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Q1: Let Suppose a rectangular channel, discharges 7547 liter/sec. of water into 8m wide apron with zero slop. Mean velocity is R - 220 ft/sec.
Calculate: (i) Height of hydraulic jump. (In unit of meter)
ii) power absorbed due to hydraulic jump. (In unit of kw)

Solution: Discharge = 7547 lit/sec $\frac{7547}{1000}$
= 7.547

width of apron = 8m
Mean velocity = 7547 - 220
= ~~22~~ 7327 ft/sec
$\frac{7327}{3.28}$ = 2233.84 m/sec

=> Height of hydraulic jump.
As 'q' is discharge per unit width

$$q = Q/b = \frac{7.547}{8}$$

$$\boxed{q = 0.943\ m^2/sec}$$

=> As critical depth (y_c) is

$$y_c = (q^2/g)^{1/3} = \left(\frac{(0.943)^2}{9.81}\right)^{1/3}$$

$$\boxed{y_c = 0.449}$$

=> critical velocity:

As $q = vy$ => $v = q/y$

=> $v_c = q/y_c = \frac{0.943}{0.449}$

=> $\boxed{v_c = 2.1 \, m/sec}$

As $v_1 > v_c$

super critical flow

=> water depth on upstream side is: (of hydraulic jump)

$Q = AV$

$Q = (by).v$

$y = Q/v.b$ => $y_1 = Q/v.b$

$$y_1 = \frac{7.547}{2.14 \times 8} = \boxed{y_1 = 0.44 \, m}$$

By formula.

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

$$y_2 = \frac{-0.44}{2} + \sqrt{\frac{(0.44)^2}{4} + \frac{2(0.44)(2.14)^2}{9.81}}$$

$$\boxed{y_2 = 0.457 \, m}$$

⇒ Difference in depth

$$\Delta y = y_2 - y_1$$
$$= 0.457 - 0.44$$
$$\boxed{\Delta y = 0.017\,m}$$

As $\Delta E = E_1 - E_2$

Also

$$Q_1 = Q_2$$
$$A_1 V_1 = A_2 V_2$$
$$b_1 y_1 V_1 = b_2 y_2 V_2$$
$$\cancel{b} \cdot y_1 \cdot V_1 \quad \cancel{b} \cdot y_2 \cdot V_2$$

$$V_2 = \frac{y_1 V_1}{y_2} = \frac{(0.44)(2233.84)}{0.457}$$
$$\boxed{V_2 = 2150.74\ m/sec}$$

⇒ Difference in specific Energy. (ΔE)

$$\Delta E = E_1 - E_2$$
$$\left(y_1 + \frac{V_1^2}{2g}\right) - \left(y_2 + \frac{V_2^2}{2g}\right)$$
$$\left(0.44 + \frac{2233.84}{2(9.81)}\right) - \left(0.457 + \frac{(2150.74)^2}{2(9.81}\right)$$
$$\boxed{\Delta E = 18570.75}$$

⇒ Power dissipation in hydraulic jump.

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

$$1000 \times 9.81 \times 7.547 \times 18570.75$$

$$\Delta P = 1374905347\ W$$

$$\boxed{\Delta P = 1374905.347\ kW}$$

Q1B

Q1 B:. A Sluice gate controls the flow in a channel of width 4m. If the discharge is 75.47 ft^3/sec and the upstream and downstream water depth is 2.9m and 1.1m respectively, Calculate the downstream velocity.
Also state the type of flow at upstream and downstream side using any equation.
~~Sto~~

Solution:

Channel width (b) = 4m
Discharge = 75.47 ft^3/sec
height of upstream side = 2.9m
" " downstream side = 1.1m

