt{\left(\frac{C_{l_\alpha}}{\pi}\right)^2 + A^2}}$$

Helmbolt equation

$$A = \frac{b^2}{S}$$

Wing dihedral



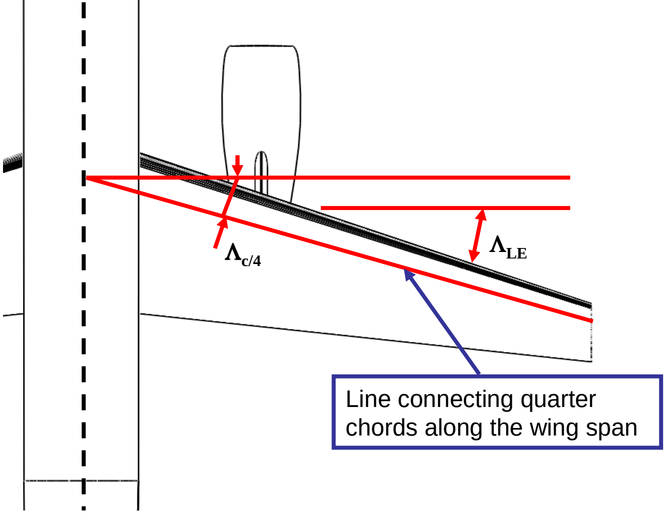
$b_3 < b_1 = b_2 < b_4$

Wing dihedral angle φ – an angle between chords' plane and horizontal plane

	Wing position		
	low	mid	high
Unswept	5 ÷ 7	2 ÷ 4	0 ÷ 2
Subsonic swept	3 ÷ 7	-2 ÷ 2	-5÷-2
Supersonic swept	0 ÷ 5	-5 ÷ 0	-5 ÷ 0

Wing sweep $\Lambda_{LE}, \Lambda_{c/4}, \Lambda_{t/c}$

$$\tan\Lambda_{LE} = \tan\Lambda_{c/4} + \left[(1-\lambda)/A\cdot(1+\lambda)\right]$$

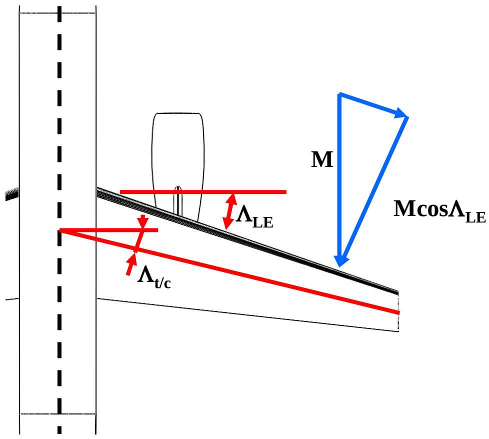


Wing sweep

$M_{eff}=M_{\infty}\cos(\Lambda_{LE})$

$M_{kryt}\sim 1/\cos^m(\Lambda_{LE})$

Wing sweep reduces effective Mach number.



$q_{eff}=q_{\infty}\cos^2(\Lambda_{LE})$

$W\sim\tan^2(\Lambda_{LE})$

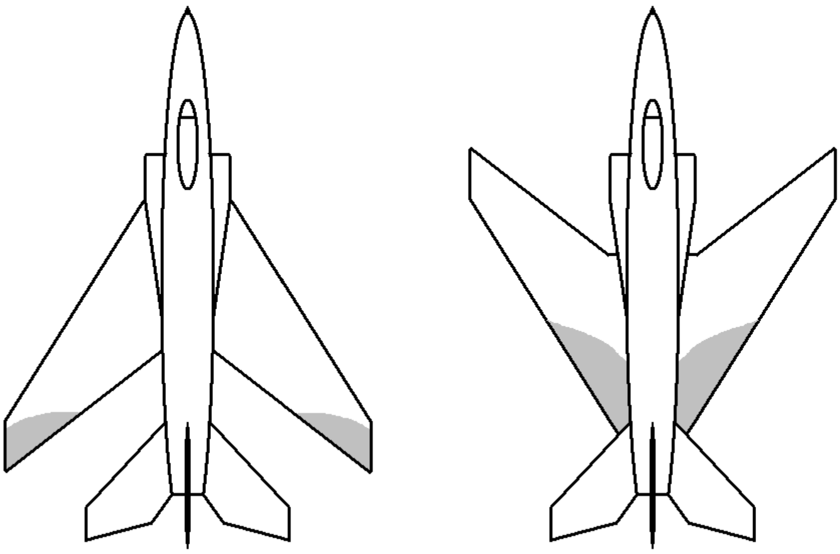
Wing sweep effect on $dC_L/d\alpha$

$$\frac{dC_L}{d\alpha} = \frac{2 \cdot \pi \cdot A}{2 + \sqrt{4 + (A \cdot \beta)^2 \cdot \left(1 + \frac{\tan^2(\Lambda_{t/c})}{\beta^2}\right)}}$$

