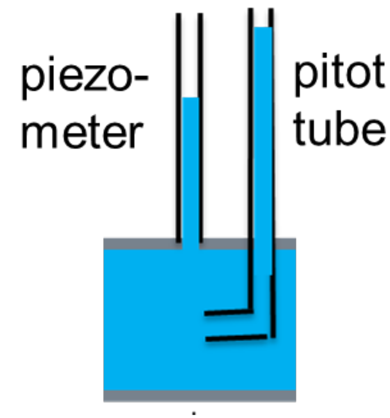
Chapter 3 (Cont.): Water Flow in Pipes

Sketching Grade Lines (HGL & EGL)

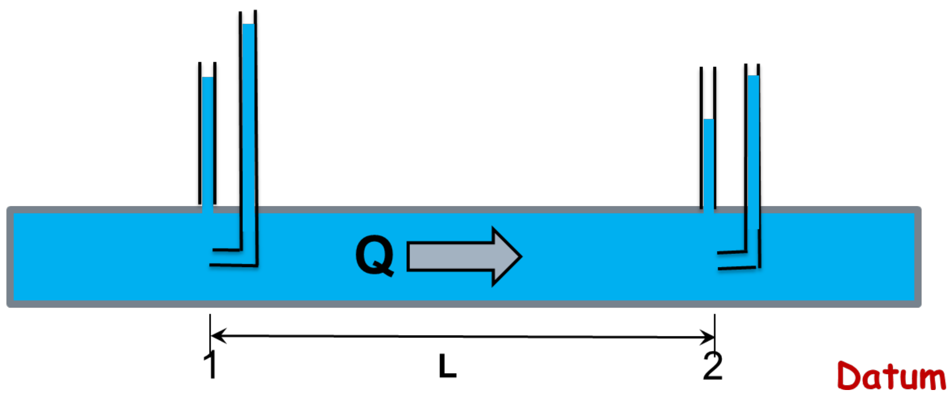
Review from the last class.

Question: How can we measure the pressure head? …pressure head plus velocity head?



Activity: Draw the hydraulic & energy grade lines (HGL & EGL) for the pipe below.

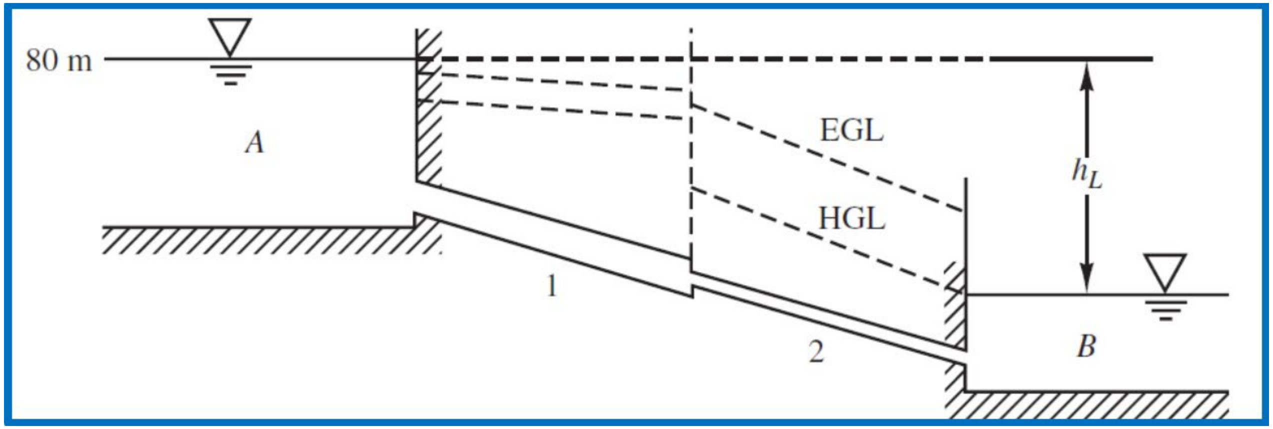
Question: Which form of energy is decreasing?



Minor Losses in Pipelines

Friction is often the major loss.

Question: What losses occur other than friction in the pipeline below? Draw the EGL and the HGL.



The general equation for minor losses is $h_L = K\left(\frac{V^2}{2g}\right)$.

Question: How do you think “K” is determined?

Ans. Lab testing by manufacturers and researchers.

