Series 4 (14 March 2025)

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4.13. The x and y components of two different velocity fields are given by:

Field 1: $u = \left(-\frac{V_o}{l}\right) x$ and $v = \left(\frac{V_o}{l}\right) y$ where V_o and l are constants, and

Field 2: $u = x^2 y$ and $v = -xy^2$

Determine the equations for the streamlines of the flow for both fields and compare the results. Is the flow the same in both cases? Explain.

4.31. As a valve is opened, water flows through the diffuser shown in Fig. P4.31 at an increasing flowrate so that the velocity along the centerline is given by

$$\boldsymbol{V} = u\hat{\mathbf{i}} = V_o(1 - e^{-ct})(1 - x/l)\hat{\mathbf{i}}$$

where V_o, c and l are constants. Determine the acceleration as a function of x and t. If V_o=3.0 m/s and l=1.5 m, what value of c (other than c=0) is needed to make the acceleration zero for any x at t=1 s? Explain how the acceleration can be zero if the flowrate is increasing with time.

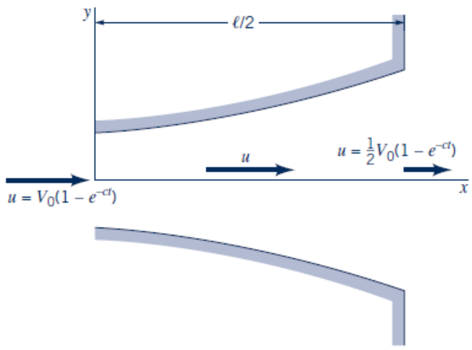
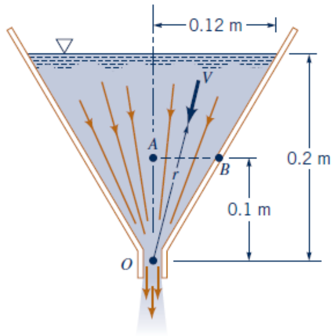


Figure P4.31

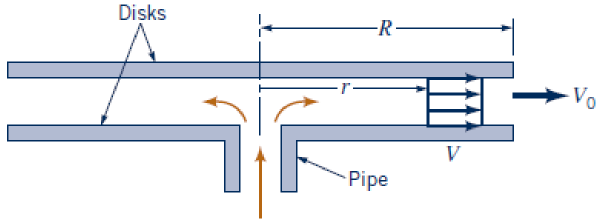
4.36. A nozzle is designed to accelerate the fluid from V_1 to V_2 in a linear fashion. That is, V=ax+b, where a and b are constants. If the flow is constant with V_1=10 m/s at x_1=0m and V_2=25 m/s at x_2=1 m, determine the local acceleration, the convective acceleration, and the acceleration of the fluid at points (1) and (2).

4.52. Water flows steadily through the funnel shown in Fig. P4.52. Throughout most of the funnel the flow is approximately radial (along rays from O) with a velocity of $V = c/r^2$, where r is the radial coordinate and c is a constant. If the velocity is 0.4 m/s when r=0.1 m, determine the acceleration at points A and B.



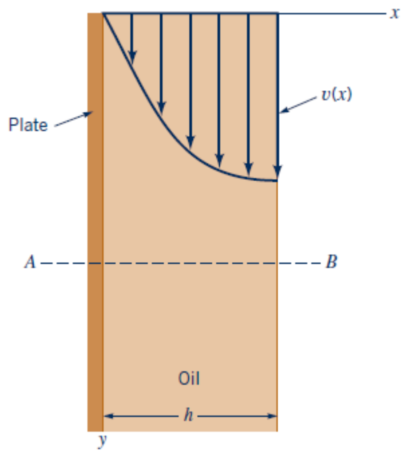
■ Figure P4.52

4.54. Air flows from a pipe into the region between two parallel circular disks as shown in Fig. P4.54. The fluid velocity in the gap between the disks is closely approximated by $V = V_0R/r$, where R is the radius of the disk, r is the radial coordinate, and V_0 is the fluid velocity at the edge of the disk. Determine the acceleration for r = 0.3, 0.6, or 0.9 m if V_0 = 1.5 m/s and R = 0.9 m.



■ Figure P4.54

4.68. A layer of oil flows down a vertical plate as shown in Fig. P4.68 with a velocity of $\mathbf{V} = (V_0/h^2)(2hx - x^2)\hat{\mathbf{j}}$ where V_0 and h are constants. **(a)** Show that the fluid sticks to the plate and that the shear stress at the edge of the layer ($x = h$) is zero. **(b)** Determine the flowrate across surface AB. Assume the width of the plate is b. (Note: The velocity profile for laminar flow in a pipe has a similar shape.)



■ Figure P4.68