Name: ______________________________

ABE 307
Fall 2017
Test 3: Take Home Test (Practice Exam)
Assigned: Dec 1st, 2017
Due: Dec 9th, 2017

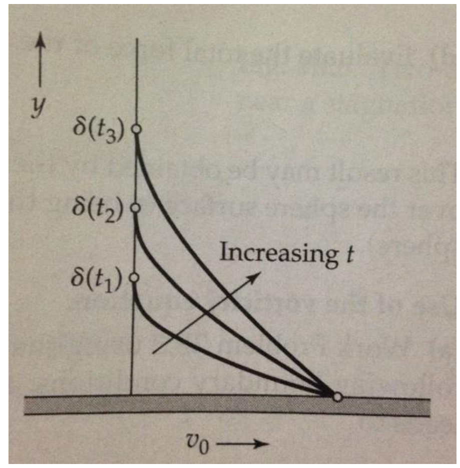
Suggested Time	90 minutes
Actual Time Spent	

Treat this Take Home Test as a real exam. Time yourself for solving, however you are free to use any amount of time needed to complete the problems. The test will only be evaluated for completeness. All problems must be fully solved, including all integrals and providing a final answer. **Solutions left incomplete will be treated as unattempted and 0 points will be given for whole test**. **Full points will be given to a complete test, regardless of accuracy of the solutions**. Also, record your actual time for the test after you have finished. Actual time spent has no implications for your points, this statistics is being collected to gain insight into proper length of exam to be used in future. **It is recommended to NOT look at class solutions or any other notes for solving this test. You may however use your <u>cheat sheet</u> prepared for final exam.**

If you need to use additional pages, that is allowed. Staple it to the main test.

Problem	Points	Points Obtained
1	30	
2	15	
3	15	
Total	60	

1. A semi-infinite body of liquid with constant density and viscosity is bounded below by a horizontal surface (the xz-plane). Initially the fluid and the solid are at rest. Then at time t=0, the solid surface is set in motion in the positive x-direction with velocity v_0 as shown in Fig below. The force of the fluid on the solid plate can be estimated by boundary layer approximation.



For the given case of transient development of boundary layer, shear stress is related to the velocity change by the given equation

$$\frac{d}{dt}\int_0^\infty \rho v_x \, dy = \tau_{yx}|_{y=0}$$

If, the approximate velocity profile is given for the boundary layer as given below. Then derive an expression for the thickness of boundary layer as function of time.

(Hint: For simplicity of derivation, use a variable change of $\eta = \frac{y}{\delta(t)}$)

$$\frac{v_x}{v_0} = 1 - \frac{3}{2}\frac{y}{\delta(t)} + \frac{1}{2}\left(\frac{y}{\delta(t)}\right)^2 \quad for\ 0 \le y \le \delta(t)$$

$$\frac{v_x}{v_0} = 0 \ for\ y \ge \delta(t)$$

2. A bubble of diameter d rises in a stagnant liquid under the effect of buoyancy. The viscosity of the liquid is μ, the density of the gas inside the bubble is ρ_g, and the density of the liquid is ρ_l. The acceleration due to gravity is g. The surface tension of the bubble is σ (Force per unit length). The bubble attains a terminal velocity U. (15)

   a. List the various parameters that U would depend on.
   b. Perform a Buckingham pi analysis to find the various non-dimensional groups for the problem.

3. Find the direction of fluid flow in the pipe shown below using Bernoulli's principle. Assume the fluid to be water with constant density, and that the flow is steady. (15)