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Section	A
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Question No# 1 Part (A)

(A) Let suppose a rectangular channel discharge 7809 litre/sec of water into a 8m wide apron with zero slope. Mean velocity is 7809-200 ft/sec.

Calcuta:-

1. Height of hydraulic Jump (In unit of m)
2. Power absorbed due to hydraulic Jump (In unit of KW)

Solution:-

⇒ Discharge = 7809 lit/sec ⇒ 7.809 m^3/sec

⇒ width of a-pron = 8m

⇒ Mean velocity = 7809-220 ⇒ 7589 ft/sec

① Height of Hydraulic Jump:-

As discharge per unit width is

$$q = \frac{Q}{b} \Rightarrow \frac{7.809}{8} \Rightarrow \boxed{0.976\, m^2/sec}$$

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⇒ As Critical depth y_c is

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{(0.976)^2}{9.81}\right)^{1/3}$$

$$y_c = 0.4596 \text{ m}$$

$$\boxed{y_c = 0.46 \text{ m}}$$

⇒ Know Critical velocity

As ⇒ $q = vy$

$$v = \frac{q}{y}$$

$$V_c = \frac{q}{y_c} \Rightarrow V_c = \frac{0.976}{0.46}$$

$$\boxed{V_c = 2 \text{ m/sec}}$$

As $V_1 > V_c$

Super-Critical Flow

Water Depth on upstream Side

$Q = AV$

$Q = (by)V$

$y = \frac{Q}{Vb}$

$y_1 = \frac{Q}{V_1 b}$

$y_1 = \frac{7.809}{2(8)}$

$\boxed{y_1 = 0.49m}$

Formula

$$y_2 = -\frac{y_1}{2} + \sqrt{\frac{y_1^2}{2} + \frac{2 y_1 V_1^2}{g}}$$

$$y_2 = -\frac{0.49}{2} + \sqrt{\frac{(0.488)^2}{2} + \frac{2(0.488)(2.16)^2}{9.81}}$$

$$\boxed{y_2 = 0.524 m}$$

⇒ Difference in depth.

$$\Delta y = y_2 - y_1$$

$$\Delta y = 0.524 - 0.488$$

$$\boxed{\Delta y = 0.036\ m}$$

As

$$\Delta E = E_1 - E_2$$

Also

$$Q_1 = Q_2$$

$$A_1V_1 = A_2V_2$$

$$b = b_1 = b_2$$

$$\cancel{b_1} y_1 v_1 = \cancel{b_2} y_2 v_2$$

$$V_2 = \frac{y_1 v_1}{y_2}$$

$$V_2 = \frac{0.488 \times 2313.5}{0.524}$$

$$\boxed{V_2 = 2154.5\ m/sc}$$

$$\Delta E = E_1 - E_2$$

$$E_1 - E_2 = \left(y_1 + \frac{v_1^2}{2g}\right) - \left(y_2 + \frac{v_2^2}{2g}\right)$$

$$E_1 - E_2 = 0.488 + \left(\frac{(2313.5)^2}{2(9.81)}\right) - \left(0.524 + \frac{(2154.5)^2}{2(9.81)}\right)$$

$$\boxed{E_1 - E_2 = 36208.527\ m}$$

(2) Power Dissipation in hydralic Jump :-

$$\Delta P = \rho g Q (E_1 - E_2)$$

$$\Delta P = 1000 \times 9.81 \times 7.809 (36208.527m)$$

$$\boxed{\Delta P = 2773800919.834\ W}$$

In KW

$$\boxed{\Delta P = 2773800.919\ KW}$$

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Question No # 1 Part (B)

(B) A Sluice gate controls the flow in a channel of width 4m. If the discharge is 7809 ft^3/sec and the upstream and downstream water depth is 2.9m and 1.1m respectively Calculate the down stream velocity.

Also state the type of flow at upstream and down stream side using any equation.

Solution:-

Given Data.