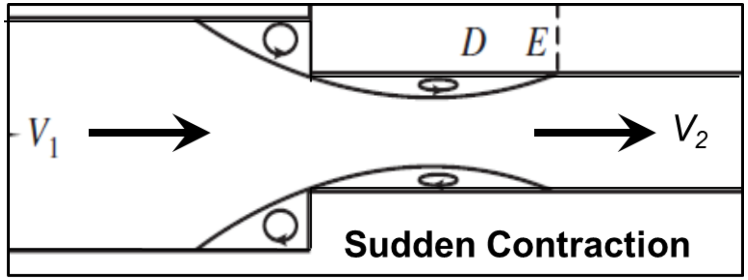
Contractions and Expansions

Many factors affect minor losses.

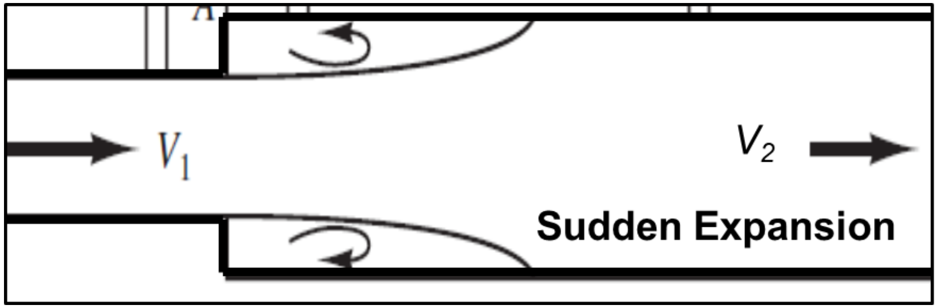
Question: Sudden contraction loss: $h_c = K_c \left[\frac{(V_2)^2}{2g} \right]$

What conditions affect the loss coefficient K_c?

Sudden expansion loss: $h_E = \frac{(V_1 - V_2)^2}{2g}.$



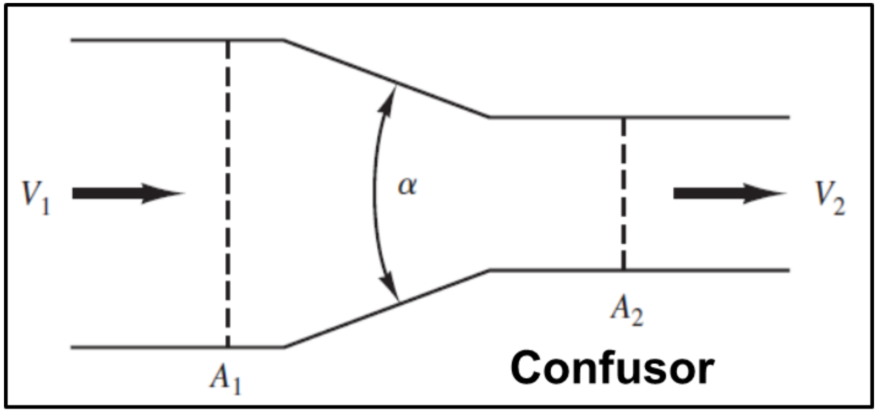
Note the secondary currents that result.



Contractions, Expansions, and Bends

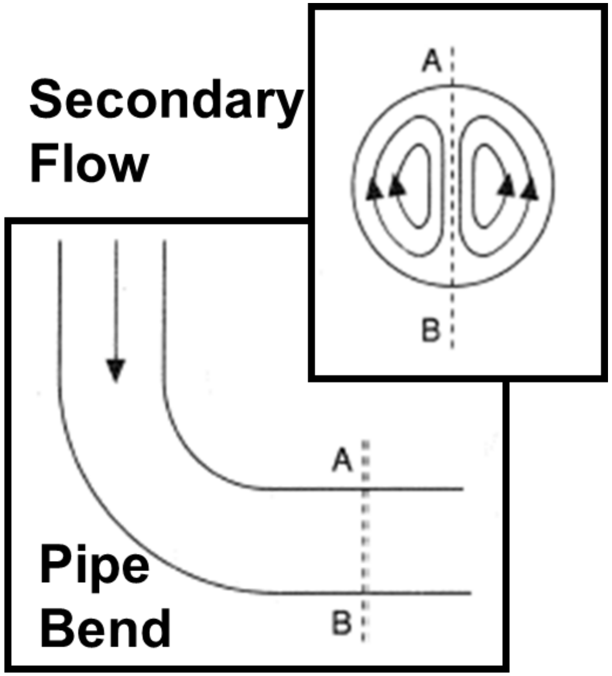
Many factors affect minor losses.

