The relevant profiles at $x = 0.5$ and $x = 0.7$ are plotted below. These figures indicate that:

- $u \gg v$
- $\dfrac{\partial u}{\partial x} \ll \dfrac{\partial u}{\partial y}$

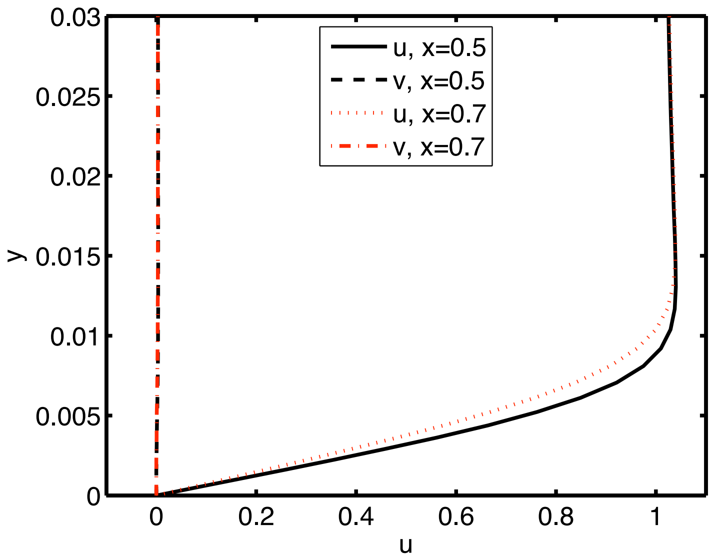


Figure 1: Comparison of u and v-velocity components.

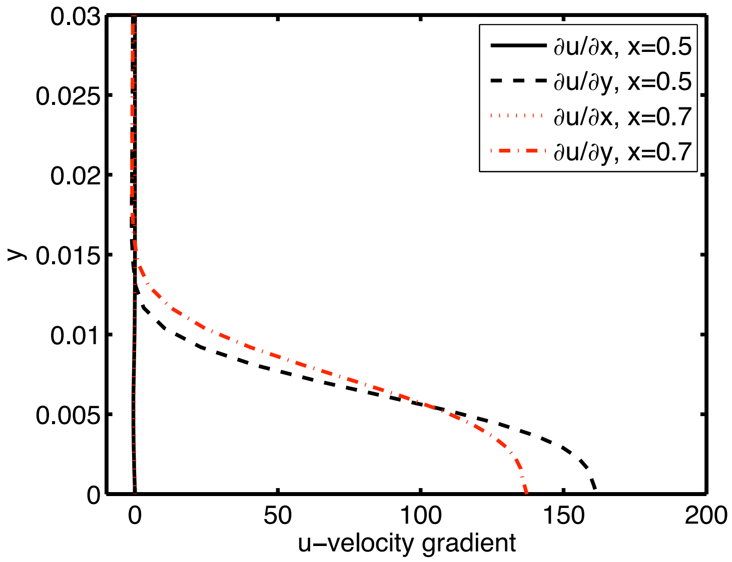


Figure 2: Comparison of u-velocity gradients in x and y-directions.

The results of plotting the u-component of velocity (both dimensional and dimensionless) are shown in Fig. 3 (left and right plot respectively). The dimensional curves show clear evidence of the growing boundary layer (increase in the region of fluid affected by the plate with increasing downstream distance). What is remarkable is the degree of collapse of the curves when plotted in Blasius coordinates. Clearly the Blasius scaling is confirmed. The difference between the scaled profiles and the Blasius solution is due to finite Reynolds number effects (the Blasius solution is valid in the limit as $\mathrm{Re} \to \infty$). At finite Reynolds number, the outer flow is not the flow past a flat plate but the flow past a parabola corresponding to the displacement thickness of the flat plate boundary layer. So the velocity at the edge of the boundary layer is not U_∞ but slightly larger.

