90/100

Fluid Lab

ENCE 4319

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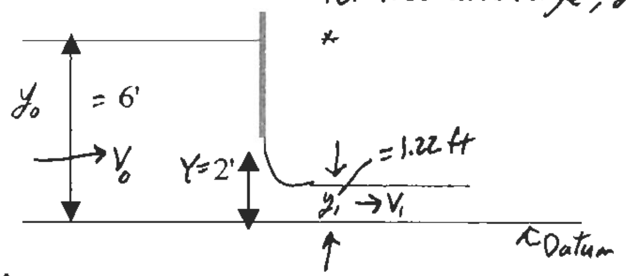
Tutorial Assignment 1.

Due 9/7/10

1. Using energy and continuity principles estimate the flow under the sluice gate shown in the sketch below. Assume: no head loss, $\alpha = \beta = 1$, W = 6 ft, Gate opening = 2 ft; y_o = 6 ft and Cc = 0.61.

For free discharge, 'y' contracts to a depth $y_1 = C_c Y = 0.61(2) = 1.22$ ft



Assumptions:

Friction Loss = Ø ; α (K.E. correction factor) = β (momentum correction factor) = 1

Equations:

Continuity: $A_oV_o = A_1V_1$; $A = W \cdot y_i$ ∴ $W \cdot y_o \cdot V_o = W \cdot y_1 \cdot V_1 \rightarrow y_o V_o = y_1 V_1$

Energy: $H_o = H_1 + h_{L_{0-1}}$; $y_o +$ [redacted] $+ \frac{V_o^2}{2g} = y_1 +$ [redacted] $+ \frac{V_1^2}{2g} + h_L$ (Ø)

OPEN CHANNEL: $H = y + \frac{V^2}{2g} + z$

Solution: $V = \frac{Q}{A}$; $V_o = \frac{Q}{6'(6')}$; $V_1 = \frac{Q}{6(1.22)}$; $6'(V_o) = 1.22'(V_1) \rightarrow V_o = \frac{1.22(V_1)}{6}$

($A_{b/f\ gate}$, $A_{a/f\ gate}$)

$6' + \frac{V_o^2}{2g} = 1.22' + \frac{V_1^2}{2g}$

$\rightarrow (2g)\left(6' + \frac{\left(\frac{1.22V_1}{6}\right)^2}{2g} - 1.22\right)(2g) = V_1^2$

$\rightarrow 307.8 = V_1^2 - 0.0413V_1^2$

$\rightarrow V_1^2 = 321.1 \rightarrow$ $V_1 = 17.91$ ft/s

$\Rightarrow 6'(V_o) = 1.22'(17.91\ ft/s)$

$\rightarrow$ $V_o = 3.64'$

$\Rightarrow Q = 3.64(36) = 131.2\ ft^3/s$

$Q = 17.91(7.32) = 131.1\ ft^3/s$ ✓

Q = 131.15 ft^3/s ✓

30/30

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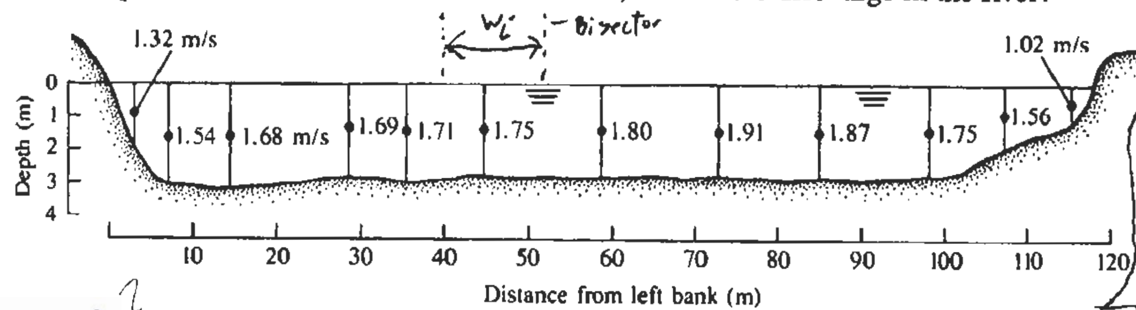
2. Find the discharge, energy and momentum correction factors for the channel shown in below.

Theory and experimental verification indicate that the mean velocity along a vertical line in a wide stream is closely approximated by the velocity at 0.6 depth. If the indicated velocities at 0.6 depth in a river cross section are measured, what is the discharge in the river?



$A_i = w_i\,(y_i)$

$A = \sum_{i=1}^{N} A_i$

$Q = \sum_{i=1}^{N} (A_i (V_i))$

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

momentum correction factor

$\beta = \frac{\sum A_i V_i^2}{A V^2}$

K.E. correc. factor

$\alpha = \frac{\sum A_i V_i^3}{A V^3}$

What's the value of α and β?

