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Open Channel Flow (OCF)

Rectangular Channel:

২| Find the hydraulic depth and hydraulic radius of rectangular channel of top width 10 m, height 5m and water half of full. [NPCBL-2017]

৩| Flow velocity of a rectangular channel is 10 ft/sec. Calculate the depth of the rectangular channel from the following figure if $n = 0.03$ and $S = 0.01$, [BCIC-2017]

৬| Water flows in rectangular concrete open channel that is 12 m wide. The channel slope is 0.0028, If the velocity of the flow is 6 m/s, Find the depth of the flow ($n = 0.013$). [RPGCL-2017]

৪| A rectangular channel width is 20 feet, Manning's co-efficient 0.021, longitudinal slope 0.0015 and discharge 300 cfs. Find normal depth and velocity. [BPDB-2018]

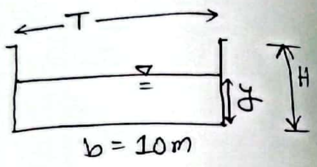
৫| A rectangular channel is 10 ft width and 3 ft depth. Determine the velocity & rate of flow if manning's coefficient is $n = 0.015$ and bed slope of the channel is, $S = 0.003$, [Combined Bank-2020]

Open Channel Flow

Rectangular channel:

\# ১। $D = ?$ $\quad R = ?$

$T = 10m$, $H = 5m$ (water half full)



Solution:

$b = T = 10m$

$y = \frac{H}{2} = 2.5m$

$$D = \boxed{y_H = \frac{A}{T}}$$

$$\Rightarrow y_H = \frac{by}{b} = \frac{10 \times 2.5}{10}$$

$$\therefore y_H = 2.5\ m$$

$$\boxed{R = \frac{A}{P}} = \frac{by}{b+2y} = \frac{10 \times 2.5}{10 + 2 \times 2.5}$$

$$\therefore R = 1.67\ m \quad \text{(Ans.)}$$

Hints:

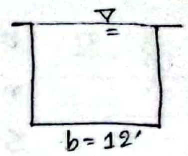
y_H = Hydraulic depth = D

P = wetted perimeter

\# ২। $V = 10$ ft/sec

$n = 0.03$

$S = 0.01$ $\quad y = ?$



Solution: Velocity,

$$\boxed{V = \frac{1.49}{n} R^{2/3} S^{1/2}} \quad \text{(FPS)}$$

$$\Rightarrow V = \frac{1.49}{n} \left(\frac{by}{b+2y}\right)^{2/3} S^{1/2}$$

$$\Rightarrow 10 = \frac{1.49}{0.03} \times \left(\frac{12 \times y}{12 + 2y}\right)^{2/3} \times (0.01)^{1/2}$$

$$\therefore y = 5.45\ ft \quad \text{(Ans.)}$$

\# ৩। $b = 12$ m

$S = 0.0028$

$V = 6$ m/s

$y = ?$ $\quad n = 0.013$

Solution:

$$\boxed{V = \frac{1}{n} R^{2/3} S^{1/2}} \quad \text{(MKS)}$$

$$\Rightarrow V = \frac{1}{n} \left(\frac{by}{b+2y}\right)^{2/3} S^{1/2}$$

$$\Rightarrow 6 = \frac{1}{0.013} \times \left(\frac{12 \times y}{12 + 2y}\right)^{2/3} \times (0.0028)^{1/2}$$

$$\therefore y = 2.55\ m \quad \text{(Ans.)}$$

8)

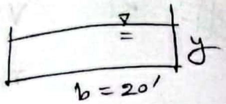
$b = 20$ ft

$n = 0.021$

$S = 0.0015$

$Q = 300$ cfs $= 300\ ft^3/s$

$y = ?$ $V = ?$



Solution: Discharge,

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$ (FPS)

$$\Rightarrow Q = \frac{1.49}{n}(by)\left(\frac{by}{b+2y}\right)^{2/3} S^{1/2}$$

$$\Rightarrow 300 = \frac{1.49}{0.021} \times (20 \times y) \times \left(\frac{20y}{20+2y}\right)^{2/3} \times (0.0015)^{1/2}$$

$$\therefore y = 3.08 \text{ ft}$$

Now, $$Q = AV$$

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

$$\Rightarrow V = \frac{300}{20 \times 3.08}$$

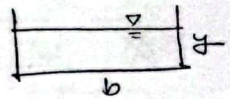
$$\therefore V = 4.87 \text{ ft/s}$$ (Ans.)

9)

$b = 10$ ft, $y = 3$ ft

$V = ?$, $Q = ?$

$n = 0.015$, $S = 0.003$



Solution:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$ (FPS)

$$\Rightarrow V = \frac{1.49}{n} \times \left(\frac{by}{b+2y}\right)^{2/3} \times (S)^{1/2}$$

$$\Rightarrow V = \frac{1.49}{0.015} \times \left(\frac{10 \times 3}{10 + 2 \times 3}\right)^{2/3} \times (0.003)^{1/2}$$

$$\therefore V = 8.27 \text{ ft/sec}$$

$$Q = AV$$

$$\Rightarrow Q = (by) \times V$$

$$= (10 \times 3) \times 8.27$$

$$\therefore Q = 248.19 \text{ ft}^3/s$$ (Ans.)

