Fall 2025

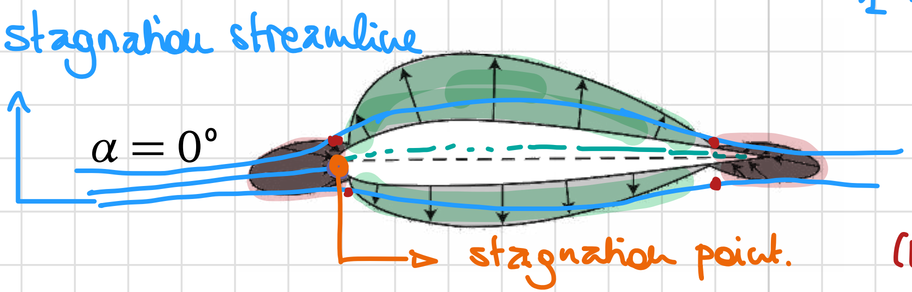
ME-445 AERODYNAMICS

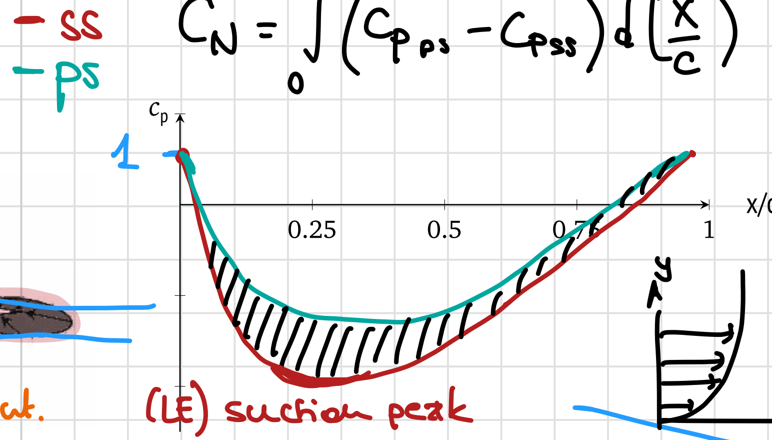
02 - Basic concepts

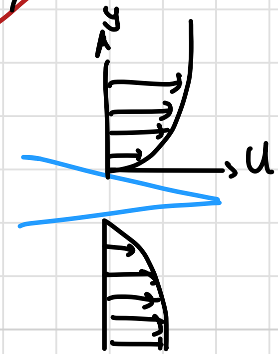
K. Mulleners

Airfoil pressure distributions

$$C_N = \int_0^1 \left(C_{p_{ps}} - C_{p_{ss}}\right) d\left(\frac{x}{c}\right)$$



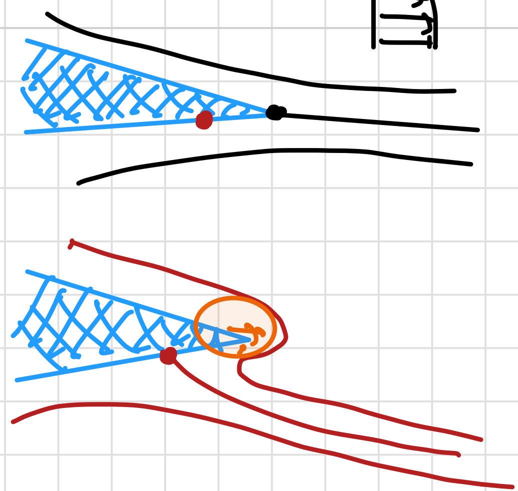




$$c_p = \frac{p - p_\infty}{\frac{1}{2}\rho u_\infty^2} \quad \begin{matrix} < 0 \\ > 0 \end{matrix}$$

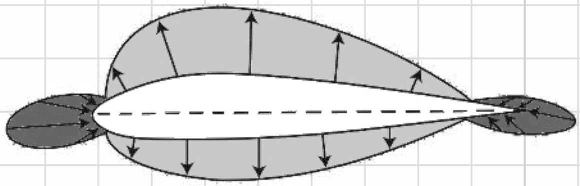
$$p_{sp} + \cancel{\frac{1}{2}\rho u_{sp}^2}^{\,0} = p_\infty + \frac{1}{2}\rho u_\infty^2$$

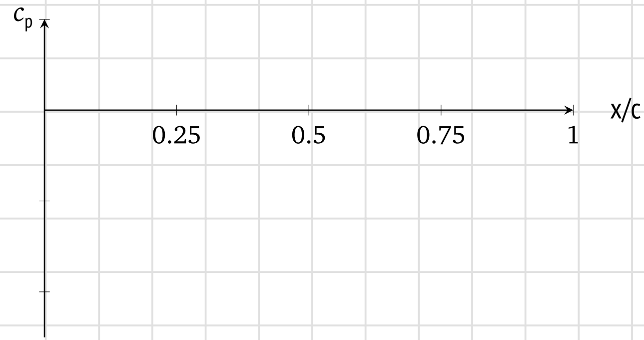
$$\Rightarrow \quad \frac{p_{sp} - p_\infty}{\frac{1}{2}\rho u_\infty^2} = 1 \quad \text{in stagnationpoint}$$

