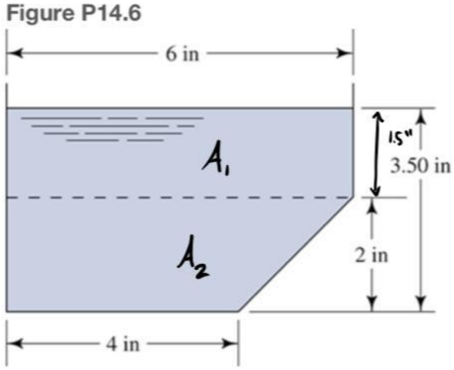
In fluid mechanics, we learned about open channel flow and measurement devices, such as the orifice plate, the Venturi meter, flow nozzles, and more. Open channel flow is classified into uniform or varied open-channel flows, as well as steady or unsteady. We use the hydraulic radius to calculate the Reynold's Number for open channels to determine the type of flow we are dealing with. We may also calculate the Froude number to find our flow's criticality. Hydraulic jumps are also discussed and we calculate the energy loss in the jump as well. In the next chapter, we learn about the needed tools in order to measure qualities of our fluids such as flow rate and velocity (though velocity is rarely required in industry). Orifice meters are simply a plate with a certain shape hole cut into it, while variable head meters such as the Venturi Meter are more elaborate. Both require Bernoulli's equation to calculate the properties at that point in the fluid. We went over how to perform the requisite calculations to design these instruments.

14.6:

14.6 Compute the hydraulic radius for the section shown in **Fig. P14.6** if water flows at a depth of 2.0 in. The section is that of a rain gutter for a house.

Figure P14.6



$$R = \frac{A}{WP}$$

$$A_1 = WD$$
$$= (6")(1.5")$$
$$= 9\,in^2$$

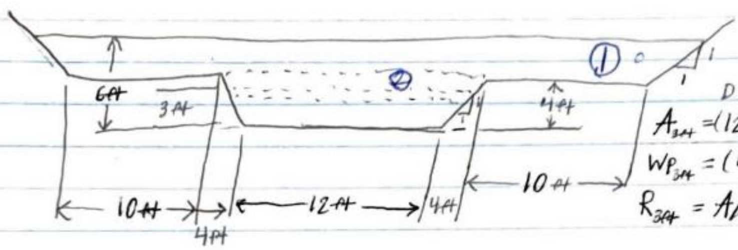
$$WP = 3.5" + 6" + 1.5" + 4" + \sqrt{8}"$$
$$= 17.83"$$

$$A_2 = \tfrac{1}{2}(4 \cdot 6) \cdot 2$$
$$A_2 = 24\,in$$

$$R = \frac{33\,in^2}{17.83\,in}$$
$$R = 1.851\,in$$

14.15:

14.15) The channel is earth with grass cover. Use $n = 0.04$. If the average slope is 0.00015, determine the normal discharge for depths of 3 and 6 ft.



$n = 0.04$

$S = 0.00015$

$D = 3ft$

$A_{3ft} = (12)(3) + (4)(3) = 48 ft^2$

$WP_{3ft} = (12) + 2\sqrt{1+1} = 14.83 ft$

$R_{3ft} = A/WP = 48/14.83 = 3.24 ft$

$$Q_{3ft} = \left(\frac{1.49}{n}\right) A R^{2/3} S^{1/2}$$

$$= \left(\frac{1.49}{0.04}\right)(48 ft)(3.24)^{2/3}(0.00015)^{1/2}$$

$$\boxed{Q_{3ft} = 47.95 \ ft^3/s}$$

$D = 2 ft$

$A_1 = (40)(2) + (1)(2) = 82 ft^2$

$WP_1 = (40) + 2\sqrt{1+1} = 42.83$

$R_1 = 82/42.83 = 1.91 ft$

$D = 4ft$

$A_2 = (12)(4) + (4)(4) = 64 ft^2$

$WP_2 = (12) + 2\sqrt{1+1} = 14.83 ft$

$R_2 = 64/14.83 = 4.32 ft$

Double Trapezoid

$$Q_{6ft} = \left(\frac{1.49}{n}\right) A_{1+2} (R_{1+2})^{2/3} (S)^{1/2}$$

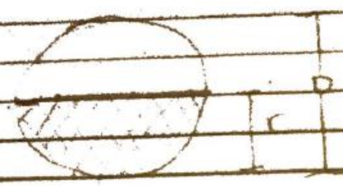
$$= \left(\frac{1.49}{0.04}\right)(82 + 64 ft)(1.91 + 4.32 ft)^{2/3}(0.00015)^{1/2}$$

$$\boxed{Q_{6ft} = 225.53 \ ft^3/s}$$

14.21:

14.21

Diagram



Slope is 0.1 %, Q = 500 gal/min or 1.114 ft³/s

From table n = 0.013

$$Q = 1.49 \cdot n^{-1} \cdot A R^{2/3} S^{1/2}$$

$$= 1.114\ ft^3/s = 1.49 \cdot (0.013) \cdot A \cdot \sqrt[3]{(r/2)^2} \cdot \sqrt{0.001}$$

$$\frac{\frac{1}{2} \cdot \pi \cdot r^2}{(r/2)^{2/3}} = \frac{1.114}{1.49(0.013)(\sqrt{0.001})} \qquad 2 - \frac{1}{3} \quad \frac{3}{3} = \frac{5}{3}$$

$$\frac{r^2}{(r/2)^{2/3}} = \frac{2 \cdot 1.114}{1.49(0.013)(\sqrt{0.001})\pi}$$

$$2 + \frac{2}{3} = \frac{8}{3}$$

$$ft^2 \cdot ft^{-2/3}$$
$$= ft^{4/3}$$

$$r = 19\ ft$$

∴

Pipe is 19 ft wide

14.36:

HW 14.36

Design The Channel cross section for each of he shapes shown in Table 14.3

$n = 0.015$ - concrete

Given

$Q = 1.25 ft^3/s$

$V = 2.75 ft/s$

$A = 0.45 ft^2$

$R = \frac{A}{WP}$ $\quad \frac{nQ}{S^{1/2}} = AR^{2/3}$

$S = \left(\frac{Q \times n}{A \times R^{2/3}}\right)^2$

Rectangle

$A = 2y^2$

$WP = 4y$

$R = y/2$

$S = \left(\frac{1.25 \times 0.015}{(2y^2)(y/2)^{2/3}}\right)^2$

$y = \sqrt{\frac{A}{2}} = \sqrt{\frac{0.45}{2}}$

$y = .47$

$S = \left(\frac{1.25 \times (0.015)}{2(.47)^2(.47/2)^{2/3}}\right)^2$

$S = 6.2 \times 10^{-7}$

Triangle

$A = y^2$

$WP = 2.83y$

$R = 0.354y$

$S = \left(\frac{(1.25)(0.015)}{(.67)^2(\frac{.67}{2})^{2/3}}\right)^2$

$y = \sqrt{A}$

$y = .67$

$S = .0023$

For Trapezoid

$A = 1.73y^2$

$WP = 3.46y$

$R = y/2$

$$S = \left(\frac{1.25 \times (0.015)}{1.73y^2 \left(\frac{y}{2}\right)^{2/3}}\right)^2$$

$$S = 7.4 \times 10^{-5}$$

$$y = \sqrt{\frac{A}{1.73}} = \sqrt{\frac{0.45}{1.73}} \rightarrow 0.512$$

for semi circle

$A = \frac{1}{2}\pi y^2$

$WP = \pi y$

$R = y/2$

$$S = \left(\frac{1.25 \times 0.015}{\left(\frac{1}{2}\right)(\pi)y^2\left(\frac{y}{2}\right)^{2/3}}\right)^2$$

$$y = \sqrt{\frac{A}{\frac{1}{2}\pi}}$$

$y = 0.538$

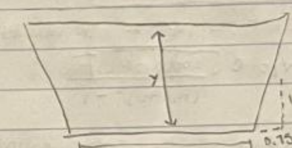
$$S = 1.4 \times 10^{-5}$$

14.42:

HW 2.3

14.42

given: $s = 1:0.75$, $Q = 0.8\ ft^3/s$, $n = 0.013$, $d = 0.05$



a) critical depth (y)

$T = b + 2zy = 3 + 2(0.75)y = 3 + 1.5y$

$A = (3 + 0.75y)y = 0.75y^2 + 3y$ $\left[\frac{Q}{A} = \sqrt{g y_h}\right]$

$y_h = \frac{A}{T} = \frac{0.75y^2 + 3y}{1.5y + 3}$ $\therefore$ $\frac{0.8}{0.75y^2 + 3y} = \sqrt{\left(\frac{0.75y^2 + 3y}{1.5y + 3}\right) \times 32.2}$

$\boxed{y = 0.129\ ft}$

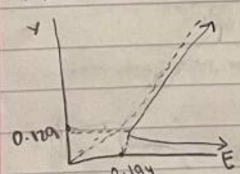
b) minimum specific energy (E)

$E = y + \frac{v^2}{2g} \therefore y + \frac{Q^2}{A^2 2g}$

$A = 0.75 \times 0.129^2 + 3 \times 0.129 = 0.39\ ft^2$

$E = 0.129 + \frac{0.8^2}{(0.39)^2(2 \times 32.2)} = \boxed{0.194\ ft}$

c) plot specific energy curve



d) $E = y + \frac{Q^2}{2A^2 g}$

$= 0.05 + \frac{0.8^2}{2(0.75 \times 0.05^2) + (3 \times 0.05)(32.2)}$

$\boxed{E = 2.07\ ft}$

e) velocity of flow + Froude number

$V = \frac{Q}{A} = \frac{0.8}{0.75y^2 + 3y} = \boxed{5.27\ ft/s}$

$N_F = \frac{V}{\sqrt{g y_h}} = \frac{5.27}{\sqrt{g\left(\frac{0.75y^2 + 3d}{3 + 1.5y}\right)}} = \boxed{4.18}$

