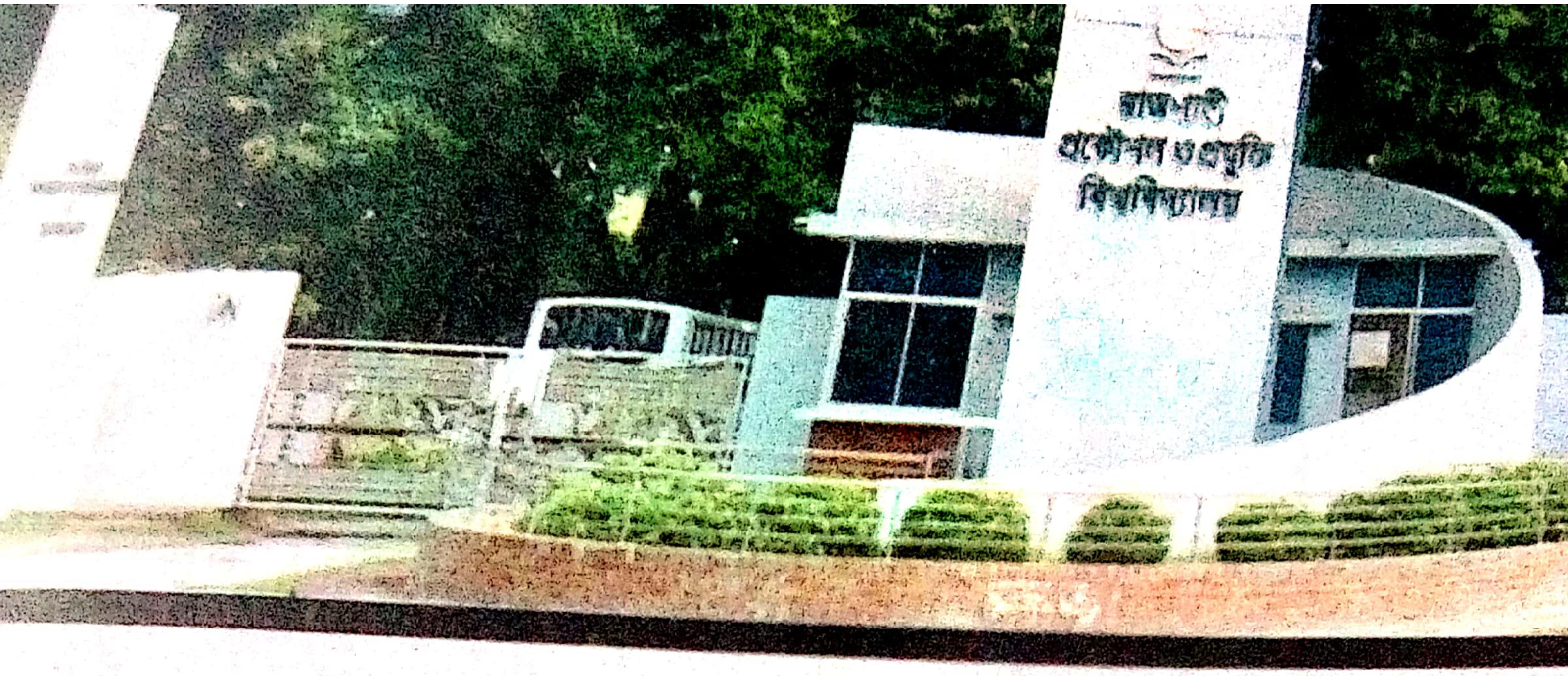

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CE - 2121

22/01/2020

Fluid Mechanics

Course Contant:

(i) Fluid dynamics

(ii) Fluid measurement

(iii) Flow through pipes

(iv) Laminar and turbulent flow

(v) Study in compressive flow in pressure conduites.

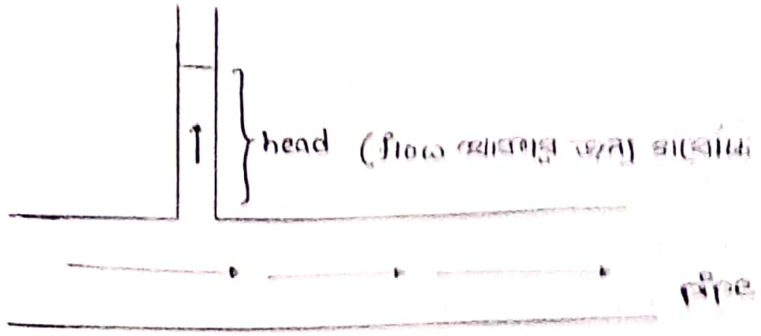
(vi) Similitude and dimenlional analysis.

