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* **Question # 01**

(Part: A) :- Let suppose a rectangular channel, discharges R liter/sec of water into a 8m wide apron with zero slope. Mean velocity is R-220 ft/sec
Calculate:
1) Height of hydraulic jump (in meter)
2) Power absorbed due to hydraulic Jump (in KW)

* **Given data:**

Rectangular channel, discharge = 7879 Lit/sec.

$\Rightarrow$ for $m^3 = \frac{7879}{1000} = \boxed{7.879\ m^3/sec.}$

Apron width = $\boxed{8m}$

Mean velocity = 7879 - 220
= 7659 ft/sec for m

$\frac{7659}{3.28} = \boxed{2335.06\ m/sec}$

* **Sol:**

* **Height of Hydraulic Jump:** As we know

"q" is discharge per unit width.

$q = Q/b$, = $\frac{7.879}{8}$ = $0.984\ m^2/sec$

$\boxed{q = 0.984\ m^2/sec}$

* **Critical depth:**

As we know critical depth (y_c) is

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{(0.984)^2}{9.81}\right)^{1/3}$$

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

* **Critical velocity:**

As we know

$$q = vy \Rightarrow v = q/y$$

$$v_c = \frac{q}{y_c} \Rightarrow v_c = \frac{0.984}{0.46}$$

$$\boxed{v_c = 2.13\,m/sec}$$

As $v_1 > v_c$ Super critical flow.

* **water depth on upstream side is :- (of hydraulic jump)**

$$Q = Av$$

$$Q = (by)\cdot v$$

$$y = \frac{Q}{v \cdot b} \Rightarrow y_1 = \frac{Q}{v \cdot b}.$$

$$y_1 = \frac{7.879}{2.13 \times 8} = \boxed{0.46\,m}.$$

By formula:

$$y_2 = -\frac{y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2 y_1 v_1^2}{g}}$$

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$$y_2 = \frac{0.46}{2} + \sqrt{\frac{(0.46)^2}{2} + \frac{2(0.46)(2.13)^2}{9.81}}$$

$$\boxed{y_2 = 0.49\,m}$$

* **Difference in depth:**

$\Delta y = y_2 - y_1$

$0.49 - 0.46 = 0.03m$

As

$\Delta E = E_1 - E_2$

Also

$Q_1 = Q_2$

$A_1 v_1 = A_2 v_2$

$b_1 \cdot y_1 \cdot v_1 = b_2 \cdot y_2 \cdot v_2$

$\cancel{b} \cdot y_1 \cdot v_1 = \cancel{b} \cdot y_2 \cdot v_2 \quad (b = b_1 = b_2)$

$$v_2 = \frac{y_1 v_1}{y_2} = \frac{0.46 \times 2335.06}{0.49}$$

$$\boxed{v_2 = 2192.09\ m/sec}$$

$\Rightarrow \Delta E = E_1 - E_2$

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

$$E_1 - E_2 = \left(0.46 + \frac{(2335.06)^2}{2(9.81)}\right) - \left(0.49 + \frac{(2192.09)^2}{2(9.81)}\right)$$

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$E_1 - E_2 = 277905.92 - 244916.82$

$E_1 - E_2 = 32989.1 m$

* Power Dissipation in hydraulic Jump:

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

$\Delta p = (1000)(9.81)(7.879)(32989.1)$

$\Delta p = 2549826176 w \quad \div 1000.$

$\Delta p = 2549826.176 kw$

* Question no 1:

* Part (b):- A sluice gate controlls the flow in a chanel width 4m. If the discharge is R ft³/sec and the upstream and down stream water depth is 2.9m and 1.1m respectively, Calculate:
Down stream velocity;
Also state the type of flow at upstream and down stream side using any equation.

* Given Data:

Discharge = 7879 ft^3/sec

Channel width = 4m

height of upstream side = 2.9m

height of down stream side = 1.1m

* Sol:

* Down Stream Velocity:-

As Specific energy is

$E_1 = E_2$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g} \longrightarrow (1)$$

$Q = AV$

$\Rightarrow A_1V_1 = A_2V_2$

$(b_1 y_1)\cdot v_1 = (b_2 y_2) v_2$

$\cancel{b}\cdot y_1 \cdot v_1 = \cancel{b}\cdot y_2 \cdot v_2$ $\quad (b = b_1 = b_2)$

$y_1 v_1 = y_2 v_2$

$\Rightarrow v_2 = \frac{y_1 v_1}{y_2}$

$v_2 = \frac{(2.9)}{(1.1)} v_1$

$\boxed{v_2 = 2.63 v_1}$ ⟶ Put in eq ①.

