MET 330 HW 2.3

Team Vortex (Team 3)

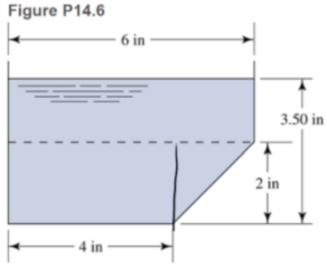
2/29/24

Chapter 14:

Problem 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



Rain gutter for Problems 14.6, 14.7, and Problems 14.11.

$4 \cdot 2 + \frac{1}{2}(2 \cdot 2) + \sout{6 \cdot 1.8}$ $\quad 4 + 2 + \sqrt{2^2 + 2^2}$

$8 + 2 = 10 \text{ in}^2$ $\quad \sqrt{8}$

8.828 inch

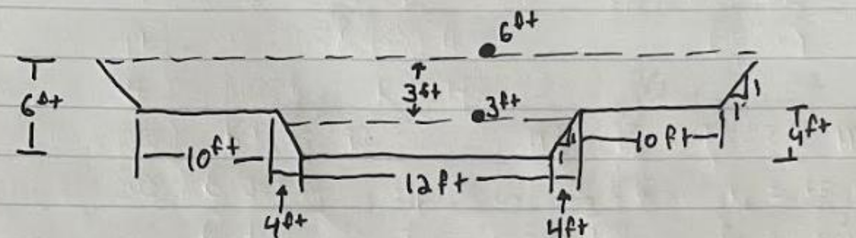
$\frac{10}{8.828} = \boxed{1.1327}$

Problem 15:

Pg. 387

Ch. 14, Problm 15: Find discarge for depths of 3ft and 6ft

Diagram:



Depth of 3ft:

$$R = \frac{A}{P} = \frac{(2 \times \frac{1}{2} \times 4 \times 3) + (12 \times 3)}{5 + 12 + 5} = 2.18$$

$$Q = AV = 4 + 80 + 16 + 48 \times \frac{1}{0.04} \times (2.18)^{2/3} \times (0.00015)^{1/2}$$

$$Q = \frac{76.13\ ft^3/s}{2}$$

$Q_1 = 38.07\ ft^3/s$ flow @ depth of 3 ft

Depth of 6ft:

$$R = \frac{A}{P} = \frac{(2 \times 0.5 \times 2 \times 2) + (40 \times 2) + (2 \times 0.5 \times 4 \times 4) + (12 \times 4)}{(2.8 + 10 + 5.65 + 12 + 5.65 + 10 + 2.8)}$$

$R = 3.02$

$$Q_2 = AV = 4 + 80 + 16 + 48 \times \frac{1}{0.04} \times (3.02)^{2/3} (0.00015)^{1/2} = 94.25\ ft^3/s$$

~~$Q_2 = 94.25\ ft^3/s$ flow @ depth of 3ft~~

$Q_1 + Q_2 = 94.25 + 38.07$

$Q = 132.32\ ft^3/s$ flow @ depth of 6th

Problem 21:

Chap 14, Problem 21:

slope = 0.001

$n = 0.013$ (table 14.1)

$Q = 500 \text{ gpm} = 1.114 \text{ ft}^3/\text{s}$

$$1.114 = \frac{1.0}{0.013} (R)^{2/3} (0.001)^{1/2}$$

$$1.114 = 76.923 (R)^{2/3} (0.0316)$$

$$0.4583 = R^{2/3}$$

$$R = 0.31$$

$$0.31 = \frac{0.5\left(\frac{\pi D^2}{4}\right)}{(\pi D)/2}$$

$$\boxed{D = 1.24 \text{ ft}}$$

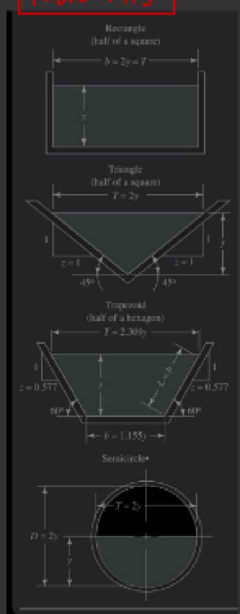
Problem 36:

14.36 It is desired to carry 1.25 ft3/s of water at a velocity of 2.75 ft/s. Design the channel cross-section for each of the shapes shown in Table 14.3 , which lists the most efficient sections for open channels.