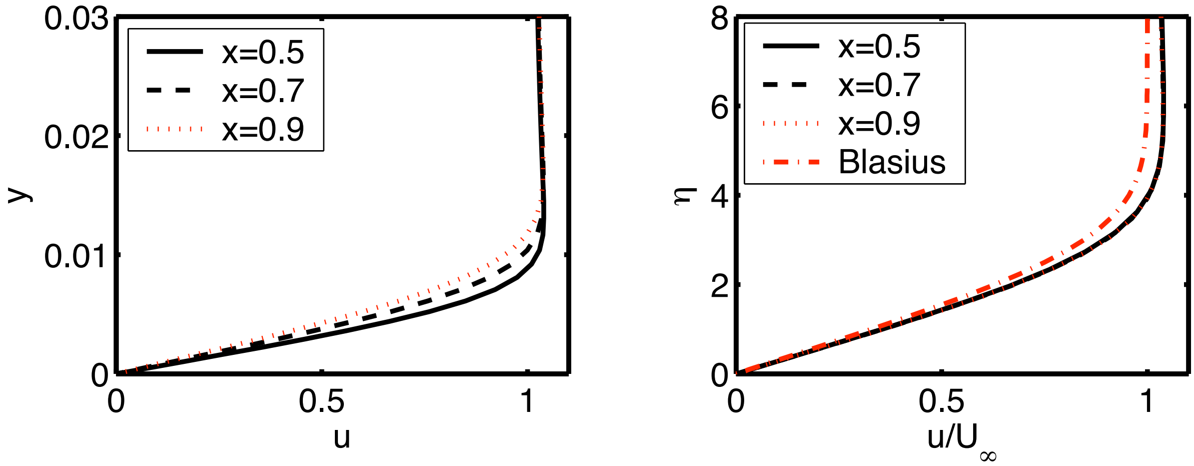


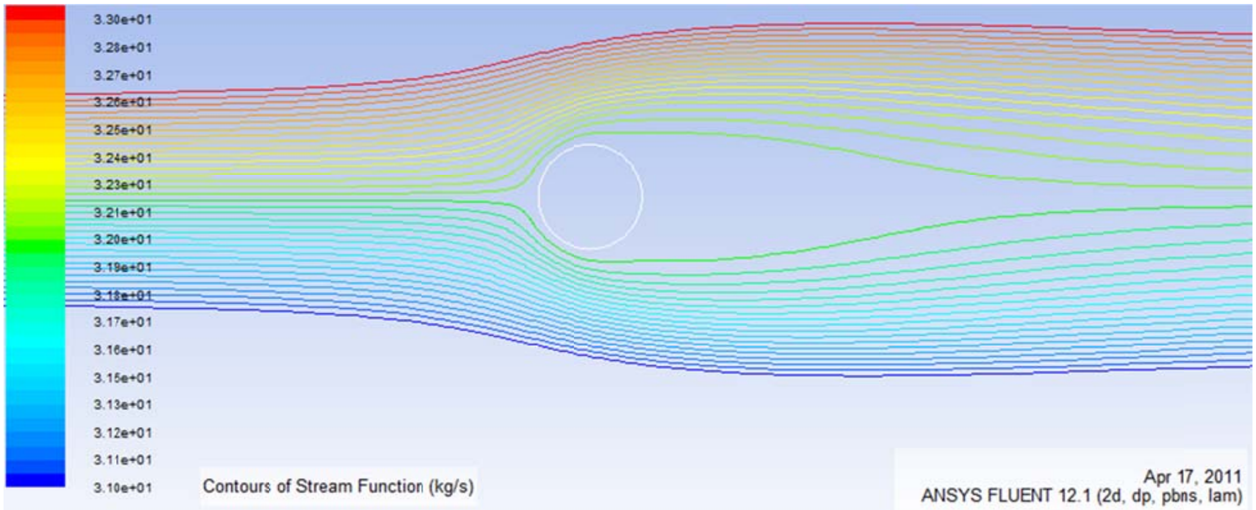
Figure 3: Velocity profiles in unscaled and scaled variables.

Problem 2:

A) C_d =1.4980

B)

Plot of Streamlines



FLUENT Value:

C_d =1.5980

% Difference =|1.526-1.498|/1.4980 = 1.87%

The FLUENT simulation results compare well with the Fonberg experiment. A finer mesh, along with a higher-order dicretization scheme would likely reduce the difference between simulation and experimental results.

Problem 3:

a) St = .173

b)

Case1: Tstep = .2

The average period using the 5 peaks in the plot of C_L vs time using time steps of .2 is:

Tavg = 6.9

The corresponding period of vortex shedding is thus:

f = 1/Tavg = .145

$$St = \frac{fD}{U} = \frac{.145\ Hz \cdot (2/\sqrt{\pi})}{1\ m/s} = .164$$

% Difference =|.173-.164|/.173 = 5.2%

Case 2: Tstep =.02

The average period using the 5 peaks in the plot of C_L vs time using time steps of .02 is:

Tavg =6.125

The corresponding period of vortex shedding is thus:

f = 1/Tavg = .163

$$St = \frac{fD}{U} = \frac{.163\ Hz \cdot (2/\sqrt{\pi})}{1\ m/s} = .184$$

% Difference =|.173-.184|/.173 = 6.4%

This suggests that using a smaller time steps does not always yield a more "accurate" solution. Nevertheless, these two time step values both compare well with the experimental result.