Gradual contractions and expansions (called confusors & diffusors) reduce minor losses.



See tables/graphs in your book for loss coefficients.

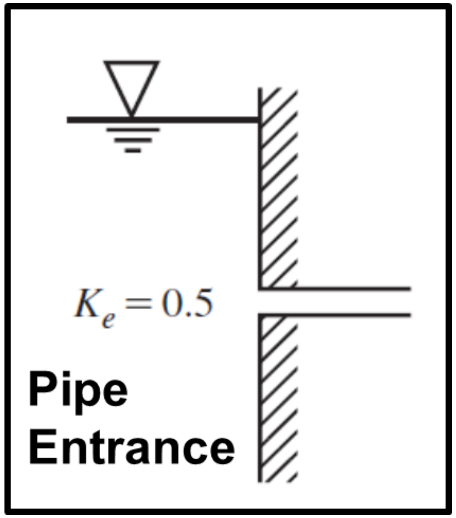
Question: Is the pressure uniform at Section A-B in the pipe bend? What results from a pressure difference?



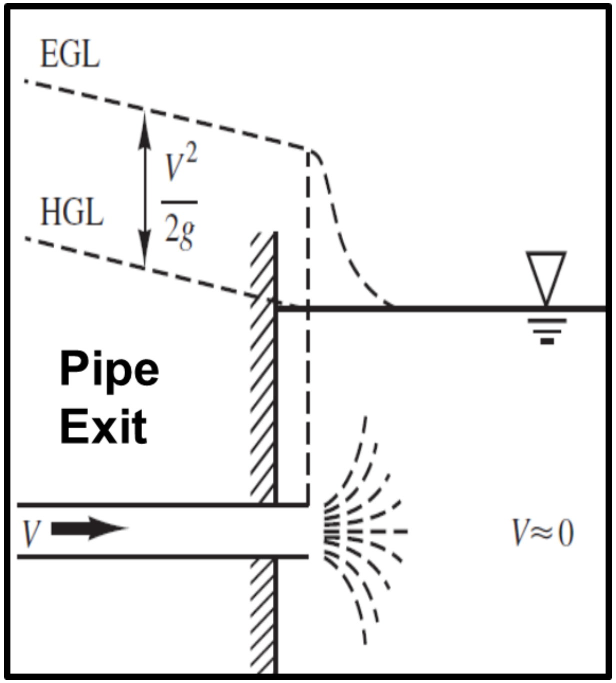
Pipe Entrance & Exit Losses

Questions: Of the losses we have covered so far, which type is most nearly like an entrance loss (reservoir supplying flow to a pipe) and an exit loss? How can an entrance loss be reduced?

They are like contraction and expansion losses.



Do the EGL and HGL lines appear reasonable at the exit? Explain.



