90 POINTS **HOMEWORK 8** **DUE: 3/10/16**

Please save your submission as HW08_[your last name].ipynb (for example, HW08_Smith.ipynb) and email it to the instructor or send a link to it on GitHub.

1. (20 points) Plot the streamlines (i.e. contours of the stream function) for the flow around a NACA 0015 airfoil using a distribution of sources/sinks.

2. (70 points) The following is from §5.3 of Katz and Plotkin "Low-Speed Aerodynamics". Suppose the slope of the camber line of an airfoil can be written like

$$\frac{d\eta_c(\theta)}{dx} = \sum_{n=0}^{\infty} B_n \cos(n\theta)$$

where $\theta = \cos^{-1}(1-2x)$ and $0 \le x \le 1$ is the chord-wise coordinate of the airfoil. Then the distribution of vortices along the line $0 \le x \le 1$ should be given by

$$\Gamma(\theta) = 2U_\infty \left[A_0 \frac{1+\cos(\theta)}{\sin(\theta)} + \sum_{n=1}^{\infty} A_n \sin(n\theta) \right]$$

where $A_0 = \alpha - B_0$ and $A_n = B_n$ for $n \ge 1$.

a. (20 points) Find the first 5 Fourier series coefficients $B_0, \ldots, B_4$ for the camber line of a NACA 2412 airfoil.

b. (20 points) Plot the flow around a thin arc (zero thickness airfoil) with this camber for $\alpha = 0°$ and $\alpha = 5°$.

c. (20 points) By the Kutta-Joukowski theorem, the total lift generated by this arc is given by

$$l = \rho U_\infty \int_0^1 \Gamma(x) dx$$

Compute the total lift for the cases plotted in part (b).

d. (10 points) The theoretical angle of attack for 0 lift is given by

$$\alpha_{l=0} = B_0 - \frac{B_1}{2}$$

Does your numerical simulation agree with this?