تالتة مدني

Hydraulics Sheet (1)

Mansoura University
Faculty of Engineering
Irrigation & Hydraulics Eng. Dept.

Sheet (1)

Hydraulics (II)
3rd Year Civil Engineering
2015 - 2016

❶ - Define the following terms:

a) Types and states of flow in the open channels.
b) Steady gradually varied flow and unsteady rapidly varied flow.
c) Smooth turbulent flow, and rough turbulent flow.
d) Concave and convex curvilinear flows.
e) The boundary layer thickness, and the turbulent boundary layer.
f) State the continuity equation of unsteady varied flow.

❷ - Compute the hydraulic radius (R), mean water depth (hydraulic depth) (D), section factor (Z), and Froude number for a triangular channel with side slope = 2:1, and water depth = 6 ft if the channel conveys a discharge of 6.0 cumecs.

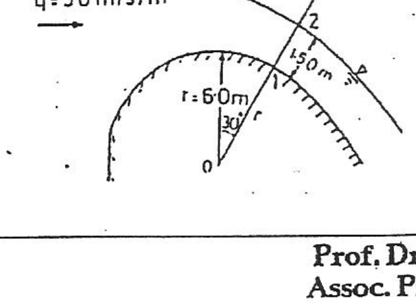
❸ - A smooth square plate 2.0m side is kept immersed in water, which moves at a velocity 40cm/sec, Find the Boundary layer thickness at a distance 0.6m from the leading edge. Take the kinematic viscosity of water as 10^{-6} m^2/sec.

❹ - A smooth plate of length 1.0 m and width 3.0 m is immersed parallel to air flow of velocity 2.0 m/sec. Find the drag force on one side of the plate and at the trailing edge find the boundary layer thickness and the displacement thickness. (For air: ρ =1.23 kg/m^3 and $\upsilon = 1.46*10^{-5}$ m^2/sec.)

❺ - While measuring the discharge in an open channel, it was found that the depth of flow increases at a rate of 0.1m/hr. If the discharge at the section was 12m^3/sec and the surface width was 15m. Estimate the discharge at 1km downstream.

❻ - Water flows through a concave curvilinear channel that has a 15 m radius of curvature; determine the pressure head if the velocity of water is 7 m/s and the flow depth is 3m.

❼ - A spillway crest having a circular arc of radius 6.0 m is shown in figure below. Estimate the pressure at point 1 when the discharge intensity is 5.0 m^3/sec per metre width by assuming constant velocity across section 1-2.



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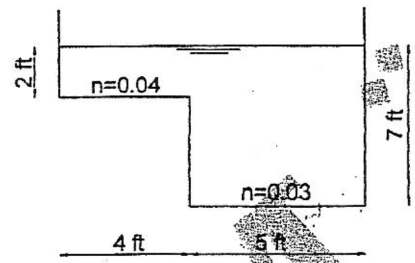
8- A wide stream carries approximately uniform flow at a depth of 3.5 m. The velocities at 0.2 and 0.8 depths are found to be 0.6 (maximum) and 0.4 m/sec respectively. Estimate:

(i) The discharge per unit width.

(ii) The values of momentum and energy coefficients.

9 - A rectangular channel has a longitudinal slope 10 cm/km, bed width 20 m Manning n=0.02, carries a discharge at a depth of 3.0m. It is found that the value of maximum water velocity is equal to 1.1m/s. Estimate the value of the energy and momentum coefficients. Estimate Chezy's coefficient, C, and the Darcy-Weisbach F.

10 - For the channel having the shown crossection and is laid on a slope of 0.0015, Determine the discharge and the velocity distribution coefficients.



