Mulhaar
ID:- 7789
Section:- A
Semester: 6th
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# Question No:- 1 (a)

## Given Data:-

Discharge, $Q = 7789$ litre/sec => $7.789 m^3/sec$
width, $b = 8m$.
Mean velocity = $7789 - 220$
$= 7569 ft/sec$
$= \frac{7569}{3.28}$
$= 2307.6 m/sec$

## Required Data:-

Height of hydraulic jump = ?
Power absorbed = ?

## Solution:-

a) Height of hydraulic jump:-

$qb = Q$
or
$q = Q/b$
$q = \frac{7.789 m^3/sec}{8m}$

$q = 0.973 m^2/sec$

For critical depth we have,

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

$$y_c = \left[\frac{(0.973)^2}{9.81}\right]^{1/3}$$

**$y_c = 0.458m$**

=> Critical velocity is;

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

$V_c = \frac{q}{y_c} \Rightarrow V_c = \frac{0.973}{0.458}$

**$V_c = 2.12 \, m/sec$**

So $v > V_c$ it is super critical flow.

=> Depth of water on upstream side.

$Q = AV$

$Q = (by).V$

$y = \frac{Q}{b.V}$

$y_1 = \frac{Q}{b.V}$

$y_1 = \frac{7.789}{8 \times 2.12}$

**$y_1 = 0.4592m$**

By formula;

$$y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1v_1^2}{g}}$$

$$= \frac{-0.4592}{2} + \sqrt{\frac{(0.4592)^2}{4} + \frac{2(0.4592)(2.12)^2}{9.81}}$$

**$y_2 = 0.460m$**

Now $\Delta y = y_2 - y_1$

$= 0.4692 - 0.4592$

$\boxed{\Delta y = 0.01 m}$

As;

$\Delta E = E_1 - E_2$

$Q_1 = Q_2$ $\quad \therefore Q = AV$

$A_1 V_1 = A_2 V_2$

$b_1 y_1 v_1 = b_2 y_2 v_2$

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

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

$V_2 = \frac{(0.459)(2307.6)}{(0.46)}$

$\boxed{V_2 = 2302.5 \text{ m/sec}}$

Since

$\Delta E = E_1 - E_2$

$E_1 - E_2 = \left(y_1 + \frac{v_1^2}{2g}\right) - \left(y_2 + \frac{V_2^2}{2g}\right)$

$= \left[0.459 + \frac{(2307.6)^2}{2(9.81)}\right] - \left[0.46 + \frac{(2302.5)^2}{2(9.81)}\right]$

$= 271408.09 - 270209.74$

$\Delta E = 1198.35$

Putting in formula for power dissipation.

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

$= (1000)(9.81)(7.789)(1198.35)$

$\boxed{\Delta P = 91566031.35 \text{ Watts}}$

# Question 1:- (b)



## Given Data:-

width, (b) = 4m.

$Q = 7789 ft^3/sec$

height of upstream side = 2.9m.

height on downstream side = 1.1m

## Required Data :-

Downstream velocity = ?

## Solution:-

As we know

$E_1 = E_2$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \quad \text{— (1)}$$

$\therefore Q = AV$

$A_1V_1 = A_2V_2$

$b_1y_1v_1 = b_2y_2V_2$

$\cancel{b}y_1V_1 = \cancel{b}y_2V_2 \qquad \therefore b = b_1 = b_2$

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

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

$$V_2 = 2.63V_1 \quad \text{— (2)}$$

Putting eq (2) in (1)

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

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

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

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

$$5.91V_1^2 = 1.8 \times 2 \times 9.8$$

$$V_1 = \sqrt{\frac{1.8 \times 2(9.8)}{5.91}}$$

$$\boxed{V_1 = 2.44 m/sec} \quad -(3)$$

Putting equation (3) in eq (2)

$$V_2 = 2.63(2.44)$$

$$\boxed{V_2 = 6.41 m/sec} \quad -(4)$$

## Froud Number:-

Upstream side

$$F_{r_1} = \frac{V_1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.45$$

$F_r = 0.45 < 1 \rightarrow$ subcritical flow

downstream side

$$F_{r_2} = \frac{V_2}{\sqrt{gy_2}} = \frac{6.41}{\sqrt{9.81 \times 1.1}} = 1.95$$

$F_r = 1.95 > 1 \rightarrow$ supercritical flow.

