



Ministry of Higher Education  
The Higher Institute of Engineering and Technology  
in New Damietta

Department: Civil Engineering  
Level: (4)  
Semester: Fall  
Subject: Open Channel Hydraulics  
Subject code: CIE 401

Date: 12/11/2017  
Time allowed: 1.5 Hours  
Full marks: 20 marks  
No. of pages: One Page

Day: Sunday

**Question (I): (10 marks)**

- (a) Write Saint-Venant Equations and from the dynamic equation discuss the different types of flow. (3 marks)
- (b) While measuring the discharge in an open channel, it was found that the depth of flow increases at a rate of 0.12 m/hr. If the discharge at the section was  $12.5 \text{ m}^3/\text{sec}$  and the surface width was 16 m, Estimate the discharge at 1.5 km downstream. (3 marks)
- (c) A rectangular channel has a longitudinal slope 12 cm/km, bed width equals 25 m, Chezy coefficient = 50, carries a discharge at a depth of 3.5 m, it is found that the maximum value of water velocity equal to 1.6 m/sec. Find the values of energy and momentum coefficients and the specific discharge. (4 marks)

**Question (II): (10 marks)**

- (a) Prove that, the flow in the trapezoidal channel is critical when the specific energy is minimum. (4 marks)
- (b) A uniform flow of  $20 \text{ m}^3/\text{sec}$  occurs in a rectangular channel 5 m width and 2.5 m water depth, Calculate: (6 marks)
- (i) The greatest allowable constriction in width for the upstream flow to be as possible as specified.
- (ii) The height of hump to produce critical depth.
- (ii) What is the effect of increasing the height of hump to 1.0 m on the water surface level?

*With my best wishes*  
Assoc. prof. Dr./ Hamdy El-Ghandour

Solution of Mid-term Exam.

Question I

(a) Saint-Venant eqs are :-

3

- Steady-state Continuity eqn:  $A_1 V_1 = A_2 V_2 = Q$

- unsteady-state " " :  $\frac{\partial Q}{\partial x} + T \frac{\partial h}{\partial t} = 0$

- Dynamic eqn

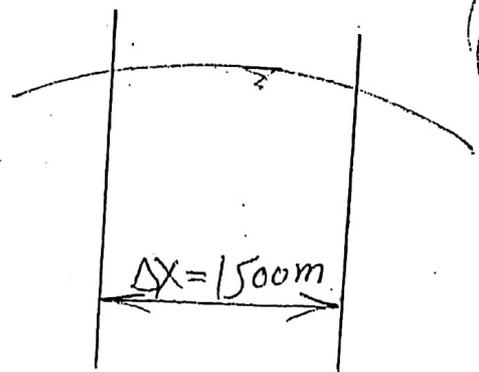
$$S_f = S_0 - \frac{\partial y}{\partial x} - \frac{\alpha V}{g} \frac{\partial V}{\partial x} - \frac{1}{g} \frac{\partial V}{\partial t} = \frac{V^2}{C^2 R}$$

(b)  $\frac{\partial h}{\partial t} = 0.12 \text{ m/hr}$ ,  $T = 16 \text{ m}$

$$\frac{\partial Q}{\partial x} + T \frac{\partial h}{\partial t} = 0$$

$$\frac{Q_2 - Q_1}{\Delta x} + T \frac{\partial h}{\partial t} = 0$$

$$\frac{(Q_2 - 12.5)}{1500} + 16 * \frac{0.12}{60 * 60} = 0$$



$Q_1 = 12.5 \text{ m}^3/\text{s}$   $Q_2 = ??$

$Q_2 = 11.7 \text{ m}^3/\text{sec}$

1

(c)  $S = 12 \text{ cm}^2/\text{km}$ ,  $b = 25 \text{ m}$ ,  $C = 50$ ,  $y = 3.5 \text{ m}$   
 $V_{\text{max}} = 1.6 \text{ m/sec}$ .

$$V = C \sqrt{R S}$$

$$R = \frac{A}{P} = \left[ \frac{25 \times 3.5}{25 + 2 \times 3.5} \right] = 2.73 \text{ m}$$

