Paper: Hydrolic Engineering:

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Q1 A: Let suppose a . . . .
. . . . jump (in unit of kw).

Given data!

Channel width = $b = 8m$.

discharge = $Q = 7.313\ m^3/sec$.

Velocity = $V = R - 220\ ft/sec$.

$V = 7313 - 220 = 7093\ ft/sec$.

$V = 2161.941\ m/sec$.

Solution:-

$$Q = qb.$$

$$q = \frac{Q}{b} = \frac{7.313}{8} = 0.9\ m^2/sec$$

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

$$= \left(\frac{(0.9)^2}{9.81}\right)^{1/3}$$

$$y_c = 0.43\ m.$$

$$q = yv$$

$$V_c = \frac{q}{y_c} = \frac{0.9}{0.43} = 2.1\ m/sec.$$

$V_1 > V_c$ Super critical

Depth of water on the upstream side of the jump.

$$Q = AV$$

$$Q = byV.$$

$$Y = \frac{Q}{bV}$$

$$Y_1 = \frac{Q}{b \times V_1} = \frac{7.313}{8 \times 2.1}$$

$$\boxed{Y_1 = 0.435m}$$

$$Y_2 = \frac{Y_1}{2} + \sqrt{\frac{Y_1^2}{4} + \frac{2Y_1V_1^2}{g}}$$

$$Y_2 = \frac{0.435}{2} + \sqrt{\frac{(0.435)^2}{4} + \frac{(2 \times 0.435) \times (2.1)^2}{9.81}}$$

$$Y_2 = -0.2175 + \sqrt{0.047 + 0.391}$$

$$Y_2 = -0.2175 + 0.6618.$$

$$\boxed{Y_2 = 0.444m}$$

$$\Delta Y = Y_2 - Y_1$$

$$\Delta Y = 0.444 - 0.435$$

$$\boxed{\Delta Y = 0.009m}$$

$\Delta E = E_1 - E_2$.

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

$$y_1 V_1 = y_2 V_2$$

$$V_2 = \frac{y_1 V_1}{y_2} = \frac{0.435 \times 2162}{0.444}$$

$$V_2 = 2118.17 \text{ m/sec.}$$

$$\Delta E = E_1 - E_2 = \left(y_1 + \frac{V_1^2}{2g}\right) - \left(y_2 + \frac{V_2^2}{2g}\right)$$

$$= 0.435 + \frac{(2162)^2}{2(9.81)} - \left(0.444 + \frac{(2118.17)^2}{2 \times 9.81}\right)$$

$$= 0.435 + \frac{4674244}{19.62}\Big) - \Big(0.444 + \frac{4486644.149}{19.62}\Big)$$

$$= 0.435 + 238238.73 - 0.444 + 228,677.07.$$

$$= 238239.165 - 228,677.154$$

$$E_1 - E_2 = 9561.651 \text{ m}.$$

Dissipation of power in Hydrolic Jump:

$$\Delta p = \rho g Q (\varepsilon_1 - \varepsilon_2)$$

$$\Delta p = 1000 \times 9.81 \times 7.313 (9561.651).$$

$$\boxed{\Delta p = 685957{,}910.41}$$

Q1B:- A sluice gate. . . . .
. . . . Using any equation.

Given data!

Width of channel, $b = 4m$.

Discharge, $Q = 207 \ m^3/sec$.

Upstream water depth $y_1 = 2.9m$.

downstream water depth $y_2 = 1.1m$.

Required:-

Down stream velocity $= V_2 = ?$

Solution:-

Specific Energy at upstream and downstream.

$$E_1 = E_2.$$

$$y_1 + \frac{V_1^2}{2g} = y = \frac{V_2^2}{2g} \longrightarrow eq \ 1.$$

Also:-

$$Q_1 = A_1 V_1 = A_2 V_2.$$

$$= b_1 y_1 V_1 = b_2 y_2 V_2.$$

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

$$y_1 V_1 = y_2 V_2.$$

$$\frac{2.9 \ V_1}{1.1} = \frac{1.1 \ V_2}{1.1}$$

$$V_2 = \frac{2.9}{1.1} V_1 \rightarrow 2.$$

$$V_2 = 2.63 V_1.$$

Subtituting values in eq ①.

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g}$$

$$2.9 + \frac{V_1^2}{2g} = 1.1 + \frac{V_2^2}{2g}$$

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

$$\frac{V_1^2}{2g} - \frac{6.9\,V_1^2}{2g} = 1.1 - 2.9$$

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

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

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

$$\frac{V_1^2}{2g} = 0.304$$

$$V_1^2 = 0.304 \times 9.81 \times 2.$$

$$V_1^2 = 5.91$$

$$\sqrt{V_1^2} = \sqrt{5.91}$$

$$V_1 = 2.43 \text{ m/sec.}$$

Put in eq ① to find V_2.

