Fluid Mechanics Homework #5

繳交期限：2019/10/23(三) 09:10

共五題，題號為：**4-36,39(a),49,77,78&79**

題號的對照書本是 **Yunus A. Cengel and John M. Cimbala "Fluid Mechanics: Fundamentals and Applications 3/e (SI Units) "**

4-36 Consider the following steady, incompressible, two-dimensional velocity field:

$$\vec{V} = (u, v) = (4.35 + 0.656x)\vec{i} + (-1.22 - 0.656y)\vec{j}$$

Generate an analytical expression for the flow streamlines and draw several streamlines in the upper-right quadrant from $x = 0$ to 5 and $y = 0$ to 6.

4-39 A steady, incompressible, two-dimensional velocity field is given by

$$\vec{V} = (u, v) = (1 + 2.5x + y)\vec{i} + (-0.5 - 3x - 2.5y)\vec{j}$$

where the x- and y-coordinates are in m and the magnitude of velocity is in m/s.

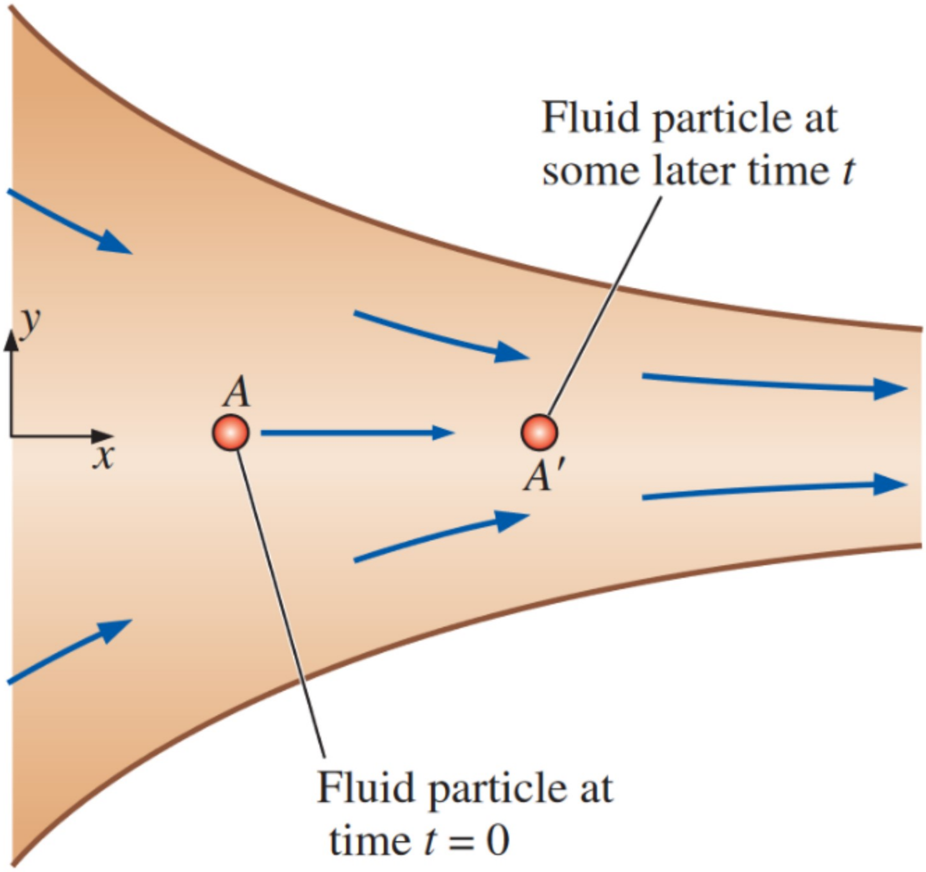
(a) Determine if there are any stagnation points in this flow field, and if so, where they are.

4-49 Converging duct flow is modeled by the steady, two-dimensional velocity field of Prob. 4–17. A fluid particle (A) is located on the x-axis at $x = x_A$ at time $t = 0$

$from\ Prob.\ 4-17$

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

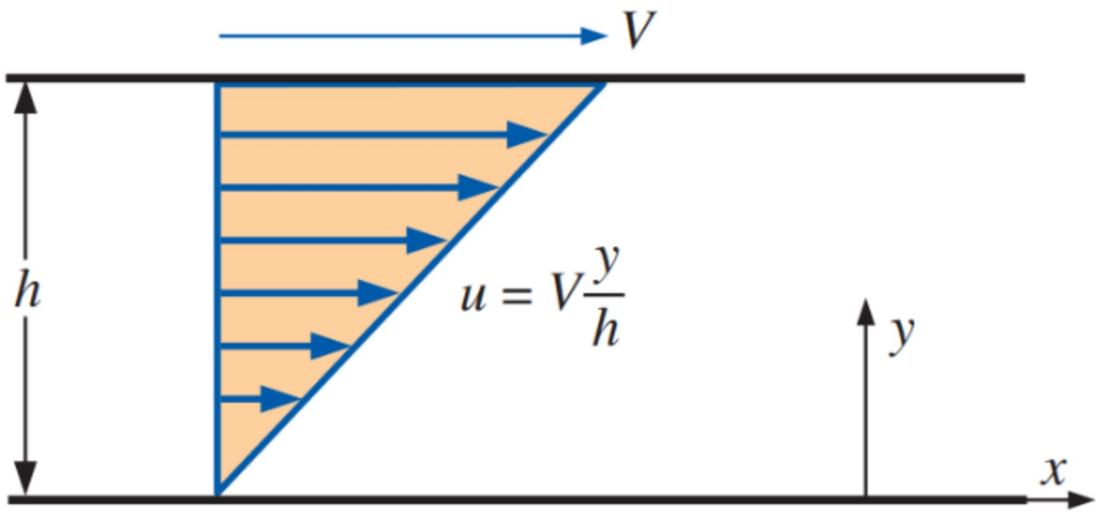
At some later time t, the fluid particle has moved downstream with the flow to some new location $x = x_{A'}$, as shown in the figure. Since the flow is symmetric about the x-axis, the fluid particle remains on the x-axis at all times. Generate an analytical expression for the x-location of the fluid particle at some arbitrary time t in terms of its initial location x_A and constants U_0 and b. In other words, develop an expression for $x_{A'}$. (*Hint:* We know that $u = dx_{\text{particle}}/dt$ following a fluid particle. Plug in u, separate variables, and integrate.)



4-77 Consider fully developed **Couette flow**—flow between two infinite parallel plates separated by distance h, with the top plate moving and the bottom plate stationary as illustrated in Fig. P4–77. The flow is steady, incompressible, and two-dimensional in the xy-plane. The velocity field is given by

$$\vec{V} = (u, v) = V\frac{y}{h}\vec{i} + 0\vec{j}$$

Is this flow rotational or irrotational? If it is rotational, calculate the vorticity component in the z-direction. Do fluid particles in this flow rotate clockwise or counterclockwise?



4-78 For the Couette flow of Fig. P4–77, calculate the linear strain rates in the x- and y-directions, and calculate the shear strain rate ε_{xy}.

4-79 Combine your results from Prob. 4–78 to form the two-dimensional strain rate tensor ε_{ij},

$$\varepsilon_{ij} = \begin{pmatrix} \varepsilon_{xx} & \varepsilon_{xy} \\ \varepsilon_{yx} & \varepsilon_{yy} \end{pmatrix}$$

Are the x- and y-axes principal axes?