6.7

6.7 A one-dimensional flow is described by the velocity field

$$u = ay + by^2$$
$$v = w = 0$$

where a and b are constants. Is the flow irrotational? For what combination of constants (if any) will the rate of angular deformation as given by Eq. 6.18 be zero?

For irrotational flow $\vec{\omega} = 0$, and for the velocity distribution given:

$$\omega_x = \frac{1}{2}\left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}\right) = 0$$

$$\omega_y = \frac{1}{2}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}\right) = 0$$

$$\omega_z = \frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right) = -\left(\frac{a}{2} + by\right)$$

Thus, $\vec{\omega}$ is not zero everywhere and the flow is not irrotational. No.

Since (from Eq. 6.18)

$$\dot{\gamma} = \frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}$$

it follows for the velocity distribution given that

$$\dot{\gamma} = a + 2by$$

Thus, there are no values of a and b (except both equal to zero) that will give $\dot{\gamma} = 0$ for all values of y. None.