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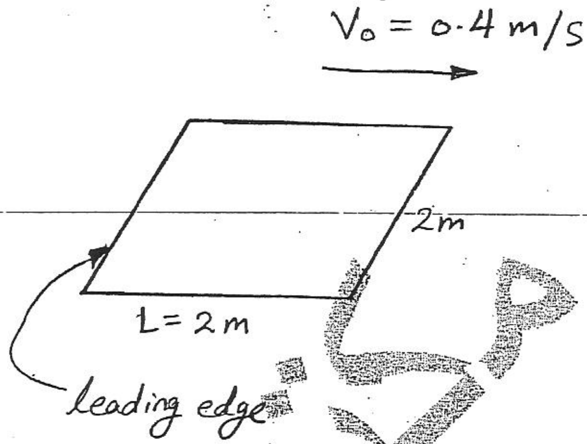
Prob (3):

Given:



~~square~~ Plate $L = 2m$

$V_o = 40$ cm/s $= 0.4$ m/s

$x = 0.6$ m

$\nu_{water} = 10^{-6}$ m^2/s

Required: $\delta_{0.6}$ "boundary layer thickness"

Sol:

$$R_x = \frac{V_o \cdot x}{\nu} = \frac{0.4 * 0.6}{10^{-6}} = 2.4 * 10^5 < 5 * 10^5$$

$\therefore$ laminar B.L.

$$\frac{\delta}{x} = \frac{5}{\sqrt{R_x}} \rightarrow \delta = \frac{5 * 0.6}{\sqrt{2.4 * 10^5}} = 6 * 10^{-3} \text{ m} = \boxed{0.6} \text{ cm}$$

Prob (4):

Given:

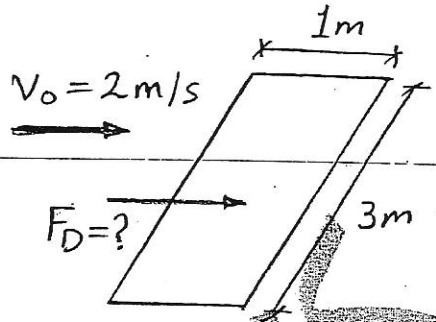
$V_o = 2\ m/s$

$x = 1\ m$

$\rho_{air} = 1.23\ Kg/m^3$

$\nu = 1.46 * 10^{-5}\ m^2/s$

Plate (1 m X 3 m)



Required: Drag force (F_D) on one side of the Plate, δ, δ_1

Sol:

$$R_x = \frac{V_o \cdot x}{\nu} = \frac{2 * 1}{1.46 * 10^{-5}} = 1.37 * 10^{5} \longrightarrow \text{laminar B.L.}$$

$$C_f = \frac{0.66}{\sqrt{R_x}} = \frac{0.66}{\sqrt{1.37 * 10^{5}}} = 1.78 * 10^{-3}$$

$$\delta = \frac{5x}{\sqrt{R_x}} = \frac{5 * 1}{\sqrt{1.37 * 10^{5}}} = 0.014\ m$$

$$\delta_1 = \frac{\delta}{3} = \frac{0.014}{3} = 0.0045\ m = 4.5\ mm$$

$$F_D = \tau_o * A = \frac{1}{2}\rho \cdot C_f \cdot V_o^2 \cdot A = \frac{1}{2} * 1.23 * 1.78 * 10^{-3} * 2^2 * (1*3)$$

$\rho \to Kg/m^3$, $V_o^2 \to m^2/s^2$, $A \to m^2$ $= [Kg \cdot m/s^2] = [N]$

$$F_D = \boxed{0.013}\ N$$

Prob (5):

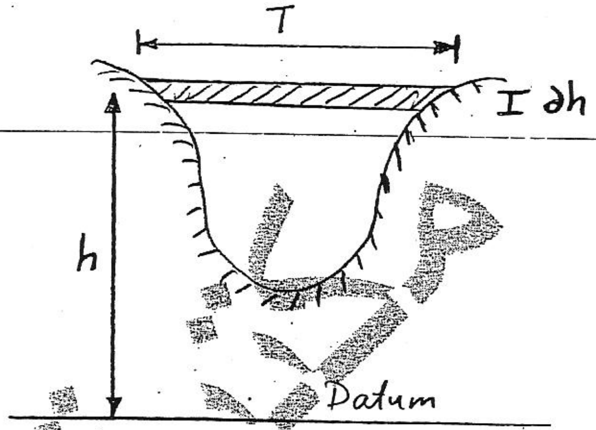
Given:

$$\frac{\partial h}{\partial t} = 0.1 \ m/hr$$

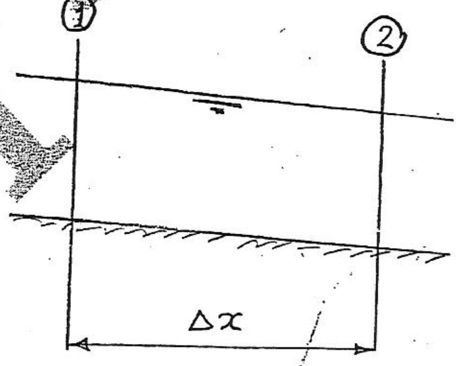
$$Q_1 = 12 \ m^3/s$$

$$T = 15 \ m$$

$$\Delta x = 1 \ Km = 1000 \ m$$



Required: Q_2



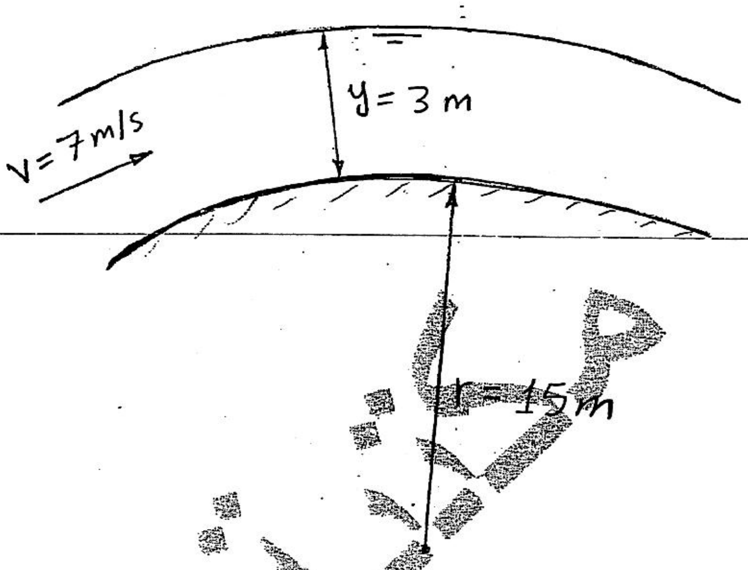
$$\frac{\partial Q}{\partial x} + T \cdot \frac{\partial h}{\partial t} = 0.0$$

$$\frac{Q_2 - Q_1}{\Delta x} + T \cdot \frac{\partial h}{\partial t} = 0.0$$

$$\frac{Q_2 - 12}{1000} + 15 * \frac{0.1}{60 * 60} = 0.0$$

get $Q_2 = \boxed{11.58} \ m^3/s$

Prob (6):



Given:

Convex channel

$r = 15\ m$

$V = 7\ m/s$

$y = 3\ m$

Required: $\frac{P}{\gamma}$ "pressure head"

Sol: $P = \gamma \cdot y - \gamma \cdot a = \gamma \cdot (y - a)$

$= \gamma \cdot \left(y - \frac{y}{g} \cdot \frac{V^2}{r}\right)$

$$\frac{P}{\gamma} = y\left(1 - \frac{1}{g} \cdot \frac{V^2}{r}\right) = 3 * \left(1 - \frac{1}{9.81} * \frac{7^2}{15}\right)$$

$= \boxed{2.0}\ m$

Prob (8):

Given: $y = 3.5\ m$, $V_{0.2y} = V_{max} = 0.6\ m/s$, $V_{0.8y} = 0.4\ m/s$

Required: q, α, β

Sol:

$$V_{mean} = \frac{V_{0.2y} + V_{0.8y}}{2} = \frac{0.6 + 0.4}{2} = \boxed{0.5}\ m/s$$

$$q = \frac{Q}{b} = \frac{V \cdot b \cdot y}{b} = V \cdot y = 0.5 * 3.5 = \boxed{1.75}\ m^3/s/m'$$

$$\epsilon = \frac{V_{max}}{V_m} - 1 = \frac{0.6}{0.5} - 1 = 0.2$$

$$\alpha = 1 + 3\epsilon^2 - 2\epsilon^3 = 1 + (3 * 0.2^2) - (2 * 0.2^3) = \boxed{1.104}$$

$$\beta = 1 + \epsilon^2 = 1 + 0.2^2 = \boxed{1.04}$$

note: $\alpha > \beta > 1$

Prob (9):