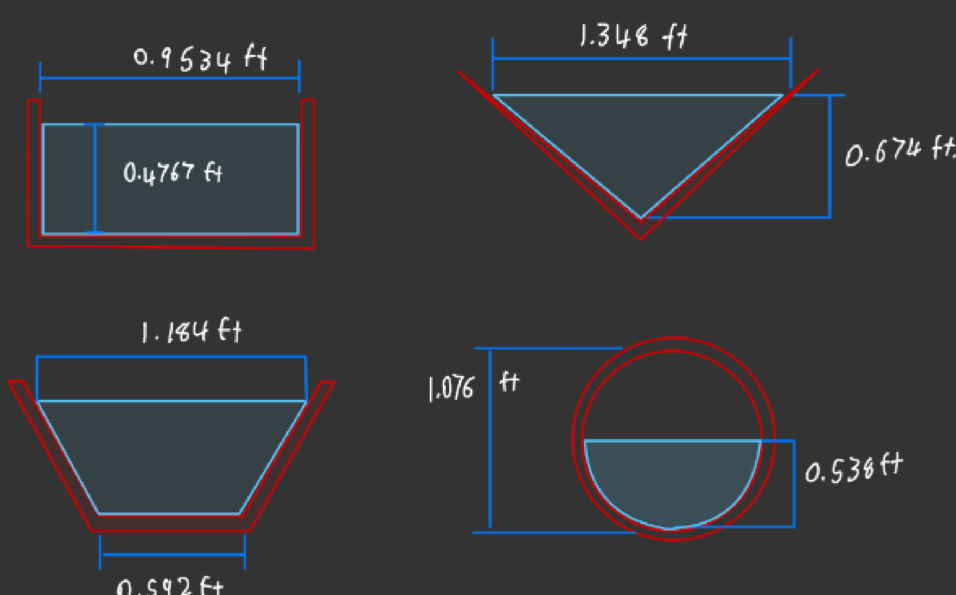
Assume Smooth surfaces: $n = 0.01$ $Q = 1.25\ ft^3/s$ $V = 2.75\ ft/s$

$$A = Q/V = \frac{1.25}{2.75} = 0.4546\ ft^2$$

Table 14.3

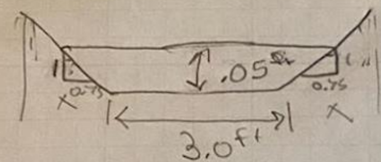


A	y	T	y	T	b
$2.0y^2$	$\sqrt{A/2}$	$2y$	0.4767	0.9534	
y^2	$\sqrt{A}$	$2y$	0.674	1.348	
$1.73y^2$	$\sqrt{\frac{A}{1.73}}$	$2.309y$	0.5126	1.184	$b = 1.155 \cdot y$ 0.592
$\frac{\pi}{2} \cdot y^2$	$\sqrt{\frac{2A}{\pi}}$	$2y$	0.538	1.076	



Problem 42:

Chapter 14 #42



$y_2 = (y_1/2)(\sqrt{1 + 8N_{F_1}^2} - 1)$

$y_2 = (.05/2)(\sqrt{1+8(1.06)^2} - 1$

$y_2 = .075$

$N_F = \frac{v}{\sqrt{gy_n}} = \frac{4.27}{\sqrt{32.2 \cdot 0.5}}$ $N_F = 1.06$

$Z = 0.75 - x$

$y_1 = 0.05$ ft $Q = .80$ ft³/s

b). critical depth:

$E = y + \frac{Q^2}{2gL^2}(1/y^2)$ $E = 0.05 + \frac{.8^2}{2(9.81)(3^2)}\left(\frac{1}{.05^2}\right)$

$E_{min} = 1.49$

a) $F_r = 1 = \frac{V}{\sqrt{gD}}$ $V = \frac{Q}{A} = \frac{.80 \text{ ft}^3/\text{s}}{.1875 \text{ ft}^2} = V = 4.27$ ft/s

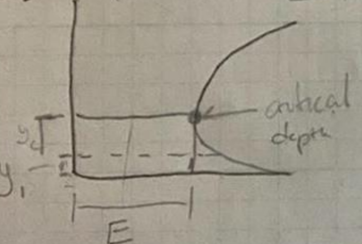
$F_r = 1 = \frac{4.27 \text{ ft/s}}{\sqrt{32.2 \text{ ft/s}^2 \cdot .05 \text{ ft}}}$ $A = WD + xD$