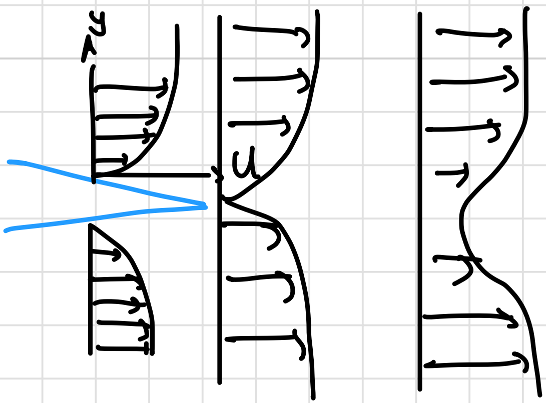


Airfoil pressure distributions

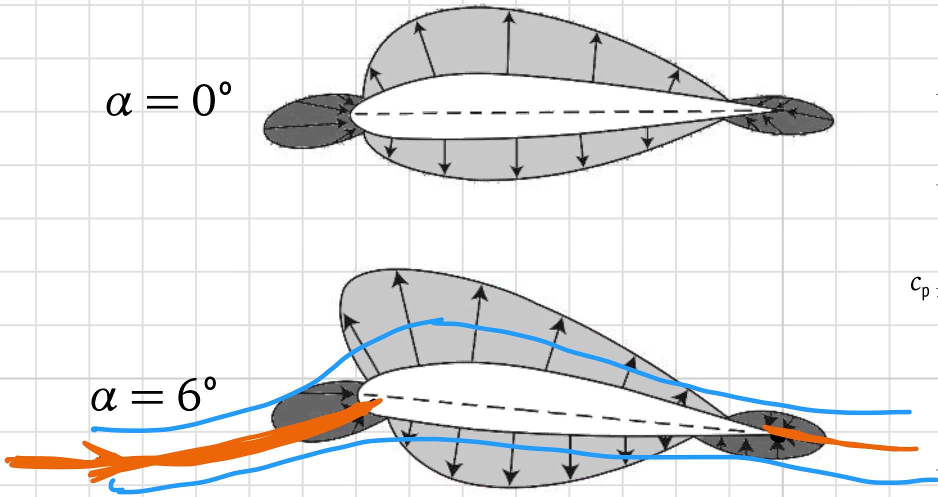
$\alpha = 0°$

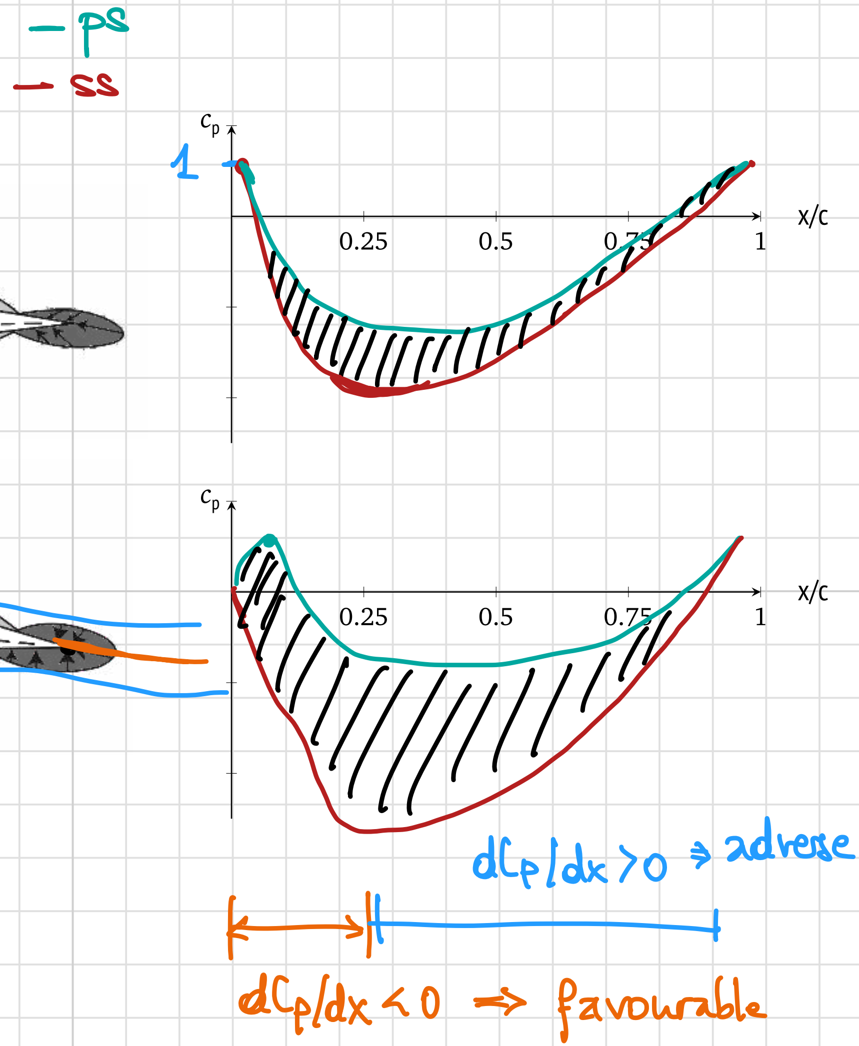






Airfoil pressure distributions

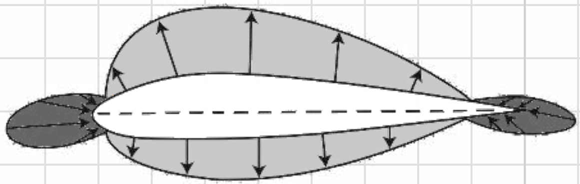


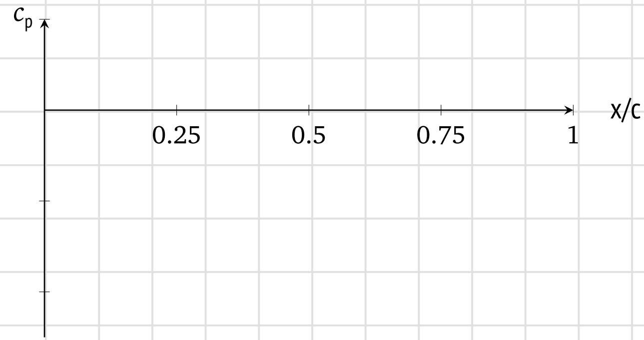


1. Suction peak ↗
2. Stagnation point moves ps