=> Downstream velocity:-

As specific Energy is

$$E_1 = E_2$$

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

Also from discharge

$$Q = AV$$

$$\Rightarrow A_1V_1 = A_2V_2$$

$$(b_1y_1).V_1 = (b_2y_2).V_2$$

$$\cancel{b}.y_1.V_1 = \cancel{b}.y_2.V_2$$

$$y_1V_1 = y_2V_2$$

$$\Rightarrow V_2 = \frac{y_1V_1}{y_2}$$

$$\Rightarrow V_2 = \frac{(2.9)}{(1.1)}V_1 \Rightarrow \boxed{V_2 = 2.63V_1}$$

Put eq (1)

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

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

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

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

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

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

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

$\Rightarrow$ Put in V_2 equation

$$V_2 = 2.63(2.44)$$

$$\boxed{V_2 = 6.41\,m/sec}$$

Type of flow using Froud Number

(1) <u>On upstream Side:-</u> $Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.45$

$Fr < 1$

Sub-critical flow.

(2) <u>On downstream Side:</u>

$$Fr_2 = \frac{V_2}{\sqrt{gy_2}} = \frac{6.41}{\sqrt{9.81 \times 1.1}} = 1.95$$

$Fr > 1$

(Super-Critical flow)

Q2A:: What is the minimum height (In unit of meter) of broad crested weir if it is to funtion critical depth on the crest If water flows along a rectangular channel at a depth of 1.8m with a discharge of 7547 ft^3/sec the channel width is 66ft.

Solution::

depth of Channel = 1.8m

Discharge = 7547 ft^3/sec

$\frac{7547}{3.28} \Rightarrow 213.87 \, m^3/sec$

width of Channel = 66ft = 20.1m

P = Weir height = ?

As

$Q = AV$

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

$V_1 = \frac{213.87}{20.1 \times 1.8} \Rightarrow 5.91 \text{ m/sec}$

=> critical Depth::

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

As,

$q = Q/b = 213.87/20.1 \Rightarrow 10.6 \text{ m}^2/\text{sec}$

$\Rightarrow y_c = \left(\frac{(10.6)^2}{9.81}\right)^{1/3} \Rightarrow \boxed{y_c = 2.25m}$

Also

$v = \sqrt{gy}$

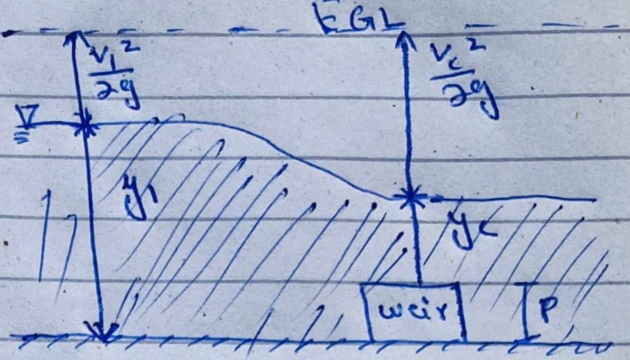
$V_c = \sqrt{g y_c}$

$V_c = \sqrt{9.81 \times 2.25} = 4.69$

$$\boxed{V_c = 4.69 \text{ m/sec}}$$

Scanned with CamScanner

From the figure



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

$$\frac{(5.91)^2}{2(9.81)} + 1.8 = \frac{(4.69)^2}{2(9.81)} + 2.25 + P$$

$$3.580 = 3.371 + P$$

$$\boxed{P = 0.209\ m}$$

The weir should have height of ~~0.20~~ 0.209 measured from the channel bed level.

Q2B: An orifice in one side of large tank is rectangular in shape 2.8 m broad and 1.5m deep. The water level on one side of the orifice is 5meter above its top edge. The water level on the other side of the orifice is 0.6m below its top edge. Calculate the discharge through orifice it co-efficient of discharge is cd=0 R.

