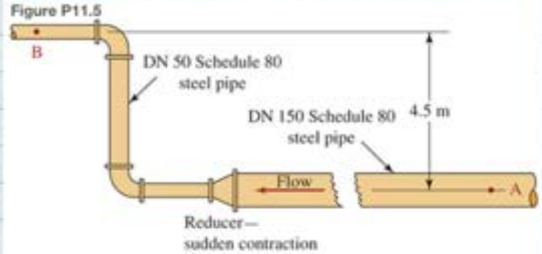
HW 3.1

Group 2: Sanchez, Perkins, Ashley, Wells, Watts

11.5 Oil is flowing at the rate of $0.015\ m^3/s$ in the system shown in **Fig. P11.5**. Data for the system are as follows:

- Oil specific weight $= 8.80\ kN/m^3$
- Oil kinematic viscosity $= 2.12 \times 10^{-5}\ m^2/s$
- Length of DN 150 pipe $= 180\ m$
- Length of DN 50 pipe $= 80\ m$
- Elbows are long-radius type
- Pressure at $B = 12.5$ Mpa

Figure P11.5



$$V_A = \frac{Q}{A} = \frac{0.015 m^3/s}{\pi \times 0.15^2} = 0.212\ m/s$$

$$V_B = \frac{0.015}{\pi \times 0.05^2} = 1.91\ m/s$$

$$h_{LA} = 0.026\left(\frac{180}{0.15}\right) \times \left(\frac{0.212}{2(9.81)}\right) = 0.0713$$

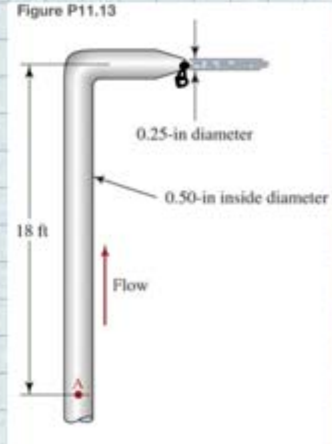
$$h_{LB} = 0.026\left(\frac{8}{0.05}\right) \times \left(\frac{1.91^2}{2(9.81)}\right) = 0.774$$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_{LA-B}$$

$$P_A = \frac{12.5}{8.8 \times 10^3} + \frac{(0.212)^2}{2(9.81)} + \frac{(1.91)^2}{2(9.81)} + 4.5 + 0.0715 + 0.774 = 13.9\ MPa$$

11.13 A device designed to allow cleaning of walls and windows on the second floor of homes is similar to the system shown in **Fig. P11.13**. Determine the velocity of flow from the nozzle if the pressure at the bottom is (a) 20 psig and (b) 80 psig. The nozzle has a loss coefficient K of 0.15 based on the outlet velocity head. The tube is smooth drawn aluminum and has an ID of 0.50 in. The 90° bend has a radius of 6.0 in. The total length of straight tube is 20.0 ft. The fluid is water at $100^\circ F$.

Figure P11.13



Cleaner with nozzle for **Problem 11.13**.

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L$$

where $h_L = K\frac{V_B^2}{2g} + f\left(\frac{L}{D}\right)\frac{V_A^2}{2g}$

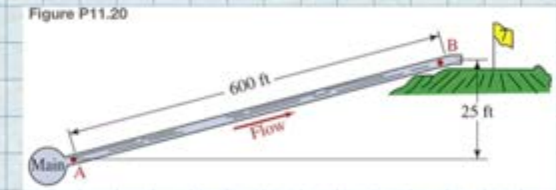
$$V_A\left(\frac{D^2\pi}{4}\right) = V_B\left(\frac{D^2\pi}{4}\right) \longrightarrow V_A = \frac{D^2 \times V_B}{D^2}$$

where $V_B = \sqrt{\dfrac{2g(P_A/\gamma + z_A - z_B)}{1 \cdot \frac{d^4}{D^4} + K + \frac{fLd^4}{D^5}}} = 30.41\ ft/s$

$V_A = 74.42\ ft/s$

11.20 **Figure P11.20** shows a pipe delivering water to the putting green on a golf course. The pressure in the main is at 80 psig and it is necessary to maintain a minimum of 60 psig at point B to adequately supply a sprinkler system. Specify the required size of Schedule 40 steel pipe to supply 0.50 ft^3 of water at 60°F.