-10

$Q = 543.8\ m^3/s$ ✓

25/35

3. Estimate the velocities and pressures in the venturi device shown below.
Assume: a) no loss in contracting flow, b) for expanding flow $h_L = 0.1(V_{max}-V_{min})^2/2g$, c) neglect friction loss, d) α = Kinetic energy correction factor = 1, e) vapor pressure 0.3 m, and f) pressure head at entrance is 250 m.

① $\frac{V_1^2}{2g} + \frac{P_1}{\gamma} = \frac{V_2^2}{2g} + \frac{P_2}{\gamma}$ ($\frac{P_1}{\gamma} = 250m$)

② $\frac{P_2}{\gamma} + \frac{V_2^2}{2g} = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + h_{L_{2-3}}$

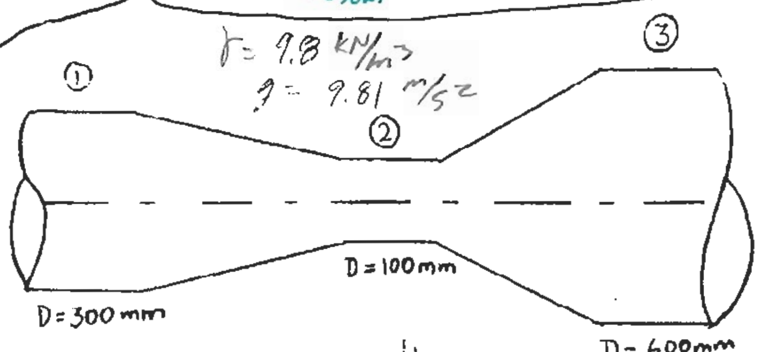
Continuity equ.: $A_1V_1 = A_2V_2 = A_3V_3 = Q = 0.2\ \frac{m^3}{s}$

Energy Balance Eqn: ① $H_{T_1} = H_{T_2} + h_{L_{1-2}}$ (→ 0)

② $H_{T_2} = H_{T_3} + h_{L_{2-3}}$

$\gamma = 9.8\ kN/m^3$

$g = 9.81\ m/s^2$



Q = 200 L/s

A_1 0.07069 m^2

A_2 = 0.007854 m^2

A_3 = 0.2827 m^2

$V_1 = \frac{Q}{A_1}$: 2.82925 m/s ✓

$V_2 = \frac{Q}{A_2}$: 25.4647 m/s ✓

$V_3 = \frac{Q}{A_3}$: 0.70746 m/s ✓

$P_1 = 250m(\gamma) = 2450\ kN/m^2$ ✓

① $\frac{(2.82925\ m/s)^2}{2\cdot 9.81[\frac{m}{s^2}]} + 250m = \frac{(25.4647\ m/s)^2}{2g} + \frac{P_2}{9.8[kN/m^3]}$

→ $P_2 = 2130\ kN/m^2$ ✓

② $\frac{2130\ kN/m^2}{9.8\ kN/m^3} + \frac{(25.4647)^2}{2(9.81)} = \frac{P_3}{9.8\ kN/m^3} + \frac{(0.70746)^2}{2(9.81)} + \frac{0.1(V_2-V_3)^2}{2(9.81)}$ ✓

→ $P_3 = 2423\ kN/m^2$

35/35

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ENCE 4319 Tutorial Assignment 1, Problem 2

z	y_i	$V_{0.6}$ (@ that depth (V_i))	W_i	A_i (= $w_i(y_i)$)	$A_i V_i$	$A_i V_i^3$
0	0	0		Ø	Ø	Ø
3	1.9	1.32	4	7.6	10.03	17.48
8	3	1.54	5.5	16.5	25.41	60.26
14	3.1	1.68	10.5	32.55	54.68	154.34
29	2.85	1.69	11	31.35	52.98	151.32
36	2.9	1.71	8	23.20	39.67	116
45	2.8	1.75	11.5	32.2	56.35	172.57
59	2.8	1.8	13.5	37.8	68.04	220.45
72	2.8	1.91	13	36.4	69.52	253.63
85	2.8	1.87	13.5	37.8	70.69	247.18
99	2.8	1.75	11.5	32.2	56.35	172.57
108	2.75	1.56	8	22	34.32	83.52
115	1.25	1.02	4.5	5.63	5.74	5.97
117	0	0		Ø	Ø	Ø
			Σ	315.23	543.79	1655.3

$4 = \frac{3-0}{2} + \frac{8-3}{2}$

$V = \frac{Q}{A} = \frac{543.79}{315.23} = 1.725$

$\beta = \frac{\Sigma A_i V_i^2}{AV^2}$?

$\alpha = \frac{\Sigma A_i V_i^3}{AV^3}$?