University of Toronto
Faculty of Applied Science and Engineering
Quiz 3 – November 10th , 2016
9:15 am – 10:15 am

SECOND YEAR – ENGINEERING SCIENCE

AER210F VECTOR CALCULUS and FLUID MECHANICS
Examiner: Sina Kheirkhah

Instructions:
(1) Closed book examination; except for a non-programmable calculator, no aids are permitted.
(2) Write your name and student number in the space provided below.
(3) Answer as many questions as you can. Parts of questions may be answered.
(4) Use the overleaf side of pages for additional or preliminary work.
(5) Do not separate or remove any pages from this exam booklet.

Family Name:_____

Given Name:_____

Student Number:_____

Tutorial Session:_____

FOR MARKER USE ONLY		
Question	Mark	Earned
1	24	
2	16	
3	15	
4	20	
5	25	
TOTAL	100	

1. Answer the following questions.

a. Define a streamline, a pathline, and a streakline.

b. What is a Newtonian fluid?

c. What is a viscous flow?

d. For flows with large Knudson numbers, how does the mean-free-path compare to the length scale of a problem?

e. Define the Reynolds number.

f. Consider a developing flow inside a pipe. Is the normal stress along the pipe centerline and inside the potential core negligible? Elaborate your answer briefly.

2. A non-dimensional group is given by: $\pi = U^a D^b \vartheta^c$, where U, D, and ϑ are flow velocity, diameter of a sphere, and fluid kinematic viscosity, respectively. Perform a dimensional analysis and obtain an expression for π.

3. Obtain the equation of the streamline for the following velocity field.

$$u = x + y + 2$$

$$v = -(x + y)$$

4. For an incompressible fluid which undergoes rigid body motion, the acceleration is given by $\vec{a} = (g_x x^2, g_y y^2, g_z z^2)$, where the gravitational acceleration is $\vec{g} = (g_x, g_y, g_z)$. If the pressure at $(x, y, z) = (0,0,0)$ is equal to the atmospheric pressure (P_0), obtain an expression for the pressure field in terms of x, y, z, g_x, g_y, and g_z. Hint: the governing equation for fluid in rigid body motion is given by: $-\vec{\nabla}P + \rho\vec{g} = \rho\vec{a}$.

5. A hemispherical container is partly filled with water, see the figure below. Estimate the force due to hydrostatic pressure exerted to the container. The radius of the container is *R* and the height of water inside the container is *h*.