3. Lift (normal) force increases.

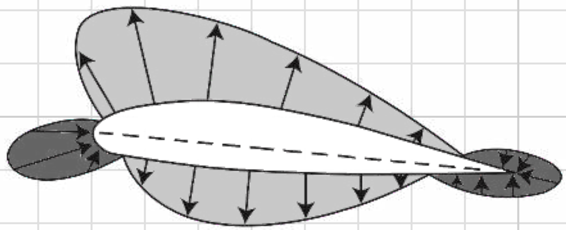
Airfoil pressure distributions

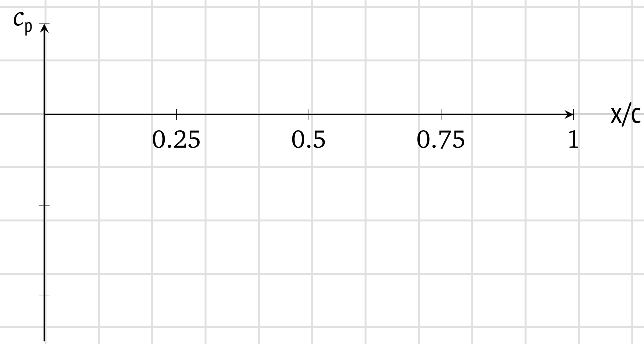
$\alpha = 0°$



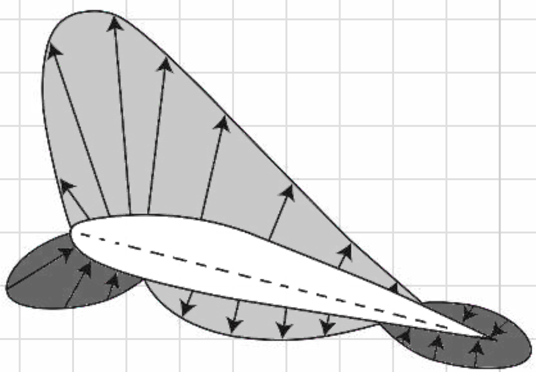


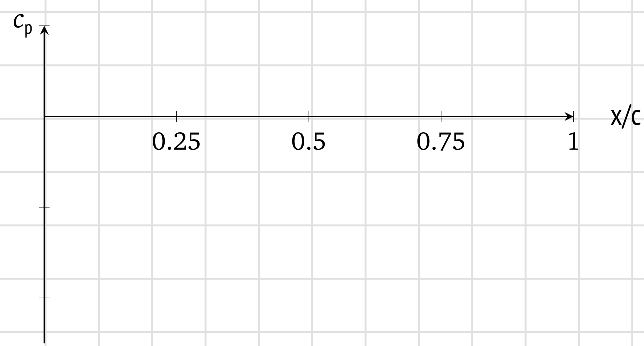
$\alpha = 6°$





$\alpha = 15°$





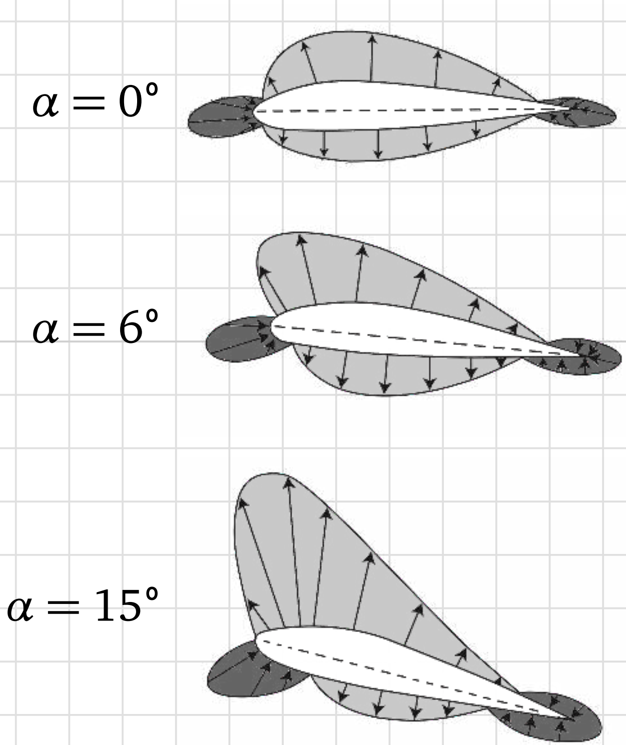