$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g}.$

$2.9 + \frac{v_1^2}{2g} = 1.1 + \frac{(2.63 v_1^2)}{2g}$

$2.9 + \frac{v_1^2}{2g} = 1.1 + \frac{6.91 v_1^2}{2g}$

$\frac{v_1^2}{2g} - \frac{6.91 v_1^2}{2g} = 1.1 - 2.9$

$\cancel{-}\frac{5.91 v_1^2}{2g} = \cancel{-} 1.8$

$5.91 v_1^2 = 1.8 \times 2(9.81)$

$v_1 = \sqrt{\frac{1.8 \times 2(9.81)}{5.91}}$

$\boxed{v_1 = 2.44 m/sec}$

Put in v_2

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$V_2 = 2.63(2.44)$

$V_2 = 6.41 \, m/sec$

* **Types Of flow Using froud Number**

① **on upstream Side:-**

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

$Fr < 1$ (sub-critical flow)

② **On down stream Side:-**

$$Fr_2 = \frac{V_2}{\sqrt{g y_2}} = \frac{6.41}{\sqrt{9.81 \times 1.1}} = 1.95$$

$Fr > 1$ (Super-Critical flow)

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* Question no: 2

Part (a):-

* Given data:

Depth of channel = 1.8 m

Discharge = 7879 ft³/sec

$= \frac{7879}{(3.28)^3} = \boxed{223.27\, m^3/sec}$

width of channel = 66 ft = 20.1 m.

Required:

P = weir height = ?

Sol:-

As $Q = AV$, $V = Q/A$

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

$V_1 = \frac{223.27}{20.1 \times 1.8} = \boxed{6.17\, m/sec}$.

Critical Depth:-

$y_c = \left(\frac{q^2}{g}\right)^{1/3}$, As , $q = Q/b = \frac{223.27}{20.1}$

$\boxed{q = 11.10\, m^2/sec}$.

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{(11.10)^2}{9.81}\right)^{1/3}$$

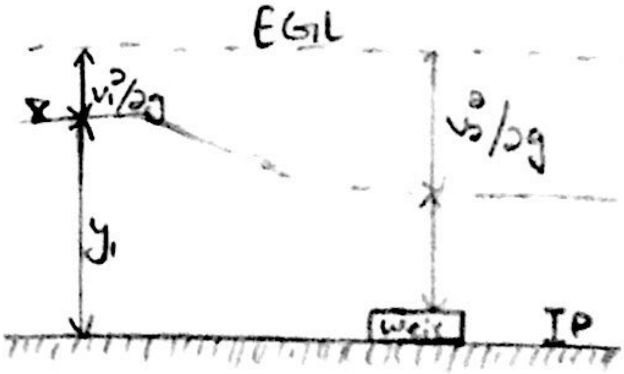
$$\boxed{y_c = 2.32\ m}$$

Also

$$V = \sqrt{gy} \quad , \quad V_c = \sqrt{g y_c}$$

$$V_c = \sqrt{9.81 \times 2.32}$$

$$\boxed{V_c = 4.77\ m/sec}$$



From the figure:

$$\frac{V_1^2}{2g} + y_1 = \frac{V_2^2}{2g} + y_c + P$$

$$\frac{(6.17)^2}{2(9.81)} + 1.8 = \frac{(4.77)^2}{2(9.81)} + 2.32 + P.$$

$$3.74 = 3.47 + P$$

$$0.27\ m = P$$

$\boxed{P = 0.27m}$ The weir should have height of 0.27m.

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* Question no2:-

(Part:B):-

* Given data:-

width = 2.8m

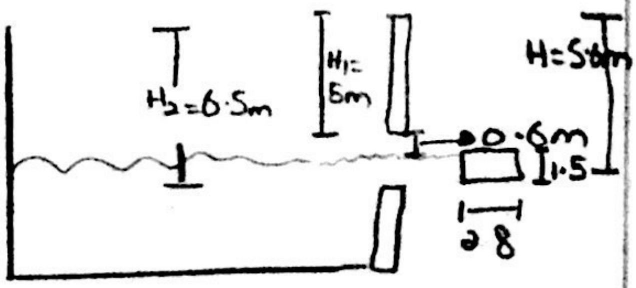
depth = 1.5m

$H_1 = 5m$

$H_2 = 6.5m$

$H = 5.6m$

$Cd = 0.7879$



* Sol:-

* Submerged Portion:-

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

$$Q_1 = 0.7879 \times 2.8(6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$$

$$\boxed{Q_1 = 20.81 m^3/sec}$$

* Free Portion:-

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

$$Q_2 = \frac{2}{3}(0.7879) \times (2.8)\sqrt{2(9.81)} \times [5.6^{3/2} - 5^{3/2}]$$

$$\boxed{Q_2 = 13.49 m^3/sec}$$

Total = $Q_1 + Q_2$

$$Q_T = 20.81 + 13.49$$

$$\boxed{Q_T = 34.3 m^3/sec}$$

* Question no 3:-

Part (A):-

* **Given data:-**

$d_1 = R - 200mm$

$7879 - 200 = \boxed{7679mm}$

$d_2 = R + 3000mm$

$= 7879 + 3000mm = \boxed{10879mm}$

Flow rate $(Q) = \boxed{0.95\ m^3/sec}$

Pressure in large pipe $= P + 800 N/m^2$

$= 7879 + 800 \Rightarrow \boxed{8679\ N/m^2}$

* **Required:**

1) The loss of head due to sudden enlargment.
2) The power loss due to sudden enlargement.
3) The pressure in the similar pipe (If the pipe is horizontal)