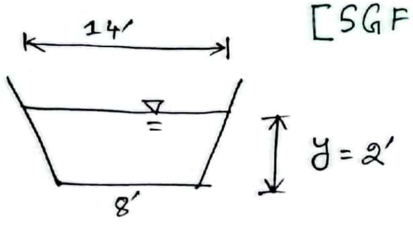
Trapezoidal Channel:

৬| A trapezoidal channel of Slope 1:1 with a bottom width 6m and depth 1.5 m, If the discharge through the channel is 15 m^3/s, find the velocity of channel.

[ERL-2015, BCPCL-2016, BCIC-2016, BGFCL-2017]

৭| The trapezoidal channel shown has a manning's coefficient of $n = 0.013$ and is laid at a slope of 0.0028, The depth of flow is 2 ft. What is the flow rate at ft^3/s?

[SGFL-2017]



৮| A trapezoidal channel of 8m width discharge water 56 m^3/s. Find out the depth of the channel if the side slope of the channel is 1:1.5, consider bed slope 0.019 and manning coefficient 0.017,

[AB-2017]

৯| The bottom width of a trapezoidal channel is 9m and depth is 5m. The side slope of the channel is 1:2, manning's coefficient $n = 0.04$ and is laid at a slope of 1/500. What is the flow rate of the channel?

[DSCC-2019]

*** Trapezoidal Channel:

৯ নং আগে Solve করবো।

৬।

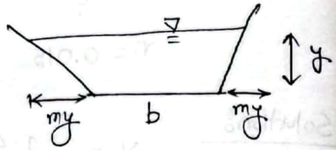
$1:m = 1:1$

$b = 6m$

$y = 1.5m$

$Q = 15\ m^3/s$

$v = ?$



Solution:

$$R = \frac{A}{P} = \frac{(b+my)y}{b + 2 \times y\sqrt{1+m^2}}$$

Area, $A = (b+my)y$

$= (6 + 1 \times 1.5) \times 1.5$

$= 11.25\ m^2$

Now, $Q = AV$

$\Rightarrow V = \frac{Q}{A} = \frac{15}{11.25}$

$\therefore V = 1.33\ m/s$ (Ans.)

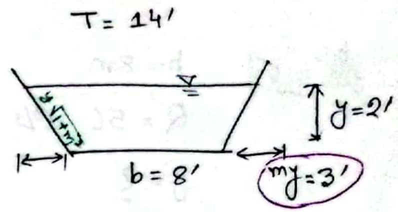
৭।

$n = 0.013$

$S = 0.0028$

$y = 2\ ft$

$Q = ?\ (ft^3/s)$



Solution: $Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$ (FPS)

$A = (b+my)y = (8+3) \times 2 = 22\ ft^2$

$$R = \frac{A}{P} = \frac{(b+my)y}{b + 2y\sqrt{1+m^2}}$$

$m = \frac{my}{y} = 1.5$

$$= \frac{22}{8 + 2 \times 2\sqrt{1+1.5^2}}$$

$\therefore R = 1.45\ ft$

Now, $Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$ (FPS)

$$= \frac{1.49}{0.013} \times 22 \times (1.45)^{2/3} \times (0.0028)^{1/2}$$

$= 170.93\ ft^3/sec$ (Ans.)

৮]

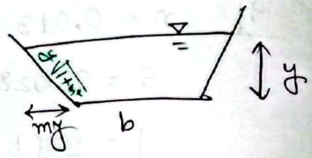
$b = 8m$

$Q = 56 \ m^3/s$

$y = ?$

$1:m = 1:1.5$

$S = 0.019$, $n = 0.017$



Solution:

$$R = \frac{A}{P} = \frac{(b+my)y}{b+2\times y\sqrt{1+m^2}}$$

$$\therefore R = \frac{(8+1.5y)y}{8+2y\sqrt{1+1.5^2}}$$

Now,

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$$\Rightarrow 56 = \frac{1}{0.017} \times (8+1.5y)y \times \left[\frac{(8+1.5y)y}{8+2y\sqrt{1+1.5^2}}\right]^{2/3} \times (0.019)^{1/2}$$

$$\therefore y = 0.898 \ m$$ (Ans.)

৯]

$b = 9m$

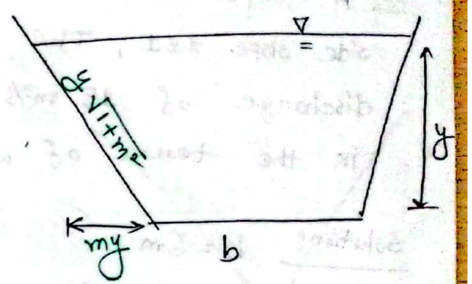
$y = 5m$

$1:2 = 1:m$ ✓

$n = 0.04$

$S = \frac{1}{500} = 0.002$

$Q = ?$



Solution:

$$R = \frac{A}{P} = \frac{(b+my)y}{b+2\times y\sqrt{1+m^2}}$$

$$\Rightarrow R = \frac{(9+2\times5)5}{9+2\times5\sqrt{1+2^2}} = 3.029 \ m$$

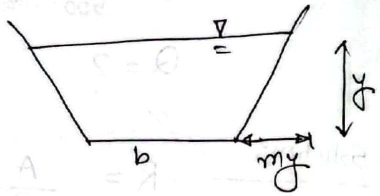
Now,

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$$= \frac{1}{0.04} \times (9+2\times5)\times5 \times (3.029)^{2/3} \times (0.002)^{1/2}$$

$$= 222.35 \ m^3/s$$ (Ans.)