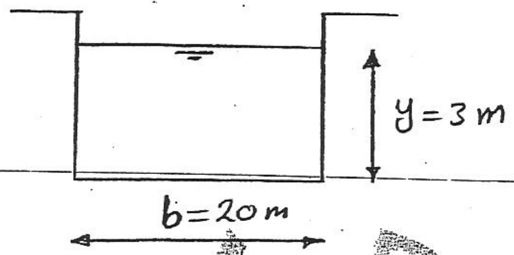
Given: $S = 10\ cm/Km = 10^{-4}$

$b = 20\ m$

$n = 0.02$

$y = 3.0\ m$

$V_{max} = 1.1\ m/s$



$A = b \cdot y = 20 * 3 = 60\ m^2$

$P = b + 2y = 20 + 2*3 = 26\ m$

$R = \frac{A}{P} = \frac{60}{26} = 2.3\ m$

Required: α, β, C, F

Sol:

$$V_m = \frac{1}{n} \cdot R^{2/3} \cdot \sqrt{S} = \frac{1}{0.02} * (2.3)^{2/3} * \sqrt{10^{-4}} = 0.87\ m/s$$

$$\epsilon = \frac{V_{max}}{V_m} - 1 = \frac{1.1}{0.87} - 1 = 0.26$$

$$\alpha = 1 + 3\epsilon^2 - 2\epsilon^3 = \boxed{1.16}$$: "energy coeff"

$$\beta = 1 + \epsilon^2 = \boxed{1.07}$$ "momentum coeff"

- $V_m = C \cdot \sqrt{R \cdot S} \rightarrow C = \frac{V_m}{\sqrt{R \cdot S}} = \frac{0.87}{\sqrt{2.3 * 10^{-4}}} = \boxed{57.4}$ "Chezy coeff"

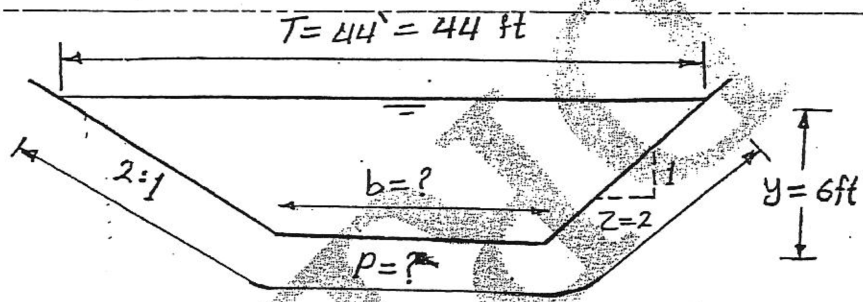
- $C = \sqrt{\frac{8g}{F}} \rightarrow 57.4 = \sqrt{\frac{8 * 9.81}{F}} \rightarrow \boxed{F = 0.02}$

"Darcy weisbach coeff"

2 - Compute the hydraulic radius (R), mean water depth (hydraulic depth) (D) and section factor (Z) for a trapezoidal channel with side slope (z)=2:1, Top width (T)=44 ft and water depth (y)=6 ft.

Prob (2):

Given:



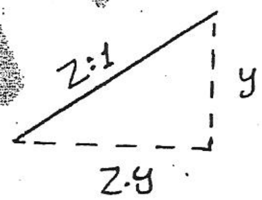
$Z = 2:1 = \frac{2}{1} = 2$

$T = 44\ ft$

$y = 6\ ft$

Required: R, D, Z

Sol:



HZ : VL

Z : 1

Zy : y

$b = T - 2*Z*y = 44 - 2*2*6 = 20\ ft$

$P = b + 2y*\sqrt{Z^2+1} = 20 + 2*6*\sqrt{2^2+1} = 46.8\ ft$

$A = b \cdot y + Z \cdot y^2 = 20*6 + 2*6^2 = 192\ ft^2$

$R = \frac{A}{P} = \frac{192}{46.8} = 4.1\ ft$

$D = \frac{A}{T} = \frac{192}{44} = 4.37\ ft$

$Z = A \cdot \sqrt{D} = 192*\sqrt{4.37} = 401\ ft^{2.5}$