# EAE 127 Applied and Computational Aerodynamics

## Project 6
Vortex Panel Method

**Submit iPython Notebook as .ipynb file in 'Assignments' section on Smartsite. 'Run All' before uploading, and also include all data so that the code may be run if needed.**
**DUE: Monday 11/15/15 2:10pm**

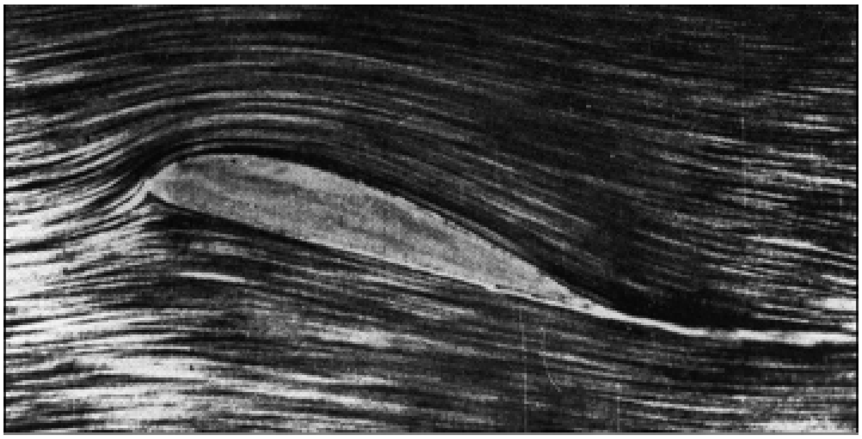
Fig. 1: Streamlines over an airfoil at angle of attack

### 1 Calculating Lift

You have been provided a vortex (lifting) panel method code. It is based on the $1^{st}$ order method described in Anderson Section 4.10, where the additional constraint of the Kutta Condition is prevented from over-defining the system by leaving one panel out of the calculation of panel strength distributions, as described on Pg. 364 of Anderson's Fundamentals.

For panel methods, lift is typically calculated by integrating the surface pressure distribution of the panel geometry. However, the Kutta-Joukowski theorem (Eqn 1) states that lift is also a function of the circulation $\Gamma$ calculated by integrating a closed contour $C$ surrounding the geometry.

$$\begin{aligned} L' &= -\rho_\infty V_\infty \Gamma \\ \Gamma &= \oint_C V \cdot d\mathbf{s} \end{aligned} \tag{1}$$

**Calculate the coefficient of lift** $C_l$ of a NACA 0012 airfoil at angle of attack $\alpha = 10^o$ by:

1. Integrating the **surface pressure distribution**
2. Calculating the **circulation** about **two**, closed, **independent** paths. (i.e. a circle and a square; NOT two concentric circles)

**Compare** the results of **each method**. (Get airfoil geometry coordinates from XFOIL).

## 2 Aerodynamic Analysis

Explore the capabilities of this vortex panel method code by varying certian simulation parameters and observing the effects. First, investigate the effect of the "missing" panel on the NACA 24012 cambered airfoil (Fig. 2) at $\alpha = 0^o$ by **plotting coefficient of lift against missing panel location** (calculate $C_l$ with the missing panel at each panel location). **Where** are the **"best"** and **"worst"** missing panel **locations**? **Plot the surface pressure distributions ($-C_P\, vs\, \frac{x}{c}$) for both** of these cases and **comment on the differences**. **Will** the best missing panel location **be the same** for $\alpha = 10^o$?

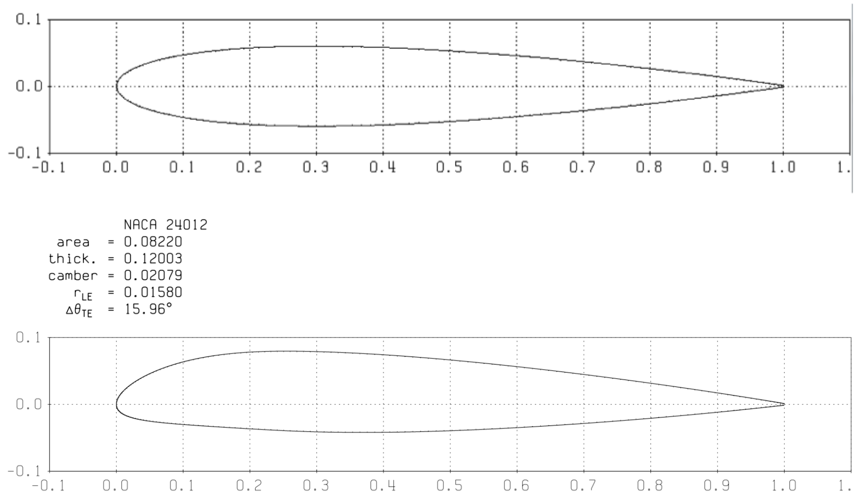


Fig. 2: NACA 0012 (Top) and NACA 24012 (Bottom) airfoil geometries

For each airfoil:

1. **Plot velocity field streamlines at $\alpha = 10^o$. Comment on effectivness** of panel method in maintaining tangency and Kutta condition
2. **Plot surface pressure distribution at $\alpha = 0^o$, $10^o$** and **compare differences** between all cases. (You may include previous surface pressure plots)
3. **Include inviscid XFOIL surface pressure plots** with previous plots and **compare**
4. **Caclulate** the panel method result for **lift curve slope $\frac{dC_l}{d\alpha}$** and **compare to thin airfoil theory** results