Why fluid dynamic is essential for us:

1. Fluid dynamics is changing our world.
2. " " is the study of fluid in motion or fluid flow.
3. " " affects every aspects of our life.
4. " " helps us to understand how our world works.
5. " " affects the blood flow to our brain and heart.

Types of head of fluid in motion:

↳ rise of water



3 types:

① Potential head or potential energy: This is due to configuration or position above some suitable datum lines.

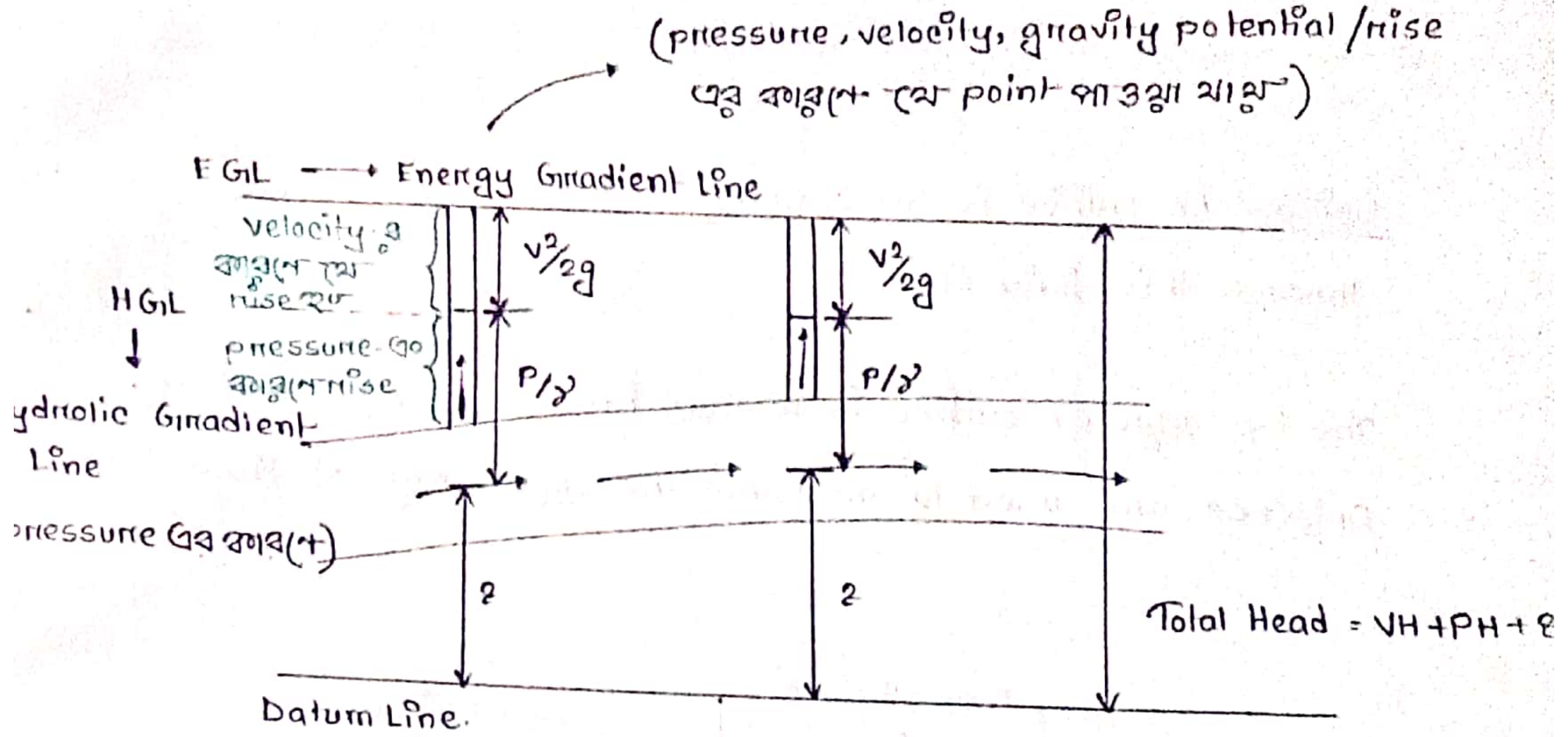
It is denoted by z. (also known as datum head)

⑪ Velocity head or kinetic energy: This is due to velocity of flowing liquid and is measured as $V^2/2g$.

