5.40 Assume ideal fluid. The pressure at section 1 in the Fig. P5.40 is 10 psi, $V_1 = 15$ fps, $V_2 = 50$ fps, and $\gamma = 60$ lb/ft^3. (*a*) Determine the reading on the manometer. (*b*) If the downstream piezometer were replaced with a pitot tube, what would be the manometer reading? Comment on the practicality of these arrangements.

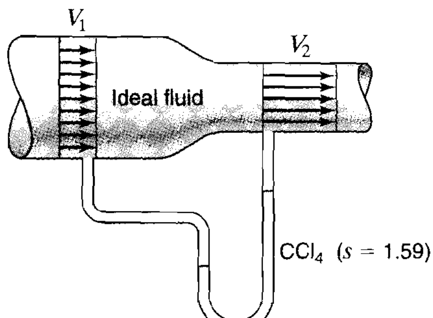


Figure P5.40

5.41 Refer to Fig. P5.40. Assume an ideal fluid with $\rho = 900$ kg/m^3. The pressure at section 1 is 100 kN/m^2, $V_1 = 10$ m/s, $V_2 = 20$ m/s. (*a*) Determine the reading on the manometer. (*b*) If the downstream piezometer were replaced with a pitot tube, what would be the manometer reading? Comment on the practicality of these arrangements.

5.42 By manipulation of Eq. (5.44), demonstrate that it represents a standard parabola of the form $z - z_0 = a(x - x_0)^2$, where a is a constant and x_0 and z_0 are the coordinates of the vertex.

5.43 Find the maximum ideal horizontal range of a jet having an initial velocity of 90 fps. At what angle of inclination is this obtained?

5.44 Repeat Exer. 5.16.1. Let $V = Q/A = 24$ fps, but assume a parabolic velocity profile.

5.45 Using Fig. X5.16.1, which depicts a two-dimensional flow in a vertical plane, find the pressure at B if the pressure at A is 32 kPa. Data are as follows: $r = 3$ m, $b = 1.2$ m, $\gamma = 9.81$ kN/m^3, $V = Q/A = 5$ m/s. Assume a parabolic velocity profile.

5.46 In Fig. P5.46 the rotor vanes are all straight and radial, $r_1 = 0.3$ ft, $r_2 = 0.9$ ft, and the height perpendicular to the plane of the figure is constant at $B = 0.25$ ft. Then $A = 2\pi rB$. If the rotation speed is 1000 rpm and the flow of liquid is 9.6 cfs, find the difference in the pressure head between the outer and the inner circumferences, neglecting friction losses. Does it make any difference whether the flow is outward or inward?

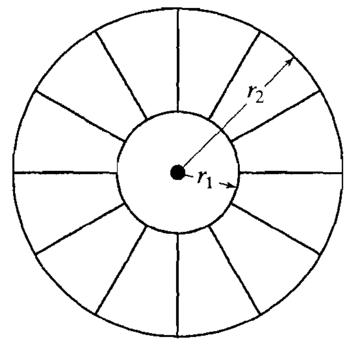


Figure P5.46

5.47 In Fig. P5.46 the vanes are all straight and radial, $r_1 = 10$ cm, $r_2 = 20$ cm, and the height perpendicular to the plane of the figure is constant at $B = 80$ mm. Then $A = 2\pi rB$. If the rotation speed is 1000 rpm and the flow of liquid is 0.3 m^3/s, find the difference in the pressure head between the outer and the inner circumferences, neglecting friction losses. Does it make any difference whether the flow is outward or inward?

5.48 An air duct of 2.5 ft by 2.5 ft square cross section turns a bend of radius 5 ft as measured to the centerline of the duct. If the measured pressure difference between the inside and outside walls of the bend is 1.5 in of water, estimate the rate of air flow in the duct. Assume standard sea-level conditions in the duct and assume ideal flow around the bend.

