Kafr El-Sheikh University		Open Channel Hydraulics (CES3119)
Faculty of Engineering		Final term exam.
Civil Engineering Dept.		Date: 24 december, 2017
Third year civil		Time : 3 hour
Examiner: Associ. Prof. Moustafa El-Enany		Full mark: **125** marks

Answer all the following five questions

Any other required data may be reasonably assumed. الامتحان مكون من في صفحتين

Question No. (1) [24 marks] (A13, B2, C1)

Design a stable hydraulic section that conveys 200cfs, n = 0.03, permissible tractive force (τ_o) = 0.4 Ib/ft^2, bed slope (S) = 0.0012, angle of internal friction (ϕ)= 30°,

$$V = \frac{1.35 - 1.19\tan\phi}{n} y_O^{2/3} S^{0.5} \quad , \quad y_O = \frac{\tau_O}{0.97\gamma S} \quad , \quad y = y_O \cos\left(\frac{\tan\phi}{y_O} x\right)$$

$$A = \frac{2.04 y_O^2}{\tan\phi} \quad , \quad T'' = \frac{n(Q_{given} - Q_{calculated})}{1.49 y_O^{5/3} S^{0.5}} \quad , \quad T' = 0.96\,T\left[1 - \sqrt{\frac{Q_{given}}{Q_{calculated}}}\right]$$

Question No. (2) [16 marks] (A13, B2, C1)

A **rectangular** channel of bed width of 5m carries a discharge of 10 m^3/sec at a depth of 0.5m, calculate the **change in water levels** in the following two cases::

a- The bed **level** is decreased by a **depression** of **1.0 m** [8 marks]

b- The bed width is **expanded** to **6m**. [8 marks]

Question No. (3) [20 marks] (A13, B14, C1)

A **model** of a **dam** is to be built with horizontal scale (L_H) = 1:2000 and vertical scale (L_V) = 1:20 according to the following data:

Prototype data: dam length = 200m , water depth = 10m, length of backwater curve is approximately 10 km, discharge = 1000 m^3/sec,

It is required to determine the **flume dimensions** and **pump discharge** in the laboratory.

(باقى الاسئلة فى الخلف)

إجابة إمتحان هيدروليكا ثالثة مدني

ديسمبر ٢٠١٧ - كلية الهندسة - جامعة كفر الشيخ

Q1 | 24 Marks

$$y_0 = \frac{\tau_0}{0.97\gamma S} = \frac{0.4}{0.97(62.4)(0.0012)} = 5.51 \text{ ft}$$

(2 marks)

$$V = \frac{1.35 - 1.19 \tan\phi}{n} y_0^{2/3} S_0^{1/2}$$

$$V = \frac{1.35 - 1.19 \tan 30^\circ}{0.03} (5.51)^{2/3} (0.0012)^{1/2}$$

$V = 2.39$ ft/sec → (2 marks)

$$A = \frac{2.04\, y_0^2}{\tan\phi} = \frac{2.04\,(5.51)^2}{\tan 30^\circ} = 107.27 \text{ ft}^2$$

(2 marks)

$$Q_{cal} = A \cdot V = 107.27 \times 2.39 = 256.38 \text{ m}^3/\text{sec}$$

(2 marks)

$$y = y_0 \cos\left(\frac{\tan\phi}{y_0} x\right)$$

$$y = 5.51 \cos\left(\frac{\tan 30}{5.51} x\right)$$

$y = 5.51 \cos(0.105\, x)$ in radian

$y = 5.51 \cos(6.019\, x)$ in degree

at $y = 0$ $\quad x = 14.95$ ft

$T = 29.9$ ft → (4 marks)