⇒ Channel width $(b) = 4m$

⇒ discharge $(Q) = 7809\ ft^3/se$

⇒ height of down stream side $= 1.1m$

⇒ height of upstream side $= 2.9m$

(1) Down stream velocity :

As Specific energy is

$$E_1 = E_2$$

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \quad \text{——— (1)}$$

we know

$$Q = AV$$

$$A_1 V_1 = A_2 V_2 \qquad b = b_1 = b_2$$

$$\cancel{b_1} y_1 V_1 = \cancel{b_2} y_2 V_2$$

$$y_1 V_1 = y_2 V_2$$

$$V_2 = \frac{y_1 V_1}{y_2}$$

$$V_2 = \frac{(2.9)\, V_1}{1.1}$$

$$\boxed{V_2 = 2.63 V_1}$$ — put in (1)

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$$2.9 + \frac{V_1^2}{2g} = \frac{1.1 + (2.63 V_1)^2}{2g}$$

$$2.9 + \frac{V_1^2}{2g} = 1.1 + \frac{6.91 V_1^2}{2g}$$

$$\frac{V_1^2}{2g} - \frac{6.91 V_1^2}{2g} = 1.1 - 2.9$$

$$\frac{-5.91 V_1^2}{2g} = -1.8$$

$$5.91 V_1^2 = 1.8 \times 2(9.81)$$

$$V_1 = \sqrt{\frac{1.8 \times 2(9.81)}{5.91}}$$

$$\boxed{V_1 = 2.44 \text{ m/sec}}$$

(2) Type of Flow at upstream and downstream side:

To Find this we will use Froud number.

$\Longrightarrow Fr_1 = \frac{V_1}{\sqrt{g y_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = \boxed{0.45}$

$Fr < 1$ {subcritical flow)

$\Longrightarrow Fr_2 \quad \frac{V_2}{\sqrt{g y_1}} = \frac{6.41}{\sqrt{9.81 \times 1.1}} = \boxed{1.95}$

$Fr > 1$ {Supercritical flow)

Question No # 2 Part (A)

(A) what is the minimum height (in the unit) of broad crested weir if it is to function critical depth on the crest. If water flows along a rectangular channel at a depth of 1.8m with a discharge of 7809 ft³/sec the channel width is 66 ft.

Solution:

⇒ Depth of channel = 1.8m

⇒ Discharge = 7809 ft³/sec

⇒ width of channel = 66 ft

⇒ P = weir height = ?

As we know

$$Q = AV$$

$$V = \frac{Q}{A} \Rightarrow V_1 = \frac{Q}{A} \Rightarrow \frac{Q}{b \times y}$$

$$V_1 = \frac{221.34}{20.1 \times 1.8} \Rightarrow \boxed{6.118 m/sec}$$

Critical Depth.