#৩০| A Trapezoidal channel has a bottom width of 6m, side slope 1:1, The depth of flow is 1.5 m at a discharge of 15 m³/s. Determine specific energy in the term of water head.



Solution: $b = 6m$

$1:m = 1:1$

$y = 1.5\,m$

$Q = 15\ m^3/s$

$$A = (b+my)\,y$$

$= (6 + 1\times1.5)\,1.5$

$= 11.25\ m^2$

$$Q = AV$$

$\therefore V = \frac{Q}{A} = 1.33\ m/s$

Specific energy, $$E = y + \frac{V^2}{2g}$$

$= 1.5 + \frac{1.33^2}{2\times9.81}$

$\therefore E = 1.59\,m$ (Ans.)

Triangular Channel:

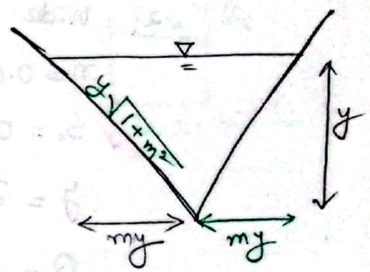
৩১| normal depth, $y = ?$

$Q = 10\ m^3/s$

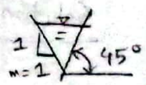
$S = 1cm/1\,Km$

$= \frac{1\ cm}{100\times1000\ cm}$

$= 1\times10^{-5}$



Best hydraulic Triangular section.



Solution: $$R = \frac{A}{P} = \frac{\frac{1}{2}\times2my\times y}{2\times y\sqrt{1+m^2}}$$

$\Rightarrow R = \frac{1\,y\times y}{2\times y\sqrt{1+1^2}}$

[## Best Triangular section, $m=1$]

$\Rightarrow R = \frac{y^2}{2\sqrt{2}\,y}$

$\therefore R = \frac{y}{2\sqrt{2}}$

$n = 0.015$

Now, $$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$\Rightarrow 10 = \frac{1}{0.015}\times y^2\times\left(\frac{y}{2\sqrt{2}}\right)^{2/3}\times\left(1\times10^{-5}\right)^{1/2}$

$\therefore y = 5.51\ m$ (Ans.)

Triangular Channel:

২২। Calculate the normal depth of earthen channel flow rate = 10 m^3/s and channel slope 1 cm/1 Km. Assume Best hydraulic triangular section.

[BIWTA - 2019]

Wide Channel:

২৩। A wide channel has $n = 0.025$ and $S_0 = 0.0025$, Calculate the normal water depth and velocity of flow if the channel discharge is 3 m^3/s.

[SGFL-2020, PGCB-2020, DPDC-2020]

২৪। A wide channel having longitudinal slope 0.001, manning's roughness coefficient = 0.02 and velocity = 1.6 m/s. Calculate the normal depth of the channel.

[PGCB-2021]

** # Wide Rectangular Channel:

$A = y = by$ (b = 1)

$R = y$

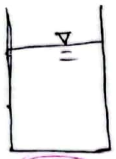
22| Wide channel

$n = 0.025$

$S_0 = 0.0025 = S$

$y = ?$, $V = ?$

$Q = 3\ m^3/s$



Solution: Wide channel. $A = y$, $R = y$

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$$\Rightarrow Q = \frac{1}{n} \times y \times y^{2/3} \times S^{1/2}$$ [wide channel]

$$\Rightarrow 3 = \frac{1}{0.025} \times y \times y^{2/3} \times (0.0025)^{1/2}$$

$$\therefore y = 1.275\ m$$

Now, $Q = AV$

$$\therefore V = \frac{Q}{A} = \frac{Q}{y} = 2.35\ m/s$$

(Ans.)

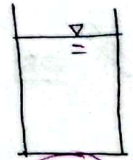
26| Wide channel.

$S = 0.001$

$n = 0.02$

$V = 1.6\ m/s$

$y = ?$



Solution: Velocity,

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

$$\Rightarrow V = \frac{1}{n} \times y^{2/3} \times S^{1/2}$$ [$A = y$, $R = y$]

$$\Rightarrow 1.6 = \frac{1}{0.02} \times y^{2/3} \times (0.001)^{1/2}$$

$$\therefore y = 1.018\ m$$

(Ans.)

Circular Channel :

২৪| A 24" diameter sewer with n=0.013 is laid on a grade of 0.015. What will be the velocity and discharge when the depth of flow is 12".

[BCIC - 2019]

২৫| A circular pipe of 20" diameter laid on a grade of 0.015 and manning's coefficient is 0.011, Find the velocity and discharge if the depth of flow is 5",

[BGDCL - 2021]

২৬| A sewer of 400 mm diameter is laid on a grade of 0.015 and manning's coefficient is 0.013, Find the velocity and discharge if the depth of flow is 100 mm.