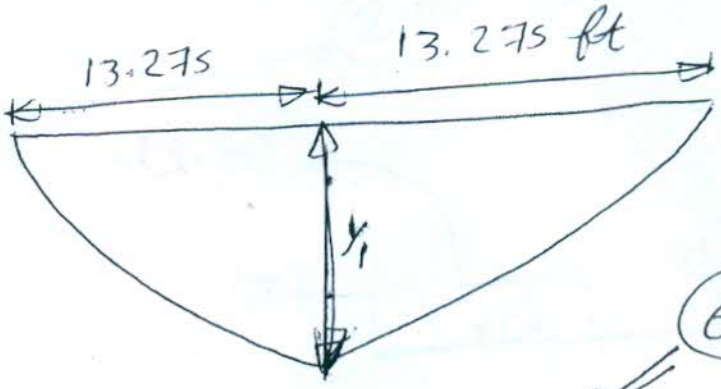
[redacted]

$$T' = 0.96\,T\left[1-\sqrt{\frac{Q_{given}}{Q_{cal}}}\right]$$

$$T' = 0.96 \times 29.9\left[1-\sqrt{\frac{200}{256.38}}\right] =$$

$T' = 3.35$ ft → (4 marks)

$T_{final} = 29.9 - 3.35 = T - T' = 26.55$ ft → (2 marks)



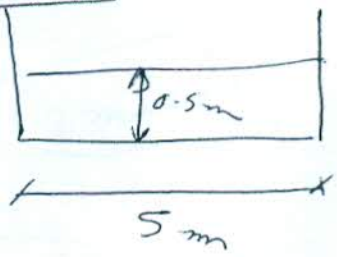
(6 marks)

X (ft)	0	3	6	9	12	13.275
Y (ft)	5.42	4.86	3.81	2.39	0.74	0

Q2: 16 Marks

Q2 $Q = 10\ m^3/sec$

$$V_1 = \frac{10}{5 \times 0.5} = 4\ m/sec$$



$$E_1 = y + \frac{V_1^2}{g} = 0.5 + \frac{(4)^2}{2 \times 9.81} = 1.32\ m$$ → (2 marks)

$$y_c = \sqrt[3]{\frac{(10/5)^2}{9.81}} = 0.74\ m$$ → (1 mark)

$y_1 < y_c \Rightarrow$ supercritical flow → (1 mark)

(a) $E_1 = E_2 - 1$

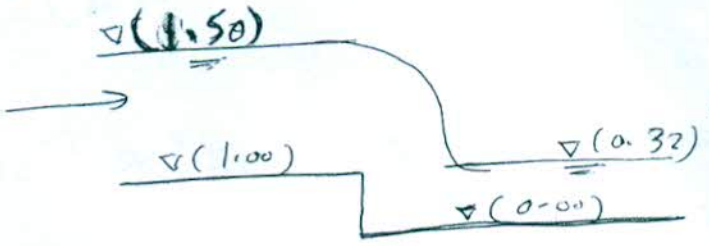
$1.32 = E_2 - 1$

$E_2 = 2.32 = y_2 + \frac{Q^2}{2gA_2^2} = y_2 + \frac{V_2^2}{2g}$

$2.32 = y_2 + \frac{100}{2 * 9.81 * 25 y_2^2}$

$2.32 = y_2 + \frac{0.20}{y_2^2}$

$y_2 \cong 0.32\,m$ → (2 marks)



(1 mark)

(1 mark)

Change in water levels $= 1.50 - 0.32 = 1.18\,m$

(b) $E_1 = E_2$ → (2 marks)

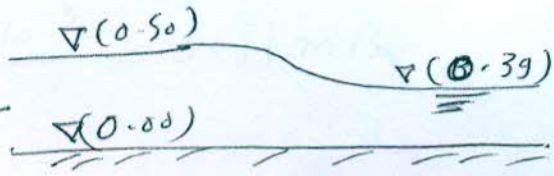
$1.32 = y_2 + \frac{100}{2g(3.6)y_2^2}$ → (2 marks)

$1.32 = y_2 + \frac{0.14}{y_2^2}$

get $y_2 \cong 0.39\,m$ → (2 marks)

Change in water levels $= 0.5 - 0.39 = 0.11\,m$

(1 mark)



(1 mark)