$$y_c = \left(\frac{(q)^2}{g}\right)^{1/3}$$

As, $q = \frac{Q}{b}$

$\Rightarrow$ ~~221.48/20.1~~

$$q = \frac{221.34}{20.1}$$

$$q = 11.1 m^3/sec$$

$$y_c = \left(\frac{(11.1)^2}{9.81}\right)^{1/3}$$

$$y_c = 2.324 m$$

$$\boxed{y_c = 2.32 m}$$

Know

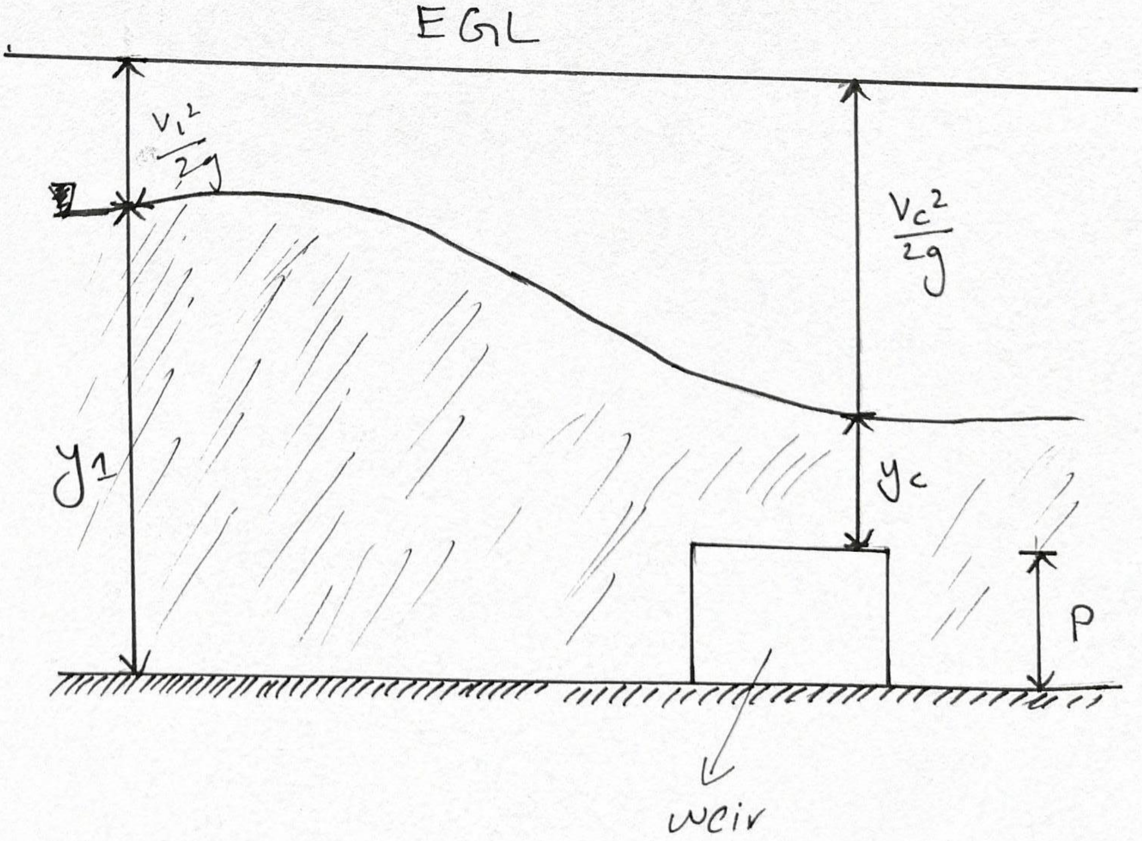
$$V = \sqrt{gy}$$

$$V_c = \sqrt{g\, y_c}$$

$$V_c = \sqrt{9.81 \times 2.324}$$

$$\boxed{V_c = 4.774 \text{ m/se}}$$

Figure.



P.T.O

(13)

$$\frac{V_1^2}{2g} + y_1 = \frac{V_c^2}{2g} + y_c + P$$

$$\frac{6.118^2}{2(9.81)} + 1.8 = \frac{4.774^2}{2(9.81)} + 2.324 + P$$

$$\frac{6.118^2}{19.62} + 1.8 = \frac{4.774^2}{19.62} + 2.324 + P$$

$$\frac{37.421}{19.62} + 1.8 = \frac{22.71}{19.62} + 2.324 + P$$

$$1.908 + 1.8 = 1.158 + 2.324 + P$$

$$3.708 = 3.48 + P$$

$$0.288 = P$$

$$\boxed{P = 0.288\,m}$$

(13) weir height should have 0.288m ~~from~~ measured from Channel bed.