Airfoil lift polar → $C_\ell(\alpha)$

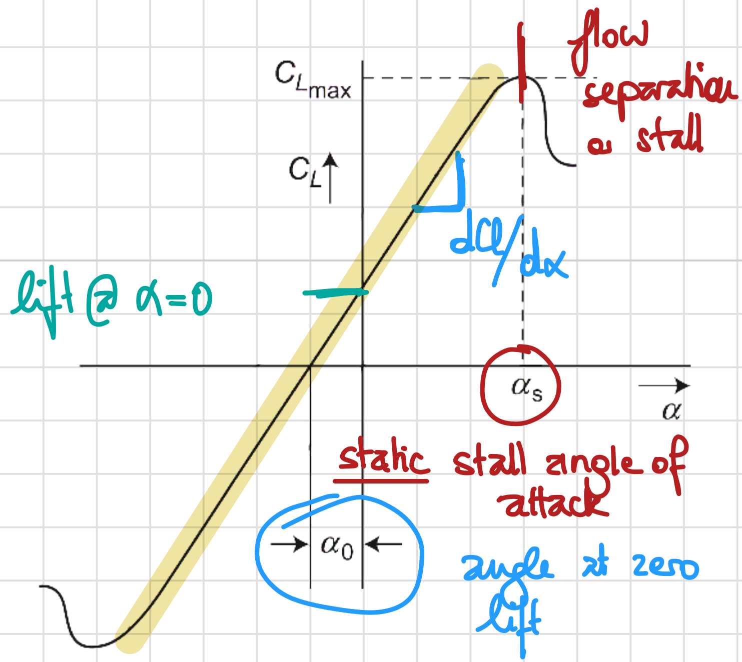
$dC_l/d\alpha$ ☐

α_0 ☐

α_{stall} ☐

$C_{l,max}$ ☐





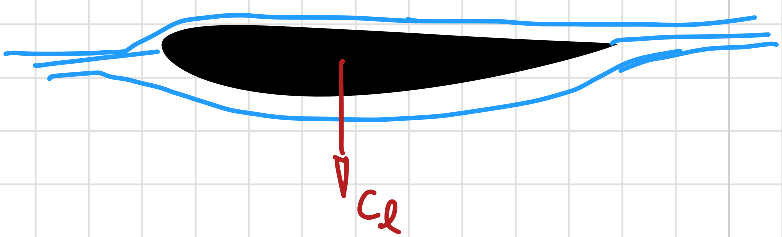
Airfoil lift polar

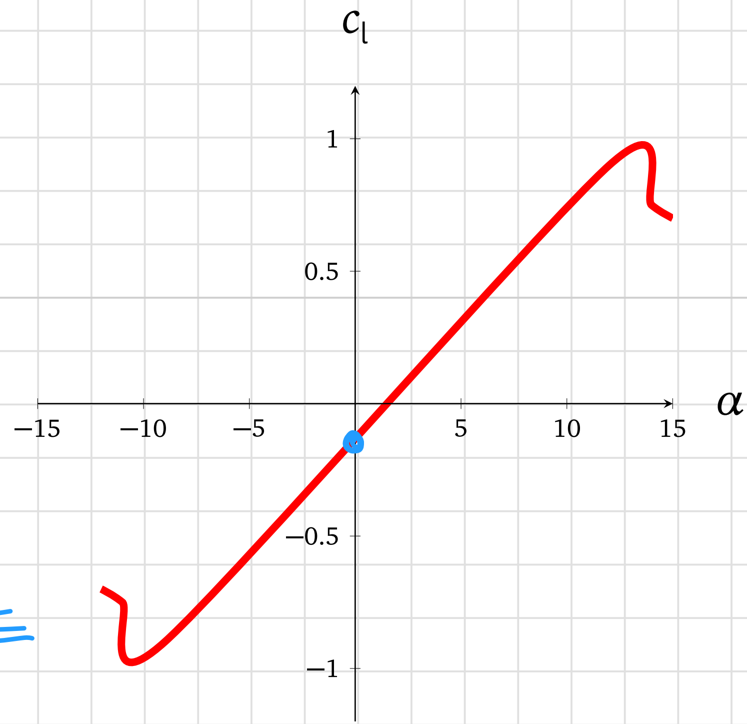
Which airfoil belongs to this curve

(A)

(B)

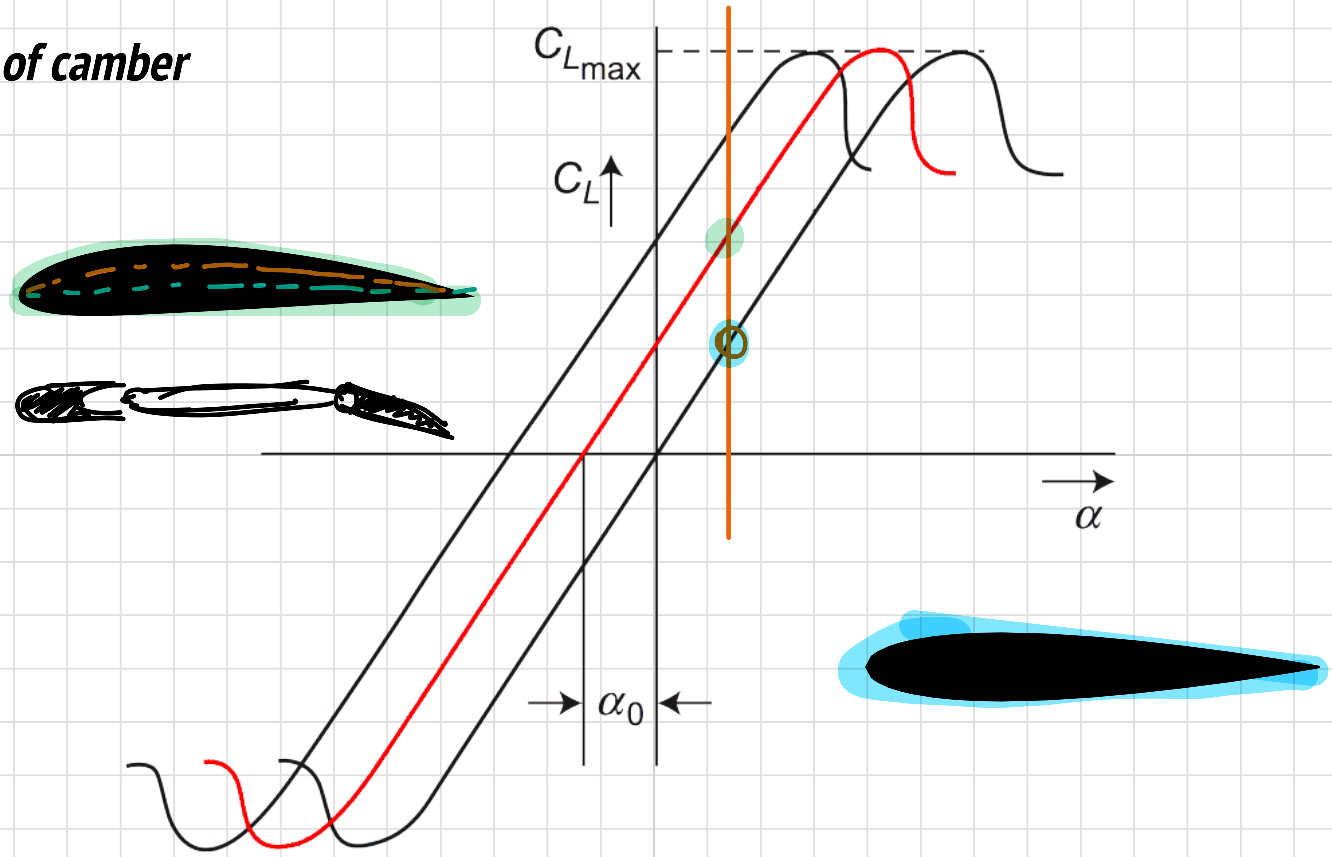
(C)