[SGFL - 2020]

Circular Channel: Half Flow

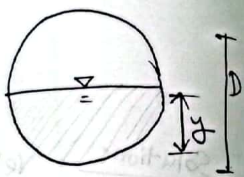
 # 28| Dia, $D = 24'' = 2\ ft$

$n = 0.013$

$S = 0.015$

$v = ?$ $Q = ?$

$y = 12'' = 1\ ft$



Solution:

$$A = \frac{\pi}{4} D^2 \times \frac{1}{2} = \frac{3.1416}{2}\ ft^2$$

$$\boxed{V = \frac{1.49}{n} R^{2/3} S^{1/2}}$$ (FPS)

$$\Rightarrow V = \frac{1.49}{n} \left(\frac{D}{4}\right)^{2/3} S^{1/2}$$

$$= \frac{1.49}{0.013} \times \left(\frac{2}{4}\right)^{2/3} \times (0.015)^{1/2}$$

$R = \frac{D}{4}$ For Circular section, Full or Half fill.

$\therefore v = 8.83\ ft/sec$

Now, $Q = AV$

$$= \frac{3.1416}{2} \times 8.83$$

$$= 13.89\ cfs$$ (Ans.)

Circular Channel: Partial Flow

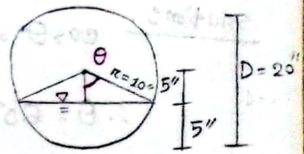
 # 29| $D = 20'' = 1.67\ ft$

$S = 0.015$, $n = 0.011$

$v = ?$, $Q = ?$

Solution:

$$\boxed{\cos\theta = \frac{\text{ভূমি}}{\text{অতিভুজ}}} = \frac{5}{10}$$



$\therefore \theta = 60°$ or 1.047 rad

$$\boxed{A = \frac{D^2}{8}(2\theta_r - \sin 2\theta)}$$

$$= \frac{(1.67)^2}{8}(2 \times 1.047 - \sin 2 \times 60°)$$

$$= 0.426\ ft^2$$

$1° = 1 \times \frac{\pi}{180}$ rad

$$\boxed{P = \theta_r \times D}$$

$$= 1.047 \times 1.67 = 1.748$$

$$\boxed{R = \frac{A}{P}} = 0.244\ ft$$

$$\boxed{V = \frac{1.49}{n} R^{2/3} S^{1/2}}$$ (FPS)

$$= \frac{1.49}{0.011} \times (0.244)^{2/3} \times (0.015)^{1/2} = 6.48\ ft/s$$

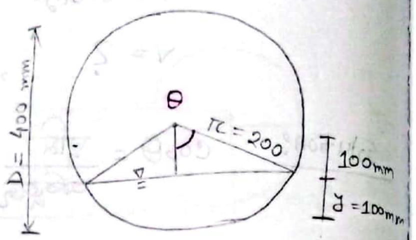
$$Q = AV = 2.76\ ft^3/s$$ (Ans.)

24) $D = 400\ mm = 0.4\ m$

$S = 0.015$, $n = 0.013$

$v = ?$, $Q = ?$

$y = 100\ mm$



Solution:

$\cos\theta = \frac{100}{200}$

$\therefore \theta = 60^\circ$ or 1.0472 rad

$$A = \frac{D^2}{8}\left(2\times\theta_r - \sin 2\theta\right)$$

$= \frac{0.4^2}{8}\left(2\times1.0472 - \sin 2\times60^\circ\right) = 0.0245\ m^2$

$$P = \theta_r \times D$$

$= 1.0472 \times 0.4 = 0.419$

$$R = \frac{A}{P} = 0.058\ m$$

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

$= \frac{1}{0.013}\times(0.058)^{2/3}\times(0.015)^{1/2} = 1.41\ m/s$

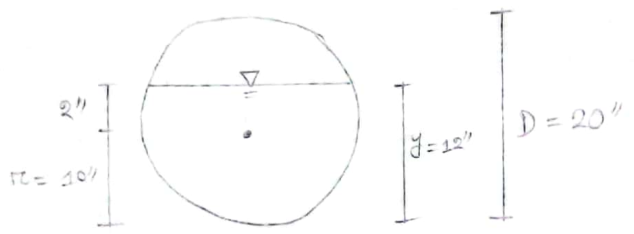
$Q = AV = 0.035\ m^3/s$ (Ans)

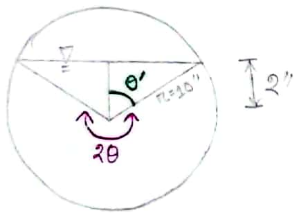
(P.T.O)

#29| A 20" diameter sewer with $n = 0.013$ is laid on a grade of 0.0015, What will be the velocity and discharge when the depth of flow is 12".

