Homework 1: AE601, Computational Fluid Mechanics

Feb. 4 2009
Due: Feb 11, 2009 (beginning of class)

Problem 1: Matlab visualization exercise

Kovasznay derived an analytical solution to the Navier-Stokes equations that describes the two-dimensional wake flow field behind a periodic array of cylinders (see Figure).

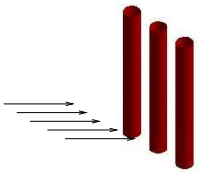

Figure 1: Kovaszney describes the wake behind a periodic array of cylinders.

The u and v velocity in x and y direction, respectively, are given by

$$u(x,y) = 1 - \exp(-\lambda x)(\cos(2\pi y)), \quad (1)$$
$$v(x,y) = -(\lambda/(2\pi))(\exp(-\lambda x))(\sin(2\pi y)), \quad (2)$$

with λ,

$$\lambda = 0.5Re + \sqrt{(0.25Re^2 + 4\pi^2)}. \quad (3)$$

where Re is the Reynolds number.

- Verify that the analytical solution satisfies the Navier-Stokes equations.

Take Re=40 and consider the solution in the rectangular domain -0.01< x <0.04 and -1.5< y <0.5

- Make a contour plot of the u-velocity in this domain on a grid with 100x100 grid points. Use the Matlab 'meshgrid' command.
- Make a streamline plot of the flow using the 'streamline' command in matlab.
- Make a vector plot using the 'quiver' command.
- Make a 2D plot using the 'plot' command of the u velocity versus y at x=-0.05 and x=0. Put in labels, a title, legends. Make a publication worthy graph.

Consult the Matlab manual for more information on the commands and their implementation. This problem must be answered in the 'computer homework' format as outlined in the handout. Briefly discuss your understanding of this flow in the report.