* **Solution:-**

* **Loss of head due to sudden enlargment.**

$d_1 = 7679mm = \boxed{7.679m.}$

$A_1 = \frac{\pi}{4} d^2 \Rightarrow \frac{\pi}{4}(7.679)^2 = \boxed{46.31\ m^2.}$

$d^2 = 10879mm = \boxed{10.879m}$

$A_2 = \frac{\pi}{4} d^2 \Rightarrow \frac{\pi}{4}(10.879)^2 \Rightarrow \boxed{92.95\ m^2}$

As $Q = Av$, $v = Q/A$

$\Rightarrow v_1 = Q/A_1 \Rightarrow \frac{0.95}{46.31}$, $v_1 = 0.020$ m/sec

$\Rightarrow v_2 = Q/A_2 \Rightarrow \frac{0.95}{92.95}$, $v_2 = 0.010$ m/sec

1) Sudden enlargement

$$h_e = \left(1 - \frac{A_1}{A_2}\right)^2 \times \left(\frac{v_1 - v_2}{2g}\right)^2$$

$$h_e = \left(1 - \frac{46.31}{92.95}\right)^2 \times \left(\frac{0.020 - 0.010}{2(9.81)}\right)^2$$

$$h_e = (0.251)(5.09 \times 10^{-4})$$

$$h_e = 1.277 \times 10^{-4} \text{ m}$$

2) Power loss due to sudden enlargement.

$$P = \rho \cdot g \cdot Q \cdot h_e$$

$$P = (1000)(9.81)(0.95)(1.277 \times 10^{-4})$$

$$P = 1.190 \text{ W}$$

3) Pressure in Smaller Pipe.

$\Rightarrow$ using bernoulie equation:

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + h_e$$

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$$\frac{P_1}{\rho g} + \frac{(0.020)^2}{(2)\times(9.81)} = \frac{8679}{(1000)\times(9.81)} + \frac{(0.010)^2}{(2)\times(9.81)} + 1.27\times10^{-4}$$

$$\frac{P_1}{9810} + 2.038\times10^{-5} = 0.884 + 5.09\times10^{-6} + 1.27\times10^{-4}$$

$$\frac{P_1}{9810} + 2.038\times10^{-5} \doteq 0.884$$

$$\frac{P_1}{9810} = 0.884$$

$$P_1 = 0.884\times9810$$

$$\boxed{P_1 = 8672.93\ N/m^2}$$

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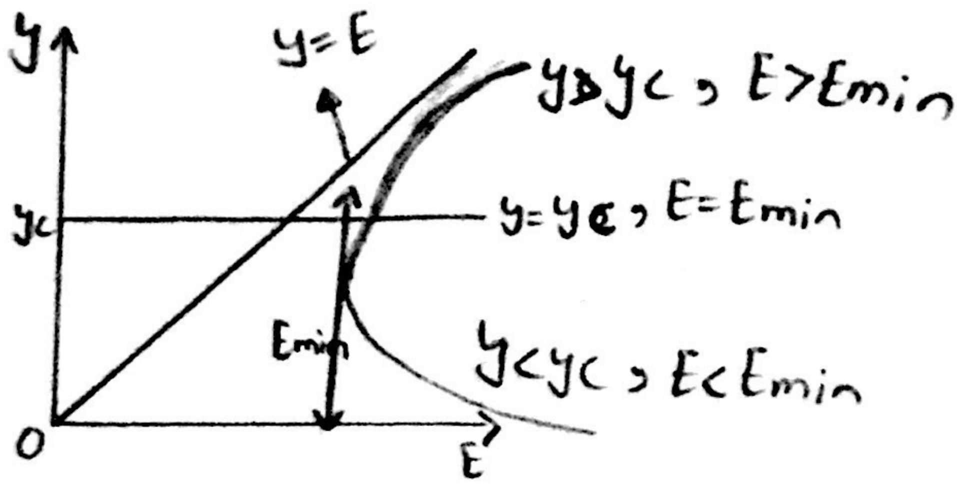
QNo: 3

Part (B):

Specific Energy:

Definition:-

The parameter "specific energy" can be used to clarify the meaning of super critical, critical and sub critical flow. in an open chanel



$y \propto E$

⇒ Blue curve indicates the flow either in which category it exist (super critical or critical or sub critical).

⇒ It is obtained as. when

$y > y_c$, $E > E_{min}$ (subcritical flow)

$y = y_c$, $E = E_{min}$ (critical flow).

$y < y_c$, $E < E_{min}$ (super critical flow).