Minor Losses

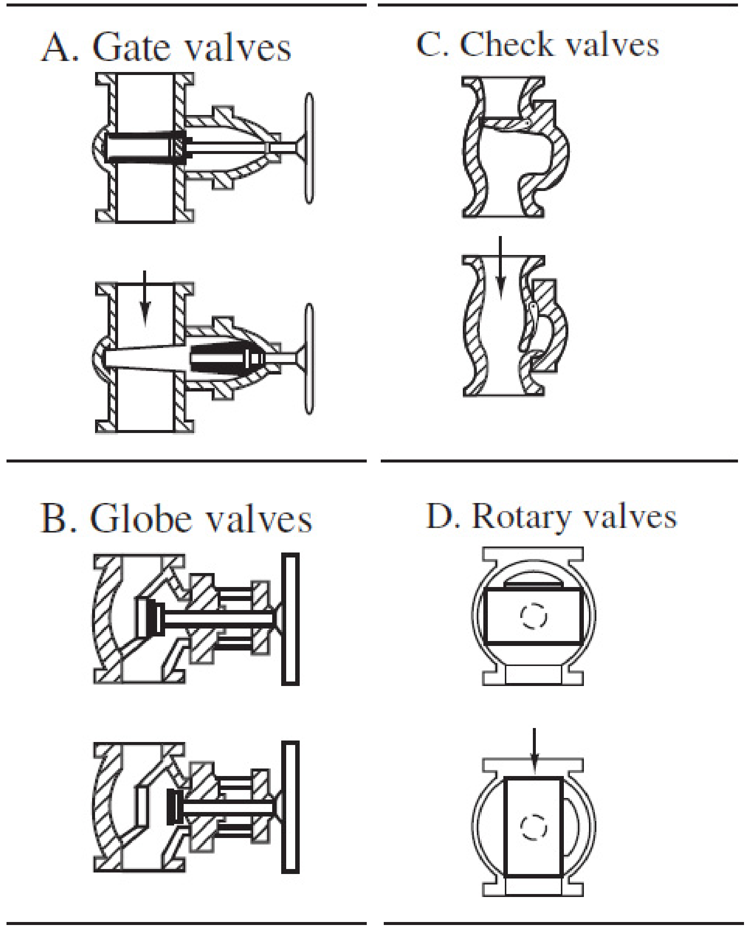
Flow valves

Questions: Based on flow patterns, which flow valve would produce the greatest loss? … the least loss?

Greatest? "B" and "D" Least? "A", then "C"

Note: Sometimes minor losses are computed with the Darcy-Weisbach equation using an equivalent length of pipe for the appurtenance causing the minor loss.

$$h_L = f\left(\frac{L_e}{D}\right)\left(\frac{V^2}{2g}\right).$$

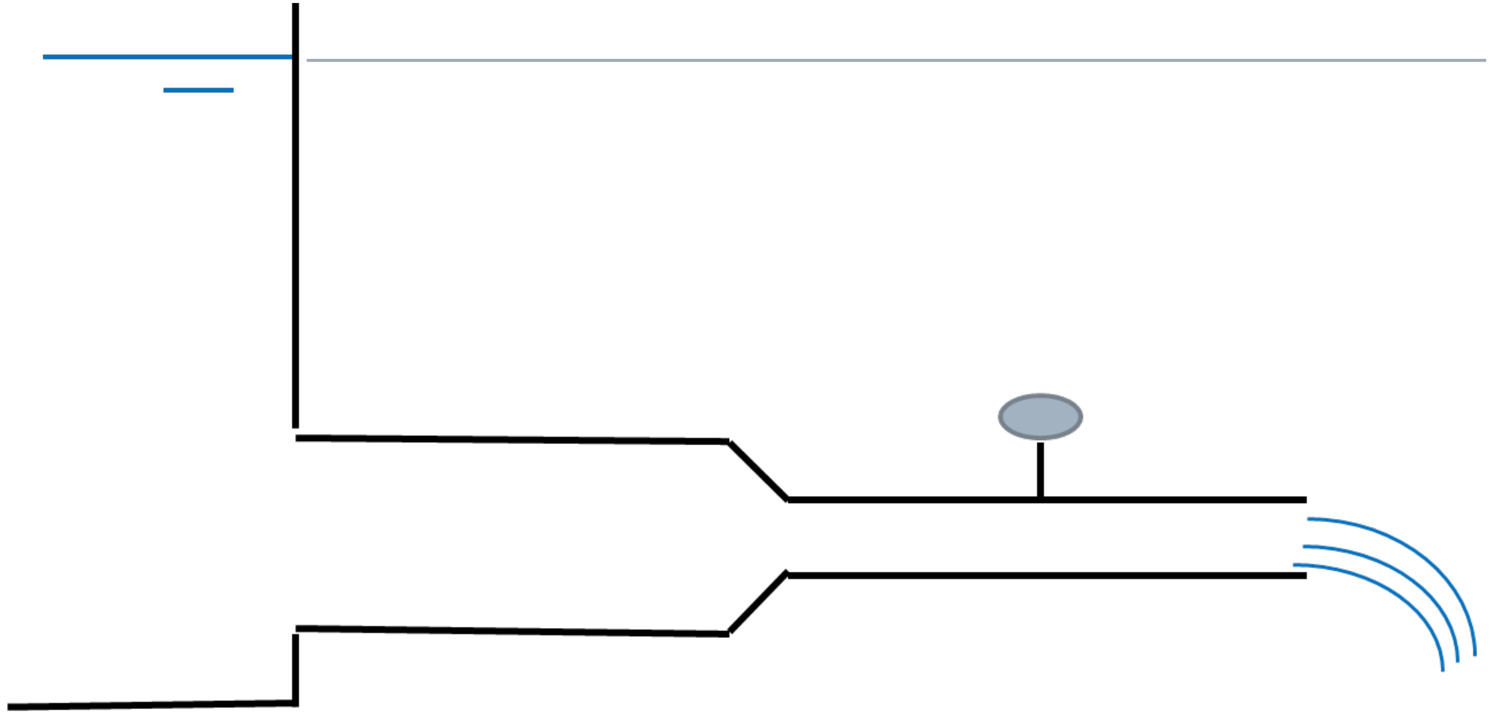


L_e = equivalent pipe length

Pipe Flow Problems (With Minor Losses) (1 of 2)