⑪ Pressure head or pressure energy: This is due to the pressure of liquid and is measured as P/γ.

* $\gamma = \rho g$

* total head = total energy per unit weight



Bernoulli's eqn: Total head of energy cons.

channel এর ভিতরে প্রত্যেক fluid এর property same

In an ideal incompressible fluid when the flow is steady and continuous, sum of pressure energy, kynetic energy and potential energy is constant along a stream / fluid line.

প্রত্যেক particle এর same veloc

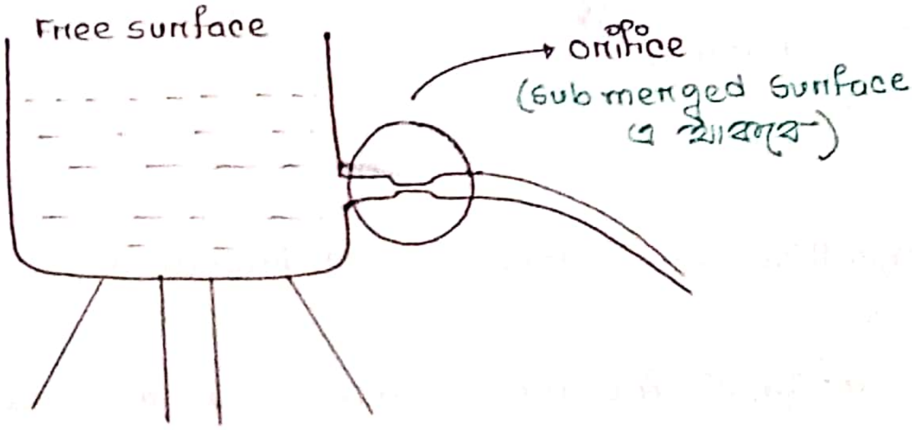
Mathematically: $\frac{P}{\gamma} + \frac{V^2}{2g} + z = \text{constant}$

Flow through orifice and mouthfice.

Orifice: An orifice is an opening in the wall or base of a vessel through this fluid flows.

The top edge of orifice is always below the free surface.

Orifices are used to measure the discharge of fluid flow



Classification of orifice:

(i) According to size:

(i) Small orifice

(ii) large orifice

(ii) According to the shape of orifice:

(i) circular orifice

(ii) Rectangular "

(iii) squre "

(iv) Triangular "

(iii) According to the shape of upstream edge:

(i) sharp edged orifice

(ii) Bell-mouthed orifice

(iv) According to discharge condition:

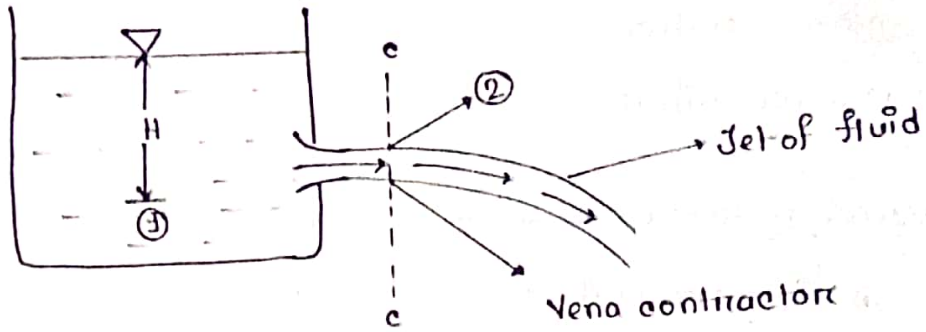
(i) Free discharge orifice

(ii) Sub-merged "

(iii) Partialy submerged "

(iv) fully submerged "

Torricelli's Theorum:



Consider 2 points ① and ② as shown in figure. Point ① is at the and point ② is the venacontractor.

↓

It is a point where cross sectional area minimum and velocity maximum.

