| **50 POINTS** | **HOMEWORK 9** | **DUE: 3/24/16** |
|---|---|---|

Please save your submission as HW09_[your last name].ipynb (for example, HW09_Smith.ipynb) and email it to the instructor or send a link to it on GitHub.

1. (20 points) Plot the normal and tangential vectors around a NACA 0010 airfoil using 20 panels, as shown in Figure 1.

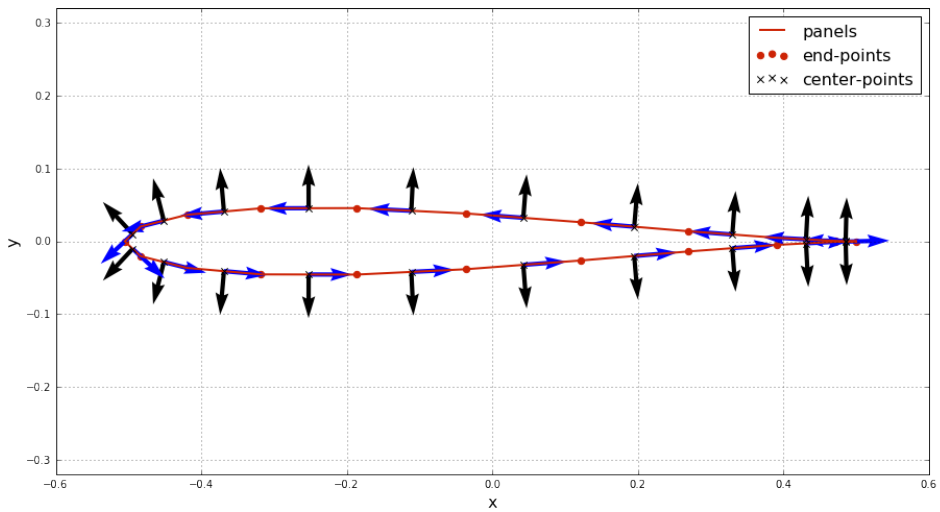


**Figure 1**

2. (30 points) Create a function to compute the induced velocity components from a constant-strength panel. A sample function header and output is provided in Figure 2.

```
def get_source_panel_velocity(p,x,y):
    """Evaluates the velocity components
induced at coordinates (x,y) by a panel p.

    Arguments
    ---------
    p -- panel from which the velocity is
induced
    x -- x-coordinate in global frame
    y -- y-coordinate in global frame

    Returns
    -------
    (u,v)-components of velocity at (x,y)
      """
```

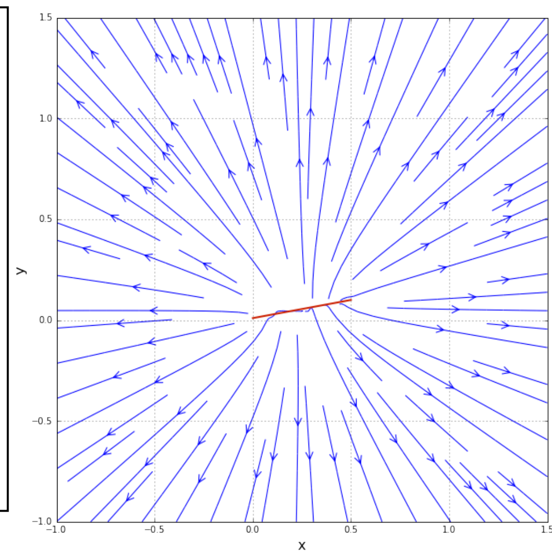


**Figure 2**

Then create a single panel with a unit strength and plot the vector field, like the one shown in Figure 2.

You may use the integral formulas you used previously for source distributions. However, these integrals may be evaluated analytically in this case because the source strength is constant along the panel. To compute the velocity components for the source distribution shown in Figure 3, you may use the following formulas:

$$u = \frac{\sigma}{2\pi}\int_{x_1}^{x_2} \frac{x - x_0}{(x - x_0)^2 + y^2}\,dx_0 = \frac{\sigma}{4\pi}\ln\frac{(x - x_1)^2 + y^2}{(x - x_2)^2 + y^2}$$

$$v = \frac{\sigma}{2\pi}\int_{x_1}^{x_2} \frac{y}{(x - x_0)^2 + y^2}\,dx_0 = \frac{\sigma}{2\pi}\left[\tan^{-1}\frac{y}{x - x_2} - \tan^{-1}\frac{y}{x - x_1}\right]$$

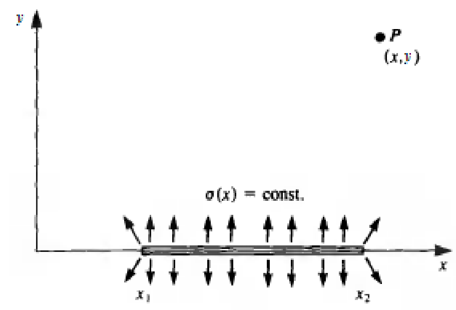


**Figure 3**

Note that these formulas are given in panel coordinates, so you will need to rotate them into the global coordinate system, since each panel is translated and rotated from horizontal.