Solution. Given Data.

width, $b = 2.8m$

depth, $d = 1.5m$

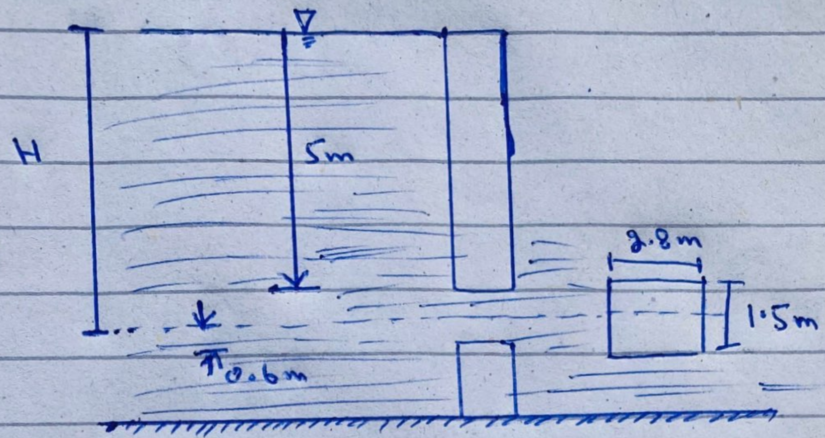
$H_1 = 5m$

$H_2 = 5 + 1.5 = 6.5m$

$H = 5 + 0.6 = 5.6m$

$Cd = 0.7547$

Discharge $Q = ?$



Solution.

As By Formula.

⇒ Discharge through Submerged Portion

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

$$= 0.7547 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$$

$$\boxed{Q = 19.93}$$

⇒ Discharge Throug free Portion:

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

$$= \frac{2}{3} \times 0.7547 \times 2.8 \sqrt{2(9.81)}\left[(5.6)^{3/2} - (5)^{3/2}\right]$$

$$\boxed{Q_2 = 12.92 \text{ m}^3/\text{sec}}$$

⇒ Total discharge

$$Q = Q_1 + Q_2$$

$$= 19.93 + 12.92$$

$$\boxed{Q = 32.85 \text{ m}^3/\text{sec}}$$

Q3A The diameter of a water pipe is suddenly enlarged from R-200mm to R+3000mm, the rate of flow through is 0.95 m^3/sec and the pressure in the larger pipe is R+800 N/m^2

Calculate:

(i) Loss of head due to Sudden enlargement

(2) The Power lost due to sudden enlargement.

(3) The Pressure in the smaller Pipe (if Pipe is horizental)

Solution:⇒

Given Data.

$d_1 = R - 200$

$7547 - 200 = 7347$

$d_2 = R + 3000$

$7547 + 3000 = 10547$

Flow rate, $Q = 0.95 m^3/sec$

Pressure in larger pipe = R+800

$= 7547 + 800$

$= 8347 N/m^2$

(i) The loss of head Due to Sudden Enlargment:

$d_1 = 7347mm \Rightarrow 7.347m$

$A_1 = \frac{\pi}{4}d^2 \Rightarrow \frac{\pi}{4}(\cancel{7.057}\ 7.347)^2$

$\boxed{A_1 = 42.39 m^2}$

$d_2 = 10547mm \Rightarrow 10.547m$

$A_2 = \frac{\pi}{4}d^2 \Rightarrow \frac{\pi}{4}(10.547)^2$

$\boxed{A_2 = 87.36 m^2}$

As

$$Q = AV$$

$$V = Q/A$$

So

$$V_1 = \frac{Q}{A_1} = \frac{0.95}{42.39}$$

$$\boxed{V_1 = 0.0224 \text{ m/s}}$$

Similarly:

$$V_2 = \frac{Q}{A_2} = \frac{0.95}{87.36}$$

$$\boxed{V_2 = 0.0108 \text{ m/sec}}$$

Finding head loss By Formula.