# Question No:- 2 (a)

## Given Data:-

Depth, $d = 1.8m$

$Q = 7789 \, ft^3/sec$

$= 7789/3.28 = ~~2374.6~~ \; 220.7 \, m^3/sec$

width, $w = 66ft \Rightarrow 20.1m$

**Required :-** $P$ = weir height = ?

## Solution :-

We know that

$Q = AV$

$V = Q/A \Rightarrow V_1 = Q/A$ $\quad \therefore A = b \times y$

$$V = \frac{Q}{b \times y}$$

$$V = \frac{220.7 \, m^3/sec}{20.1 \times 1.8}$$

$$\boxed{V_1 = 6.10 m/sec}$$

For critical Depth :-

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

$$q = Q/b \Rightarrow \frac{220.7}{20.1}$$

$$\boxed{q = 10.9 \, m^2/sec}$$

$$y_c = \left[ \frac{(10.9)^2}{9.81} \right]^{1/3}$$

$$\boxed{y_c = 2.29\,m}$$

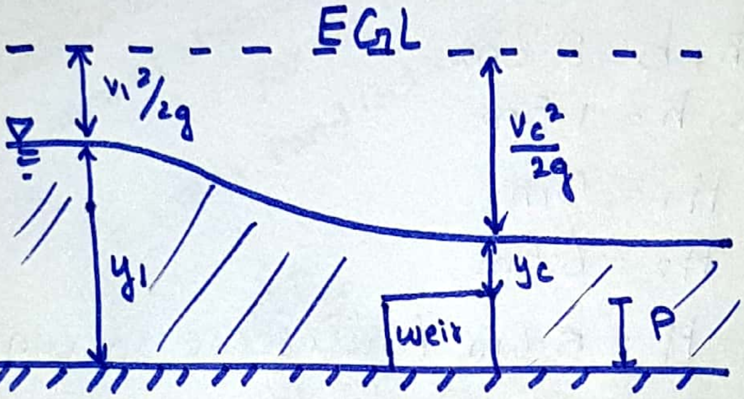
Also,

$$V = \sqrt{gy}$$

$$V_c = \sqrt{gy_c}$$

$$V_c = \sqrt{9.81(2.29)}$$

$$\boxed{V_c = 4.739\,m/sec}$$




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

$$\frac{(6.10)^2}{2(9.81)} + 1.8 = \frac{(4.739)^2}{2(9.81)} + 2.29 + P$$

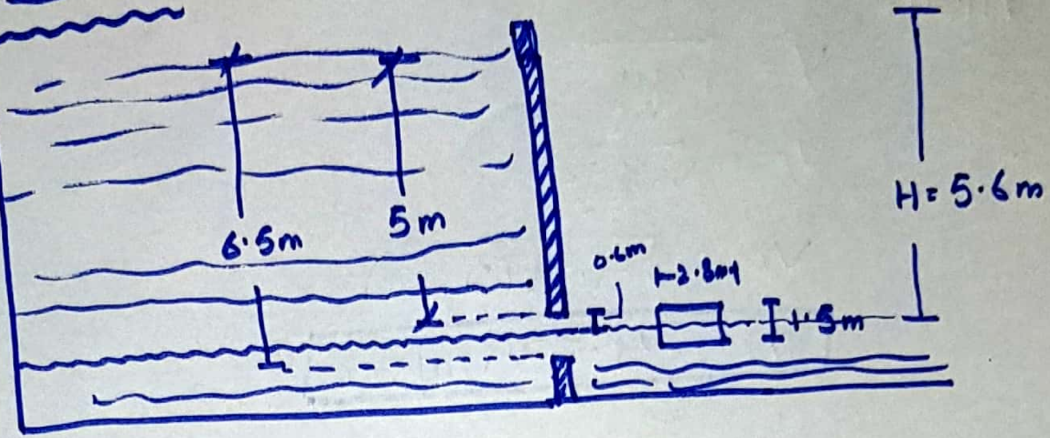
$$3.69 = 3.43 + P$$

$$\boxed{P = 0.255}$$

The weir should have a height of 0.223m from the bed of the channel.

# Question No:- 2(b)

## Given Data:-




width, $b = 2.8m$
depth, $h = 1.5m$
$H_1 = 5m$
$H_2 = 6.5m$
$H = 5.6m$ (difference in water level)
$Cd = 0.77$

## Solution:-

### Submerged Portion:-

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

$$Q_1 = 0.77 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2(9.8 \times (5.6)}$$

$$\boxed{Q_1 = 20.32 m^3/sec}$$

### Free Portion:-

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

$$Q_2 = \frac{2}{3}(0.77) \times (2.8)\sqrt{2 \times 9.81} \times [5.6^{3/2} - 5^{3/2}]$$

$$Q_2 = 13.18 m^3/sec$$

Total Discharge "Q":

$$Q = Q_1 + Q_2$$

$$Q = 20.32 + 13.18$$

$$Q = 33.5 m^3/sec$$

# Question No:- 3(a)

## Given Data:

$d_1 = R - 200mm$

$= ~~7789~~ - 200$

$d_1 = 7589mm$

$d_2 = R + 3000$

$= 7789 + 300$

$d_2 = 10789mm$

$Q = 0.95 m^3/sec$

Pressure, $P = R + 800 N/m^2$

$= 7789 + 800$

$P = 8589 N/m^2$

## Required Data:-

Head loss due to enlargement = ?

Power loss due to enlargement = ?

Pressure in the small pipe = ?

