4.21

4.21 The fluid velocity along the x axis shown in Fig. P4.21 changes from 6 m/s at point A to 18 m/s at point B. It is also known that the velocity is a linear function of distance along the streamline. Determine the acceleration at points A, B, and C. Assume steady flow.

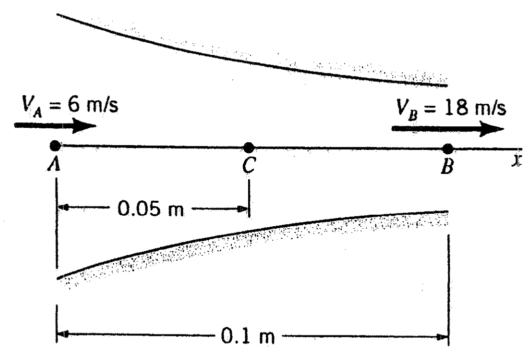

FIGURE P4.21

$\vec{a} = \frac{\partial \vec{V}}{\partial t} + \vec{V}\cdot\nabla\vec{V}$ With $u = u(x)$, $v = 0$, and $w = 0$

this becomes

$$\vec{a} = \left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x}\right)\hat{i} = u\frac{\partial u}{\partial x}\hat{i} \qquad (1)$$

Since u is a linear function of x, $u = C_1 x + C_2$ where the constants C_1, C_2 are given as: $u_A = 6 = C_2$

and $u_B = 18 = 0.1C_1 + C_2$

or $C_1 = 120$, $C_2 = 6.$

Thus, $u = (120x + 6)\frac{m}{s}$ with $x \sim m$

From Eq. (1)

$$\vec{a} = u\frac{\partial u}{\partial x}\hat{i} = (120x + 6)\frac{m}{s}\left(120\frac{m}{m \cdot s}\right)\hat{i}$$

or

for $x_A = 0$, $\vec{a}_A = 720\,\hat{i}\,\frac{m}{s^2}$

for $x_B = 0.05\,m$, $\vec{a}_B = 1440\,\hat{i}\,\frac{m}{s^2}$

and

for $x_C = 0.1\,m$, $\vec{a}_C = 2160\,\hat{i}\,\frac{m}{s^2}$