

1.) FLOW KINEMATICS: THREE COMPONENTS OF VELOCITY

$$\mathbf{V} = u_x \hat{i} + u_y \hat{j} + u_z \hat{k} \quad \text{GIVEN BY:}$$

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

$$u_y = xy + yz + z^2$$

$$u_z = -3xz - z^2/2 + 4$$

a) IS THE FLOW IRROTATIONAL?

$$\text{IRROTATIONAL: } \text{CURL}(\mathbf{V}) = \mathbf{0}, \quad \nabla \times \mathbf{V} = \mathbf{0}$$

$$\nabla = \frac{\partial}{\partial x} \hat{i} + \frac{\partial}{\partial y} \hat{j} + \frac{\partial}{\partial z} \hat{k}$$

$$\nabla \times \mathbf{V} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ u_x & u_y & u_z \end{vmatrix} = \hat{i} \left(\frac{\partial}{\partial y} u_z - \frac{\partial}{\partial z} u_y \right) - \hat{j} \left(\frac{\partial}{\partial x} u_z - \frac{\partial}{\partial z} u_x \right) + \hat{k} \left(\frac{\partial}{\partial x} u_y - \frac{\partial}{\partial y} u_x \right)$$

$$\nabla \times \mathbf{V} = \hat{i} [0 - (y + 2z)] - \hat{j} [-3z - (2z)] + \hat{k} [y - (2y)]$$

$$\nabla \times \mathbf{V} = (-y - 2z) \hat{i} + (5z) \hat{j} + (-y) \hat{k} \neq \mathbf{0}$$

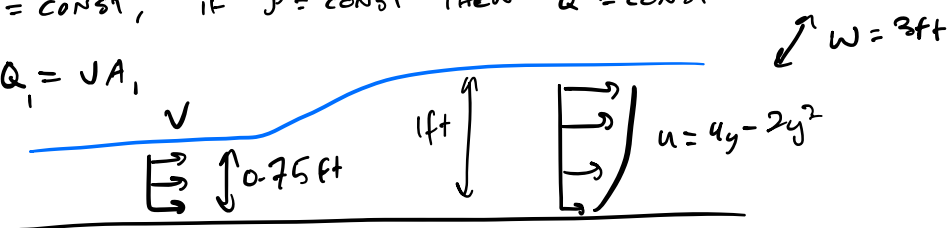
$\nabla \times \mathbf{V} \neq \mathbf{0} \therefore$ FLOW IS NOT IRROTATIONAL

2.)

FLOW CONSERVATION LAWS: ENTRANCE TO 3FT WIDE CHANNEL, UNIFORM VELOCITY V . DOWNSTREAM VELOCITY $u = 4y - 2y^2$ [ft/s, ft] FIND V .

$\dot{M} = \text{CONST}$, IF $\rho = \text{CONST}$ THEN $Q = \text{CONST}$

$$Q_1 = VA_1$$



$$Q_2 = \int u dA = w \int u dy = w \int_0^1 u_y - 2y^2 dy$$

$$Q_2 = w \left[2y^2 - \frac{2}{3}y^3 \right]_0^1 = w \left(2 - \frac{2}{3} \right) = 3 \left(\frac{4}{3} \right) = \boxed{4 \frac{ft^3}{s}}^{Q_2}$$

$$Q_1 = Q_2 = 4 \text{ ft}^3/\text{s}$$

$$Q_1 = VA_1, \quad V = \frac{Q_1}{A_1} = \frac{4 \text{ ft}^3/\text{s}}{(2 \cdot 0.25)} = \boxed{1.78 \text{ ft/s}}$$

3.)

NON-DIMENSIONALIZATION. FLAT PLATE, LENGTH L , VELOCITY V .
FLUID DENSITY ρ & VISCOSITY μ . OSCILLATION FREQUENCY f
AMPLITUDE A

LENGTH L	L
VELOCITY V	L/t
DENSITY ρ	M/L^3
VISCOSITY μ	$M/L-t$
FREQUENCY f	$1/t$
AMPLITUDE A	L

a) WHAT IS A NON-DIMENSIONAL GROUP THAT INCLUDES FREQUENCY?

$$\pi_a = \frac{fL}{V}$$

b) GROUP THAT INCLUDES AMPLITUDE

$$\pi_b = \frac{Af}{V}$$

c) GROUP THAT f, A MAY DEPEND ON (DON'T INCLUDE f, A)

$$\pi_c = \frac{\rho VL}{\mu}$$