Eq ① ⇒ $y_1 + \frac{V_1^2}{2g} = y_2 - \frac{V_2^2}{2g}$

$$2.9 + \frac{(2.43)^2}{2g} = 1.1 + \frac{V_2^2}{2g}$$

$$2.9 + \frac{5.91}{2\times 9.81} = 1.1 + \frac{V_2^2}{2g}$$

$$2.9 + 0.301 = 1.1 + \frac{V_2^2}{2g}$$

$$3.20 - 1.1 = \frac{V_2^2}{2g}$$

$$2.10 = \frac{V_2^2}{2g}$$

$$2.10 \times 2g = \frac{V_2^2}{\cancel{2g}} \times \cancel{2g}$$

$$2.10 \times 2g = V_2^2$$

$$\sqrt{V_2^2} = \sqrt{2.10 \times 2 \times 9.81}$$

$$\sqrt{V_2^2} = \sqrt{41.20}$$

$$V_2 = 6.41 \text{ m/sec}$$

To find type of flow we use froud number upstream for.

$$Fr_1 = \frac{V_1}{\sqrt{g y_1}} = \frac{2.43}{\sqrt{9.8 \times 2.9}}$$

$$Fr_1 = \frac{2.43}{5.33}$$

$Fr_1 = 0.45$ Super critical flow.

Down stream - Fr_2

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

$$Fr_2 = \frac{6.41}{3.28}$$

$Fr_2 = 1.95$ Sub. critical flow.

Q No 2: A- What is the minimum - - - -
- - - - - - - - - width is 66 ft.

Given data!

$y = 1.8\ m.$

$b = 20.11\ m.$

$Q = 7.313\ ft^3/sec = 7.313\ m^3/sec.$

Required data!

$P =$ weir hight = ?

Solution:-

$$V_1 = \frac{Q}{A} = \frac{Q}{By}$$

$$V_1 = \frac{7.313}{20.11 \times 1.8} = \frac{7.313}{36.196}$$

$$V_1 = 0.2020\ m/sec.$$

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

$Q = q b.$

$q = \frac{Q}{b}.$

$$Y_c = \left(\frac{(7.313)^2}{(20.11)^2 \times 9.81}\right)^{1/3}.$$

$$Y_c = \left(\frac{53.479}{404.41 \times 9.81}\right)^{1/3} = \left(\frac{53.479}{3967.28}\right)^{1/3}$$

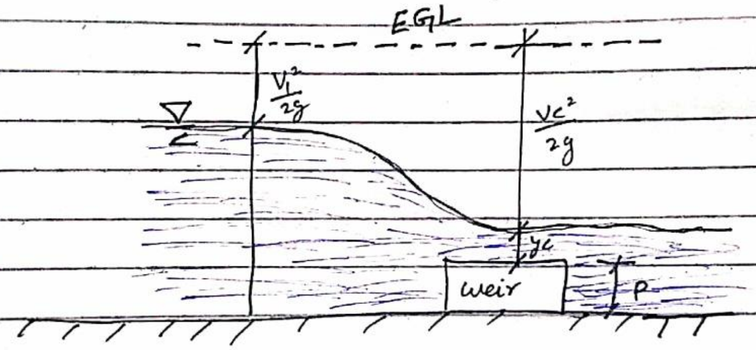
$$Y_c = \cancel{0.237\ m}.\ 0.237\ m.$$

$$V = \sqrt{gY}$$

$$V_c = \sqrt{gY_c}$$

$$V_c = \sqrt{9.81 \times 0.237}$$

$$V_c = 1.524 \text{ m/sec.}$$



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

$$= \frac{(0.2020)^2}{19.62} + 1.8 = \left(\frac{(1.524)^2}{19.62} + 0.237 + P\right)$$

$$2.079 \times 10^{-3} + 1.8 = 1.043 + 0.237 + P.$$

$$P = 0.522 \text{ m.}$$

Thus the weir should have a hight of 0.522 m measured from the bed level.

Q No 2: B:- An orifice in one . . . .
. . . . $Cd = 0.R$

Given data!

$b = 2.8\ m$

$d = 1.5m$

$H_1 = 5m$

$H_2 = 5 + 1.5 = 6.5m$

$H = 5 + 0.6 = 5.6m$

$Cd = 0.73$

Required:-

$Q = ?$

Solution:-

Discharge through Submerge portion.