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

$$= \left(1 - \frac{42.39}{87.36}\right)^2 \frac{(0.022 - 0.010)^2}{2(9.81)}$$

$$\boxed{h_e = 1.944 \times 10^{-6} \text{ m}}$$

(b) Power lost due to Sudden Enlargment:

$$P = \rho g Q h_e$$

$$= (1000)(9.81)(0.95)(1.944 \times 10^{-6})$$

$$\boxed{P = 0.0181 \text{ W}}$$

C. Pressure In the smaller Pipe:

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

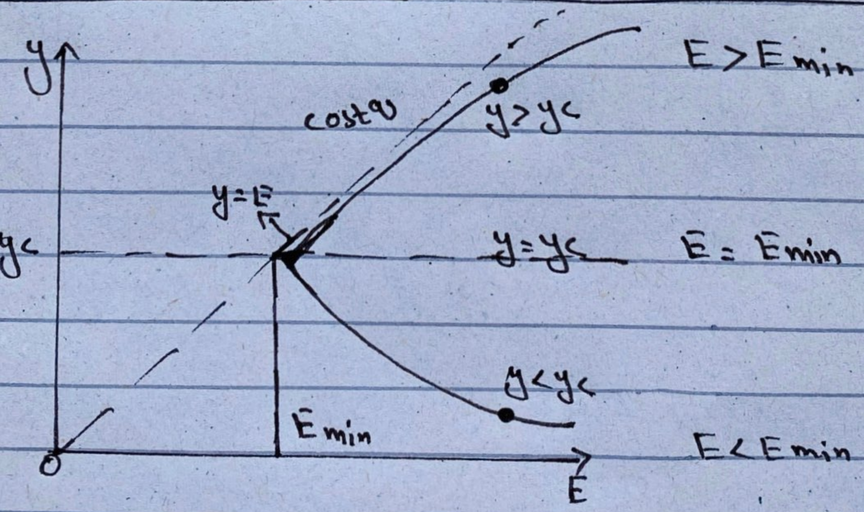
$$\frac{P_1}{9810} + \frac{(0.02)^2}{2(9.81)} = \frac{8347}{9810} + \frac{(0.01)^2}{2(9.81)} + 1.944 \times 10^{-6}$$

$$\Rightarrow \frac{P_1}{9810} + 2.038 \times 10^{-5} = 0.850$$

$$P_1 = 0.850 \times 9810$$

$$\boxed{P_1 = 8338.5 \ N/m^2}$$

Q3B



The eq 3 is the three degree Polynomial equation and can be used to prepare a plot of specific energy and depth of water (E-y)

How it is obtained:

As we know that

Total Energy = Potential energy + Kinectic energy

$$T.E = P.E + K.E$$

$$= mgh + \frac{1}{2} mv^2$$

$$= Wh + \frac{1}{2}\frac{W}{g}v^2 \qquad \because W = mg, \; m = W/g$$

ignoring 'w' weight of water

$$T.E = h + \frac{v^2}{2g}$$

$$\boxed{T.E = y + \frac{v^2}{2g}}$$

As we know that $Q = Av$

$V = Q/A \Rightarrow V^2 = Q^2/A^2$

Put v^2 in eq 1

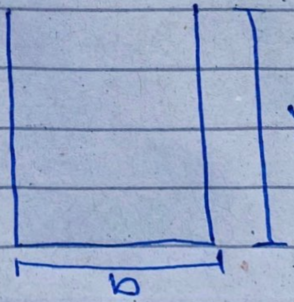
$$E = y + \frac{Q^2}{A^2 2g} \quad — 2$$

Let Suppose the channel is rectangular

$A = y \times b \longrightarrow x$

Also $Q = q b \longrightarrow y$

Put x & y in eq 2



$$E = y + \frac{Q^2}{A^2 2g} \quad — 3$$

$$E = y + \frac{Q^2}{y^2 b^2 2g} \quad \text{putting } x$$

$$E = y + \frac{q^2}{2gy} \quad (\text{Putting } y)$$

$$E - y = \frac{q^2}{2gy^2}$$

$$(E-y)y^2 = \frac{q^2}{2g}$$

$$(E-y)y^2 = \text{Constant} \rightarrow eq^3 \rightarrow eq\ 3$$

As q & g are constant.

⟹ Critical depth is flow depth corresponding to minimum specific energy

$y > y_c$ Subcritical flow

$y = y_c$ critical flow

$y < y_c$ Super critical flow

The End