

# 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:

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

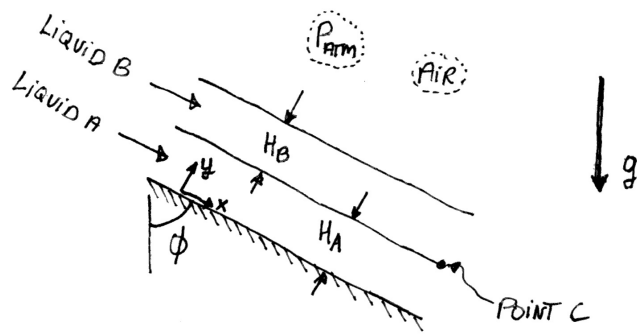
$$\vec{v} = \frac{y}{2\mu} \frac{\partial P}{\partial x} (y - H) \vec{i}$$

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

- Find the wall shear stress  $\tau_w$  on each plate due to the fluid friction.
- Derive an expression for the Darcy friction factor function of Reynolds number. Clearly define your Reynolds number.
- Write down the hydraulic diameter for this problem.
- 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  $\phi$ , the gravitational acceleration  $g$ , as well as the fluid properties  $\rho_A, \mu_A, \rho_B, \mu_B$ , 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  $x, y, H_A, H_B, g, \phi$ .
- (b) Derive an expression for  $H_B$  as a function of  $H_A, q_C, g, \phi$ , and the fluid properties  $\rho_A, \rho_B, \mu_A, \mu_B$ .