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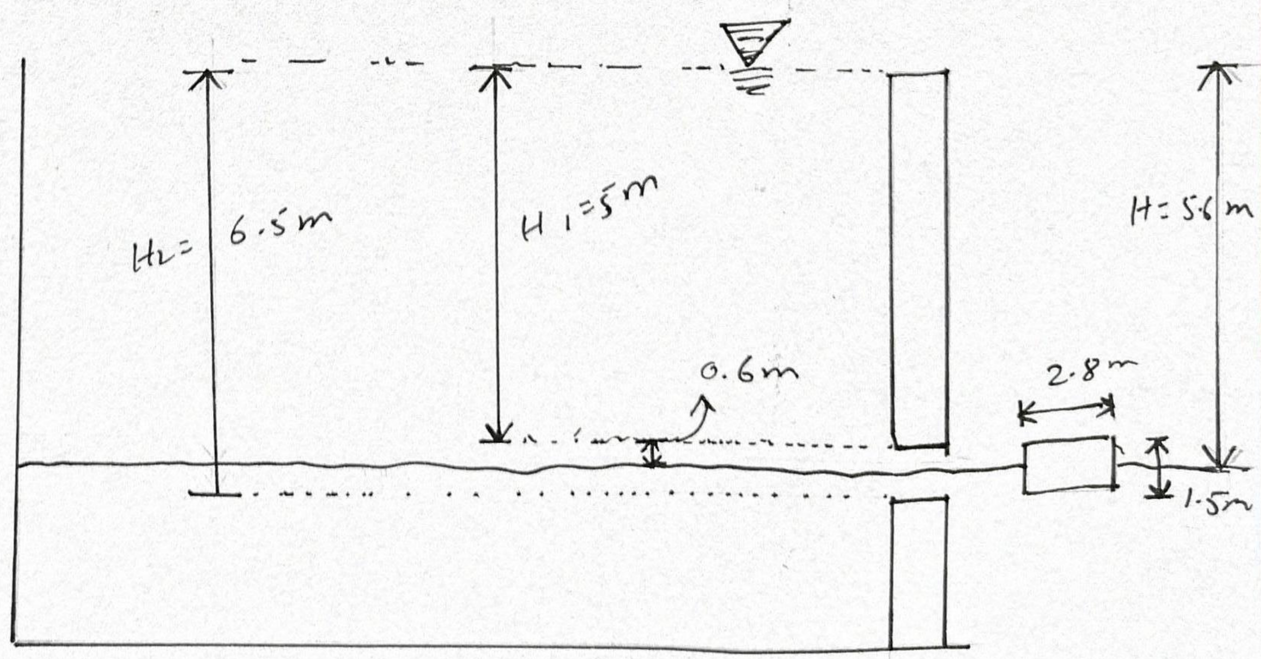
Question No#2 Part (B)

(B) The orifice in one side of large tank is rectangular in shape 2.8m broad and 1.5m deep. The water level on one side of the orifice is 5 meter above its top edge. The water level on the other side of th orifice is ~~5m~~ 0.6m below it top edge. Calculate the discharge through the orifice if Cofficient of discharge is Cd = 0.7809

Figure



(15)

Given

⇒ width = 2.8 m
⇒ depth = 1.5 m
⇒ H_1 = 5 m
⇒ H_2 = 6.5 m
⇒ H = 5.6 m
Cd = 0.7809

Submerged portion.

$Q_1 = cd \times b \times (H_2 - H) \times \sqrt{2gH}$

$Q_1 = 0.78 \times 2.8 \times (6.5 \times 5.6) \times \sqrt{2(9.81) \times 5.6}$

$Q_1 = 20.59\ m^3/sec$

Free portion:

$Q_2 = \frac{2}{3} \times cd \times b \sqrt{2g} \times [H^{3/2} - H_1^{3/2}]$

$Q_2 = \frac{2}{3} \times 0.78 \times 2.8 \sqrt{2(9.81)} \times 5.6^{3/2} - 5^{3/2}$

$Q_2 = 13.360\ m^3/sec$

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Total discharge =

$$Q = Q_1 + Q_2$$

$$Q = (20.592 + 13.360)\ m^3/sec$$

$$\boxed{Q = 33.5\ m^3/sec}$$

Question No # 3 Part (A)

(A) The diameter of a water pipe is suddenly enlarged 7809- 200mm to 7809+3000mm. The rate of the flow through Is $0.95 m^3/sec$ and the pressure in the larger pipe is 7809+800 N/m^2.