[BCIC-2019]

Solution:





$D = 20'' = 1.67$ ft

$y = 12'' = 1$ ft

$v = ?$, $Q = ?$

$1^\circ = 1 \times \frac{\pi}{180}$ rad

$$\cos\theta' = \frac{2}{10}$$

$\therefore \theta' = 78.46^\circ$ ~~or 1.37 rad~~

$$2\theta = 360^\circ - 2\theta'$$

$= 203.08^\circ$

$\therefore \theta = 101.54^\circ$ or 1.77 rad

$$A = \frac{D^2}{8}\left(2\times\theta_r - \sin 2\theta\right)$$

$= 1.37$ ft^2

$$P = \theta_r \times D$$

$= 1.77 \times 1.67 = 2.96$

$R = \frac{A}{P} = 0.463$ ft

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$ (FPS)

$= \frac{1.49}{0.013} \times (0.463)^{2/3} \times (0.0015)^{1/2}$

$= 2.66$ ft/s

$Q = AV$

$= 3.64$ ft^3/s (Ans.)

Froude Number ; Hydraulic Jump :

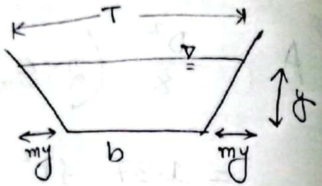
১৮| A Trapezoidal channel has a bottom width of 6m and a side slope of 2:1. Calculate the discharge, top width and Froude number of the flow in the channel if the depth of flow is 2m and mean velocity of the flow 3m/s. [BB-2021]

১৯| A trapezoidal channel of 1.5m depth and 6m bottom width with a flow velocity 10 m/s has a side slope of 1:2. Find out if the flow is sub-critical or super critical ? [BKB-2018]

২০| The sequent depth ratio of a hydraulic jump in a rectangular channel is 16.48, Find the Froude number at the beginning of jump and type of jump. [BWDB-2014]

২১| A rectangular channel 6m wide and discharge 1200 l/s of water into a 6m wide apron with zero slope with a mean velocity of 16 m/s. What is the height of hydraulic jump? [BWDB-2016]

Froude Number ; Jump :



২১ $b = 6m$

$2:1 = m:1$ $\therefore m = 2$

$Q = ?$ $T = ?$ $Fr = ?$

$y = 2m$, $V = 3 m/s$

Solution: Top Width. $T = b + 2my = 14 m$

$A = (b+my) \times y = (6+2\times2)\times2 = 20 \ m^2$

$Q = AV = 60 \ m^3$

Now, $y_H = \frac{A}{T} = \frac{20}{14} = 1.43 \ m$

$\therefore$ Froude Number,

$$Fr = \frac{V}{\sqrt{g \times y_H}}$$

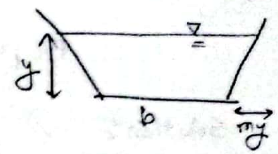
$$= \frac{3}{\sqrt{9.81 \times 1.43}}$$

$\therefore Fr = 0.80$ (Ans)

২২ $y = 1.5m$ $1:2 = 1:m$

$b = 6m$ $m = 2$

$V = 10 m/s$ $Fr = ?$



Solution: $A = (b+my) \times y$

$= (6 + 2\times1.5)1.5 = 13.5 \ m^2$

$T = b + 2my$

$= 6 + 2\times2\times1.5 = 12 m$

$y_H = \frac{A}{T} = \frac{13.5}{12} = 1.125 \ m$

Froude Number, $Fr = \frac{V}{\sqrt{g \times y_H}}$

$$= \frac{10}{\sqrt{9.81 \times 1.125}}$$

$= 3.01$

$\because Fr > 1$, So Supercritical flow. (Ans)

20| Sequent depth ratio, $\frac{h_2}{h_1} = 16.48$,

$Fr_1 = ?$ = Froude number at beginning

Solution:

$$\frac{h_2}{h_1} = \frac{1}{2}\left(\sqrt{1+8\,Fr_1^2} - 1\right)$$

$$\Rightarrow 16.48 = \frac{1}{2}\left(\sqrt{1+8\,Fr_1^2} - 1\right)$$

$$\therefore Fr_1 = 12$$

As, $Fr_1 = 12 > 9$. so, Jump is Strong. (Ans.)

21| $b = 6m$, $Q = 1200\ l/s$

$h_j = ?$ $= 1.2\ m^3/s$

$V = 16\ m/s = V_1$

Solution:

$$V_1 = \frac{Q}{A_1} = \frac{Q}{by_1} = \frac{Q}{bh_1}$$

$$\therefore h_1 = \frac{Q}{bV_1} = 0.0125\ m = y_1$$

$h_1 = y_1$

$h_2 = y_2$

$$Fr_1 = \frac{V_1}{\sqrt{g \times y_1}} = 45.69$$

$$\frac{h_2}{h_1} = \frac{1}{2}\left(\sqrt{1+8\,Fr_1^2} - 1\right)$$

$$\Rightarrow \frac{h_2}{0.0125} = \frac{1}{2}\left(\sqrt{1+8\times 45.69^2} - 1\right)$$

$$\therefore h_2 = 0.8\ m$$

$\therefore$ height of hydraulic jump, $h_j = h_2 - h_1$

$= 0.7875\ m$ (Ans.)

