Homework #7

MEMS 0071 - Introduction to Fluid Mechanics

Assigned: October 27$^{\text{th}}$, 2019
Due: November 1$^{\text{st}}$, 2019

Problem #1

Given an incompressible fluid that flows past a sphere with radius r. If the fluid velocity is

$$\vec{V} = V_o\left(1 + \frac{r^3}{x^3}\right)\hat{\imath}$$

where V_o is the free-stream velocity, determine the acceleration vector of the fluid.

Problem #2

For a two-dimensional steady flow give as

$$\vec{V} = \left(\frac{V_o}{L}\right)(-x\hat{\imath} + y\hat{\jmath})$$

where V_o and L are constants, determine the acceleration vector of this flow.

Problem #3

Fluid is steadily flowing through a nozzle, which has a shape described as

$$\frac{y}{L} = \pm\frac{0.5}{\left(1 + \frac{x}{L}\right)}$$

which is valid for the ranges -0.5<y/L<0.5 and 0<x/L<1. If the pressure field of the fluid is described as

$$P - P_o = -\left(\frac{\rho V_o^2}{2}\right)\left(\frac{x^2 + y^2}{L^2} + \frac{2x}{L}\right)$$

and V_o and P_o are the velocity and pressure at the origin, determine the time rate of change of the pressure field through the nozzle.

Problem #4

For a two-dimensional steady flow, if the velocity field is given as

$$\vec{V} = (x^2 + y^2)\hat{\imath} - 2xy\hat{\jmath}$$

determine if the flow is rotational or irrotational.

Problem #5

Given the following velocity field for an incompressible fluid

$$u = x^2 + y^2 + z^2$$

$$v = xy + yz + z$$

$$w = ?$$

Determine the z-component of velocity that satisfies continuity.

Problem #6

If the velocity field of planar flow between two plates is described as

$$u = 0.002(1 - 10(10^3)y) \text{ [m/s]}$$

which is valid in the range of -10<y [mm]<10, determine the vorticity and shear strain rate when y=5 [mm].

Problem #7

Consider a situation of planar Couette flow, where the top plate is moving in the positive x-direction with a velocity in the positive x-direction of 0.32 [m/s] and the bottom plate is stationary. If the velocity profile between the two plates is described as

$$u = (40y - 800y^2) \text{ [m/s]}$$

where y is the height of the channel, taken as 10 [mm], determine the shear stress acting on the bottom. Take the dynamic viscosity of the fluid to be 897 μPa-s.