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

$= 0.73 \times 2.8 \times (6.5 - 5.6) \times (\sqrt{2 \times 9.81 \times 5.6}$.

$Q_1 = 2.04 \times 0.9 \times 10.48$

$\boxed{Q_1 = 19.27\ m^3/sec}$

Discharge through free portion.

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

$Q_2 = \frac{2}{3} \times 0.73 \times 2.8 \sqrt{2 \times 9.81} \left[(5.6)^{3/2} - (5)^{3/2}\right]$

$= 0.66 \times 0.73 \times 2.8 \times 4.42 \times (13.25 - 11.18)$

$= 0.66 \times 0.73 \times 2.8 \times 4.42 \times 2.07$

$$\boxed{Q_2 = 12.29 \ m^3/sec}$$

Total discharge = $Q = Q_1 + Q_2$

$Q = 19.27 + 12.29$

$$\boxed{Q = 31.56 \ m^3/sec}$$

Q No 3 A:- The diameter . . . . if the pipe is horizontal.

Given data /

$P_1 = 7313 + 800\ N/m^2 = 8113\ N/m^2$

$d_1 = 7313 + 200 = 7313\,mm = 7.113\,m.$

$A_1 = \frac{\pi}{4} d^2 = \frac{3.14}{4} \times (7.113)^2$

$A_1 = 39.71\,m^2.$

$d_2 = 7313 + 3000 = 10313\,mm = 10.313\,m.$

$A_2 = \frac{\pi}{4} d^2 = \frac{3.14}{4} (10.313)^2$

$A_2 = 83.50\,m^2.$

$Q = 0.95\,m^3/sec.$

$Q = AV.$

$V = \frac{Q}{A}.$

$V_1 = \frac{Q}{A_1} = \frac{0.95}{39.71}$

$\boxed{V_1 = 0.024\ m/sec}$

$V_2 = \frac{Q}{A_2} = \frac{0.95}{83.50}$

$\boxed{V_2 = 0.011\ m/sec}$

A):- Head loss due to sudden enlargement.

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

$$h_e = \left(1 - \frac{39.74}{83.90}\right)^2 \frac{(0.024 - 0.011)^2}{19.62}$$

$$h_e = 0.275 \frac{(0.013)^2}{19.62}$$

$$h_e = 0.275 (8.613 \times 10^{-6}).$$

$$\boxed{h_e = 2.368 \times 10^{-6} m}$$

B:- Power loss due to sudden enlargement.

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

$$P = 1000 \times 9.81 \times 0.95 \times 2.368 \times 10^{-6}.$$

$$\boxed{P = 0.022 \, w}$$

C: The pressure in the larger pipe if the pipe line is horizontal.

Apply Bernouil equation.

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

$$\frac{8113}{1000 \times 9.81} + \frac{(0.024)^2}{2(9.81)} = \frac{P_2}{1000 \times 9.81} + \frac{(0.011)^2}{2 \times 9.81} + 2.368 \times 10^{-6}$$

$$\frac{8113}{9810} + \frac{(5.76 \times 10^{-4})}{19.62} = \frac{P_2}{9810} + \frac{(1.2 \times 10^{-4})}{1962} + 2.368 \times 10^{-6}$$

$$0.827 + 2.93 \times 10^{-5} = \frac{P_2}{9810} + 6.167 \times 10^{-6} + 2.368 \times 10^{-6}$$

$$0.830 = \frac{P_2}{9810} + 1.46 \times 10^{-11}$$

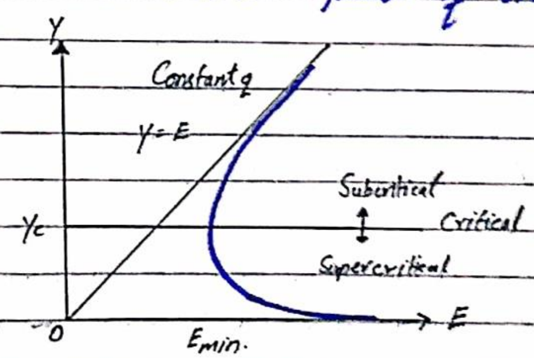
$$0.830 = \frac{P_2}{9810} + 1.46 \times 10^{-11}$$

