**ME4/560 Intermediate Fluid Mechanics**

**Assignment #1 Due Oct. 11, 2016 IN CLASS**

This problem can be worked on in *groups of two* (ME460 students must work with ME460 students and similarly for ME560 students). Grading will be based on presentation clarity and completeness, including description of solutions. In other words the report must describe the process used and identify and justify the equations used, present and describe the results and also provide a discussion and conclusion.

To complete this assignment you will need to find the proper expression for the Navier-Stokes equation. You should review nondimensionalizing the equation based on velocity, pressure, length and time scales. This can be found in most fluids texts and it will be discussed in class.

Here we are going to look at some very low Reynolds number conditions and try to solve for the flow and other things along the way. The goal is to appreciate simplifications needed to analyze the flow and to understand the important flow physics that is being modeled.We are not going to try to go into all of the theory behind it, but hopefully understand the solution and interpret it properly.

1. Start with the full blown Navier-Stokes equations for an incompressible flow with constant viscosity. Write this equation out in tensor notation and nondimensioanlize it using the scaling variable: U for velocity, U/L for pressure, L/U for time and express your result in terms of needed nondimensional terms and any nondimensional parameters – identify what these parameters are in the equation and what they represent physically.
2. Now simplify the nondimensional equation for the condition of very viscous flow, explain how this is being simplified.
3. A simple trajectory problem will now be used to illustrate nondimensional presentation of data – consider a sphere of diameter D = 0.1m and weight W=1 kg that starts a trajectory at 45o from the horizontal at a velocity of Vo in a fluid of density = 10 kg/m3.. The sphere travels over flat terrain and there is a drag force acting on it. The sphere eventually hits the ground. You are to determine the distance travelled by the sphere and the height of the highest point.
   1. First take the simple F=mdV/dt equation for the sphere and nondimensionalize it using scales: W for force (weight of sphere), Vo for velocity, D the sphere diameter and D/Vo for time.
   2. What are the nondimensional parameters that emerge from the nondimensionalization of the equation? Call them P1 and P2. What do they represent physically?
   3. Use the nondimensional x (horizontal) and y (vertical) components of this equation and solve for the nondimensional trajectory. To do this you can assume that the drag coefficient remains constant during the entire flight. But you will have to use a proper equation for the drag force to do this. Do this for two values of P1 (0.001 and 0.01) and P2 (0.1 and 1.0)
   4. Now determine the values of the actual trajectory length vs Vo for the cases of P – interpret your results. That is, plot the trajectory length in meters versus Vo for a range of Vo from 5 - 25 m/s. Determine the drag coefficient that corresponds to each case.