Model answer

Ashraf

Sinai University
Faculty of Engineering Sciences
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Name:

Subject: Fluid Mechanics (2)
Quiz: (2)
Time: 30 min
I.D:

Answer the following questions

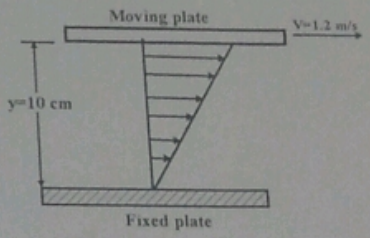
1- If the velocity of incompressible flow is $V=2yi+3xj$. Does this flow satisfy continuity? If so, find the stream function $\psi(x,y)$ and check the flow rotational or irrotational.

2- A viscous fluid is contained between two infinite plates as shown in the figure. If the velocity of the upper plate is 1.2 m/s. the fluid has viscosity is 7.8×10^{-5} and density is 800 kg/m^3. If v=u=0, neglect body force and pressure gradient in x-direction, find the following:

a- Deduce the equation of u-velocity

b- The velocity at a distance equals 2.5 cm from fixed plate (i.e y=2.5 cm)

c- The shear stress of the upper plate to maintain it at 1.2 m/s velocity.



1- Continuity eqn :

- $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$

$u = 2y, \quad v = 3x$

$\therefore \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 + 0 = 0 \therefore$ flow satisfy Continuity.

- $u = \frac{\partial \psi}{\partial y}$ and $v = -\frac{\partial \psi}{\partial x}$

$\therefore d\psi = u\,dy - v\,dx$

$\int d\psi = \int 2y\,dy - \int 3x\,dx$

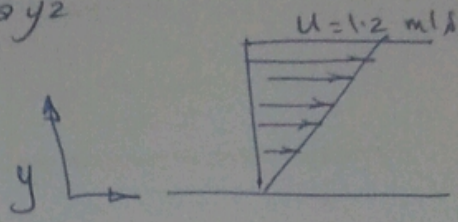
$\therefore \psi = y^2 - \frac{3}{2}x^2 + Const$

- $\xi_z = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$

$\xi_z = 3 - 2 = 1 \neq$ zero the flow is rotational

2- after reduction Navier-Stokes eq:

a- $\mu \frac{\partial^2 u}{\partial y} = 0 \quad \therefore \frac{\partial^2 u}{\partial y^2} = 0$



$\frac{\partial u}{\partial y} = C_1$

and $u = C_1 y + C_2$

at $y = 0 \rightarrow u = 0 \quad \therefore 0 = 0 + C_2 \quad \therefore C_2 = 0$

at $y = 0.1\,m \rightarrow u = 1.2 \quad \therefore 1.2 = 0.1\,C_1 \quad \therefore C_1 = 12$

$\therefore u = 12y$

b- at $y = 2.5\,cm = 0.025\,m$

$\therefore u = 12 * \frac{2.5}{100} = 0.3\ m/s$

c- $\tau_{xy} = \mu \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right)$

$\tau_{xy} = 7.8 * 10^{-5} [12 + 0] = 0.936 * 10^{-3}\ N/m^2$