(when the water is normally flowing)

let, the flow is steady and at a constant head H, applying Bernoulli's eqn at point ① and ② gives,

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

point ① and ② same level, $\therefore z_1 = z_2$

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

We can write,

$$\frac{P_1}{\rho g} = H$$

$$\left\{ \begin{array}{l} P = \gamma H \\ \therefore P \propto H \end{array} \right.$$

For point ② $\longrightarrow$

$$\frac{P_2}{\rho g} = 0 \quad [\text{atmospheric pressure}]$$

For ① velocity V_1, for ② velocity V_2 $\longrightarrow$ $\therefore V_2 \gg V_1$

$\therefore V_1 = 0$ [V_1 is very small in comparison to V_2 as area of tank is very large as compared to area of jet of the fluid.]

From ① $\longrightarrow$

$$H + 0 = 0 + \frac{V_2^2}{2g}$$

$$\Rightarrow \boxed{V_2 = \sqrt{2gH}}$$

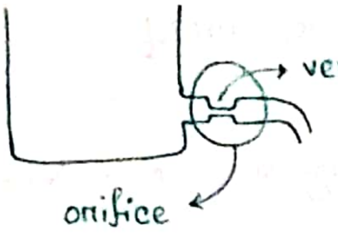
This is theoritical velocity.

Actual velocity will be less than this value.

Hydraulic co-efficience: (C_d, C_c, C_v, C_r) → 4 types

$\boxed{C_c}$ → Co-efficient of contraction = $\dfrac{\text{Area of jet of Vena Contractan}}{\text{Area of orifice}}$

$$\boxed{C_c = \frac{a_c}{a}}$$



$\boxed{C_r}$ → Co-efficient of resistance is the ratio of loss of head in the orifice to the head of water available at the exit of the orifice is known as co-efficient of resistance.

It is denoted by C_r.

$$\boxed{C_r = \frac{\text{loss of head of orifice}}{\text{Head of water}}}$$

$\boxed{C_d}$ → Co-efficient of discharge

$$C_d = \frac{\text{Actual discharge}}{\text{Theoritical discharge}} = \boxed{\frac{Q}{Q_{th}} = C_d}$$

$$= \frac{\text{Actual velocity} \times \text{Actual area}}{\text{Theoritical velocity} \times \text{Theoritical area}}$$

(Flowed)

Standard value for hydrolic co-efficiences:

(i) Co-efficient of velocity, $C_v = 0.95 - 0.99$

(ii) " " contraction, $C_c = 0.61 - 0.69$

(iii) " " discharge, $C_d = 0.61 - 0.65$

Prob: An orifice is 60 mm in diameter. It is discharging water under a head of 9 meters. If $C_d = 0.6$ and $C_v = 0.9$, Find actual discharge, actual velocity of jet at vena conductore.

$\Rightarrow$ $d = 60$ mm

$H = 9$ m

$C_v = 0.9$

$C_d = 0.6$

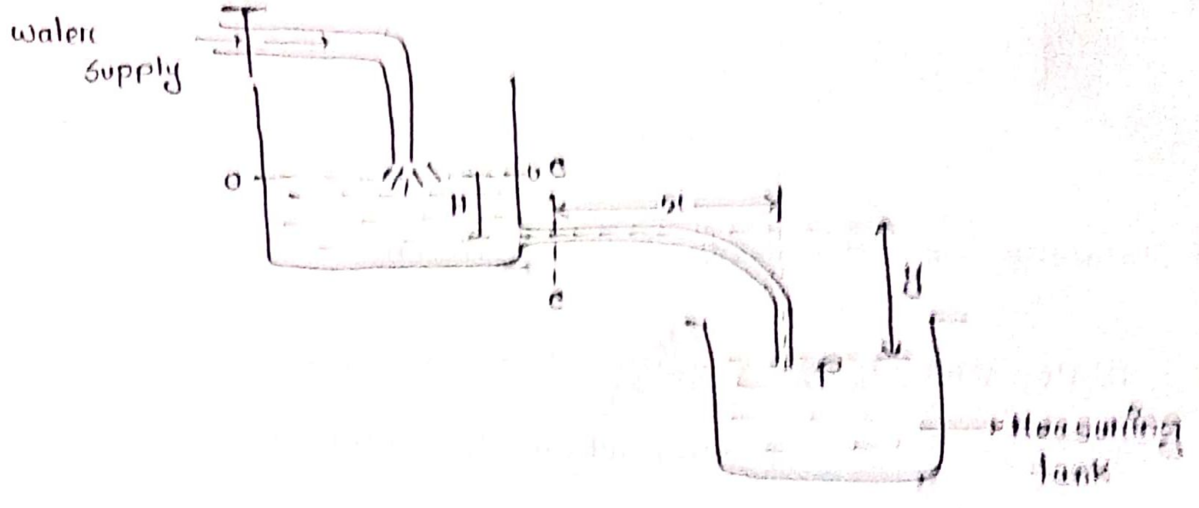
$$C_d = \frac{\text{Actual discharge}}{\text{Theoritical discharge}}$$