15.4:

HW 15.4

Calculate the deflection of a water manometer if the orifice diameter is 1.0 and Diameter is 7 in

1 in = 0.83 ft
7 in = 0.583 ft
10 in = 0.833

A_1

Sg = 0.83
dynamic $v = 2.5 \times 10^{-6}$

$$V_2 = \frac{C \sqrt{2gh}}{1 - \left(\frac{A_2}{A_1}\right)^2}$$

$$A_1 = \frac{\pi}{4}(0.833) = 0.55$$

$$h = \frac{\left(\frac{V_1}{A_2}\right)\left(1 - \frac{A_2}{A_1}\right)^2}{2g}$$

$$A_2 = \left(\frac{\pi}{4}\right)(0.083)^2$$

$$\downarrow$$

$$5.5 \times 10^{-3}$$

For 1 inch

$$h = \frac{\frac{(0.56)}{.0055} \times \left(1 - \left(\frac{5.5 \times 10^{-3}}{0.55}\right)^2\right)}{2 \times 32.18}$$

h = .159 ft for 1 in

.159 × 0.83

.13 ft

For 7 inch $A_2 = \frac{\pi}{4}(0.583)^2$

0.2670

$$h = \frac{\left(\frac{0.056}{0.2670}\right) 1 - \left(\frac{0.2670}{0.55}\right)^2}{2(32.18)}$$

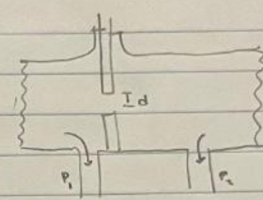
= .003 ft

.168 ... × 0.83 = .0021 ft For 7 in

15.9:

MET 330

15.9



$\dot{Q}$ = 700 to 1000 gpm

= 1.56 to 2.23 ft^3/s

manometer = 0 to 8 in

= 0 to 0.67 ft

$A_1 = 1.25E-1\ ft^2 \quad C = 0.6 \quad d = 0.35\ ft$

$$A_2 = \frac{A_1}{\sqrt{\frac{2gh\left(\frac{\gamma_m}{\gamma_w}-1\right)}{(Q/A_1 \times C)^2}+1}} = \frac{1.25E-1}{\sqrt{\frac{541.08}{194.05}+1}} = \boxed{0.64\ ft^2}$$

$$\left[\begin{array}{l} 2gh\left(\frac{\gamma_m}{\gamma_w}-1\right) = 2 \times 32.2 \times 0.67 \times \frac{844.9}{62.4} - 1 = 541.08 \\ (Q/A_1 \times C)^2 = (2.23/0.1254 \times C)^2 = 323.4 \times 0.6^2 = 194.05 \end{array}\right]$$

$$\frac{d}{D} = \frac{0.35}{5\,in \times \frac{1}{12}} = \boxed{0.85\ ft}$$

$$V = \frac{Q}{A} = \frac{2.23}{0.64} = 3.48\ ft/s$$

$$Re = \frac{(1.8)(3.48)(0.42)}{6.91E-4} = 3.8E3$$

15.15:

15.15) A ~~Pitot~~-Static tube is inserted into a duct carrying air at standard atmosphere pressure and a temperature of A differential manometer reads 0.24 in. of water. Calculate the Velocity of flow.

$g = \cancel{9.81}\ 32.174\ ft/s^2$

$h = 0.02\ ft$

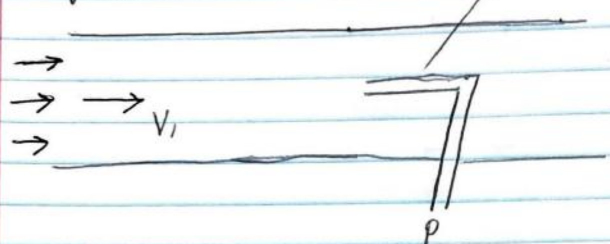
$T = 68°F$

$\gamma = $ air at $20°C$ or $68°F$

$\gamma_{H_2O} = 62.3\ lb/ft^3$

$\gamma = 0.0752\ lb/ft^3$

$$V_1 = \sqrt{2gh(\gamma_g - \gamma)/\gamma}$$



$$\cancel{V_1 = \sqrt{\frac{2(32.174\ ft/s^2)(0.02\ ft)(0.0752 - 62.3\ lb/ft^3)}{62.3\ lb/ft^3}}}$$

$$V_1 = \sqrt{\frac{(2)(32.174\ ft/s^2)(0.02\ ft)(62.3 - 0.0752\ lb/ft^3)}{0.0752\ lb/ft^3}}$$

$$\boxed{V_1 = 32.63\ ft/s}$$