$3 + 0.05 + 0.75 \cdot 0.05$

$A = .1875$ ft²

$F_r = 1 = 3.37$ a) = 3.37

c) $F_r = 3.37$ $E = 1.49$



d) specific energy for given

$E = y + v^2/2g$

$E = 0.05 \text{ ft} + (4.27)^2 / 2(32.2 \text{ ft/s}^2$

$E = 0.33$

e) velocity of flow and Froude #

$y = 0.05$ $S = 1.25$ $R = \frac{A}{WP}$

$A = ((b+zy)y)$

$V = \frac{1.0}{n} S^{1/2} R^{2/3}$ $WP = b + 2y\sqrt{1+z^2}$

@ y_1: $V = \frac{1.0}{0.013}(1.25)^{1/2} \cdot \frac{((3+.75)(.05))(.05)}{(3+2(.05)\sqrt{1+.75^2}}$

@ y_2: $V = \frac{1.0}{0.013}(1.25)^{1/2} \cdot \frac{(3+.75)(.75)(.75)}{(3+2(0.75)\sqrt{1+.75^2}}$

V @ $y_2 = 71.75 \rightarrow Q = VA = 71.75 \cdot .1875 = 13.45$ ft³/s

V @ $y_1 = 83.73 \rightarrow Q = VA \cdot 83.73 \cdot .1875 = 15.7$ ft³/s

f) Required slopes

Paythag

$a^2 + b^2 = c^2$

$a = 1$ $b = .75$

$1^2 + .75^2 = c^2$

$c = 1.25$

Chapter 15:

Problem 4:

15.4 A sharp-edged orifice is placed in a 10-in-diameter pipe carrying ammonia. If the volume flow rate is 25 gal/min, calculate the deflection of a water manometer (a) if the orifice diameter is 1.0 in and (b) if the orifice diameter is 7.0 in. The ammonia has a specific gravity of 0.83 and a dynamic viscosity of 2.5 * 10^-6 lb*s/ft^2.

$Q = 25\,gal/min = 0.0557\ ft^3/s$

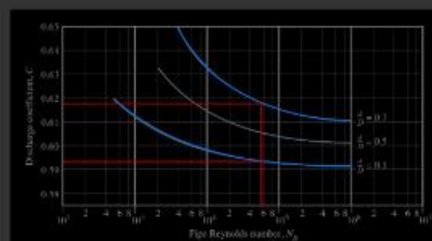
$\eta_d = 2.5 \times 10^{-6}\ lb \cdot s/ft^2$

$S_g = 0.83$

From table F.2:

$A = 0.5479\ ft^2$

$D = 10.02\ in = 0.835\ ft$



$V = \frac{Q}{A}$

$V = \frac{0.0557}{0.5479} = 0.1017\ ft/s$

$R_n = \frac{\rho \cdot V \cdot D}{\eta_d}$

$R_n = \frac{(0.1017) \cdot (0.835) \cdot (0.83)}{2.5 \times 10^{-6}}$

$R_n = 5.47 \times 10^4$

$V = C \sqrt{\frac{2g(\gamma_w - \gamma_a)/h}{(A_1/A_2)^2 - 1}}$

$A_r = (A_1/A_2)^2 - 1$

$h = \frac{A_r \cdot V^2 \cdot \gamma_w}{2 \cdot g (\gamma_w - \gamma_a) \cdot C^2}$

(A) $d/D = 1/10.02 = 0.1 \quad C = 0.594$

$A_2 = \left(\left(\tfrac{1}{12}\right)/2\right)^2 \cdot \pi = 0.00545\ ft^2$

$A_r = (0.548 / 0.00545)^2 - 1 = 10109$

$h = \frac{10109 \cdot 0.1017^2 \cdot 62.4}{2 \cdot 32.2\ (62.4 - 51.8) \cdot 0.594^2} = \boxed{27\ ft}$

(B) $d/D = 7/10.02 = 0.7 \quad C = 0.618$

$A_2 = \left(\left(\tfrac{7}{12}\right)/2\right)^2 \cdot \pi = 0.267\ ft^2$

$A_r = (0.548 / 0.267)^2 - 1 = 3.212$

$h = \frac{3.212 \cdot 0.1017^2 \cdot 62.4}{2 \cdot 32.2\ (62.4 - 51.8) \cdot 0.618^2} = \boxed{0.00795\ ft}$

Problem 9:

15.9 A flow nozzle is to be installed in a 5-in Type K copper tube carrying linseed oil at 77 °F. A mercury manometer is to be used to measure the pressure difference across the nozzle when the expected range of the flow rate is from 700 gal/min to 1000 gal/min. The manometer scale ranges from 0 to 8.0 in of mercury. Determine an appropriate diameter of the nozzle.