$$\Rightarrow Q_{th} = a \times \sqrt{2gH}$$

$a = \frac{1}{4}\pi d^2 \longrightarrow$ area of orifice

$$C_v = \frac{\text{Actual velocity}}{\text{Theoritical velocity}}$$

Determination of Hydraulic co-efficient by co-ordinate method



① Determination of co-efficient of velocity:

Figure shows a tank containing water at a constant level, maintained by a constant supply. Let the water flow out of the tank through a orifice fitted in one side of the tank.

Let the section c-c represents the point of vena contraction. Consider a particle of water in the jet at P.

Let, x = horizontal distance travelled by the particle at time t.

y = verticle distance betn c-c and P.

V = Actual velocity of the jet at vena contraction.

H = constant water head.

$\therefore$ Horizontal distance, $x = vt$ ——— (I)

Verticle distance, $y = \frac{1}{2} g t^2$ ——— (II)

From eqn (I) $\rightarrow$

$$t = \frac{x}{v}$$

From (II) $\rightarrow$

$$y = \frac{1}{2} g \times \frac{x^2}{v^2} = \frac{g x^2}{2 v^2}$$

$$\therefore \boxed{v = \sqrt{\frac{g x^2}{2y}}}$$

Actual velocity.

$$\therefore C_v = \frac{\text{Act. velocity}}{\text{Theo. velocity}}$$

$$= \frac{\sqrt{\frac{g x^2}{2y}}}{\sqrt{2gH}}$$

$$\boxed{C_v = \frac{x}{\sqrt{4yH}}}$$

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Determination of co-efficient of discharge:

The water flowing through the orifice under the cons. head H is collected in a measuring tank for a known time t. The rise of water level in the measuring tank is noted down. The actual discharge through the orifice.

$$Q = \frac{\text{Area of measuring tank} \times \text{rise of water level in the measuring tank}}{\text{time } (t)}$$

Theoritical discharge, Q_{th} = Area of orifice $\times \sqrt{2gH}$

$= a \times V_{th}$

$= a \times \sqrt{2gH}$

$$C_d = \frac{Q}{Q_{th}}$$

$$\boxed{C_d = \frac{Q}{a \times \sqrt{2gH}}}$$

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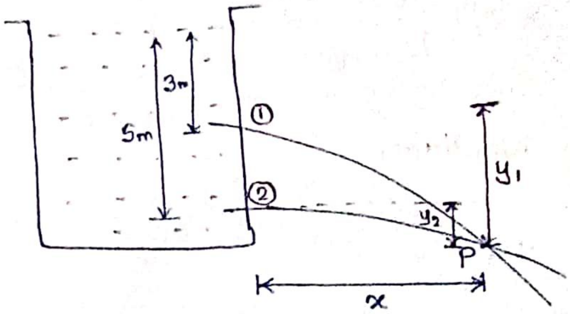
Prob: A tank has two identical orifices on one of its verticle side. The upper orifice is 3 meter below the water surface and lower one is 5m below the water surface. If the value of C_v for each orifice 0·96. Find the point of intersections at 2 jets.



⇒ Height of water from orifice, 1, $H_1 = 3m$

$H_2 = 5m$

lets P is the point of intersection of 2 jets coming from orifice 1 and 2.

x = hor. dis from P.