1. The loss of Head due to sudden ~~ed~~ enlargement.
2. The Powe loss due to sudden enlargement
3. The pressure in the smaller Pipe (If the pipe is horizontal)

Solution:

⇒ diameter = d_1 = 7809 - 200mm ⇒ 7609mm

⇒ diameter = d_2 = 7809 + 300mm ⇒ 8109mm

⇒ Flow rate = Q ⇒ $0.95 m^3/sec$

⇒ Pressure in big Pipe = ~~R~~ 7809 + 800 N/m^2 ⇒ 8609 N/m^2

(1) Loss of Head due to Sudden enlargement:

$d_1 = 7609\ mm \Rightarrow 7.60\ m$

$d_2 = 8109\ mm \Rightarrow$ ~~8.8~~ $8.10\ m$

$A_1 = \frac{\pi}{4} d^2 \Rightarrow 45.34$

$A_2 = \frac{\pi}{4} d^2 \Rightarrow 51.5$

$Q = AV$

$V = \frac{Q}{A_1}$

$\Rightarrow V_1 = \frac{0.95}{45.34} \Rightarrow$ **0.02 m/sec**

$V_2 = \frac{Q}{A_2}$

$\Rightarrow V_2 = \frac{0.95}{51.5} \Rightarrow$ **0.018 m/sec**

② So By formula of sudden elargement.

$$h_e = \left(1 - \frac{A_1}{A_2}\right)^2 \times \left(\frac{V_1 - V_2}{2g}\right)^2$$

$$h_e = \left(1 - \frac{45.3}{51.5}\right)^2 \times \left(\frac{0.020 - 0.018}{2g}\right)^2$$

$$h_e = 0.014 \left(\frac{4 \times 10^{-6}}{19.62}\right)$$

$$\boxed{h_e = 2.95 \times 10^{-9}\ m}$$

② **Power loss due to Sudden enlargement:**

$$P = \rho g Q h_e$$

$$P = (1000)(9.81)(0.95)(2.95 \times 10^{-9})$$

$$\boxed{P = 2.74 \times 10^{-5}\ W}$$

(3) Pressure in smaller Pipe

Use Bernoulli's Equation

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_e.$$

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2(9.81)} = \frac{8605}{(1000)(9.81)} + \frac{(0.018)^2}{2(9.81)} + 2.95\times 10^{-9}$$

