Name: _____

HOUR EXAM II: Internal & External Incompressible Viscous Flows

Closed Books, Closed Notes

Thursday April 24, 2003

Instructions

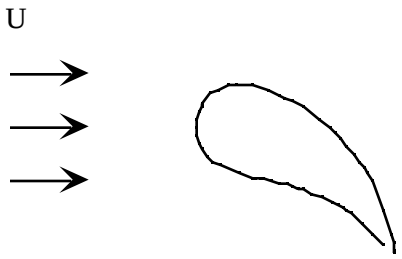
1. Do *not* begin the exam until instructed to do so.
2. This exam is closed books and closed notes. Examination test notes are provided.
3. Write on the exam script only, and write ONLY on the front side of any page. Extra paper can be obtained from the instructor.
4. On all graphs, be absolutely *neat* and *clear* about distinguishing features, curvature, relative magnitudes and labels.
5. For any iterative problems, perform at least 2 iterations and use at least 4 significant figures.
6. Reference any tables, charts and figures from the test notes that are used in any calculations.
7. Clearly indicate the part of the problem, i.e. a, b, etc., to which your analyses corresponds.
8. Show all work. Show all equations in symbolic form, all numerical substitutions, and all calculations.

GOOD LUCK!

Problem	Points	Possible
1		5
2		25
3		20
Total		50

Problem 1

(a) *Clearly* sketch the streamlines for an airfoil flying at the angle of attack corresponding to stalling with the free stream velocity U indicated below. Note that when stalling occurs, the flow separates from the airfoil.



(b) A plane flying at an angle of attack greater than that for stalling is falling. In words, describe the action that the pilot needs to take in order to recover and explain why.

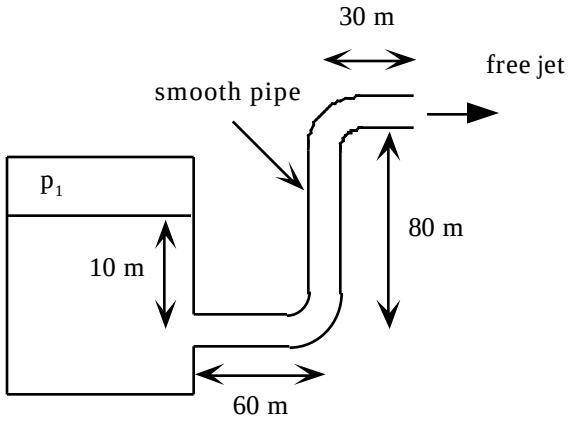
(c) Perform a double back flip, landing on your head, –OR– derive the unsteady conservation of momentum equations in cylindrical coordinates for a viscoelastic fluid, –OR– estimate the friction factor for a gasoline flow through a constant-diameter galvanized iron pipe with a 3 cm inside-diameter pipe carrying a mass flowrate of 0.013 kg / s.

Problem 2

As shown, pressurized air in a tank carrying methanol drives flow through a smooth pipe which exits to the atmosphere. Methanol has density ρ=791 kg/m^3 and viscosity μ=0.000598 Pa•s.

(a) Neglecting all minor losses, determine the flowrate Q through the 5-cm diameter pipe for p_1=900 kPaG. If the solution is iterative, use a friction factor value of f=0.016 for the first guess.

(b) Using the answer from part (a), estimate the energy per unit mass due to friction which is lost to fittings, i.e. due to the sharp-edged exit having loss coefficient 0.5 and the regular 90° threaded elbows having loss coefficients 1.5.



Problem 3

For the three large glycerin reservoirs shown, the free surface elevations are z_A=200 m, z_B=H (unknown) and z_C=0. Each pipe has an inside diameter of 25 cm and a friction factor f=0.025, which is independent of Reynolds numbers for all flows considered here. The lengths of pipes are L_1=300 m, L_2=200 m and L_3=100 m. The flowrate from reservoirs A and B into reservoir C is 0.5 m^3/s. Neglecting all minor losses, determine the velocities in pipes 1 and 2 and the free surface elevation H of reservoir B.