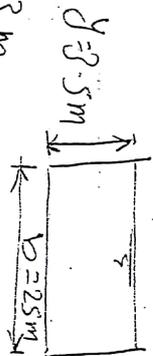
$$V = 50 * (2.73)^{1/2} * \left( \frac{12}{105} \right)^{1/2} = 0.905 \text{ m/sec}$$

$$E = \frac{V_{\text{max}}}{V_{\text{mean}}} - 1 = \frac{1.6}{0.905} - 1 = 0.768$$

$$A = 1 + 3E^2 - 2E^3 = 1.86$$

$$B = 1 + E^2 = 1.59$$

$$Q = V \cdot y = 0.905 * 3.5 = 3.17 \text{ m}^3/\text{sec/m}$$



(4)

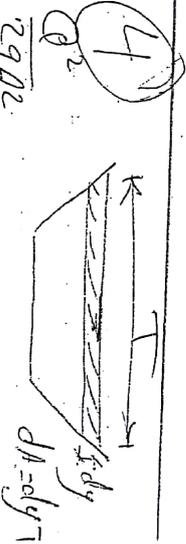
Question II

(a)  $E = y + \frac{V^2}{2g} = y + \frac{Q^2}{2gA^2}$

$$\frac{dE}{dy} = 1 + \frac{1}{2g} \left[ Q^2 * 2A^{-3} \frac{dA}{dy} + A^2 * 2g \frac{dQ}{dy} \right], \frac{dA}{dy} = T$$

$$\underset{=0}{=} 0 = 1 - \frac{Q^2 T}{A^3 g} \Rightarrow 1 = \frac{(Q/A)^2}{g} = \frac{V^2}{g}$$

$$1 = \frac{V}{\sqrt{gD_{\text{mean}}}} = Fr \Rightarrow \text{The flow is critical}$$



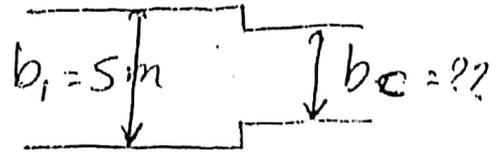
(2)

(b)  $Q = 20 \text{ m}^3/\text{sec}$ ,  $b = 5 \text{ m}$ ,  $y = 2.5 \text{ m}$ .

$$Fr = \frac{V}{\sqrt{g y}} = \frac{4/2.5}{\sqrt{9.81 \times 2.5}} = 0.323 < 1 \quad \text{Subcritical}$$

(i)  $E_1 = E_c$

$$y_1 + \frac{v_1^2}{2g} = 1.5 \sqrt[3]{\frac{q^2}{g}}$$



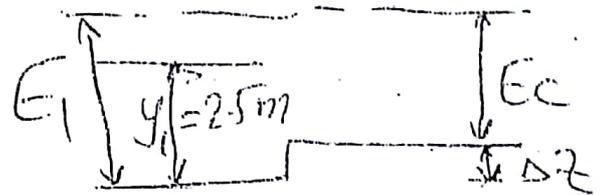
$$2.5 + \frac{(20/2.5 \times 5)^2}{2 \times 9.81} = 1.5 \sqrt[3]{\frac{9^2}{9.81}} \rightarrow q = 7.27$$

$$b_c = \frac{Q}{q} = \frac{20}{7.27} = \underline{\underline{2.75 \text{ m}}}$$

(2)

(ii)  $E_1 = E_c + \Delta z_c$

$$y_1 + \frac{v_1^2}{2g} = 1.5 \sqrt[3]{\frac{q^2}{g}} + \Delta z_c$$



$$2.5 + \frac{(20/2.5 \times 5)^2}{2 \times 9.81} = 1.5 \sqrt[3]{\frac{(20/5)^2}{9.81}} + \Delta z_c$$

$$\Delta z_c = \underline{\underline{0.865 \text{ m}}}$$

(2)

(iii) IF Hump is increased to 1.0m  $\rightarrow$  choking occurs

$$y_1 + \frac{q^2}{2g y_1^2} = 1.5 \sqrt[3]{\frac{q^2}{g}} + \Delta z_g$$

$$y_1 + \frac{4^2}{2 \times 9.81 y_1^2} = 1.5 \sqrt[3]{\frac{4^2}{9.81}} + 1.0$$

$$y_1 = \underline{\underline{2.65 \text{ m}}}$$

(2)

(3)