<u>Review Lecture and Study Guide</u>
<u>Final Exam, ABE 307, Fall 2017</u>

1. **Velocity Distribution With More Than One Independent Variable**
   Section 4.1, Read Lecture Note on Two dimensional flow in Channel, Examples 4.1-1 and 4.1-2 in book., Problems in HW 5

   <u>Class Lectures</u> – Unsteady state Semi Infinite fluid, Unsteady State Parallel plate, Flow in Rectangular channel

   <u>Expectation:</u>
   - Be able to apply Navier Stokes equation in multiple dimension, unsteady state (All Navier Stokes Equation will be provided)
   - Be able to write the boundary conditions for multiple variable dependence and also for change of variable provided.
   - Be able to simplify with given variable change (know how the chain rule applies when you are changing the equation to a different variable)

2. **Stream function, Potential Flow, Boundary Layer Theory and Velocity Profile:**
   Read Section 4.3, 4.4, Examples – 4.3-1 , 4.4-1 HWs 6, 7

   a. We used stream function and potential function to get velocity. Complex potential was related to velocity components. Then using the equation of motion that gave Bernoulli equation to get pressure distribution (the Bernoulli equation for incompressible, potential flow, Eqn 4.3-5).
   b. Using Navier Stokes Equation in two dimensions, Equation of Continuity and assuming steady state, we simplified to arrive at the Prandtl Boundary Layer Equations (Eqn 4.4-9 and 4.4-10 in book)
      - Prandtl Boundary Layer Equations (Will be Provided)
   c. Simplifying, Prandtl Boundary Layer Equations with Potential Flow equation for relation between pressure gradient and velocity gradient, Von Karman Equation is derived. Eqn 4.4-13
      - Von Karman Equation (Will be Provided)
   d. Using Von-Karman equation and Assumed velocity profiles provides “approximate boundary layer solutions” which is used for “boundary layer thickness”, velocity dependence on x and y, consequently the drag force. (Example 4.4-1)
      <u>Expectation:</u> You will be able to apply these procedures on different kind of geometries provided (Cartesian coordinate and cylindrical co-ordinates). All assumptions will be provided. Any simplifying assumption that you make with reasonable justification will be acceptable.

3. **Dimensional Analysis:** Read Lectures Dimensional Analysis Introduction, Buckingham Pi Theorem (HW 7, Class Problem, Example problem from last year exam)

   a. Using dimensional analysis to obtain functional relationship for a given variable with other variables in a system.
   b. Using Buckingham Pi Theorem to obtain dimensionless numbers and use for design of systems.

   Expectation: Can use Buckingham Pi Theorem for a given problem to identify the dimensionless numbers and relationship between different variables to form dimensionless numbers. Check the dimensional homogeneity for any given equation that describes the fluid flow situation.

4. **Friction Factors:** Read Introduction to Chapter 6, Sections 6.1, 6.2 and 6.3
   Examples 6.2-1, 6.2-2 and 6.3-1 (Class Example from Fall 2015 Final Exam, HW 8)

   a. Friction factors are introduced to be able to compute losses easily without going through the rigorous process of writing Navier stokes equation etc.
   b. Understand the concept of how friction factor relates forces by fluid with geometrical parameters of the system. Be able to use various geometries to relate the forces and system dimensions.
   c. Two common system – Pipe friction factor and friction factor for submerged spheres. Understand the derivation and relation of friction factor with dimensionless numbers.
   d. Be able to use the relationship between friction factor (f), other dimensionless numbers to calculate the unknowns. (Two methods were discussed – redrawing of graph or using the already available friction factor chart with new function for drawing line to get solution)
   e. Be able to use friction factor charts in both cases – fluid flow in pipe and submerged spheres.

   Expectation: Be able to develop relationship for friction factor and system parameter for new system. And use the known relationship between friction factor and other variable to get unknowns. Use of simultaneous equations or graphs for solutions.

5. **Macroscopic Balances For Isothermal Flow Systems**
   Read Introduction to chapter, 7.1, 7.2, 7.4, 7.5, 7.6 , Examples from Book : 7.1-1, 7.2-1, 7.5-1, 7.6-1, 7.6-5 , Class Examples, HW 8

   a. Writing mass balance. Application to flow problems. An example was done in class.
   b. Writing momentum balance. (General equation will be provided, you are expected to identify all the terms for a given system.)
   c. Mechanical Energy Balance (General equation will be provided, not the generalized form of 7.5-10)
   d. Viscous loss calculations. The table for "friction loss factors" e_v will be provided. Rh or hydraulic radius for different geometry will be given. Expected to understand where losses are occurring in the system such as compression, expansion and resistances.

<u>Expectation:</u> Be able to use these balances for system provided of any geometry, simplifying in proper dimensions. Understand the forces of fluid on the system etc. Be able to calculate viscous losses, be able to combine the e_v with friction factor calculations in case of pipe system. Be able to derive simple equations by application of macroscopic balances such as we did for Venturimeter in the class. Know principles of Venturimeter and Orificemeter.