Airfoil lift polar

Effect of camber

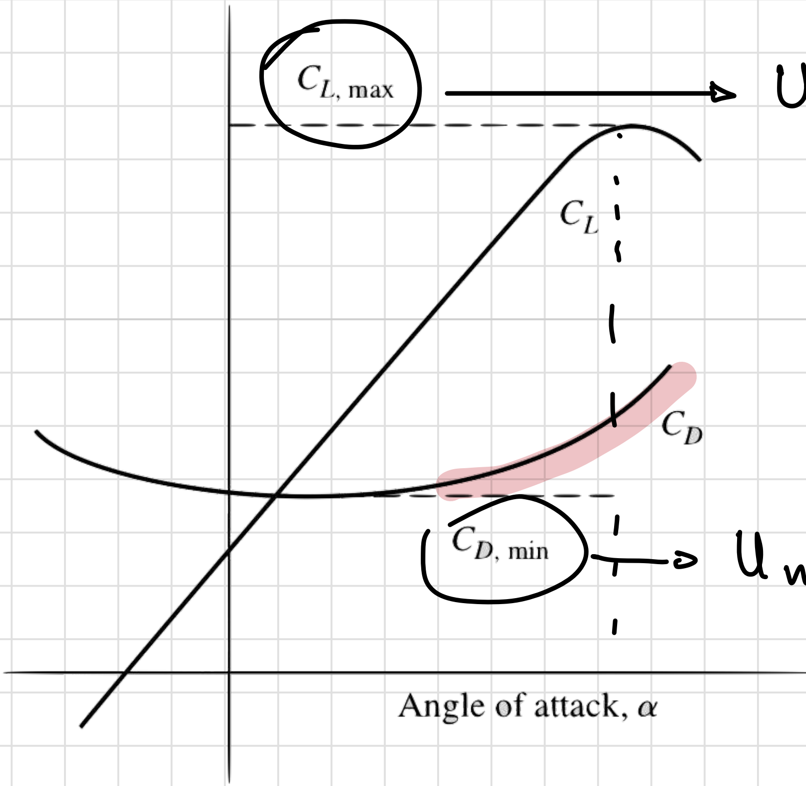


Lift and drag

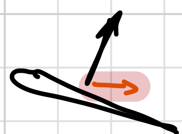
Constant cruising flight

$T = D \qquad L = W$

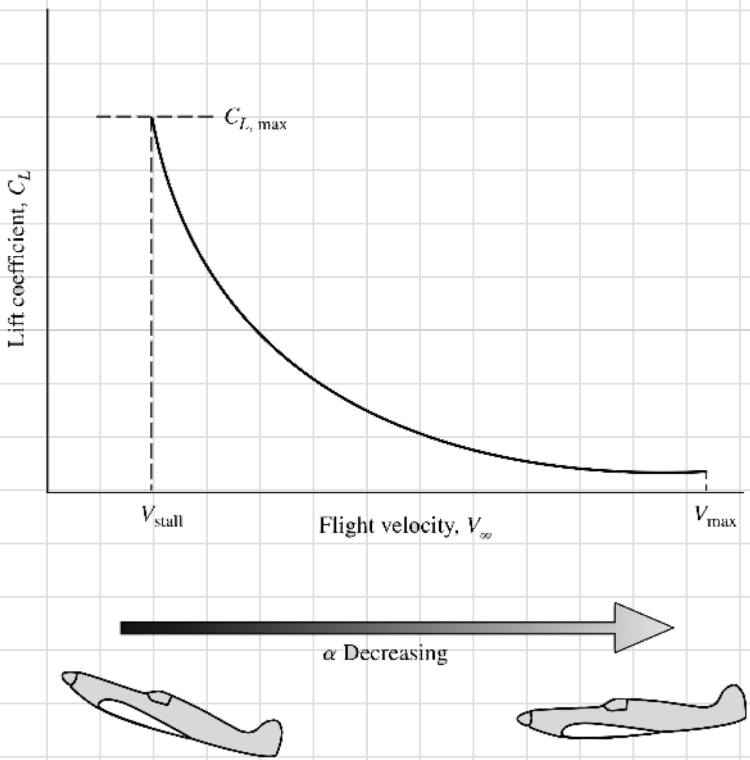
$$C_l = \frac{L}{\frac{1}{2}\rho U_\infty^2 c} \overset{\text{in cruise}}{=} \frac{W}{\frac{1}{2}\rho U_\infty^2 c}$$