5.49 An air duct of 1.2 m by 1.2 m square cross section turns a bend of radius 2.4 m as measured to the centerline of the duct. If the measured pressure difference between the inside and outside walls of the bend is 50 mm of water, estimate the rate of air flow in the duct. Assume standard sea-level conditions in the duct and assume ideal flow around the bend.

fluid is (*a*) water, (*b*) ammonia with a specific gravity of 0.83, (*c*) gas with a specific weight of 12.5 N/m^3. *Ans.* 8.89 m, 9.63 m, 2805.32 m

7.63. A 12″ pipe line carries oil of specific gravity 0.811 at a velocity of 80.0 ft/sec. At points *A* and *B*, measurements of pressure and elevation were 52.6 psi and 100.0 ft and 42.0 psi and 110.0 ft, respectively. For steady flow, find the lost head between *A* and *B*. *Ans.* 20.2 ft

7.64. A stream of water 75 mm in diameter discharges into the atmosphere at a velocity 24.4 m/s. Find the power in the jet using the datum plane through the center of the jet. *Ans.* 33 kW

7.65. A reservoir supplies water to a horizontal 6″ pipe 800 ft long. The pipe flows full and discharges into the atmosphere at the rate of 2.23 cfs. What is the pressure in psi midway in the pipe, assuming the only lost head is 6.20 ft in each 100 ft of length? *Ans.* 10.7 psi

7.66. A 100-mm-diameter jet of water is discharged (horizontally) from a nozzle into the air. The flow rate of the water jet is 0.22 m^3/s. Determine the power in the jet. Assume the jet of water is at the datum. *Ans.* 86.2 kW

7.67. Oil of specific gravity 0.750 is pumped from a tank over a hill through a 24″ pipe with the pressure at the top of the hill maintained at 25.5 psi. The summit is 250 ft above the surface of the oil in the tank, and oil is pumped at the rate of 22.0 cfs. If the lost head from tank to summit is 15.7 ft, what horsepower must the pump supply to the liquid? *Ans.* 645 hp

7.68. A pump draws water from a sump through a vertical 6″ pipe. The pump has a horizontal discharge pipe 4″ in diameter that is 10.6 ft above the water level in the sump. While pumping 1.25 cfs, gages near the pump at entrance and discharge read −4.6 psi and +25.6 psi, respectively. The discharge gage is 3.0 ft above the suction gage. Compute the horsepower output of the pump and the head lost in the 6″ suction pipe. *Ans.* 10.7 hp, 2.4 ft

7.69. Compute the lost head in a 150-mm pipe if it is necessary to maintain a pressure of 231 kPa at a point upstream and 1.83 m below where the pipe discharges water into the atmosphere at the rate of 0.0556 m^3/s. *Ans.* 21.7 m

7.70. A large tank is partly filled with water, the air space above being under pressure. A 2″ hose connected to the tank discharges on the roof of a building 50 ft above the level in the tank. The friction loss is 18 ft. What air pressure must be maintained in the tank to deliver 0.436 cfs on the roof? *Ans.* 32.1 psi

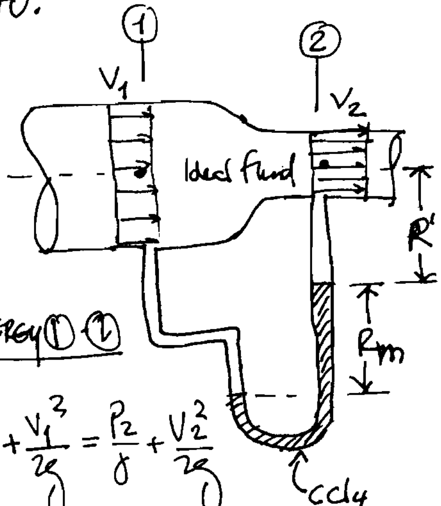
7.71. Water flows from section 1 to section 2 in the pipe shown in Fig. 7-20. For the data given in the figure, determine the velocity of flow and the fluid pressure at section 2. Assume that the total head loss from section 1 to section 2 is 3.00 m. *Ans.* 8.00 m/s, 260 kPa