$$0.830 - 1.46 \times 10^{-11} = \frac{P_2}{9810}$$

$$0.830 - 1.46 \times 10^{-11} \times 9810 = P_2$$

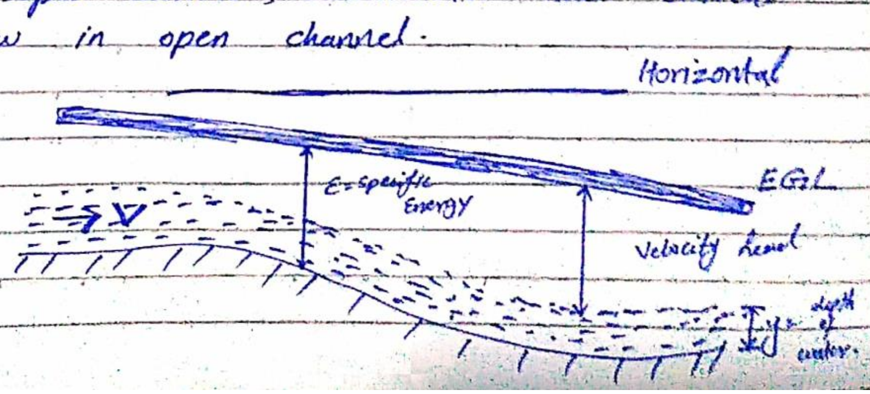
$$\boxed{P_2 = 0.829\ N/m^2}$$

Q3B:- What does this blue . . . . point of view.



Specific Energy & Critical depth:-

The parameter, specific energy can be used to clarify the meaning of super critical, subcritical and critical flow in open channel.



Y = Water depth.
V = flow velocity.
EGL = Energy grade line (Energy line).
E = Specific Energy.

Specific energy at any cross sectional in an open channel is the sum of kinetic energy due to velocity and depth of water.

Specific energy = Depth of water + K.E.

$$E = y + \frac{V^2}{2g} \rightarrow (1).$$

As we know that $Q = AV$.

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

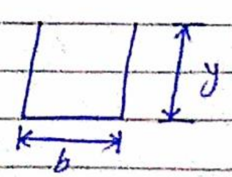
$$V^2 = \frac{Q^2}{A^2}$$

Put V^2 in eq (1).

$$E = y + \frac{Q^2}{A^2 2g} \longrightarrow (2).$$

Let suppose the channel is rectangular so then $A = y \times b. \longrightarrow (x)$.

Also $Q = qb$.



∴ "Q" Total discharge.
q is discharge at specific Area.
b = bridth of channel.

$Q = q\,b.$

$$q = \frac{Q}{b} \rightarrow (y)$$

Putting eq (x) and (y) in eq (2).

$$\mathcal{E} = y + \frac{Q^2}{A^2 2g} \rightarrow \text{eq } (2).$$

$$\mathcal{E} = y + \frac{Q^2}{y^2 \times b^2 \times 2g} \rightarrow (x) \text{ put.}$$

$$\mathcal{E} = y + \frac{q^2}{y^2 \times 2g} \text{ — } (y) \text{ — put.}$$

$$\mathcal{E} = y + \frac{q^2}{2gy^2}.$$

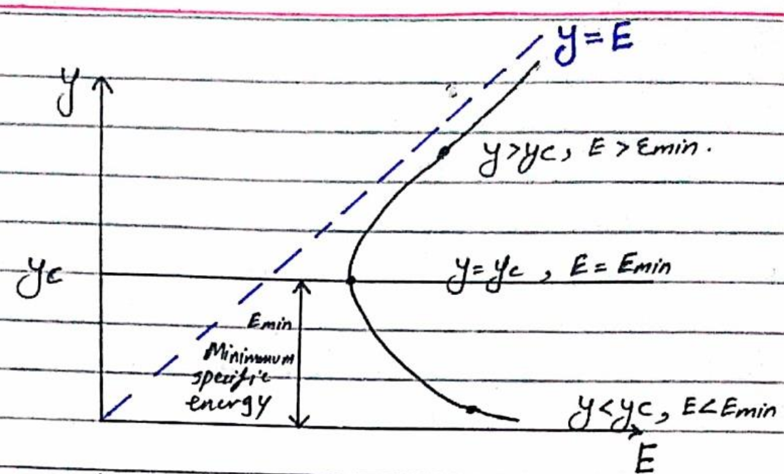
$$\mathcal{E} - y = \frac{q^2}{2gy^2}$$

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

$$(\mathcal{E} - y)\,y^2 = \text{Constant} \text{ — } (3).$$

As q, $2g$ are constant.

Equation (3) can be used to prepare a plot of specific energy "E".



Critical depth:-

Critical depth is flow depth corresponding to minimum specific energy.

$\therefore$ $y > y_c$ —— Sub critical flow.

$y = y_c$ —— Critical flow.

$y < y_c$ —— Super Critical flow.