$$\frac{P_1}{9810} + 0.0000203 = 0.877 + 0.0000165 + 2.95\times10^{-9}$$

$$\frac{P_1}{9810} + 0.0000165 + 2.95\times10^{-9} - 0.0000203$$

$$\frac{P_1}{9810} = 0.876$$

$$P_1 = 0.876\times9810$$

$$\boxed{P_2 = 8593.56 N/m^2}$$

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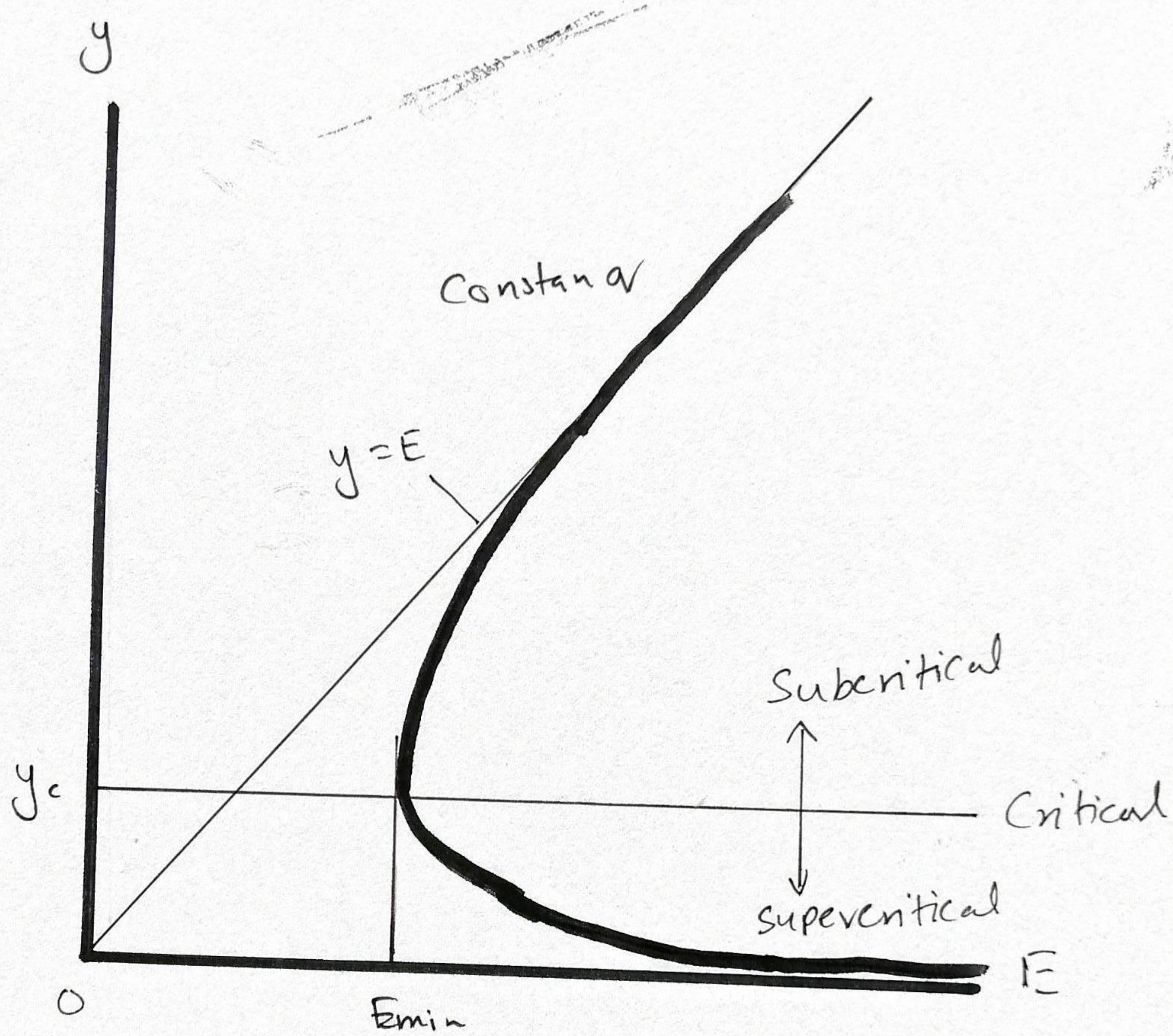
Question No # 3 Part (B)



What does this blue curve indicate How it is obtained Explain the above figure from each and every point of view.

P.T.O

Blue Curve :-

From the Figure the blue curve is the three degree polynomial curve which shows the flow is critical, sub critial or super critical flow

⇒ The middle point shows the depth of water is equal to the critical depth coresponding to minimum energy so the flow is critical flow.

$y = y_c$ and $E = E_{min}$

⇒ The top point show the depth of water is greather then the critical depth.

~~y<y~~ $y > y_c$ and $E > E_{min}$

⇒ The Lower point show the depth of water is less then the critical depth $y < y_c$ and $E < E_{min}$

Specific Energy :-

Specific Energy is the parameter that Can be used to clarify the meaning of Subcritical, critical and Supercritical flow an in open channel. The graph shows the depth of water y and critical depth y_c.

Critical depth :-

Critical depth is the depth of water at which minimum Specific energy is obtained.

Equation of Specific Energy:

From the ~~degi~~ derivation of Specific energy equation there is three degree polynomial equation is obtained.

P.T.O

$$(E-y)\,y^2 = q^2/2g \quad \text{———} \; ☆$$

E = Specific Energy

y = depth of water.

q = discharge per unit width in unit of m^2/sec.

END

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