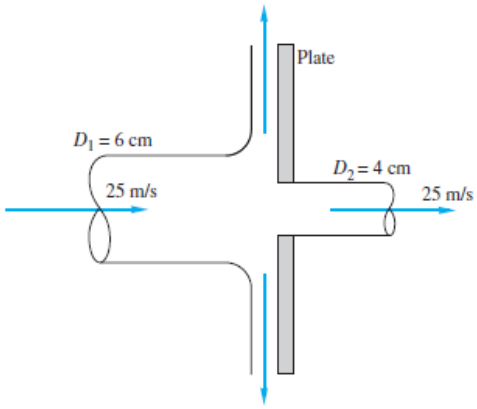
October 27, 2023

Mechanical, Automotive and Materials Engineering
Fluid Mechanics I
MECH3233-F23
Assignment Problems Set #6

Due: Thursday, November 2, 2023, at 11:59 p.m.

Problem 1 (4 points): The 6-cm-diameter 20°C water (ρ = 998 kg/m^3) jet strikes a plate containing a hole of 4-cm diameter. Part of the jet passes through the hole, and part is deflected as shown below. Determine the horizontal force required to hold the plate.



Problem 2 (4 points): The x and y components of a two-dimensional velocity field are given by

$$u = \frac{U_o x}{L} \qquad v = \frac{-U_o y}{L}$$ U_o and L are constants

a) Calculate the acceleration vector, $\vec{a}$.
b) If L = 1.5 m and the magnitude of the acceleration at (x, y) = (2 m, 1 m) is 25 m/s^2, find the value of U_0.

Problem 3 (3 points): Converging duct, flow is modeled by the steady, two-dimensional, incompressible velocity field $\vec{V} = (u, v) = (U_0 + bx)\vec{\imath} - by\vec{\jmath}$. The pressure field is given by

$$P = P_0 - \frac{\rho}{2}\left[2U_0 bx + b^2\left(x^2 + y^2\right)\right]$$

where P_0 is the pressure at x = 0. Generate an expression for the rate of change of pressure ***following a fluid particle***. Note that U_0 and b are constants.
Hint: Use the material derivative.

Problem 4 (5 points): A bird is flying in a room with a velocity field of $\vec{V}$ = (u, v, w) = 0.6x + 0.2t – 1.4 (m/s). The room is heated by a heat pump so that the temperature distribution at steady state is T (x, y, z) = 400 – 0.4y – 0.6z – 0.2 (5 – x)^2 (°C). Calculate the temperature change that the bird feels after 10 seconds of flight, as it flies through x = 1 m.