7.72. Water is pumped from reservoir *A* at elevation 750.0′ to reservoir *E* at elevation 800.0′ through a 12″ pipeline. The pressure in the 12″ pipe at point *D*, at elevation 650.0′, is 80.0 psi. The lost heads are: *A* to pump suction $B = 2.0$ ft, pump discharge *C* to $D = 38V^2/2g$, and *D* to $E = 40V^2/2g$. Find discharge *Q* and horsepower supplied by pump *BC*. *Ans.* 5.95 cfs, 82 hp

7.73. A horizontal Venturi meter has diameters at inlet and throat of 24″ and 18″, respectively. A differential gage connected to inlet and throat contains water that is deflected 4″ when air flows through the meter. Considering the specific weight of air to be constant at 0.0800 lb/ft^3 and neglecting friction, determine the flow in cfs. *Ans.* 276 cfs

7.74. Water is to be siphoned from a tank at the rate of 0.0892 m^3/s. The flowing end of the siphon pipe must be 4.27 m below the water surface. The lost head terms are $1.50V^2/2g$ from tank to summit of siphon and $1.00V^2/2g$ from summit to end of siphon. The summit is 1.52 m above the water surface. Find the size pipe needed and the pressure at the summit. *Ans.* 150 mm, −45 kPa

5.40.



$\gamma = 60\ lb/ft^3$

$P_1 = 10\ psi$

$V_1 = 15\ fps \quad V_2 = 50\ fps$

(a) $R_m = ?$

(b) if d/s piezometer replaced by PITOT tube, $R_m = ?$

Comment on the practicality of these arrangements.

ENERGY ① ②

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$$

- HORIZONTAL PIPE $z_1 = z_2$
- no energy losses

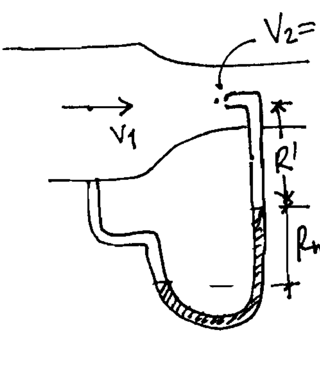
$$\frac{P_1 - P_2}{\gamma} = \frac{V_2^2 - V_1^2}{2g} \quad (A)$$

MANOMETER: $P_1 + \gamma(R' + R_m) - s\gamma_w R_m - \cancel{\gamma R'} = P_2$

$$P_1 - P_2 = s\gamma_w R_m - \gamma R_m = (s\gamma_w - \gamma) R_m$$

$$\frac{P_1 - P_2}{\gamma} = \left(s\frac{\gamma_w}{\gamma} - 1\right) R_m \quad (B) \Rightarrow (A) = (B) \Rightarrow \left(s\frac{\gamma_w}{\gamma} - 1\right) R_m = \frac{V_2^2 - V_1^2}{2g}$$

$$\boxed{R_m = \frac{V_2^2 - V_1^2}{2g\left(s\frac{\gamma_w}{\gamma} - 1\right)} = \frac{50^2 - 15^2}{2\times 32.2\times\left(1.59\times\frac{62.4}{60} - 1\right)} = 54.05^m}$$

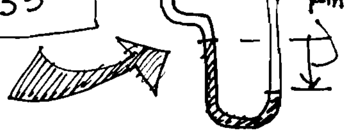


ENERGY ① ②: $\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + 0$ $\boxed{\text{STAGNATION}}$

$$\frac{P_1 - P_2}{\gamma} = -\frac{V_1^2}{2g} = \left(s\frac{\gamma_w}{\gamma} - 1\right) R_m$$

$$R_m = -\frac{V_1^2}{2g\left(s\frac{\gamma_w}{\gamma} - 1\right)} = -\frac{15^2}{2\times 32.2\left(1.59\cdot\frac{62.4}{60} - 1\right)}$$

$$\boxed{R_m = -5.35^m}$$

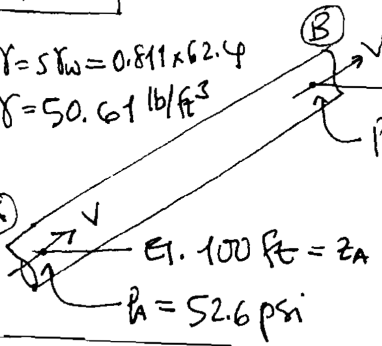


$\boxed{\text{Schaum } 7.63.}$ $D = 12'' = 1\text{ ft},\ s = 0.811,\ V = 80.0\text{ ft/sec}$