$$D = 4.805\text{ in} = 0.4004\text{ ft}$$

$$A = 0.1259\text{ ft}^2$$

$$Q_L = 700\text{ gal/min} = 1.559\text{ ft}^3/\text{s}$$

$$Q_H = 1000\text{ gal/min} = 2.228\text{ ft}^3/\text{s}$$

$$V_L = \frac{Q_L}{A} = \frac{1.559}{0.1259} = 12.38\text{ ft/s}$$

$$V_H = \frac{Q_H}{A} = \frac{2.228}{0.1259} = 17.69\text{ ft/s}$$

$$h_L = 0\text{ ft}$$

$$h_H = 0.667\text{ ft}$$

$$\nu = 3.84 \times 10^{-4}\text{ ft}^2/\text{s}$$

Use largest flow rate and h.

$$Q = A_1 C\sqrt{\frac{2gh((\gamma_m/\gamma_f)-1)}{(A_1/A_2)^2 - 1}}$$

$$C = 0.9975 - 6.53 \cdot \sqrt{(d/D)/R_N}$$

$$A_2 = \frac{A_1}{\sqrt{\left(\frac{2gh((\gamma_m/\gamma_f)-1)}{\left(\frac{Q}{A_1 \cdot C}\right)^2}\right)+1}}$$

$$A_2 = \pi d^2/4$$

$$\pi d^2/4 = \frac{A_1}{\sqrt{\left(\frac{2gh((\gamma_m/\gamma_f)-1)}{\left(\frac{Q}{A_1 \cdot (0.9975 - 6.53 \cdot \sqrt{(d/D)/R_N})}\right)^2}\right)+1}}$$

Problem 9 (continued):

D	0.4004	(ft)				
A_1	0.1259	(ft^2)				
v	0.000384	(ft^2/s)				
Q low	700	(gal/min)				
Q high	1000	(gal/min)				
Q low	1.559607	(ft^3/s)				
Q high	2.22801	(ft^3/s)				
V low	12.38767	(ft^2/s)				
V high	17.69667	(ft^2/s)				
Rn low	1.29E+04					
Rn high	1.85E+04					
C low	0.95					
C high	0.96					
C	A_2	d (ft)	d/D	d (inch)	h low	h high
0.951	0.077036	0.313186	0.782183	3.758235	0.517538	1.057391
0.952	0.076968	0.313047	0.781835	3.756559	0.517373	1.057055
0.953	0.076899	0.312907	0.781486	3.754884	0.517209	1.056721
0.954	0.07683	0.312768	0.781138	3.753211	0.517046	1.056387
0.955	0.076762	0.312628	0.78079	3.751541	0.516883	1.056055
0.956	0.076694	0.312489	0.780443	3.749872	0.516721	1.055723
0.957	0.076626	0.31235	0.780096	3.748205	0.516559	1.055393
0.958	0.076558	0.312212	0.77975	3.746541	0.516397	1.055063
0.959	0.07649	0.312073	0.779404	3.744878	0.516236	1.054735
0.96	0.076422	0.311935	0.779058	3.743217	0.516076	1.054408
0.961	0.076354	0.311797	0.778713	3.741558	0.515916	1.054081

Problem 15:

Chp. 15, Problem 15:

Find the velocity of flow in Duct:

Standard temp = 68°

differential manometer : 0.24 in of water = 0.02 ft

$\gamma_w = 62.3 \ lb/ft^3$ @ 70°F

$\gamma_A = 0.075 \ lb/ft^3$ @ 70°F

$$V = \sqrt{2gh(\gamma_w - \gamma_A)/\gamma_A}$$

$$V = \sqrt{2(32.2)(0.02)(62.3 - 0.075)/0.075}$$

$V = 32.689$ ft/s Velocity in Duct

Reflection:

Open Channel Flow was the topic of this chapter. Open channel is defined by a flow that is exposed to the atmosphere. In this configuration the pressure of the flow is equal to the atmosphere. That being said, the only means of manipulating the flow is by changing the size, shape, or slope of the channel. The homework took this concept and had us provide the required area or shape that would be necessary to create a desired flow rate.

Flow measurements cover the uses of several types of meter that can read certain aspects of a flow, examples of these meters are an vortex, a variable head meter, and a turbine flowmeter. An example of a variable head meter can be an orifice plate, which is inserted into the pipe to change the concentration point of the flow. The meters can be used in several situations, another type of device that was introduced in flow measurements is a velocity probe. This goes directly into the pipe and measures the velocity in a pipe using a stagnation point as a reference. All the meters/ probes can have Bernoullis applied to them to solve for the desired value in that pipe.