Figure P11.20



$V = \frac{4Q}{\pi D^2}$, $V^2 = \frac{16Q^2}{\pi^2 D^4}$

$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_{L_{A-B}}$

$Re = \frac{\rho V D}{\mu} = \frac{VD}{\nu}$ where $V = \frac{4(0.5)/\pi}{0.321} = 6.173$ ft/s

$\frac{\Delta P}{\gamma} - z_B = f \frac{8LQ^2}{g\pi^2} \frac{1}{D^5}$

$D = \sqrt[5]{\frac{f \frac{8LQ^2}{g\pi^2}}{\frac{P_A - P_B}{\gamma} - z_B}}$ where $f = \frac{.25}{\left[\log\left(\frac{1}{3.7(D/\varepsilon)} + \frac{5.74}{Re^{0.9}}\right)\right]^2}$ where $D/\varepsilon = \frac{0.321 \text{ ft}}{0.00015 \text{ ft}} = 2140.8$

⇓ ⇓

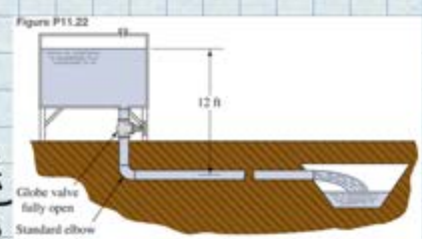
$D = \sqrt{\frac{0.01913 \frac{8(600)(0.5)}{(32.2)(\pi)^2}}{\frac{(80-60)}{62.4} - 25}}$ $f = \frac{0.25}{\log\left(\frac{1}{3.7(D/\varepsilon)} + \frac{5.74}{Re^{0.9}}\right)^2}$ where $Re = \frac{(6.173)(0.321)}{1.21 \times 10^{-5}}$

⇓ ⇓

$D = 0.321$ ft $f = 0.0191$

11.22 The tank shown in **Fig. P11.22** is to be drained to a sewer. Determine the size of new Schedule 40 steel pipe that will carry at least 400 gal/min of water at through the system shown. The total length of pipe is 75 ft.

Figure P11.22



$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L$

$\frac{\frac{16Q^2}{\pi^2 D^4}}{2g} + 0.5\frac{\frac{16Q^2}{\pi^2 D^4}}{2g} + 340 f_T \frac{\frac{16Q^2}{\pi^2 D^4}}{2g} + f\frac{L}{D}\frac{16Q^2}{\pi^2 D^4}\frac{1}{2g} + 30 f_T \frac{\frac{16Q^2}{\pi^2 D^4}}{2g}$

$\frac{16Q^2}{\pi^2 D^4}\frac{1}{2g}\left(1 + 0.5 + 340 f_T + f\frac{L}{D} + 30 f_T\right) = -12$

LHS RHS

L	75	ft	Roughness	0.00015	ft	
D	0.059	ft				
Q	0.891204	ft3/s				
g	32.2	ft/s				
f	0.025					
Z	12	ft				
Kinematic V	0.0000121	ft^2/s				
		LHS			RHS	
	P1	P2	P3		P1	
	106259.1763	0.015528	42.52966102		12	
		LHS		RHS		% diff
		70173.397		12		-584678%
		70173.397				
		70173.397				
		70173.397				
		70173.397				
		70173.397				
		70173.397				
			Re	D/e	f	new f vs old f
			518123256.1	393.33333	0.0249892	0%

$D = 0.059$ ft

11.23 **Figure P11.23** depicts gasoline flowing from a storage tank into a truck for transport. The gasoline has a specific gravity of 0.68 and the temperature is $25^\circ C$. Determine the required depth h in the tank to produce a flow of 1500 L/min into the truck. Because the pipes are short, neglect the energy losses due to pipe friction, but do consider minor losses.

$$A = \frac{\pi}{4} d^4 = \frac{\pi}{4}(0.90)^2 = 6.581 \times 10^{-3}\ m^2$$

$$V_B = \frac{Q}{A} = \frac{1500}{6581 \times 10^{-3}} = 3.92\ m/s$$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L$$

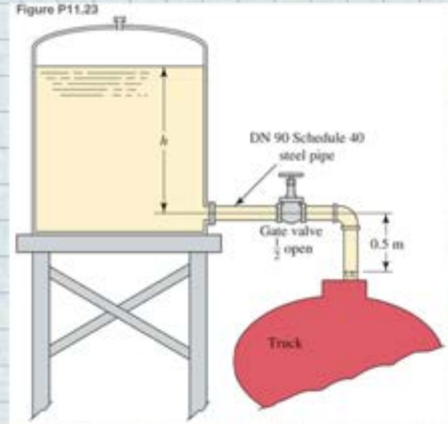
$$h_L = 0.5\frac{V^2}{2g} + 160 f_T \frac{V_B^2}{2g} + 30 f_T \frac{V^2}{2g}$$

$$\rightarrow h_L = 0.5\frac{(3.92)^2}{19.6} + 160(0.018)\frac{(3.92)^2}{19.6} + 0.44 = 3.06\,m$$

$$3.06 + \frac{3.92^2}{19.6} = 3.84 = h + 0.5$$

$$\rightarrow h = 3.5\ m$$

Figure P11.23



Weekly Reflection

In the recent lessons, we focused on series pipeline systems, covering three main problem types: calculating energy losses, determining flow rates, and figuring out pipe diameters. We learned that to find the right flow rate and pipe diameter, iterations in Excel are necessary, highlighting the importance of trial and error in these calculations. Specifically, we looked at scenarios where either the flow rate or the pipe diameter was known, and we had to compute the other. Using Excel was particularly helpful for these exercises, as it allowed us to efficiently perform iterations and calculate percentage differences, making it a valuable tool for tackling the complexities of fluid mechanics problems.