ME 106 Project 1

Due Date: October 20, 2017

In this project you will write a numerical code to draw streamlines and pathlines when given a velocity field. Include a print out of your code (with comments), along with a typed write-up explaining your work including derivations for equations used in your code, and any plots asked for in the assignment. You may use any program you are comfortable with (Matlab, Python, FORTRAN, C/C++, Java, IDL, etc), however, suggested functions below are given for Matlab.

Part 1: Streamlines

A vel.mat file has been posted to the bcourses website. Import this data into your code using the **load** command in Matlab. Once you've loaded this information you should have a u and v matrix for the flow field at a specific time.

a) Begin by plotting the velocity field using **quiver** (or the equivalent in another coding language). The domain should extend from $0 \leq x \leq 1$ and $0 \leq y \leq 1$.

b) Write a function that allows you to pick a point on your quiver plot (x_o, y_o) and will draw a streamline for you based on that starting location. To pick a starting location on the quiver plot you may find the function **ginput** helpful. Recall that the streamline equation is

$$\frac{dx}{u} = \frac{dy}{v} = ds \tag{1}$$

Using the u and v data solve for the flow field, and use $\Delta s = 0.001$. Begin with Eqn. 1, to find the next position in the flow field. Once you've found you're new location you will want to solve for the velocity components at that position based on the velocity field given. Use bilinear interpolation (**interp2**) to find the true value of (u,v) at the next step.

Turn in the quiver plot with 10 streamlines drawn on it. Note you may use the function **streamline** in Matlab to check your answer, but you must write your own function to draw the streamlines.

Part 2: Flow Around A Moving Cylinder

We are going to plot information for a cylinder moving in still fluid. The velocity field for such a flow is given as

$$u = \frac{a^2 \left(x + Ut\right)^2 - y^2}{\left(\left(x + Ut\right)^2 + y^2\right)^2} \tag{2}$$

$$v = \frac{2a^2 \left(x + Ut\right) y}{\left(\left(x + Ut\right)^2 + y^2\right)^2} \tag{3}$$

Set $a = 1$, $U = 1$, and your domain to $-4 \leq x \leq 4$ and $-4 \leq y \leq 4$.

a) Plot the velocity field using **contourf** in Matlab (or the equivalent in other languages) for $t = 0$.

b) Using the function created in Part 1, draw 8 streamlines on your velocity field created in Part 2a for $t = 0$. For this part draw streamlines that pass through the points (-2, 0), (2, 0), (-0.75, 1), (-0.75, -1), (-0.5, 1), (-0.5, -1), (-0.25, 1), and (-0.25, -1). You may change Δs from part a.

c) Now a bug has landed in the flow field described in Part 2 at $x_o = -1.1$ and $y_o = 0.2$. Draw the pathline the bug will make for $0 \leq t \leq 100,000$ with a time step of $\Delta t = 0.2$. Recall the equation for a pathline is

$$u = \frac{dx}{dt} \quad v = \frac{dy}{dt} \tag{4}$$

You may use **ODE45** if you find this helpful otherwise you are encouraged to write your own function. You may find it easy for this program to answer the question with the velocity field expressed as

$$u_r = \frac{-Ua^2}{R^2}\cos(\theta) \tag{5}$$

$$u_\theta = \frac{-Ua^2}{R^2}\sin(\theta) \tag{6}$$

Where,

$$R = \sqrt{(x + Ut)^2 + y^2} \tag{7}$$

$$\cos(\theta) = \frac{(x + Ut)}{R} \tag{8}$$

$$\sin(\theta) = \frac{y}{R} \tag{9}$$