MAE571 Fall 2014, Homework #7
Due Wednesday, December 3

1. Based on the discussion in Section 4.5 in the textbook, reproduce Figs. 4.4b and 4.4d but specifically for the cases with $B = 1$ and $B = 5$. See Eq. (4.39) for the definition of B. Note that the lines in those figures are the streamlines, which are the contours of the stream function, ψ. In addition, also plot the contours of the velocity potential, ϕ, for the two cases with $B = 1$ and $B = 5$. For the convenience of making the plots, you may normalize the velocity (u, v) by U, and (x, y) by a (the radius of the cylinder). (50%)

2. *Background*: Under the right conditions, a viscous flow passing around an obstacle may generate corner eddies. A few sketches of the phenomena from the textbook are reproduced below. Specifically, concerning Fig. 7.3, an analytic treatment in the textbook indicates that corner eddies can be generated only when the angle of the corner is not too wide (< 146.3° in the idealized model discussed in pp. 230-232). Although we did not have time to discuss the analytic work, some insights into the subject can be gained from quick numerical simulations.
Task: Use Ansys-Fluent to investigate the behavior of a 2-D flow going around an obstacle similar to the setting depicted in Fig. 7.3. The goal is to demonstrate how the emergence of corner eddies depends on the angle of the corner. Specifically, your work should help illustrate how well the theoretical prediction mentioned above works. To simplify the calculation, a strictly 2-D setup can be used in Ansys-Fluent. (This can be done by choosing "2-D" under "Geometry" from the beginning.) Multiple runs with different angles of the corner should be performed. A corner vortex (if it exists) in the simulation can be visualized with a contour plot of the 2-D stream function. It is recommended that the relevant flow parameters (the inflow velocity, viscosity, etc.) be chosen such that the Reynolds number of the flow is not too high. This will enable the convergence of simulation when you choose the "Viscous - laminar" model in Ansys-Fluent to seek a steady solution.
(50%)

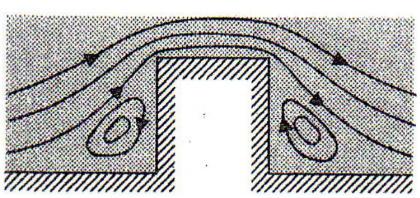

Fig. 7.1 in Acheson. In this case, the corner angle is 90°.

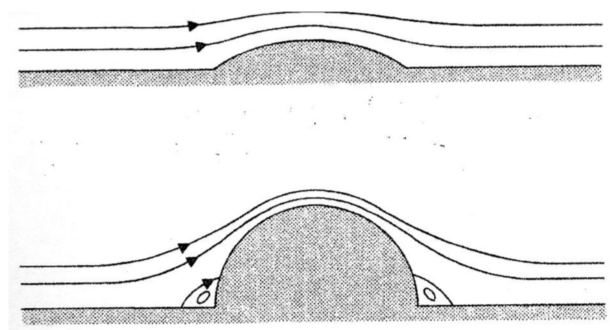

Fig. 7.3 in Acheson, after Higdon (1985). A corner eddy does not form when the angle at the corner is too large.