Q3 : 20 Marks

$L_m = \frac{10000}{2000} = 5\ m$ → 3 marks

$H_m = \frac{10}{20} = 0.5\ m$ → 3 marks

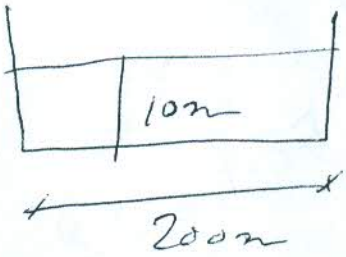
$B_m = \frac{200}{2000} = 0.1\ m$ → 3 marks

$$\frac{Q_m}{Q_p} = L_V^{3/2}\ L_H$$

$$\frac{Q_m}{1000} = \left(\frac{1}{20}\right)^{3/2} \frac{1}{(2000)}$$

$Q_m = 5.59 \times 10^{-3}\ m^3/sec = 5.59\ lit$ → 3 marks

$V_p = \frac{1000}{200 \times 10} = 0.5\ m/sec$

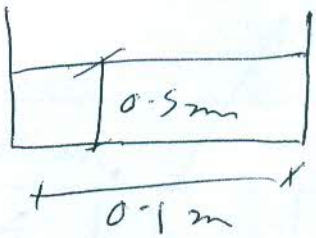


$A_p = 10 \times 200 = 2000\ m^2$

$P_p = 220\ m$

$R_p = \frac{2000}{220} = 9.09\ m$ → 4 marks

$(R_e)_p = \frac{VR}{\nu} = \frac{0.5\ (9.09)}{1 \times 10^{-6}} = 4.55 \times 10^6 > 2000$ turbulent



$A_m = 0.05\ m$

$V_m = \frac{5.59 \times 10^{-3}}{0.05} = 0.11\ m/sec$

$R_m = 0.1\,m$

$R_m = \frac{0.05}{1.1} = 0.045\,m$

4 marks

$(R_e)_m = \frac{VR}{\nu} = \frac{0.05 * 0.045}{1 * 10^{-6}} = 2272.727000$

turbulent flow

O.K

$Y_m = 0.5\,m$ O.K

Q4: 25 Marks

Q4) $\frac{Q_1}{Q_2} = \frac{N_1 D_1^3}{N_2 D_2^3}$

$\frac{H_1}{H_2} = \frac{(N_1 D_1)^2}{(N_2 D_2)^2}$

5 marks

$N_1 = 350\ rpm$, $D_1 = 30\,cm$

$N_2 = 300\ rpm$, $D_2 = 35\,cm$

$\frac{Q_2}{Q_1} = 1.37$ (req; given)

$\frac{Q_1}{Q_2} = \frac{N_1 D_1^3}{N_2 D_2^3} = \frac{350 * (30)^3}{300\,(35)^3} = 0.73$ (given; req)

$\frac{H_1}{H_2} = \frac{(N_1 D_1)^2}{(N_2 D_2)^2} = \frac{(350)^2\,(30)^2}{(300)^2\,(35)^2} = 1$ (given; req)

10 marks

Single pump, $N_2 = 300\,rpm$, $D_2 = 35\,m$

H (m)	30	25	21	17	11	5
Q (lit/sec)	0	36.99	47.95	60.28	73.98	87.68

6 pumps (3 series + 2 parallel)

