80 POINTS **HOMEWORK 3** **DUE: 2/4/15**

Please save your submission as HW03_[your last name].ipynb (for example, HW03_Smith.ipynb) and email it to the instructor or send a link to it on GitHub.

1. (20 points) Consider the flow field shown in Figure 1, which is the solution to Problem 1(a) from Homework 2. It consists of a source of strength $\sigma = 2$ at location $(-2,0)$, sink of strength $\sigma = -2$ at location $(2,0)$.

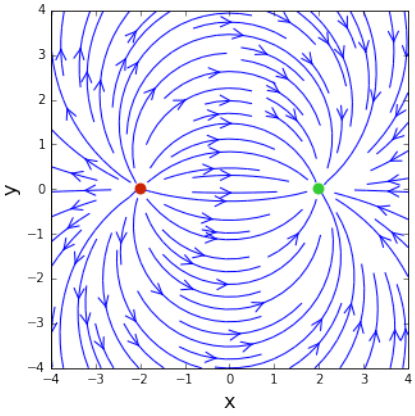

Figure 1

a. (10 points) Calculate the flow between the points $(4,2)$ and $(4,-2)$ using integration of the vector field, i.e. $\oint(\mathbf{v}\cdot\mathbf{n})ds$, and using the difference in stream function values, i.e. $\Psi(B)-\Psi(A)$.

b. (10 points) Calculate the flow between the points $(0,2)$ and $(0,-2)$ using integration of the vector field, i.e. $\oint(\mathbf{v}\cdot\mathbf{n})ds$, and using the difference in stream function values, i.e. $\Psi(B)-\Psi(A)$. You will notice the values don't match this time. Why not? Hint: think about what happens to the `atan2` function when you cross the ±180° line.

2. (20 points) Show that the dividing streamlines for a source in a free stream, shown in red in Figure 2, are given by $\Psi = \pm\sigma/2$. Please use a markdown cell and Latex to show your derivation.

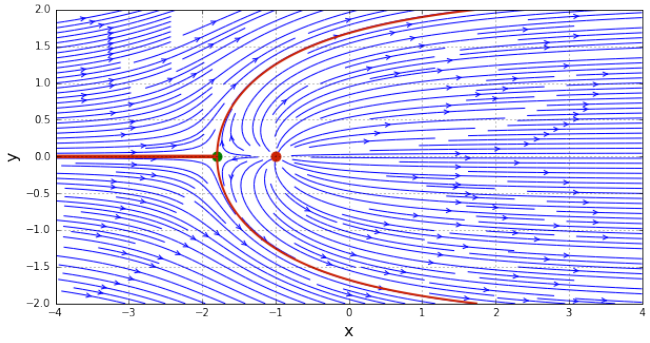

Figure 2

3. (30 points) An equal-strength source and sink placed in a flow produces a Rankine oval, as shown in Figure 3.

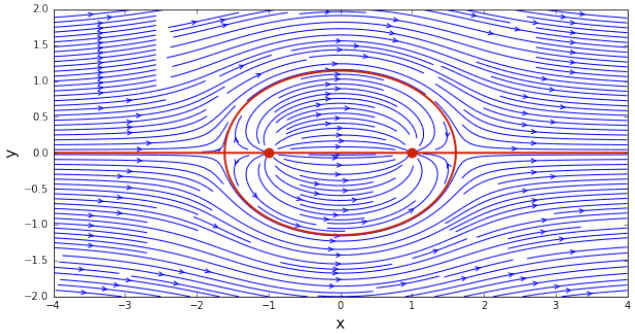

Figure 3

Derive the formulas for the length and width of the oval based on the strength of the source/sink σ, the free stream velocity U_∞, and the separation distance between the source and sink d.

Check your formulas by plotting 3 examples of Rankine ovals using different parameters.

4. (10 points) Plot the coefficient of pressure C_p for the flow shown in Figure 2. In this case, $\sigma = 5$ and $U_\infty = 1$. Use a filled contour plot and color bar and shown in Source & Sink in a Freestream. Comment briefly on the trends you see.