Hints:

① $Fr = \frac{V}{\sqrt{g \times y_H}}$

② $Fr_1 = \frac{V_1}{\sqrt{g \times y_1}} = \frac{V_1}{\sqrt{g \times h_1}}$

$y_2 > y_1$, $h_2 > h_1$ (Always)

③ $Fr = \frac{V_c}{\sqrt{g \times y_c}}$ ($Fr \to 1$)

$\Rightarrow 1 = \frac{V_c}{\sqrt{g \times y_c}}$

(concept) → BWDB, WARPO ইত্যাদি Exam এ আসতে পারে।

২২। In a hydraulic jump occurring in a rectangular channel of 3m width, the discharge is 7.8 m^3/s and the depth before the jump is 0.28 m. Estimate (i) sequent depth, and (ii) the energy loss in the jump.

২৩। A hydraulic jump takes place in a rectangular channel with sequent depths of 0.25 m and 1.50 m at the beginning and end of the jump respectively. Estimate the —

(i) Discharge per unit width of the channel, and

(ii) Energy Loss.

২৪। A 2.5m wide rectangular channel has a specific energy of 1.50 m when carrying a discharge of 6.48 m^3/s. Calculate the alternate depths and corresponding Froude numbers.

22)

$b = 3m$

$Q = 7.8\ m^3/s$

$y_1 = 0.28\ m$

$y_2 = ?$

$\Delta E_L = ?$

Solution:

$$V_1 = \frac{Q}{A} = \frac{Q}{by_1} = 9.286\ m/s$$

$$Fr_1 = \frac{V_1}{\sqrt{g \times y_1}} = 5.603$$

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1 + 8\,Fr_1^2} - 1\right)$$

$$\Rightarrow \frac{y_2}{0.28} = \frac{1}{2}\left(\sqrt{1 + 8 \times 5.603^2} - 1\right)$$

$$\therefore y_2 = 2.08\ m$$

Now, Energy loss,

$$\Delta E_L = \frac{(y_2 - y_1)^3}{4 \times y_1 \times y_2}$$

$$= \frac{(2.08 - 0.28)^3}{4 \times 2.08 \times 0.28}$$

$$= 2.503\ m$$

(Ans.)

26)

$y_1 = 0.25\ m$

$y_2 = 1.50\ m$

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

$\Delta E_L = ?$

Solution:

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1 + 8 \times Fr_1^2} - 1\right)$$

$$\Rightarrow \frac{1.50}{0.25} = \frac{1}{2}\left(\sqrt{1 + 8 \times Fr_1^2} - 1\right)$$

$$\therefore Fr_1 = 4.583$$

Now, $$Fr_1 = \frac{V_1}{\sqrt{g \times y_1}}$$

$$\Rightarrow 4.583 = \frac{V_1}{\sqrt{9.81 \times 0.25}}$$

$$\therefore V_1 = 7.177\ m/s$$

Discharge per unit width, $$q = V_1 y_1 = 1.79\ \frac{m^3/s}{m}$$

Energy loss, $$\Delta E_L = \frac{(y_2 - y_1)^3}{4 y_1 y_2} = 1.302\ m$$

(Ans.)

Critical depth:

২৫) Calculate the critical depth and corresponding specific energy for a discharge of 5 m^3/s in the following channels –

(a) Rectangular channel, $B = 2.0$ m

(b) Triangular channel, $m = 0.5$.

[Concept & Formula]

২৬) Calculate the normal depth and critical depth of rectangular wide channel having discharge per meter width = 3 m^2/s, manning's co-efficient = 0.025 and slope = 0.0005.

[BADC - 2020]

28| $b = 2.5m$

$E = 1.50$ m

$Q = 6.48\ m^3/s$

~~$y_1, Fr_1 = ?$~~

~~$y_2, Fr_2 = ?$~~

Solution: Specific Energy,

$$E = y + \frac{V^2}{2g}$$

$E \nearrow y \rightarrow Fr = ?$

$\searrow y \rightarrow Fr = ?$

$$\Rightarrow E = y + \frac{Q^2}{2g\,A^2}$$

$$\therefore \boxed{E = y + \frac{Q^2}{2g\,(by)^2}}$$

$$\Rightarrow 1.50 = y + \frac{6.48^2}{2 \times 9.81 \times (2.5 \times y)^2}$$

$y = 0.626$ m , 1.296 m

For, $y = 0.626$, $\boxed{Fr = \frac{V}{\sqrt{g \times y}} = \frac{Q}{A\sqrt{gy}}} = 1.67$

So Super critical Flow ($Fr > 1$)

For, $y = 1.296$ m , $\boxed{Fr = \frac{Q}{A\sqrt{gy}}} = 0.56$

So Subcritical Flow ($Fr < 1$)

(Ans.)

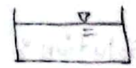
Critical Depth:

29| $y_c = ?$ $E_c = ?$

$Q = 5\ m^3/s$

(a) $B = 2m = b$ (b) $m = 0.5$

Solution: (a) Rectangular channel:



$$\boxed{y_c^3 = \frac{Q^2}{g\,b^2}}$$

$$\Rightarrow y_c^3 = \frac{5^2}{9.81 \times 2^2}$$

Critical depth, $\therefore y_c = 0.86$ m

And, $\boxed{E_c = 1.5 \times y_c} = 1.29$ m (Ans.)

