4–7C What is the *Eulerian description* of fluid motion? How does it differ from the Lagrangian description?

4–8C Is the Lagrangian method of fluid flow analysis more similar to study of a system or a control volume? Explain.

4–17 Consider steady, incompressible, two-dimensional flow through a converging duct (Fig. P4–17). A simple approximate velocity field for this flow is

$$\vec{V} = (u, v) = (U_0 + bx)\vec{i} - by\vec{j}$$

where U_0 is the horizontal speed at $x = 0$. Note that this equation ignores viscous effects along the walls but is a reasonable approximation throughout the majority of the flow field. Calculate the material acceleration for fluid particles passing through this duct. Give your answer in two ways: (1) as acceleration components a_x and a_y and (2) as acceleration vector $\vec{a}$.

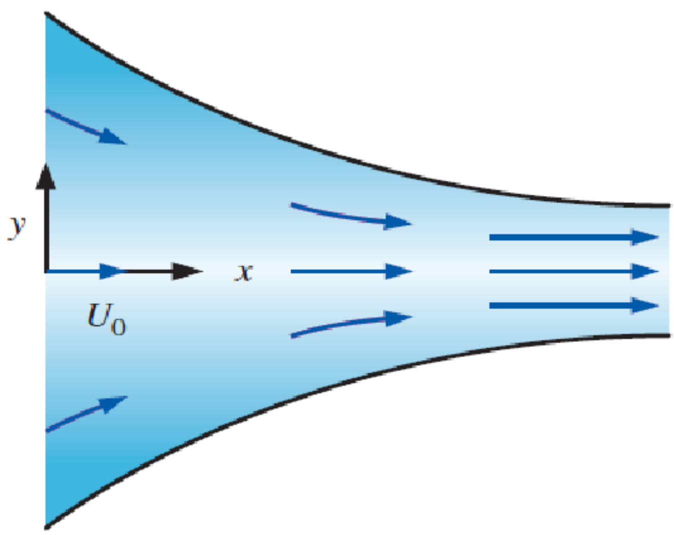

FIGURE P4–17

4–18 Converging duct flow is modeled by the steady, two-dimensional velocity field of Prob. 4–17. The pressure field is given by

$$P = P_0 - \frac{\rho}{2}\left[2U_0bx + b^2(x^2 + y^2)\right]$$

where P_0 is the pressure at $x = 0$. Generate an expression for the rate of change of pressure *following a fluid particle*.

4–19 A steady, incompressible, two-dimensional velocity field is given by the following components in the xy-plane:

$$u = 1.85 + 2.33x + 0.656y$$

$$v = 0.754 - 2.18x - 2.33y$$

Calculate the acceleration field (find expressions for acceleration components a_x and a_y), and calculate the acceleration at the point $(x, y) = (-1, 2)$. *Answers:* $a_x = 0.806$, $a_y = 2.21$

4–20 A steady, incompressible, two-dimensional velocity field is given by the following components in the xy-plane:

$$u = 0.205 + 0.97x + 0.851y$$

$$v = -0.509 + 0.953x - 0.97y$$

Calculate the acceleration field (find expressions for acceleration components a_x and a_y) and calculate the acceleration at the point $(x, y) = (2, 1.5)$.

4–21 The velocity field for a flow is given by $\vec{V} = u\vec{i} + v\vec{j} + w\vec{k}$ where $u = 3x$, $v = -2y$, $w = 2z$. Find the streamline that will pass through the point (1, 1, 0).

4–24 A steady, incompressible, two-dimensional (in the xy-plane) velocity field is given by

$$\vec{V} = (0.523 - 1.88x + 3.94y)\vec{i} + (-2.44 + 1.26x + 1.88y)\vec{j}$$

Calculate the acceleration at the point $(x, y) = (-1.55, 2.07)$.

4–58 A general equation for a steady, two-dimensional velocity field that is linear in both spatial directions (x and y) is

$$\vec{V} = (u, v) = (U + a_1x + b_1y)\vec{i} + (V + a_2x + b_2y)\vec{j}$$

where U and V and the coefficients are constants. Their dimensions are assumed to be appropriately defined. Calculate the x- and y-components of the acceleration field.

4–108 The velocity field for an incompressible flow is given as $\vec{V} = 5x^2\vec{i} - 20xy\vec{j} + 100t\vec{k}$. Determine if this flow is steady. Also determine the velocity and acceleration of a particle at (1, 3, 3) at $t = 0.2$ s.

4–109 Consider fully developed axisymmetric Poiseuille flow—flow in a round pipe of radius R (diameter $D = 2R$), with a forced pressure gradient dP/dx driving the flow as illustrated in Fig. P4–109. (dP/dx is constant and negative.) The flow is steady, incompressible, and axisymmetric about the x-axis. The velocity components are given by

$$u = \frac{1}{4\mu}\frac{dP}{dx}(r^2 - R^2) \qquad u_r = 0 \qquad u_\theta = 0$$

where μ is the fluid's viscosity. Is this flow rotational or irrotational? If it is rotational, calculate the vorticity component in the circumferential (θ) direction and discuss the sign of the rotation.

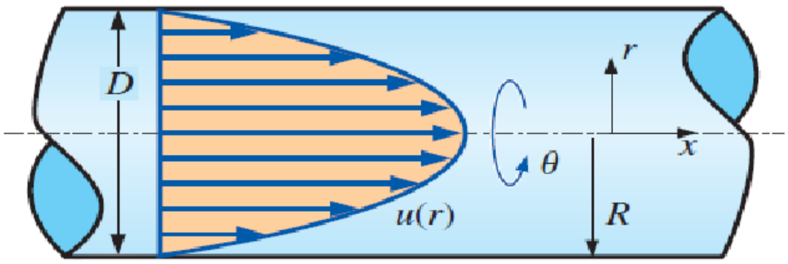

FIGURE P4–109

4–126 A steady, incompressible, two-dimensional velocity field is given by

$$\vec{V} = (u, v) = (0.65 + 1.7x)\vec{i} + (1.3 - 1.7y)\vec{j}$$

where the x- and y-coordinates are in meters and the magnitude of velocity is in m/s. The y-component of the acceleration vector a_y is

(a) $1.7y$ (b) $-1.7y$ (c) $2.89y - 2.21$ (d) $3.0x - 2.73$
(e) $0.84y + 1.42$