EAE 127 Applied and Computational Aerodynamics

Project 5

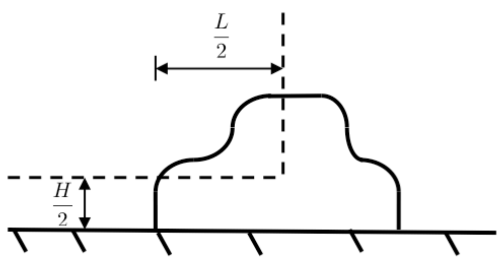
Airfoil Performance

Submit iPython Notebook as a .ipynb file and as a .html file ('Run All' before downloading)
DUE: 11/02/2015 2:10pm

Problem 1 – Car Source Panel Method

You are tasked with mounting a sensor to a car such that it is located in flow undisturbed by the motion of the car when the car is traveling at $25mph$. As the criteria for undisturbed flow, use points where the x-velocity of the flow is less than 1% greater than that of the freestream velocity ($\frac{u}{U_\infty} = 1.01$).

Modify the source panel method code from Project 4 to simulate the flow over a land **vehicle geometry of your design** and **plot the geometry with surrounding potential flow streamlines**. **Determine the distance** from the vehicle center to undisturbed flow on both a **vertical line through the vehicle center** and a **horizontal line in front of the vehicle at a height of half the height of the vehicle**. If the criteria for undisturbed flow yields unreasonable results for mounting a sensor, **find the minimum u/U_∞ ratio** that will allow sensor mounting (use engineering judgment). Hint: Model the ground as a horizontal dividing streamline (i.e. mirror your geometry like the Quonset hut.)



Problem 2 – Part A

Perform a preliminary parametric study on airfoil performance of the P-51D Mustang aircraft for the following design conditions:

Wing Area (S) :	235 ft^2
Root Chord Length (c) :	8.48 ft
Cruise Speed (V_{cruise})	362 mph
Geometric Cruise Altitude (h) :	23000 ft
Loaded Weight (W) :	9200 lbs
Dynamic Viscosity at h (μ) :	3.25×10^{-7} $\frac{slug}{ft \cdot s}$

From the given parameters, **calculate the design Reynolds number and the 3-D lift coefficient for level flight at cruise** ($C_{L,Cruise}$). Use this lift coefficient as a preliminary basis for the 2-D cruise lift coefficient ($C_{l,Cruise}$).

(NOTE: In practice, 2-D and 3-D lift coefficients at a given flight condition will not be the same for a given wing due to the 3-D effects of finite wings. This design assumption represents one possibility for a first step in what would be an iterative design process).

Problem 2 – Part B
Three airfoil geometries will be considered in this study: a symmetric NACA 0012 airfoil, the original P-51D airfoil, and a modern Natural Laminar Flow NLF 414F airfoil. **Plot each of the geometries** given the surface coordinates in true dimensions (i.e. feet).

For each airfoil, obtain inviscid polar data and viscous polar data at the design Reynolds number using XFOIL. Using Python, **plot inviscid and viscous lift curves** (C_l vs. α) and **drag polars** (C_l vs. C_d) of all of the airfoils **on two plots total**. **Comment on the differences in airfoil performance**.

Problem 2 – Part C
For each airfoil, using viscous results, **find angle of attack at stall** (α_{stall}), **maximum lift coefficient** ($C_{l,max} = C_l(\alpha_{stall})$), and **drag coefficient at stall** ($C_d(\alpha_{stall})$). Additionally, for the design $C_{l,Cruise}$, **find α_{cruise} and $C_d(\alpha_{cruise})$.** Finally, find the **maximum lift to drag ratio for each airfoil $(C_l/C_d)_{max}$. Comment on the differences in airfoil performance at these conditions**, and **analyze the advantages and disadvantages** of each. Based on the results, **which airfoil performs best** under the given design criteria?

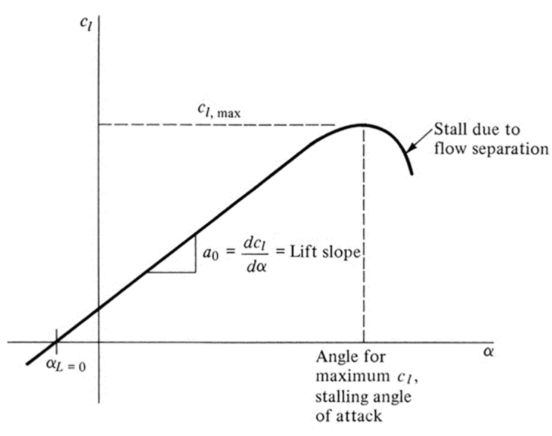


Figure 5.6 Sketch of a typical lift curve.