CLL 231: Fluid Mechanics for Chemical Engineers

Minor Examination

Date:14-Feb-2022 (Schedule: - 8:00 am to 9:30 am)

Total Marks: 25 **Duration: 1h 30 min**

Instructions: Any assumption needs to be stated explicitly.

Short answers:

1. Why is unstable equilibrium called equilibrium at all? (**0.5**)

2. What could cause acceleration in the fluid element for steady state flow? Explain with the equation in x-direction. (**1**)

3. What are the reasons of minor losses in pipe flow? Answer based on the concepts we discussed in the lecture session. (**1**)

4. For incompressible flow, how can we relate dilation to the divergence of velocity field? (**1.5**)

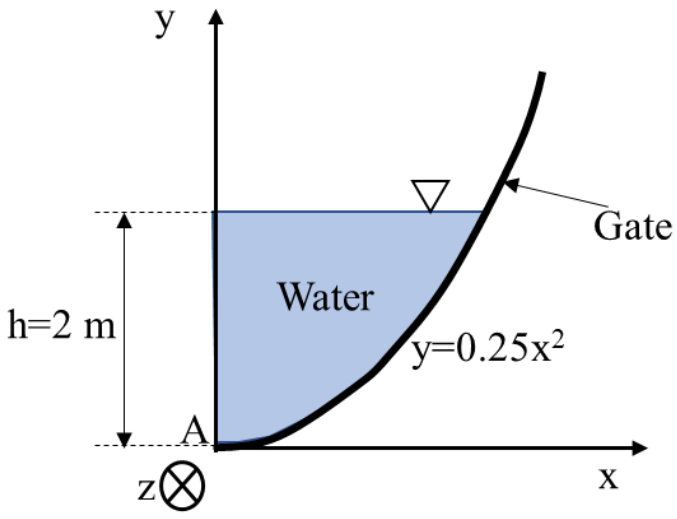
5. What causes the viscosity of fluids in motion? Why does the viscosity of gasses increase with increasing temperature? Explain based on the discussion we had in the lecture session. (**1+0.5**)

6. What could be a common feature between a control mass and a control volume system? (**0.5**)

Mathematical problems:

7. You are performing an experiment with two fluids contained between two parallel plates. Each plate is 1 m^2 in area. Viscosity and thickness of the fluid at the bottom are $\mu_1 = 0.1$ N.s/m^2, $h_1 = 0.5\ mm$ and those of the top fluid are $\mu_2 = 0.15$ N.s/m^2, $h_2 = 0.3\ mm$ respectively. How much force (F) do you need to apply to move the upper plate at a speed of 1 m/s? What is the fluid velocity at the interface between two fluids at this condition? The bottom plate is at rest. (**2+2**)

8. A parabolic gate shown in the sketch is 2 m wide (w) in z-direction and pivoted at point 'A'. Determine the magnitude of the vertical force on the gate due to water. (**3.5**)



water near a parabolic gate

9. A steady, two-dimensional (in the xy-plane) velocity field is given by

$$\vec{V} = (0.523 - 1.88x + 3.94y)e_i + (-2.44 + 1.26x + 1.88y)e_j$$

a) Verify that this flow is ***incompressible*** in nature.

b) Calculate the ***acceleration*** at the point (x, y) → (4,1) (**1+2**)

10. Velocity potential of an irrotational flow field of water (density=1000 kg/m^3) is given as $\phi = x + x^2 - y^2$. Determine expression for the velocity field and the stream function. Calculate the pressure difference between two points (0,0) and (1,2). Lengths are measured in meters. Hint: Assume that the integral factor in x-direction is zero. (**1+1+2.5**)

11. In my village, one person was siphoning water (density 62.4 lb/ft^3) from a container by a 2-inch (inner diameter) pipe. Flow of water at a given instant is shown in the sketch below. As you are a smart engineer, you are told to determine the velocity and pressure at point **A** and the volumetric flowrate of water at the exit (point **B**)**.** What are the values? Neglect any losses in pipe flow. Acceleration due to gravity in FPS unit is 32.2 ft/s^2. (**1+1+2**)