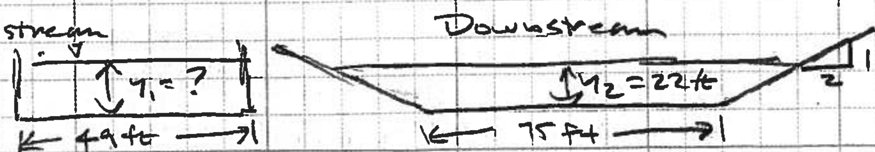
5 [2.6] Given: Subcritical transition. $Q = 12600$ cfs $K_L = 0.5$



$\Delta z = -1$ ft

Find: y_1

$E_1 = E_2 + \Delta z + h_L$

$$y_1 + \frac{Q^2}{2gA_1^2} = y_2 + \frac{Q^2}{2gA_2^2} + (-1\text{ ft}) + K_L \left| \frac{1}{A_2^2} - \frac{1}{A_1^2} \right| \frac{Q^2}{2g}$$

$A_2 = y_2(b_2 + my_2) = 22\text{ ft}\,[75\text{ ft} + 2(22\text{ ft})]$
$= 2618\text{ ft}^2$

$A_1 = b_1 y_1 = (49\text{ ft})\, y_1 = 49 y_1$

See Excel sheet below

10

Problem 2.6
Upstream rectangular cross section
$b_1 =$ 49 ft
Downstream trapezoidal cross section
$b_2 =$ 75 ft $g =$ 32.2 ft/s2
$m =$ 2
$y_2 =$ 22 ft
$Q =$ 12600 cfs
$\Delta z =$ -1 ft
$K_L =$ 0.5

$$E_1 = E_2 + \Delta z + h_L$$
$$y_1 + \frac{Q^2}{2gA_1^2} = y_2 + \frac{Q^2}{2gA_2^2} + \Delta z + K_L \left| \frac{1}{A_2^2} - \frac{1}{A_1^2} \right| \frac{Q^2}{2g}$$
$$A_2 = y_2(b_2 + my_2)$$
$$A_1 = b_1 y_1$$

A_2 (ft²)	E_2 (ft)	y_1 (ft)	A_1 (ft2)	E_1 (ft) rhs	h_L (ft)	$E_2+\Delta z+h_L$ lhs	rhs - lhs
2618	22.36	19.88	974.17	22.48	1.12	22.48	1.4E-06

5.77 ft
19.88 ft
-4.47 ft

TEXAS TECH UNIVERSITY
J. H. MURDOUGH
ASCE STUDENT CHAPTER

NAME ____ DATE ____

COURSE ____ SHEET ____ OF ____

20

6) Problem 2.10 (i) Circular culvert $d = 1.0$ m on steep slope at entrance.
Upstream total head $E_1 = 1.3$ m
Find Q
(ii) Repeat (i) for square 1.0 m box culvert

(i) Circular pipe – see spreadsheet for equations for partially full circular pipe.

I tried different Q values, found the corresponding y_c for that Q, then found

$$E_c = y_c + \frac{Q^2}{2gA_c^2}$$

10

I stopped at $\boxed{Q = 2.12\ m^3/sec}$ $y_c = 0.83$ m

(ii) Box culvert $b = 1.0$ m

$$E_1 = 1.3\text{m} = y_c + \frac{V_c^2}{2g} = E_c$$

For rectangular channel $E_c = \frac{3}{2} y_c$

10

$$\rightarrow y_c = \frac{2}{3}(1.3\text{m})$$

$$= 0.87\text{m}$$

$$E_c = \frac{3}{2}(0.87\text{m}) = 0.87\text{m} + \frac{V_c^2}{2(9.81\text{m/s}^2)}$$

$$(0.43\text{m})(2)(9.81\text{m/s}^2) = V_c^2$$

$$V_c = 2.92\ \text{m/sec}$$

$$Q = VA = V_c\, b\, y_c = (2.92\text{m/sec})(1\text{m})(0.87\text{m})$$

$$\boxed{Q = 2.54\ \text{m}^3/\text{sec}}$$

Problem 2.10

g = 9.81 m^2/sec

Upstream total energy = 1.3 m

Circular Pipe

d = 1 m

y_c (m)	θ_c (rad)	A_c (m^2)	B_c (m)	A_c^3/B_c	Q (m^3/s)	E_c (m)
0.83	4.60	0.70	0.75	0.457	2.116	1.30