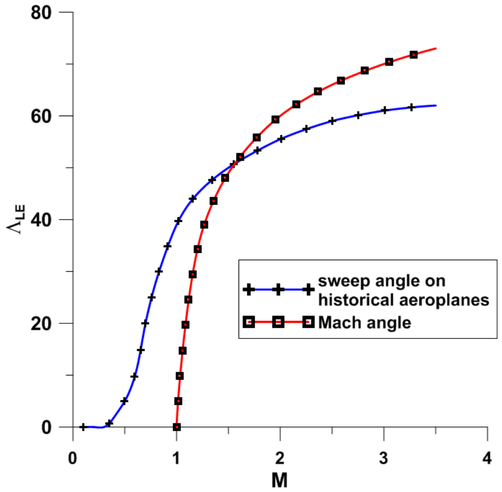
$$\beta = \sqrt{1 - M_{eff}^2}$$

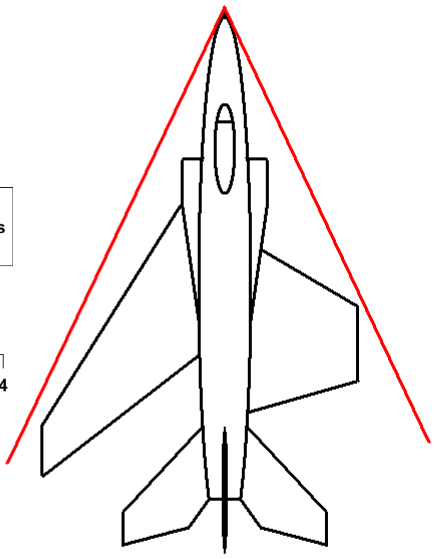
$$M_{eff} = M_\infty \cos \Lambda_{LE}$$

Wing sweep effect on separation

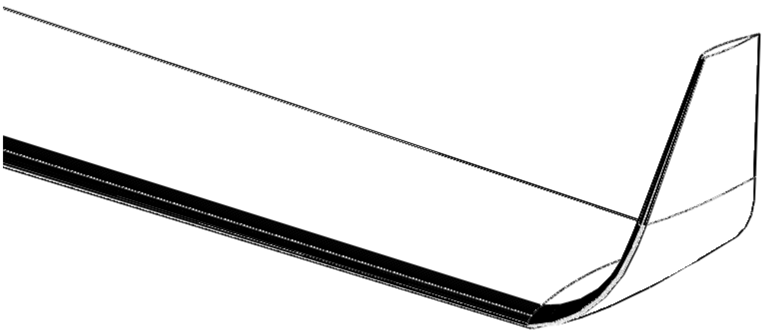


Wing sweep at supersonic speeds

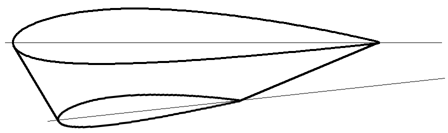




Winglets

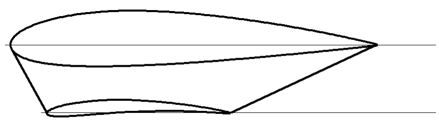


Wing twist



Geometric twist

Aerodynamic twist

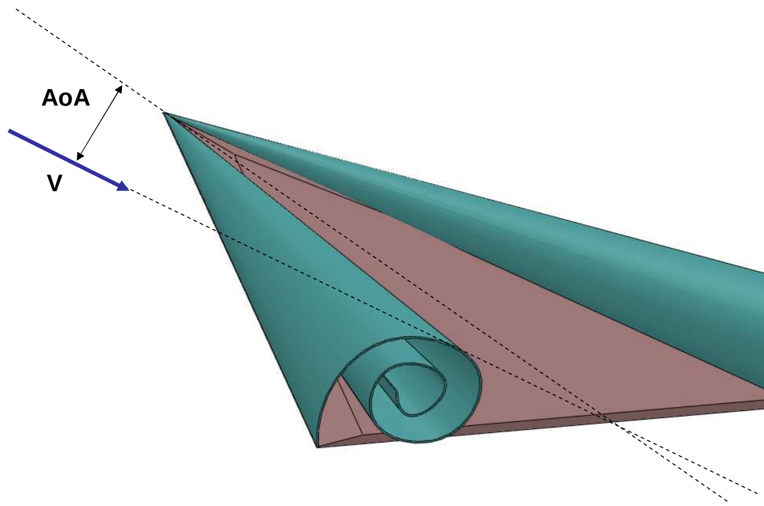


Wing twist

Geometric twist

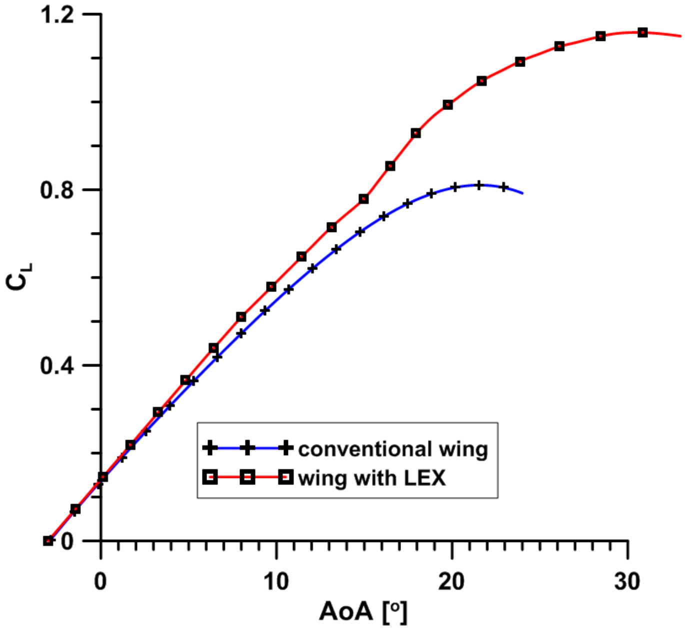
Aerodynamic twist

Delta wings



Leading Edge eXtensions

LEX effect on lift coefficient



Vortex generators


AIR FOR


NO GRAB