(b) Triangular channel:

$$\boxed{y_c^5 = \frac{2Q^2}{g\,m^2}}$$

$$\Rightarrow y_c^5 = \frac{2 \times 5^2}{9.81 \times 0.5^2}$$

$\therefore y_c = 1.83$ m

$\boxed{E_c = 1.25 \times y_c} = 2.28$ m (Ans.)

28 Rectangular Wide channel.

$y = ?$ $\quad y_c = ?$

$\frac{Q}{b} = q = 3 \ m^2/s$

$n = 0.025$, $S = 0.0005$

Solution:

(a) Normal Depth:

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$b = 1$

Wide Channel,

$A = y$

$R = y$

$\therefore Q = q = 3 \ m^3/s$

$\Rightarrow Q = \frac{1}{n} y \times y^{2/3} \times S^{1/2}$

$\Rightarrow 3 = \frac{1}{0.025} \times y^{5/3} \times (0.0005)^{1/2}$

$\therefore y = 2.067 \ m$ (Ans.)

(b) Critical Depth:

$$y_c^3 = \frac{Q^2}{g b^2}$$

$\Rightarrow y_c^3 = \frac{q^2}{g}$ $\quad \left[q = \frac{Q}{b}\right]$

$\Rightarrow y_c^3 = \frac{3^2}{9.81}$

$\therefore y_c = 0.972 \ m$ (Ans.)

29 Critical depth of a wide channel is 1.01m and normal depth is 1.12m. Bed slope is 0.0001, Width of water main is 4.8m. Find discharge of water main of the given section.

[BWDB-2019]

Solution:

$y_c = 1.01 \ m$

$y = 1.12 \ m$ (No use)

$S = 0.0001$ (No use)

$b = 4.8 m$, $Q = ?$

Critical depth, $$y_c^3 = \frac{Q^2}{g b^2}$$

$\Rightarrow (1.01)^3 = \frac{Q^2}{9.81 \times 4.8^2}$

$\therefore Q = 15.26 \ m^3/s$ (Ans.)

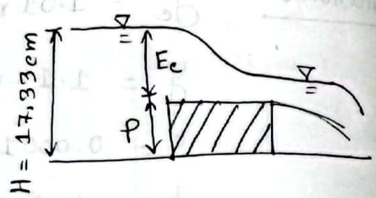
** 26] Determine the height of Broad crested weir. Width of flume = 25 cm, Actual discharge is 7020.5 cm^3/s. Ignore head loss.

<u>Solution:</u> $b = 25$ cm

$Q = 7020.5$ cm^3/s

ht, P = ?

$g = 981$ cm/s^2



$$y_c^3 = \frac{Q^2}{g b^2}$$

$$\Rightarrow y_c^3 = \frac{(7020.5)^2}{981 \times 25^2}$$

$\therefore y_c = 4.32$ cm

Now, Water head over weir (or Specific Energy),

$$E_c = 1.5 \times y_c$$

$= 6.48$ cm

$\therefore$ Height of Weir, $P = H - E_c$

$= 10.85$ cm (Ans.)

Broad Crested Weir:

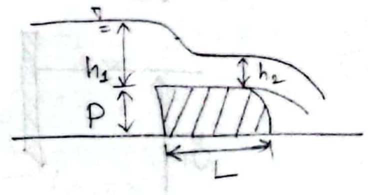
26.2] A broad crested weir is built in a rectangular channel of width 2m. The height of the weir crest above the channel bed is 1.20m and the head over the weir is 0.8 m. Calculate the discharge.

<u>Solution:</u> $b = 2$m

$h_1 = 0.8$m

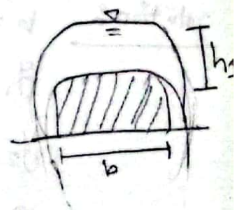
$P = 1.20$ m

$Q = ?$



Discharge for Broad Crested Weir,

$$Q = 1.705 \times b (h_1)^{1.5}$$ (MKS)

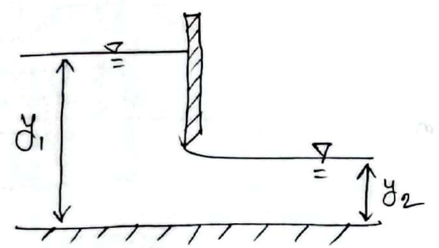


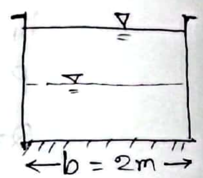
$= 1.705 \times 2 \times (0.8)^{1.5}$

$= 2.44$ m^3/s (Ans.)