$V_A = V_B = V = 80\text{ ft/s}$

$\gamma = s\gamma_w = 0.811 \times 62.4$

$\gamma = 50.61\ \text{lb/ft}^3$



$h_L = ?$

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

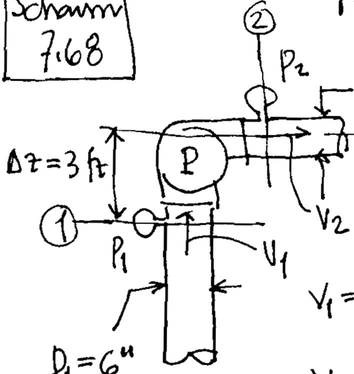
$$h_L = \frac{P_A - P_B}{\gamma} + z_A - z_B$$

$$\boxed{h_L = \frac{(52.6 - 42.0)\times 144}{50.61} + (100 - 110) = 20.16\text{ ft}}$$

$\boxed{\text{Schaum } 7.68}$ $\gamma = 62.4\ \text{lb/ft}^3$

$P_1 = -4.6$ psi TAKE $z_1 = 0$

$P_2 = +25.6$ psi $z_2 = 3$ ft



$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} + h_p = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$

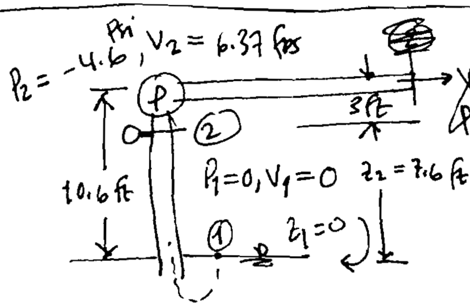
$$V_1 = \frac{4Q}{\pi D_1^2} = \frac{4\times 1.25}{\pi\times(6/12)^2} = 6.37\text{ fps}$$

$$V_2 = \frac{4Q}{\pi D_2^2} = \frac{4\times 1.25}{\pi\times(4/12)^2} = 14.32\text{ fps}$$

$$-\frac{4.6\times 144}{62.4} + 0 + \frac{6.37^2}{2\times 32.2} + h_p = \frac{25.6\times 144}{62.4} + 3 + \frac{14.32^2}{2\times 32.2} \Rightarrow h_p = 75.25\text{ ft}$$

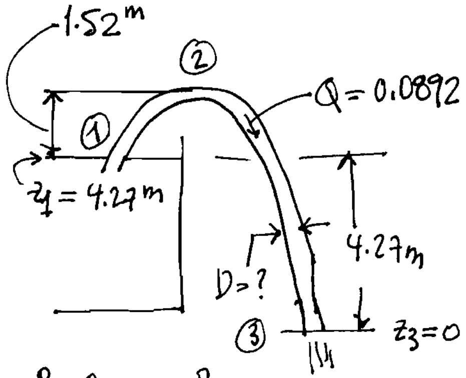
$$\boxed{P = \frac{\gamma Q h_p}{550} = \frac{62.4\times 1.25\times 75.25}{550} = 10.67\text{ hp}}$$

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} - h_L = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$



$$0 + 0 + 0 - h_L = -\frac{4.6\times 144}{62.4} + 7.6 + \frac{6.37^2}{2\times 32.2}$$

$$\boxed{h_L = 2.38\text{ ft}}$$



$$h_{L_{1-2}} = 1.50\frac{V^2}{2g}$$

$$h_{L_{2-3}} = 1.00\frac{V^2}{2g}$$

ENERGY 1 - 3

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} - \sum h_L = \frac{P_3}{\gamma} + z_3 + \frac{V_3^2}{2g}$$

$P_1 = 0$ $\quad P_3 = 0$

$V_1 = 0$ $\quad V_3 = \frac{4Q}{\pi D^2} = V$

$z_1 = 4.27\,m$ $\quad z_3 = 0$

$$0 + 4.27 + 0 - 2.50\frac{V^2}{2g} = 0 + 0 + \frac{V^2}{2g}$$

My hand-written solution went wrong in here because I used g = 32.2 !!! which is the value of g in the British Gravitational (English) system, rather than the proper value g = 9.81 in the International System (S.I.). So, I decided to do the solution in Maple as shown in the next page.

