Series 11 (16 May 2025)

TAs: *Cemre Celikbudak, Soroush Rafiei, Sokratis Anagnostopoulos, Ramin Mohammadi, Ellen Jamil Dagher, Veronika Pak, El Ghali Jaidi, Coline Jeanne Leteurtre*

8.15 Some fluids behave as a non-Newtonian power-law fluid characterized by $\tau = -C(du/dr)^n$, where *n*=1, 3, 5, and so on, and C is a constant. (If n=1, the fluid is the customary Newtonian fluid.) (**a**) For flow in a round pipe of a diameter *D*, integrate the force balance equation (Eq. 8.3) to obtain the velocity profile:

$$u(r) = \frac{-n}{(n+1)}\left(\frac{\Delta p}{2lC}\right)^{1/n}\left[r^{(n+1)/n} - \left(\frac{D}{2}\right)^{(n+1)/n}\right]$$

(**b**) Plot the dimensionless velocity profile u/V_c, where V_c is the centerline velocity (at r=0), as a function of dimensionless radial coordinate $r/(D/2)$, where D is the pipe diameter. Consider values of *n*=1, 3, 5, and 7.

8.18 Glycerin at 20 °C flows upward in a vertical 75 mm diameter pipe with a centerline velocity of 1.0 m/s. Determine the head loss and pressure drop in a 10 m length of the pipe.

8.20 At time *t=0,* the level of water in tank *A* shown in Fig. P8.20 is 0.6 m above that in tank *B*. Plot the elevation of the water in tank *A* as a function of time until the free surfaces in both tanks are at the same elevation. Assume quasisteady conditions –that is, the steady pipe flow equations are assumed valid at any time, even though the flowrate does change (slowly) in time. Neglect minor losses. *Note*: Verify and use the fact that the flow is laminar.

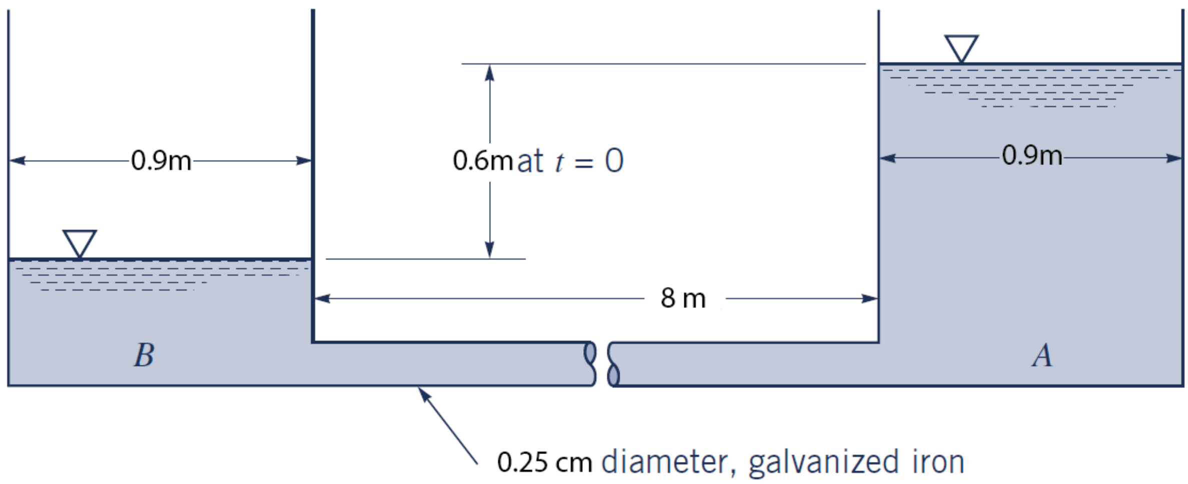
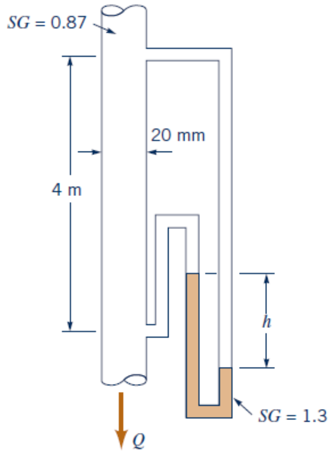


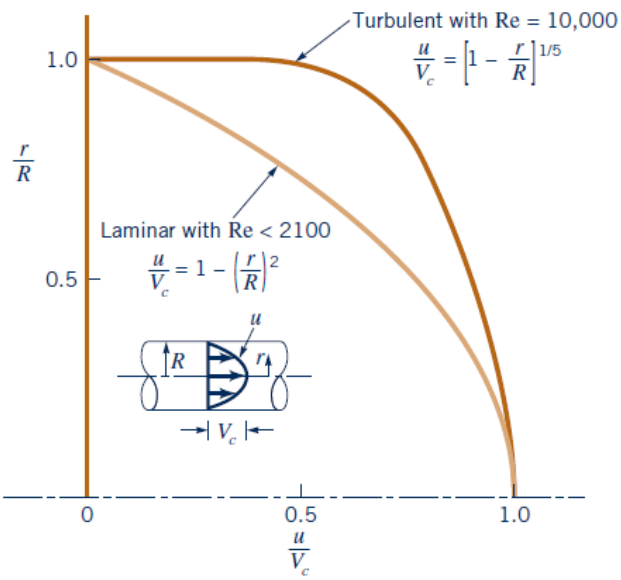
Figure P8.20

8.25 Oil of $SG = 0.87$ and a kinematic viscosity $v = 2.2 \times 10^{-4}\ m^2/s$ flows through the vertical pipe shown in Fig. P8.25 at a rate of $4 \times 10^{-4}\ m^3/s$. Determine the manometer reading, h.



■ Figure P8.25

8.30 As shown in Fig. P8.30, the velocity profile for laminar flow in a pipe is quite different from that for turbulent flow. With laminar flow the velocity profile is parabolic; with turbulent flow at Re=10,000 the velocity profile can be approximated by the power-law profile shown in the figure. (**a**) For laminar flow, determine at what radial location you would place a Pitot tube if it is to measure the average velocity in the pipe. (**b**) Repeat part (**a**) for turbulent flow with Re=10,000.



■ Figure P8.30

8.43 Water flows downward through a vertical 10 mm diameter galvanized iron pipe with an average velocity of 5.0 m/s and exits as a free jet. There is a small hole in the pipe 4 m above the outlet. Will water leak out of the pipe through this hole, or will air enter into the pipe through the hole? Repeat the problem if the average velocity is 0.5 m/s.