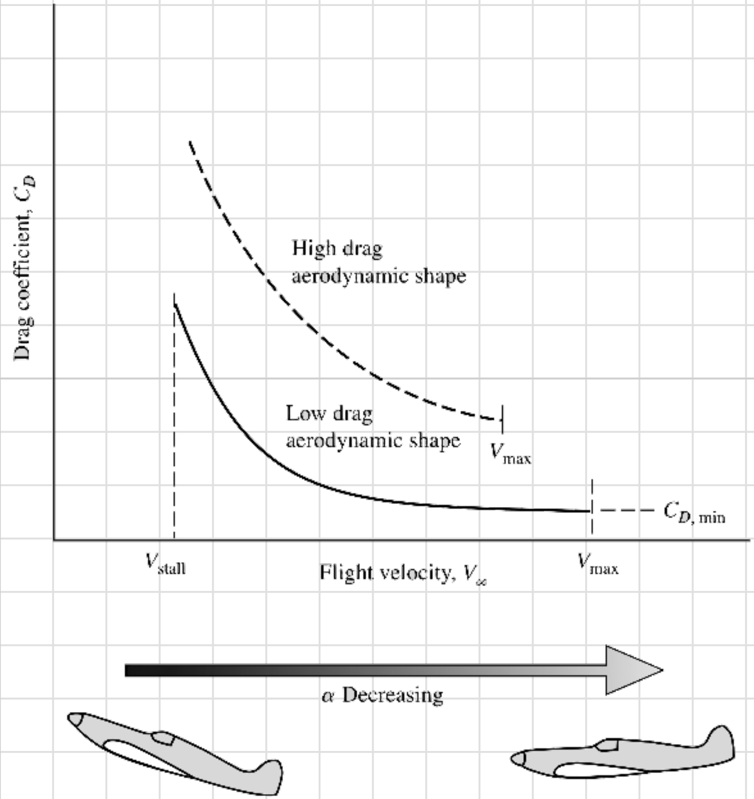


$$C_d = \frac{D}{\frac{1}{2}\rho U_\infty^2 c} \overset{\text{const.}}{=} \frac{T}{\frac{1}{2}\rho U_\infty^2 c}$$



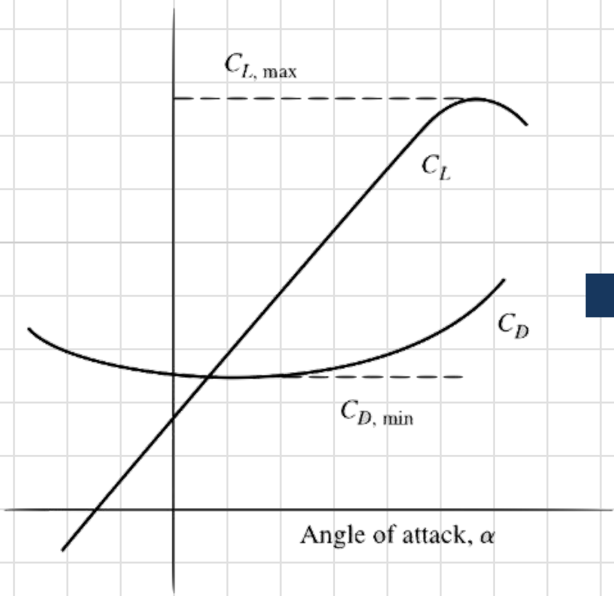
Variation of force coefficients with flight velocity

