2020 Fundamentals of Fluid Mechanics B Midterm Exam

Thursday March 26th 2020
11:00 — 12:15

INSTRUCTIONS

- USE FUNDAMENTALS OF FLUID MECHANICS TABLES THAT WERE DISTRIBUTED.
- ALL QUESTIONS HAVE EQUAL VALUE; ANSWER ALL 2 QUESTIONS.
- WRITE YOUR SOLUTIONS IN SINGLE COLUMN FORMAT, WITH ONE STATEMENT FOLLOWING ANOTHER VERTICALLY.
- WRITE YOUR SOLUTIONS NEATLY SO THAT THEY ARE EASY TO READ AND VERIFY.
- DON'T WRITE ONE LINE WITH TWO EQUAL SIGNS.
- HIGHLIGHT YOUR ANSWERS USING A BOX.

Question #1

Recall that for Poiseuille flow between two plates, we obtained:

$$\frac{\dot{m}}{W} = -\frac{\rho H^3}{12\mu}\frac{\partial P}{\partial x}$$

$$\vec{v} = \frac{y}{2\mu}\frac{\partial P}{\partial x}(y-H)\vec{i}$$

where W is the width of the plates (along z) and H is the distance between the two plates (along y). Do the following:

(a) Find the wall shear stress τ_w on each plate due to the fluid friction.

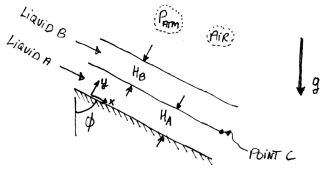
(b) Derive an expression for the Darcy friction factor function of Reynolds number. Clearly define your Reynolds number.

(c) Write down the hydraulic diameter for this problem.

(d) Rewrite your Reynolds number and friction factor in terms of the hydraulic diameter.

Question #2

Consider two fluid layers flowing along a plane as follows:



Given the plane inclination ϕ, the gravitational acceleration g, as well as the fluid properties ρ_{A}, μ_{A}, ρ_{B}, μ_{B}, and starting from the mass and momentum transport equations, do the following:

(a) Knowing that the speed of the flow at point C is q_C, derive an expression for the velocity within fluid A and fluid B as a function of q_C, and x, y, H_{A}, H_{B}, g, ϕ.

(b) Derive an expression for H_{B} as a function of H_{A}, q_{C}, g, ϕ, and the fluid properties ρ_{A}, ρ_{B}, μ_{A}, μ_{B}.