To learn more about Maple visit my web page:

http://www.engineering.usu.edu/cee/faculty/gurro/Maple.html

$restart : unprotect(\gamma) : D$

$p1 := 0 \cdot [\![Pa]\!] : V1 := 0 \cdot \frac{[\![m]\!]}{[\![s]\!]} : z1 := 4.27 \cdot [\![m]\!] : p3 := 0 \cdot [\![Pa]\!] : V3 := V : z3 := 0 \cdot [\![m]\!] :$

$z2 := 1.52 \cdot [\![m]\!] + 4.27 \cdot [\![m]\!] : V2 := V : g := 9.81 \cdot \frac{[\![m]\!]}{[\![s]\!]^2} : \gamma := 9810 \cdot \frac{[\![N]\!]}{[\![m]\!]^3} : Q := 0.0892 \cdot \frac{[\![m]\!]^3}{[\![s]\!]} :$

$hL_{12} := \frac{1.5 \cdot V^2}{2 \cdot g} : hL_{23} := \frac{1.0 \cdot V^2}{2 \cdot g} :$

$Eq1 := \frac{p1}{\gamma} + z1 + \frac{V1^2}{2 \cdot g} - \left(hL_{12} + hL_{23}\right) = \frac{p3}{\gamma} + z3 + \frac{V3^2}{2 \cdot g}$

$$4.27\,[\![m]\!] - \frac{0.1274209990\,V^2\,[\![s]\!]^2}{[\![m]\!]} = \frac{0.05096839960\,V^2\,[\![s]\!]^2}{[\![m]\!]} \qquad (1)$$

$solve(Eq1, V)$

$$-\frac{4.892484031\,[\![m]\!]}{[\![s]\!]}, \frac{4.892484031\,[\![m]\!]}{[\![s]\!]} \qquad (2)$$

Use the positive value:

$V := \frac{4.892484031\,[\![m]\!]}{[\![s]\!]}$

$$\frac{4.892484031\,[\![m]\!]}{[\![s]\!]} \qquad (3)$$

$Eq2 := Q = \frac{V \cdot \pi \cdot DD^2}{4}$

$$\frac{0.0892\,[\![m]\!]^3}{[\![s]\!]} = \frac{1.223121008\,[\![m]\!]\,\pi\,DD^2}{[\![s]\!]} \qquad (4)$$

$solve(Eq2, DD)$

$$-0.1523606364\,[\![m]\!], 0.1523606364\,[\![m]\!] \qquad (5)$$

Use the possitive value

$DD := 0.1523606364\,[\![m]\!]$

$$0.1523606364\,[\![m]\!] \qquad (6)$$

$Eq3 := \frac{p1}{\gamma} + z1 + \frac{V1^2}{2 \cdot g} - hL_{12} = \frac{p2}{\gamma} + z2 + \frac{V2^2}{2 \cdot g}$

$$2.440000000\,[\![m]\!] = \frac{1}{9810}\,\frac{p2\,[\![m]\!]^3}{[\![N]\!]} + 7.010000000\,[\![m]\!] \qquad (7)$$

$Eq3$

$$2.440000000\,[\![m]\!] = \frac{1}{9810}\,\frac{p2\,[\![m]\!]^3}{[\![N]\!]} + 7.010000000\,[\![m]\!] \qquad (8)$$

$solve(Eq3, p2)$

$$-\frac{44831.70000\,[\![N]\!]}{[\![m]\!]^2} \qquad (9)$$

which is equivalent to $-44831.70000\,[\![Pa]\!]$ or -44.83 kPa