$H = 3H$

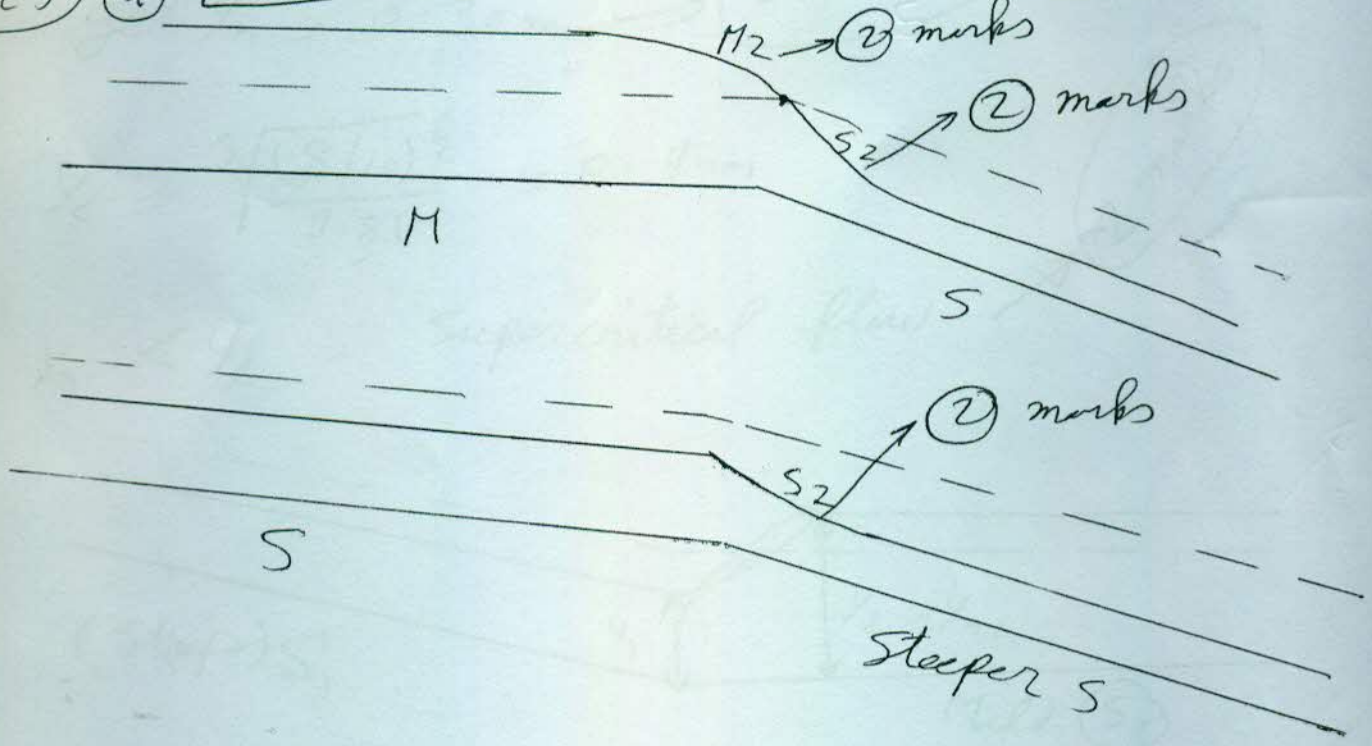
$Q = 2Q$

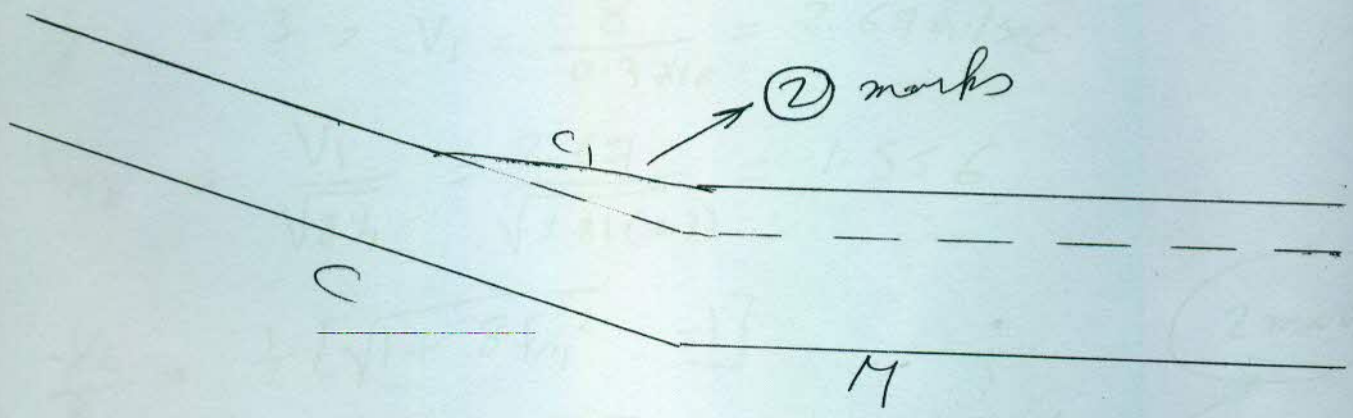
10 marks

H (m)	90	75	63	51	33	15
Q (lit/sec)	0	73.98	95.9	120.56	147.96	175.36

Q5 : 45 marks

Q5 (a) 8 Marks



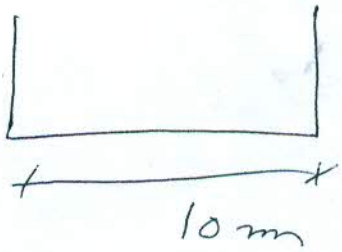


b)

$Q = 8\ m^3/sec$

$n = 0.02$

$S_1 = 0.0153$



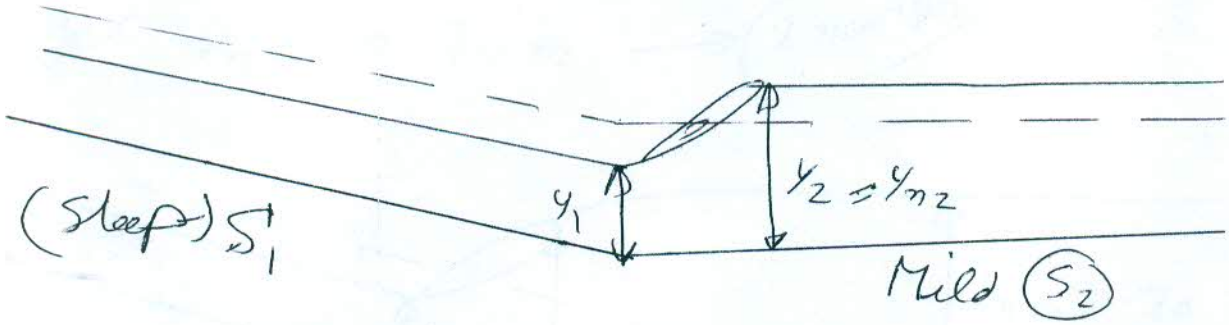
$$Q = \frac{1}{n}\frac{A^{5/3}}{P^{2/3}} S_1^{1/2}$$

$$8 = \frac{1}{0.02}\frac{(10y_n)^{5/3}}{(10+2y_n)^{2/3}}(0.0153)^{1/2}$$

get $y_n = 0.30m$ → (2 marks)

$$y_c = \sqrt[3]{\frac{(8/10)^2}{9.81}} = 0.4m$$

$y_n < y_c$ supercritical flow → (2 marks)



$y_1 = 0.3$, $V_1 = \frac{8}{0.3 \times 10} = 2.67 m/sec$

$$Fn_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.67}{\sqrt{9.81(0.3)}} = 1.556$$

$$\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1+8Fn_1^2} - 1\right]$$

$$\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1+8(1.556)^2} - 1\right]$$, get $y_2 = 0.53m$ → (2 marks)

