CHEN3030 Fluid Mechanics
Short Quiz: Fluid Kinematics

The 2-D velocity vector field for a fluid is given as follows:

$$\vec{v}(x,y,t) = u(x,y,t)\hat{i} + v(x,y,t)\hat{j} = (xt+2y)\hat{i} + (xt^2 - yt)\hat{j}$$

a. Determine an expression for the x-directed component of the acceleration vector.

b. What are the values of the x-directed velocity and the x-directed acceleration at the point x = 0.5 m and y = 1 m at t = 2 seconds?

$$\vec{a} = \frac{\partial \vec{v}}{\partial t} + \frac{\partial \vec{v}}{\partial x} u + \frac{\partial \vec{v}}{\partial y} v = a_x \hat{i} + a_y \hat{j}$$

$$\vec{v} = u\hat{i} + v\hat{j}$$

now

$$a_x = \frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}$$

$$= x + (xt+2y)(t) + (xt^2 - yt)(2)$$

$$= x + xt^2 + 2yt + 2xt^2 - 2yt$$

$$\therefore \boxed{a_x = x + 3xt^2} \quad \text{ans}$$

at $x = 0.5$ m, $y = 1$ m, and $t = 2$ sec ← point of interest

$$u = xt + 2y\Big|_{pt} = (0.5)(2) + 2(1) = \boxed{3 \text{ m/s}} \quad \text{ans}$$

$$a_x = x + 3xt^2\Big|_{pt} = 0.5 + 3(0.5)(2)^2$$

$$= 0.5 + 6.0$$

$$= \boxed{6.5 \text{ m/s}^2} \quad \text{ans}$$

Note: the flow is **unsteady** since both u and v are explicit functions of time, t

the flow is **non-uniform** since both u and v are explicit functions of the spatial variables, x and y.