Example Problem – Solve on White Board

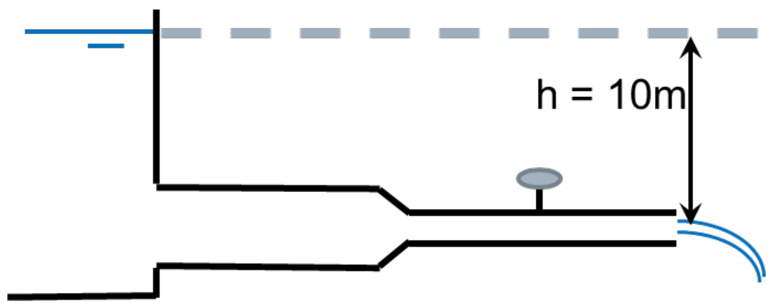
Sketch the EGL and HGL of the pipe system below.



Pipe Flow Problems (With Minor Losses) (2 of 2)

Example Problem – Solve on White Board

Find Q (20°C water) if the pipes are DIPs and 100 m long. Pipe 1: D = 20 cm with a sharp-edged entrance, followed by a 45° confusor to Pipe 2: D = 14 cm and a fully open globe valve.



Solution:

$$h_1 = h_2 + \frac{V_2^{\,2}}{2g} + h_e + h_{f1} + h_c{'} + h_{f2} + h_v;\ 10 = (1 + 0.04 + 714f_2 + 10)\frac{V_2^{\,2}}{2g} + (0.5 + 500f_1)\left(\frac{V_1^{\,2}}{2g}\right)$$

$$V_1 = 0.49V_2;\ \frac{\varepsilon_1}{D_1} = 0.0006;\ \frac{\varepsilon_2}{D_2} = 0.000857;\ f_1 = 0.0175;\ f_2 = 0.019;$$

Final $V_2 = 2.73$ m/s, $V_1 = 1.34$ m/s; $f_1 = 0.0185$; $f_2 = 0.0195$; So Q = 42.1 L/s

Homework Problems:

Water Supply Pump Station in Somaliland

Note all of the minor losses in the pipelines.

Example Problem Solution (1 of 2)

Sketch the EGL and HGL of the pipe system below. Also, find Q of 20°C water. Both pipes are DIPs and 100 m long. Pipe 1: D = 20 cm with a sharp-edged entrance, followed by a . 45° confusor to Pipe 2: D = 14 cm, and a fully open globe valve.

$$\text{Balancing energy: } h_1 = h_2 + \frac{V_2^{\,2}}{2g} + h_L \text{ or}$$

$$10\text{ m} = \frac{V_2^{\,2}}{2g} + h_e + h_{f1} + h_c{}' + h_{f2} + h_v$$

$$10 = \frac{v_2^{\,2}}{2g} + 0.5\left(\frac{v_1^{\,2}}{2g}\right) + f_1\left(\frac{100}{0.2}\right)\left(\frac{v_1^{\,2}}{2g}\right) + 0.04\left(\frac{v_2^{\,2}}{2g}\right) + f_2\left(\frac{100}{0.14}\right)\left(\frac{v_2^{\,2}}{2g}\right) + 10\left(\frac{v_2^{\,2}}{2g}\right)$$

$$10 = (1 + 0.04 + 714f_2 + 10)\frac{V_2^{\,2}}{2g} + (0.5 + 500f_1)\left(\frac{V_1^{\,2}}{2g}\right)$$ Note: **Ignore confusor.**

