Prince of Songkla University
Faculty of Engineering

Midterm Test
7 August 2005
215-342 Mechanics of Fluids II

Semester 1/2548
13:30 – 16:30
Room R300

Name ______________________________ ID ______________

Direction:

1. All types of calculators, and dictionaries are permitted.
2. There are totally 6 problems, 9 pages. Solve all of them, will you?
3. A two-page, hand-written A4 paper is allowed. No photocopy, please.

Perapong Tekasakul
Instructor

Problem No.	**Full score**	**Your mark**
1	**15**	
2	**15**	
3	**10**	
4	**10**	
5	**15**	
6	**15**	
Total	**80**	

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1. Answer all questions as good as you can. Give sufficient detail of your description. (15 points)

   1.1 Why in fluid analysis Eulerian approach is preferred to the Lagrangian approach? (2 points)

   1.2 Describe the meanings of *streamlines, pathlines*, and *streaklines*. When all these lines coincide? (4 points)

   1.3 At what condition the Navier-Stokes equations can be used? (2 points)

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1.4 Describe the difference between *linear deformation* and *angular deformation*. (2 points)

1.5 What is the relationship between *streamline* and *stream function*. (2 points)

1.6 Describe the step you need to do in order to obtain a velocity profile in a circular tube. (3 points)

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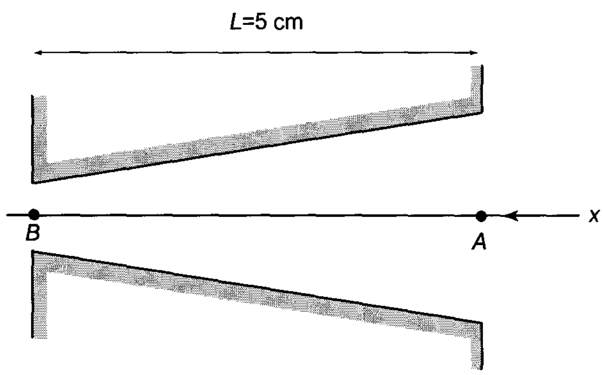
2. Water flows in a garden hose with a velocity of 3 m/sec, travels through a 5-cm-long nozzle, and exits the nozzle with a velocity of 20 m/sec. Determine acceleration of the water at the inlet (A) and the exit of the nozzle (B). The velocity is known to be a linear function of the distance. Assume steady flow.
(15 points)



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3. The velocity components of an incompressible, two-dimensional velocity field are given by

$$u = y^2 - x(1+x)$$
$$v = y(2x+1)$$

(a) Is the flow irrotational?
(b) Show that the flow satisfies conservation of mass.
(10 points)

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4. A two-dimensional, incompressible flow is given by

$$u = -y$$

$$v = x$$

Show that the streamline passing through the point $x = 10$ and $y = 0$ is a circle centered at the origin. (10 points)

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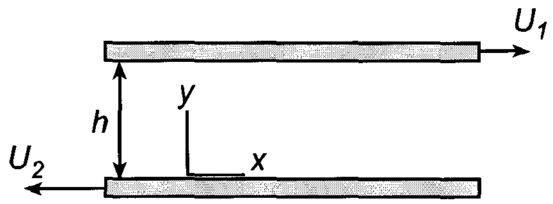
5. An incompressible, viscous fluid is placed between horizontal, infinite, parallel plates as shown in the figure below. The two plates move in the different directions with different velocities, U_1 and U_2. No pressure gradient in the x direction exists. Determine the velocity distribution between the plates. List all assumptions needed. (15 points)



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6. A viscous fluid is contained between two infinitely long, vertical, concentric cylinders. The outer cylinder has a radius r_o and rotates with an angular velocity ω. The inner cylinder is fixed and has a radius r_i. Derive the solution for the velocity distribution in the gap. Assume neither velocity nor pressure are functions of θ and that there are no velocity components other than the tangential component.
(15 points)

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Life Savior

Continuity Equation

Cartesian coordinates

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x}(\rho u)+\frac{\partial}{\partial y}(\rho v)+\frac{\partial}{\partial z}(\rho w)=0$$

Cylindrical coordinates

$$\frac{\partial \rho}{\partial t}+\frac{1}{r}\frac{\partial}{\partial r}(\rho r V_r)+\frac{1}{r}\frac{\partial}{\partial \theta}(\rho V_\theta)+\frac{\partial}{\partial z}(\rho V_z)=0$$

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x}(\rho u)+\frac{\partial}{\partial y}(\rho v)+\frac{\partial}{\partial z}(\rho w)=0$$

Navier-Stokes Equations

Cartesian coordinates

x-component: $$\rho g_x-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)=\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}\right)$$

y-component: $$\rho g_y-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)=\rho\left(\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}\right)$$

z-component: $$\rho g_z-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)=\rho\left(\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}\right)$$

Cylindrical coordinates

r-component: $$\rho g_r-\frac{\partial p}{\partial r}+\mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V_r}{\partial r}\right)-\frac{V_r}{r^2}+\frac{1}{r^2}\frac{\partial^2 V_r}{\partial \theta^2}-\frac{2}{r^2}\frac{\partial V_\theta}{\partial \theta}+\frac{\partial^2 V_r}{\partial z^2}\right]$$
$$=\rho\left(\frac{\partial V_r}{\partial t}+V_r\frac{\partial V_r}{\partial r}+\frac{V_\theta}{r}\frac{\partial V_r}{\partial \theta}-\frac{V_\theta^2}{r}+V_z\frac{\partial V_r}{\partial z}\right)$$

θ-component: $$\rho g_\theta-\frac{1}{r}\frac{\partial p}{\partial \theta}+\mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V_\theta}{\partial r}\right)-\frac{V_\theta}{r^2}+\frac{1}{r^2}\frac{\partial^2 V_\theta}{\partial \theta^2}+\frac{2}{r^2}\frac{\partial V_r}{\partial \theta}+\frac{\partial^2 V_\theta}{\partial z^2}\right]$$
$$=\rho\left(\frac{\partial V_\theta}{\partial t}+V_r\frac{\partial V_\theta}{\partial r}+\frac{V_\theta}{r}\frac{\partial V_\theta}{\partial \theta}+\frac{V_r V_\theta}{r}+V_z\frac{\partial V_\theta}{\partial z}\right)$$

z-component: $$\rho g_z-\frac{\partial p}{\partial z}+\mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V_z}{\partial r}\right)+\frac{1}{r^2}\frac{\partial^2 V_z}{\partial \theta^2}+\frac{\partial^2 V_z}{\partial z^2}\right]$$
$$=\rho\left(\frac{\partial V_z}{\partial t}+V_r\frac{\partial V_z}{\partial r}+\frac{V_\theta}{r}\frac{\partial V_z}{\partial \theta}+V_z\frac{\partial V_z}{\partial z}\right)$$