$A_2 = 0.53 \times 10 = 5.3\,m$

$P_2 = 0.53(2) + 10 = 11.06\,m$

$$8 = \frac{1}{0.02} \frac{(5.3)^{5/3}}{(11.06)^{2/3}} S_2^{1/2}$$

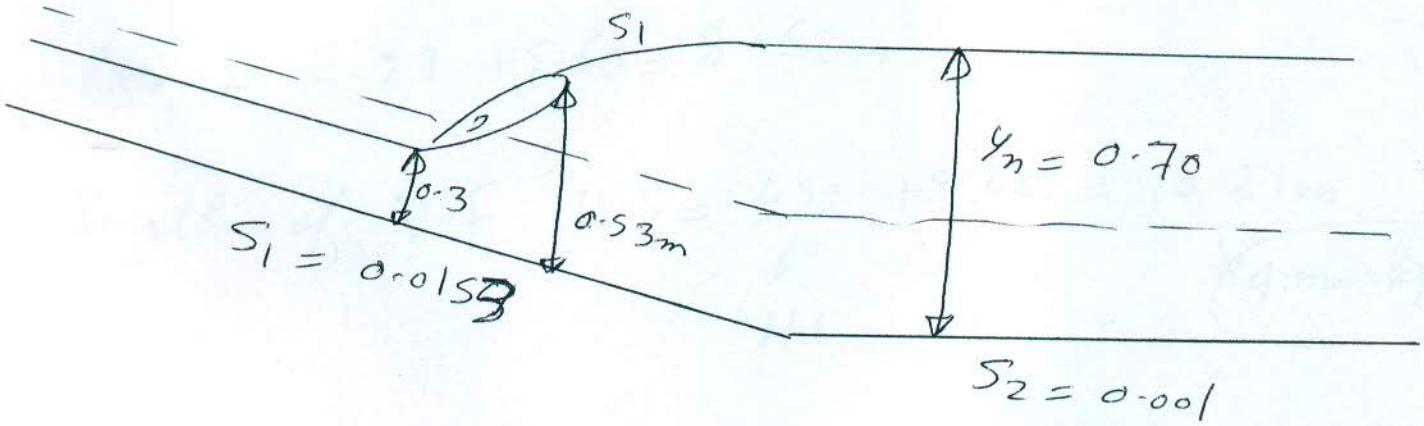
get $S_2 = 0.0024\,m$ → 3 marks

$\therefore$ $\boxed{\text{Second slope value} \geq 0.0024}$ → 3 marks

for $S_2 = 0.001$

$$8 = \frac{1}{0.02} \frac{(10 y_n)^{5/3}}{(10 + 2y_n)^{2/3}} (0.001)^{1/2}$$

get $y_n \cong 0.70\,m$ → 2 marks



length of H.J $= 6.9(y_2 - y_1) = 6.9(0.53 - 0.3) = 1.59\,m$

↓

2 marks

S_1 from 0.53 m to 0.70 m

y	A	V	E	ΔE	R	Sf	$\overline{Sf}$	ΔX
0.53	5.3	1.51	0.65		0.48	0.0021		
				0.04			0.00185	
0.615	6.15	1.23	0.69		0.55	0.0013		2.97 m
				0.08			0.00115	5.65 m
0.70	7	1.14	0.77		0.61	0.0010		

8 marks

$$V = \frac{1}{n} R^{2/3} \, Sf^{1/2}$$

$$Sf = \frac{V^2 n^2}{R^{4/3}}$$

$$\Delta X = \frac{\Delta E}{S_0 - \overline{Sf}}$$

$$S_0 = 0.0153$$

$$\Delta X = 2.97 + 5.65 = 8.62 \text{ m}$$

length of V-F U.S = 1.59 + 8.62 = 10.21 m

$L_{H.J}$ L_{S_1}

4 marks

length of ~~V-F~~ D.S = Zero → 4 marks

S_1 from 0.53 m to 0.70 m

y	A	V	E	ΔE	R	Sf	$\overline{Sf}$	ΔX
0.53	5.3	1.51	0.65		0.48	0.0021		
				0.04			0.00185	
0.615	6.15	1.23	0.69		0.55	0.0013		2.97 m
				0.08			0.00115	5.65 m
0.70	7	1.14	0.77		0.61	0.0010		

8 marks

$$V = \frac{1}{n} R^{2/3} Sf^{1/2}$$

$$Sf = \frac{V^2 n^2}{R^{4/3}}$$

$$\Delta X = \frac{\Delta E}{S_0 - \overline{Sf}}$$

$$S_0 = 0.0153$$

$$\Delta X = 2.97 + 5.65 = 8.62 \text{ m}$$

length of V-F U.S = 1.59 + 8.62 = 10.21 m

$L_{H.J}$ L_{S_1}

4 marks

length of V-F D.S = Zero → 4 marks