Example Problem Solution (2 of 2)

$$\text{But: } A_1V_1 = A_2V_2;\ \left[\frac{\pi(0.2)^2}{4}\right]V_1 = \left[\frac{\pi(0.14)^2}{4}\right]V_2;\ \text{Thus, } V_1 = 0.49V_2$$

$$10 = (1 + 0.04 + 714f_2 + 10)\frac{V_2^{\,2}}{2g} + (0.5 + 500f_1)(0.49V_2)^2/2g)$$

$$V_2^{\,2} = \frac{196}{(10.1 + 714f_2 + 120f_1)}\quad \text{Now; } N_{R1} = \frac{D_1V_1}{v} = 200{,}000V_1 \ \&\ N_{R2} = 140{,}000V_2$$

$$\frac{\varepsilon_1}{D1} = \frac{0.12\text{ mm}}{200\text{ mm}} = 0.0006;\quad \frac{\varepsilon_2}{D_2} = \frac{0.12\text{ mm}}{140\text{ mm}} = 0.000857;$$

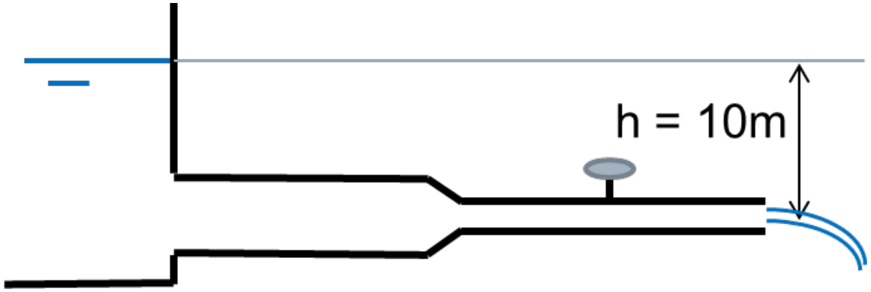
Assume complete turbulence : $f_1 = 0.0175$; $f_2 = 0.019$; So $V_2 = 2.76$ m/s, $V_1 = 1.35$ m/s

Checking: $N_{R1} = 270{,}000$ & $N_{R2} = 386{,}000$; : $f_1 = 0.0185$; $f_2 = 0.0195$;

So $V_2 = 2.73$ m/s, $V_1 = 1.34$ m/s

Ck: $N_{R1} = 268{,}000$ & $N_{R2} = 382{,}000$;

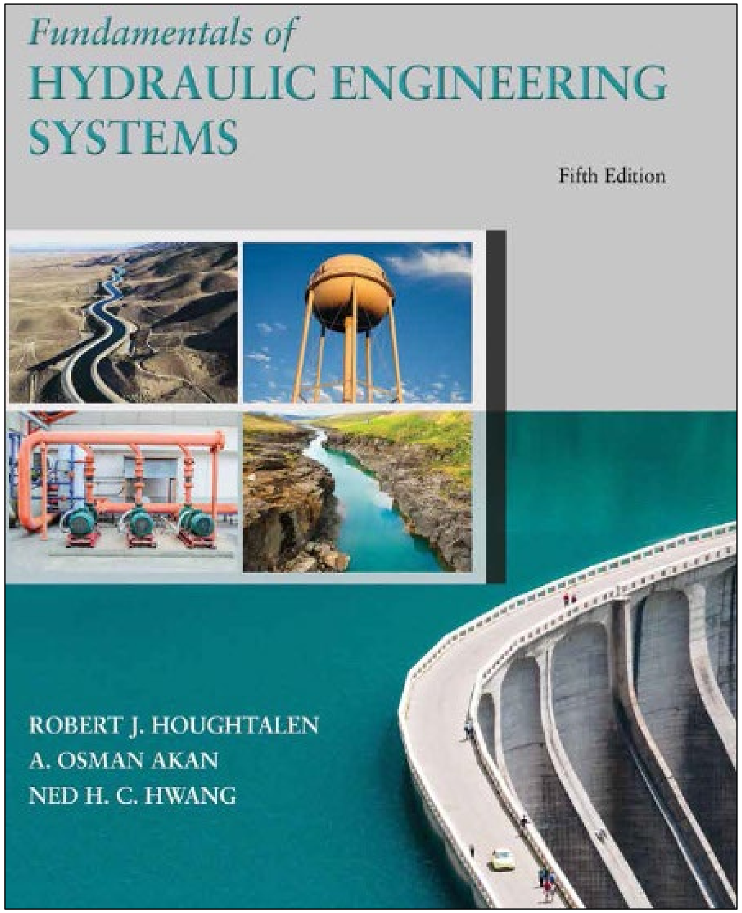
$f_1 = 0.0185$; $f_2 = 0.0195$; So $Q = 42.1$ L/s



Copyright

Fundamentals of Hydraulic Engineering Systems

Fifth Edition



Chapter 3e

Water Flow in Pipes