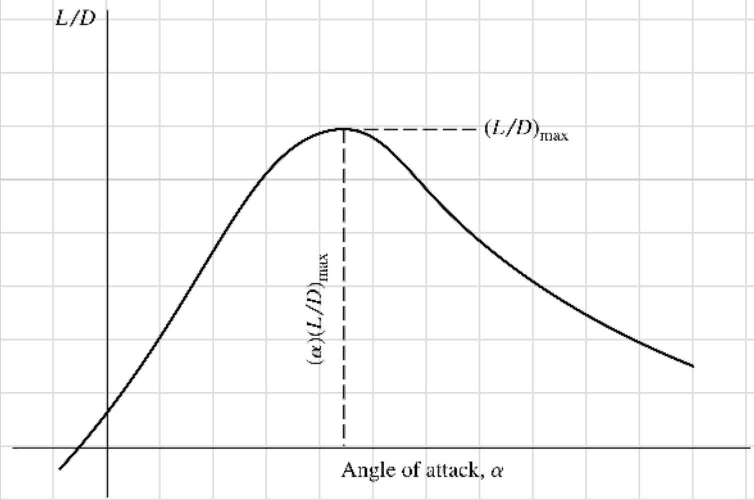




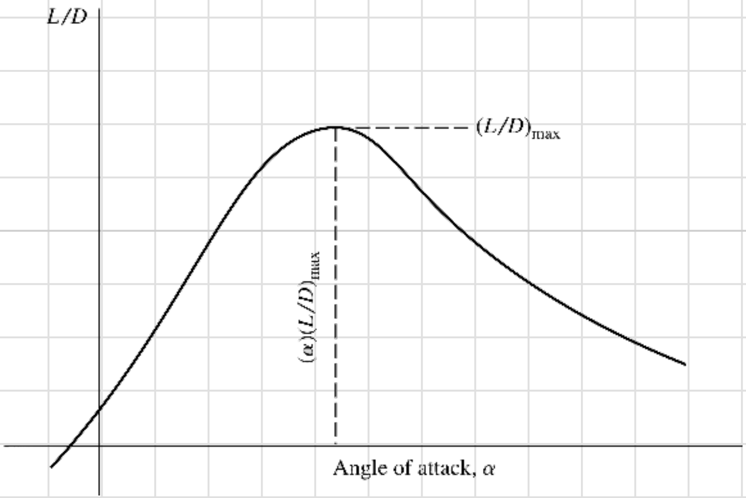
Lift-to-drag ratio

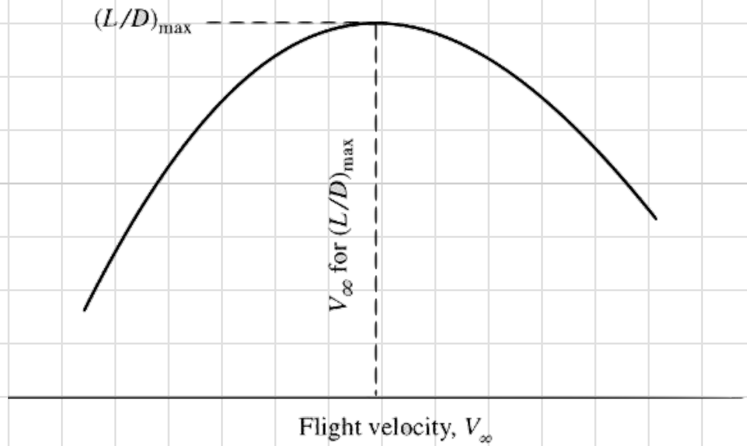
$$C_L/C_D = \frac{L}{\frac{1}{2}\rho U_\infty^2 c} \cdot \frac{\frac{1}{2}\rho U_\infty^2 c}{D}$$



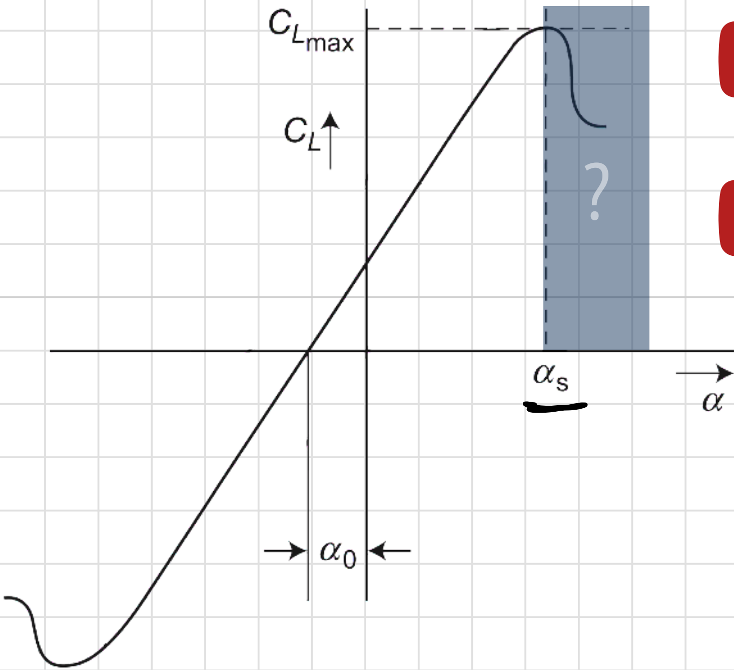


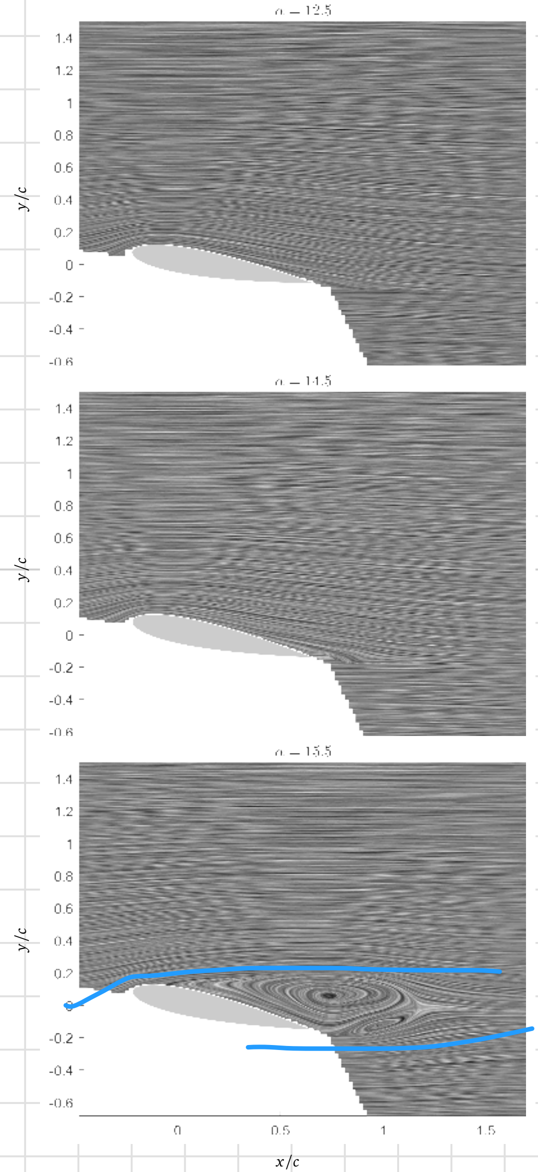
Lift-to-drag ratio



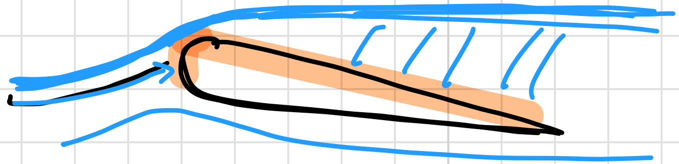


Airfoil stall



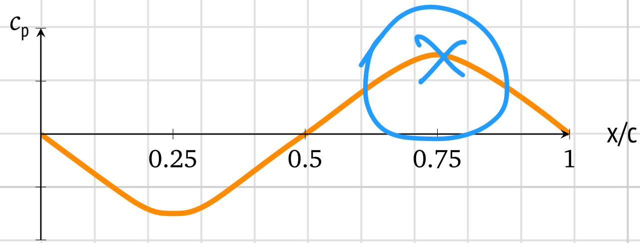


Airfoil stall

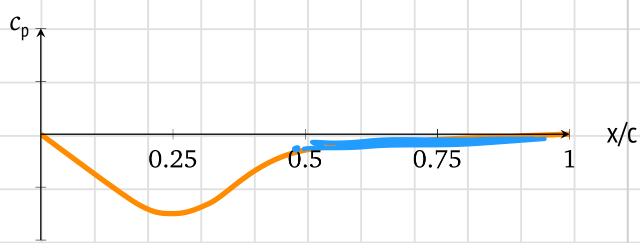


Which suction surface pressure distribution is more likely to correspond to the airfoil with flow separation?