Upward Step ; Sluice Gate :

** ২৯) A sluice gate in a 2m wide horizontal rectangular channel is discharging freely as shown in figure. If the depths are small distance upstream (y_1) and downstream (y_2) are 2.5m and 0.2m respectively. Estimate the Discharge in the channel. Neglect energy loss in the gate. [BIWTA-2023]





Solution :

$b = 2m$

$y_1 = 2.5m$

$y_2 = 0.2m$

$Q = ?$

$A_1 V_1 = A_2 V_2$

$\Rightarrow (by_1) V_1 = (by_2) V_2$

$\Rightarrow y_1 V_1 = y_2 V_2$

$\Rightarrow 2.5 V_1 = 0.2 V_2$

$\therefore V_2 = 12.5 V_1$ ———— (i)

Energy Equation

And,

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

$$\Rightarrow 2.5 + \frac{V_1^2}{2\times 9.81} = 0.2 + \frac{(12.5 V_1)^2}{2\times 9.81}$$

$\therefore V_1 = 0.539$ m/s [at upstream]

Now, Discharge, $Q = A_1 V_1$

$\Rightarrow Q = (by_1) V_1$

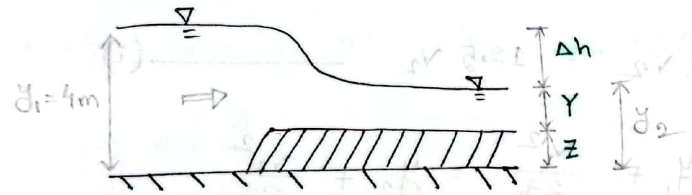
$= (2\times 2.5)\times 0.539$

$= 2.696$ m³/s

(Ans.)

Q01 A rectangular channel is 3m wide and depth of water 4m flows at a velocity of 2 m/s. In the downstream a smooth upward step in the channel bed to produce a depth 1.5m. Calculate the change in water level. [BWDB-2019]

Solution:



$b = 3m$ $\quad Y = 1.5m$

$y_1 = 4m$

$V_1 = 2 m/s$ $\quad$ Here, $y_2 = Y + Z$

$Y = 1.5m$ $\quad \Delta h = y_1 - y_2$

Now,

$$A_1V_1 = A_2V_2$$

$$\Rightarrow (by_1)V_1 = (bY)V_2$$

$$\Rightarrow 4 \times 2 = 1.5 \times V_2$$

$$\therefore V_2 = 5.33 \text{ m/s}$$

Hints:
যতটুকু জায়গা দিয়ে Water flow হবে তার ht. = Y

Energy Equation,

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

$$\Rightarrow y_1 + \frac{V_1^2}{2g} = (Y+Z) + \frac{V_2^2}{2g}$$

$$\Rightarrow 4 + \frac{2^2}{2 \times 9.81} = (1.5 + Z) + \frac{5.33^2}{2 \times 9.81}$$

$$\therefore Z = 1.256 \text{ m}$$

$\therefore$ Change in height, $\Delta h = y_1 - y_2$

$$\therefore \Delta h = y_1 - (Y+Z)$$

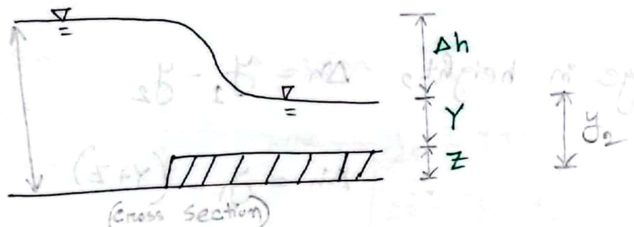
$$= 4 - (1.5 + 1.256)$$

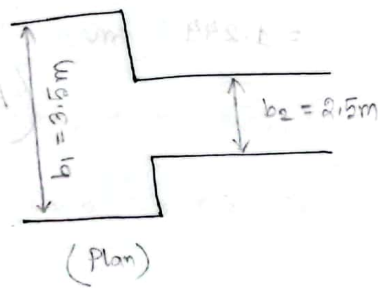
$$= 1.244 \text{ m}$$

(Ans.)

02) The width of a horizontal channel is reduced from 3.5m to 2.5m and the floor is raised by 0.25 m in elevation at a given section. At the upstream, the depth of flow is 2m and the kinetic energy correction factor $\alpha = 1.15$, If the drop in water surface elevation at the contraction is 0.2 m at discharge, Determine Discharge when energy loss is neglected. $\alpha = 1$ at contraction. [Concept]

Solution:





$b_1 = 3.5m$

$b_2 = 2.5m$

$Z = 0.25m$

$y_1 = 2m$

$\alpha_1 = 1.15$

$\Delta h = 0.2\ m$

$\alpha_2 = 1$

$y_2 = y_1 - \Delta h = 1.8m$

$Y = y_2 - Z = 1.55m$

$$A_1 V_1 = A_2 V_2$$

$\Rightarrow (b_1 y_1) V_1 = ~~(b_2 y_2) V_2~~ (b_2 Y) V_2$

$\Rightarrow (3.5 \times 2) \times V_1 = (2.5 \times 1.55) \times V_2$

$\therefore V_2 = 1.806 \times V_1$ ——— (i)

Energy Equation,

$$y_1 + \alpha_1 \frac{V_1^2}{2g} = y_2 + \alpha_2 \frac{V_2^2}{2g}$$

$\Rightarrow 2 + \frac{V_1^2}{2 \times 9.81} \times 1.15 = 1.8 + \frac{(1.806 \times V_1)^2}{2 \times 9.81} \times 1$

$\therefore V_1 = 1.363\ m/s$ [at upstream]

Discharge, $Q = A_1 V_1$

$\Rightarrow Q = (b_1 y_1) V_1$

$= 3.5 \times 2 \times 1.363$

$= 9.54\ m^3/s$ (Ans.)