$$\theta = 2\cos^{-1}\left[1 - 2\left(\frac{y_c}{d}\right)\right]$$

$$A = (\theta - \sin\theta)\frac{d^2}{8}$$

$$B = d\sin\left(\frac{\theta}{2}\right)$$

$$\frac{Q^2}{g} = \frac{A_c^3}{B_c}$$

$$E = y_c + \frac{Q^2}{2gA_c^2}$$

Find y_c by Goal Seek for that Q, see if E_c = 1.30 m

2.15 Given: USGS study of natural channels

$\frac{y}{D} = 1.55$ for 761 measurements

Find: (a) $\frac{y}{D}$ for (i) triangular
(ii) parabolic
(iii) rectangular channels

(b) Bankfull Q for $F_1 = 1.0$, $\frac{y}{D} = 1.55$, $B_1 = 100\text{ ft}$, $y_1 = 10\text{ ft}$

(a) (i) triangle

$$D = \frac{A}{B} = \frac{my^2}{2my} = \frac{y}{2}$$

$$\underline{\frac{y}{D}} = \frac{y}{y/2} = \underline{2}$$

(ii) parabolic

$$D = \frac{A}{B} = \frac{\frac{2}{3}By}{B(y/y_1)^{1/2}} = \frac{2/3\, B y_1}{B} = \frac{2}{3}y$$

$y = y_1$

$$\underline{\frac{y}{D}} = \frac{y}{\frac{2}{3}y} = \underline{1.5}$$

(iii) rectangular

$$D = \frac{A}{B} = \frac{by}{b} = y$$

$$\underline{\frac{y}{D}} = \frac{y}{y} = \underline{1}$$

Natural channel closer to parabolic

(b)
$$F_1 = \frac{Q B_1^{1/2}}{g^{1/2} A_1^{3/2}}$$

$$Q = \frac{F_1\, g^{1/2} A_1^{3/2}}{B_1^{1/2}}$$

$$A_1 = D B_1 = \frac{y}{1.55} B_1 = \left(\frac{10\text{ ft}}{1.55}\right)(100\text{ ft}) = 645\text{ ft}^2$$

$$Q = \frac{(1.0)(32.2\text{ ft/s}^2)^{1/2}(645\text{ ft}^2)^{3/2}}{(100\text{ ft})^{1/2}}$$

$$\boxed{Q = 9300\text{ cfs}}$$

$F_1 = 1$, so this would be critical discharge

Problem 2.19

Given: [i] Rectangular sharp-crested weir, L = 1.0 ft, b = 5 ft, P = 1.0 ft

[ii] 90 V-notch, P = 1.0 ft

Find: Plot head vs. Q for H = 0 to 0.5 ft

[i]

$$Q = \frac{2}{3}\sqrt{2g}C_{de}L_eH_e^{1/2}$$

$$L_e = L + k_L$$

$$H_e = H + k_H$$

L =	1 ft		
b =	5 ft		
P =	1 ft		
L/b =	0.2		
g =	32.2 ft/s^2		
k_L =	0.0025 m =	0.0082 ft	Fig. 2.23[c]
L_e =	1.0082 ft	C_{de}	Fig. 2.23[b]
k_H =	0.003 ft		

18

12

H (ft)	He (ft)	He/P	Cde	Q (cfs)
0	0	0	0.58	0.00
0.05	0.053	0.053	0.58	0.04
0.1	0.103	0.103	0.58	0.10
0.15	0.153	0.153	0.58	0.19
0.2	0.203	0.203	0.58	0.29
0.25	0.253	0.253	0.58	0.40
0.3	0.303	0.303	0.575	0.52
0.35	0.353	0.353	0.575	0.65
0.4	0.403	0.403	0.575	0.79
0.45	0.453	0.453	0.575	0.95
0.5	0.503	0.503	0.575	1.11

[ii]

$$Q = C_{de}\frac{8}{15}\sqrt{2g}\,\tan\frac{\theta}{2}H_e^{5/2}$$

$$H_e = H + k_H$$

k_H = 0.0008 m = 0.0026 ft   Fig. 2.24[b]

C_{de} = 0.578

4

8

H (ft)	He (ft)	Q (cfs)
0	0	0.000
0.05	0.053	0.002
0.1	0.103	0.008
0.15	0.153	0.023
0.2	0.203	0.046
0.25	0.253	0.079
0.3	0.303	0.125
0.35	0.353	0.183
0.4	0.403	0.254
0.45	0.453	0.341
0.5	0.503	0.443