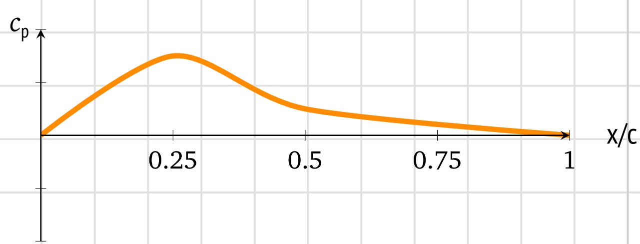
(A)

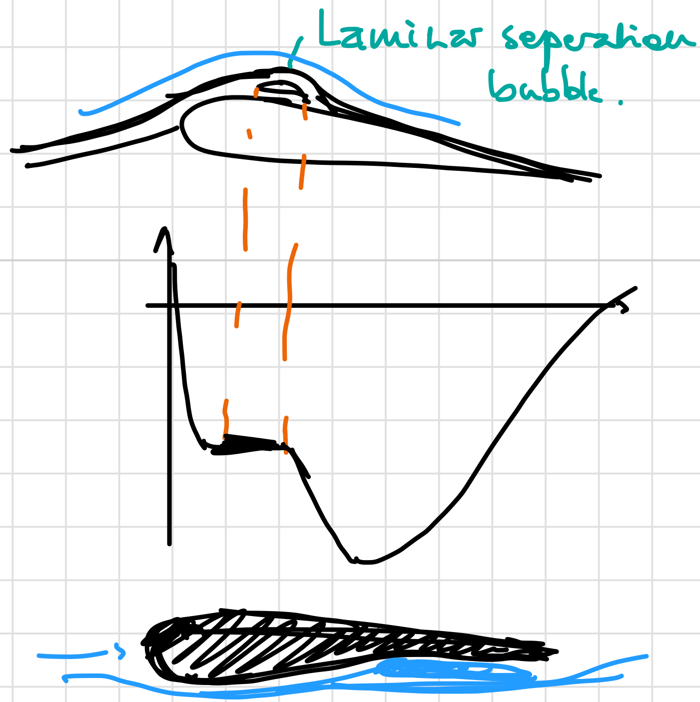


(B)



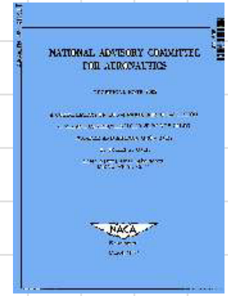
(C)

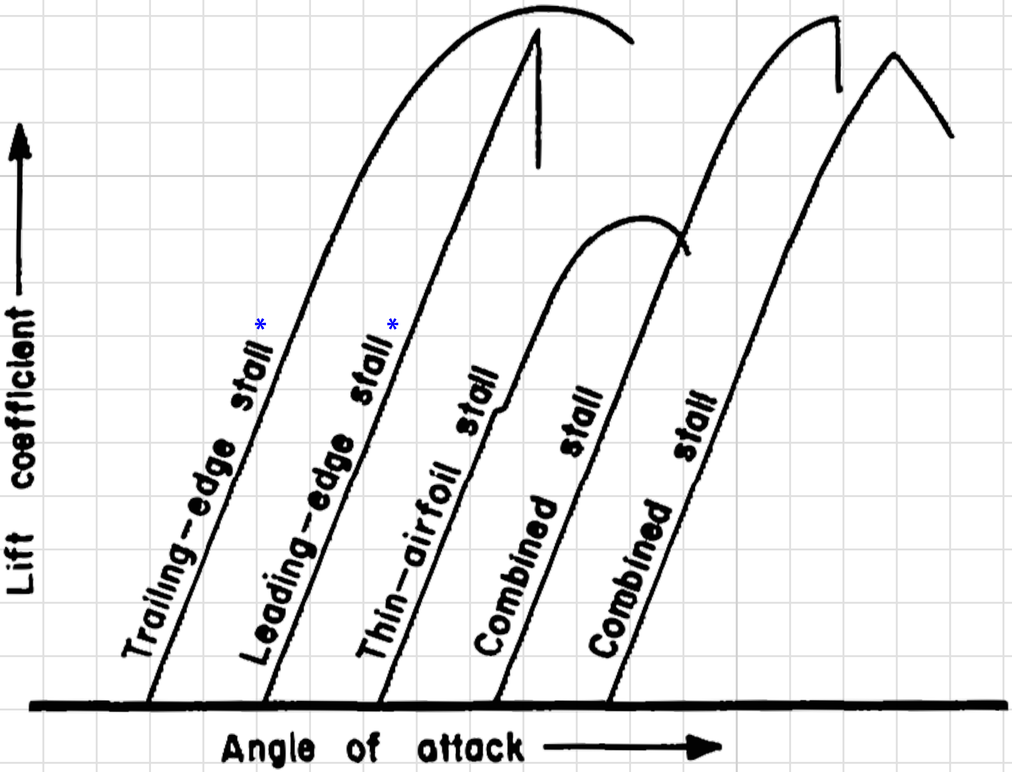




Airfoil stall

Different stall types





Airfoil stall

Different stall types