Introduction to Marine Hydrodynamics (NA235)

(2014-2015, 2nd Semester)

Assignment No.2

(Eight problems, to be submitted on March 19th, 2015)

Problem 1: Consider an axial rotation of a fluid at a constant angular acceleration (ε_0) like a rigid body. Express its position, velocity and acceleration from Lagrangian and Eulerian descriptions.

Problem 2: Assume three velocity components in a three-dimensional velocity field are:

$$u = ax$$
$$v = ay$$
$$w = -2az$$

Where a is a constant. Verify that the streamline of this flow is an intersection of two curved surfaces $y^2 z = \text{const}$ and $\frac{x}{y} = \text{const}$.

Problem 3: the velocity field of a flow is given as:

$$\vec{V} = (x+1)t^2\vec{i} + (y+2)t^2\vec{j}$$

Determine the pathline and streamline equations at time t=1 and at point (2, 1).

Problem 4: The velocity profile in a flow field is given as:

$$\begin{cases} u = yz + t \\ v = xz - t \\ w = xy \end{cases}$$

(1) Is the flow steady? (2) Determine the acceleration of the fluid particle through a field position (1, 1, 1).

Problem 5: Verify that the acceleration field of an irrotational flow is a potential field.

Problem 6: Assume the velocity fields of two flows are:

$(a)\ \vec{V} = (-\Omega y, \Omega x, 0)$

$(b)\ \vec{V} = (-\Omega y / r^2, \Omega x / r^2, 0)$

Where Ω is a constant, and $r^2 = x^2 + y^2$. (1) Generate the streamline equations of these two flows; (2) Is the flow rotational or irrotational? Determine the velocity potential of the irrotational flow.

Problem 7: The velocity profile of a flow is given as:

$$\begin{cases} u = a\, y(y^2 - x^2) \\ v = a\, x(y^2 - x^2) \end{cases}$$

Where *a* is a constant. (1) Generate the streamline equation and plot the streamlines; (2) Is the flow rotational? If it is irrotational, determine the velocity potential function and plot the equipotential lines.

Problem 8: Consider a viscous fluid flows through the surface of a flat plate. The velocity profile near the plate is given as: $u = u_0 \sin\frac{\pi y}{2a}$, where u_0, a are constant, y is the distance to the plate. Determine the strain rates on the plate.