## Solution:-

### 1- Head Loss Due to Sudden Enlargement

$d_1 = 7.58m$

$A_1 = \frac{\pi (d_1)^2}{4} = 45.12m^2$

$d_2 = 10.78m$

$A_2 = \frac{\pi d_2^2}{4} = 91.26m^2$

We Know that

$Q = AV$

$V = Q/A$

$V_1 = Q/A_1 = \frac{0.95}{45.12} = 0.021 m/sec$

$V_2 = Q/A_2 = \frac{0.95}{91.26} = 0.01 m/sec$

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

$$h_e = \left(1 - \frac{45.12}{91.26}\right)^2 \times \frac{(0.021 - 0.01)^2}{2(9.81)}$$

$$\boxed{h_e = 1.57 \times 10^{-6} m}$$

### 2. Power Loss Due to Sudden Enlargement.

$P = \rho g Q h_e$

$= (1000)(9.81)(0.95)(1.57 \times 10^{-6})$

$$\boxed{P = 0.0146 W}$$

## 3. Pressure In Smaller Pipe.

Bernoulli's equation.

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

$$\frac{P_1}{1000 \times 9.81} + \frac{(0.021)^2}{2(9.81)} = \frac{P_2}{(1000)(9.81)} + \frac{(0.01)^2}{2(9.81)} + 1.57 \times 10^{-6}.$$

$$\frac{P_1}{9810} + 2.24 \times 10^{-5} = \frac{8589}{9810} + 5.09 \times 10^{-6} + 1.57 \times 10^{-6}.$$

$$\frac{P_1}{9810} + 2.24 \times 10^{-5} = 0.875$$

$$P_1 = 0.8755 \times 9810$$

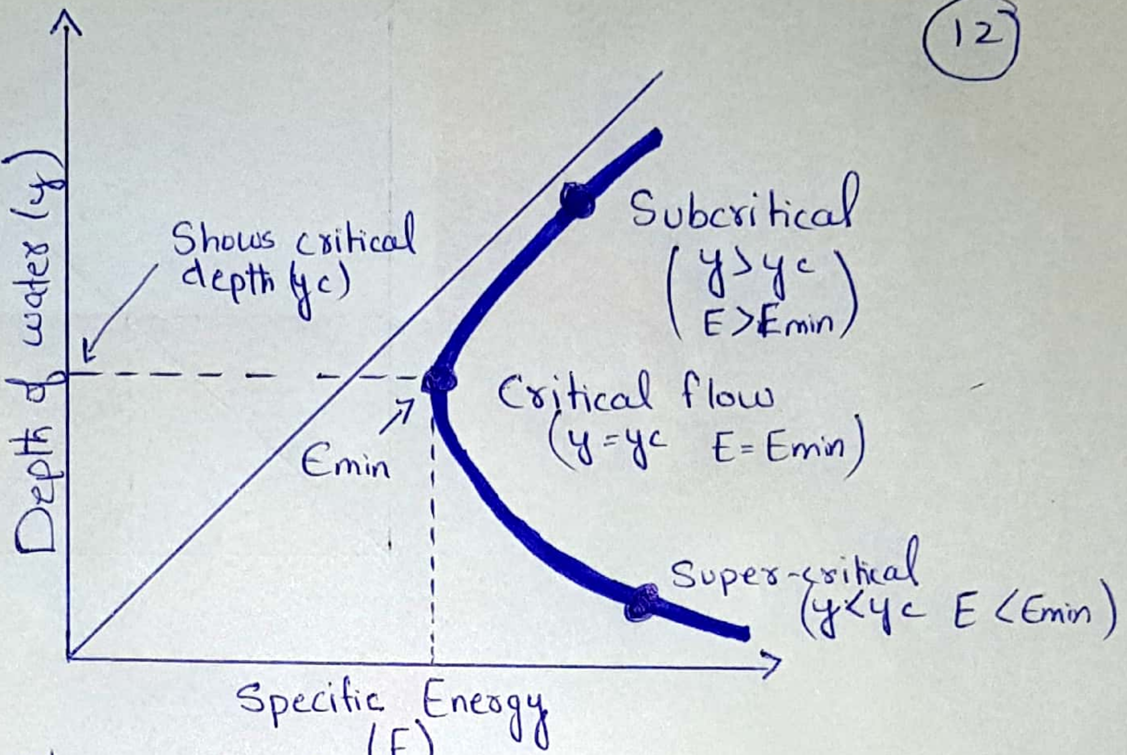
$$\boxed{P_1 = 8588.6 \ N/m^2}$$ **Answer.**

## Question No:- 3 Part(b)

### Specific Energy:

Specific energy is the energy length, head which is relative to channel bottom.
It is expressed in terms of
- → K.E
- → P.E
- → Inertial energy.

S.E is the parameter we use to know what type of flow exists in the channel.




x-axis shows specific energy.
y-axis shows water depth.

⇒ A 3° polynomial equation can be obtained from Specific energy equation.

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

∴ E = specific energy.
q = discharge per unit breadth
y = depth of water.

→ The graph shows a relation b/w 'y' and 'yc'.

→ The straight solid line shows the relation as;
specific energy ∝ water depth.

→ The polynomial curve shows 3 points.

1) Top point represents sub-critical flow where water depth is greater than critical depth (E > Emin)

2) Middle point represents critical depth being equal to water depth i.e critical flow. (E = Emin)

3) Bottom point represents super-critical flow where water depth is less than critical depth (E < Emin).