y_1 = ver. dis from orifice ①

y_2 = ver dis from orifice ⑪

$$y_1 = y_2 + (5-3)$$

$$\Rightarrow y_1 = y_2 + 2$$

For orifice ① $\longrightarrow$

$$C_{v_1} = \frac{x}{\sqrt{4 y_1 H_1}} \quad [H_1 = 3\,m] \quad \text{—— ①}$$

For orifice ⑪ $\longrightarrow$

$$C_{v_2} = \frac{x}{\sqrt{4 y_2 H_2}} \quad [H_2 = 5\,m] \quad \text{—— ⑪}$$

① and ⑪ are identical,

$$C_{v_1} = C_{v_2}$$

$$\Rightarrow \frac{x}{\sqrt{4 y_1 3}} = \frac{x}{\sqrt{4 y_2 5}}$$

$$\Rightarrow \frac{x}{\sqrt{12(y_2+2)}} = \frac{x}{\sqrt{20 y_2}}$$

$$\Rightarrow y_2 = 3\,m$$

y_2 এর মান ① নং এ বসিয়ে,

$$0.96 = C_{v_1} = \frac{x}{\sqrt{4 \times 5 \times 3}}$$

$$\Rightarrow x = 7.24\,m$$

* Ex. 8.8

Flow through large orifice:

① Available head of a liquid is less than 5 times the height of orifice.

point-এ point এ velocity change হলে → discharge change হবে.

$$Q = C_d \times (b \times d) \times \sqrt{2gH}$$

$d \rightarrow H_2 - H_1$

Discharge through a large orifice:

large: $Q = \frac{2}{3} C_d \times b \sqrt{2g} \left[H_2^{3/2} - H_1^{3/2} \right]$

small: $Q = C_d \times a \times \sqrt{2gH}$, $H \rightarrow H_1 + d/2$

Mouth piece:

extention of pipe

↳ length 2 to 3 time dia.

Classification of mouthpiece.

Flow through an external cylindrical mouthpiece.

eddy-র জন্যে head loss হয়. $h_L = \frac{(V_1 - V_2)^2}{2g}$

$C_d = C_v \times C_c$

actual, $V = 0.855 \sqrt{2gH}$

theoritical, $V_t = \sqrt{2gH}$

** # কেন mouthpiece এ oripiece এর চেয়ে discharge বেশি হয়?

Practice Prob : 13

Time required for emptying a hemispherical tank.

$$T = \frac{\pi}{C_d a \sqrt{2g}}$$

Bansal prob – 7.19 (page 336)

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Flow over notches and weirs:

V-notch

masonry

notch and weir:

↳ submerged condition এ থাকবে,

Nappe and crest-1

Types of Notches:

(i) Steeped notch.
(ii)
(iii)
(iv)
(v)

Types of weir:

Dischange over a Rectangular Notch or weir:

Area of strip = $A = L \times dh$

$$dQ = C_d L \, dh \sqrt{2gh}$$

$$Q = \frac{2}{3} C_d L \sqrt{2g} \, [H]^{3/2}$$

Practic prob #-14

Discharge over a triangular Notch or Weir:

Area of strip = $2 \tan \theta/2 \times (H-h) \times dh$

$$Q = 2 C_d \tan \theta/2 \times \sqrt{2g} \left[\frac{Hh^{3/2}}{3/2} - \frac{h^{5/2}}{5/2} \right]_0^H$$

$$= \frac{8}{15} C_d \tan \theta/2 \times \sqrt{2g} \times H^{5/2}$$

Practice Prob # 15

Ans: 357·2 mm

$$Q = \frac{2}{3} C_d L \sqrt{2g} H^{3/2}$$

$$Q = \frac{8}{15} C_d \tan \frac{\theta}{2} \sqrt{2g} H^{5/2}$$

12/02/2020

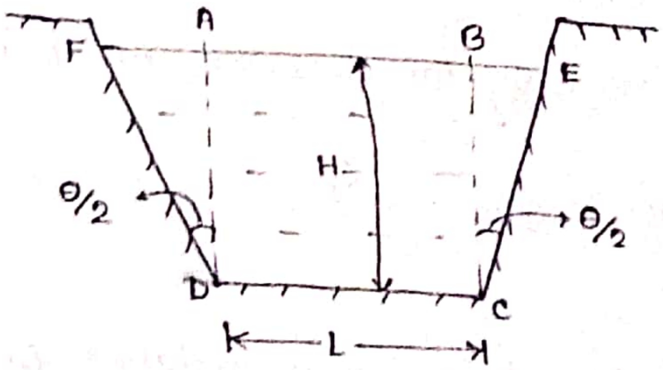
Advantages of triangular notch over a rectangular weir:

(i) For a right angle v-notch or weir, the expression for the computation of discharge is very simple. ($Q = 1.417 H^{2.5}$)

(ii) In a given triangular notch, only one reading that is Head (H) is required to be taken for the measurement of discharge.

(iii) For a low discharge, a triangular notch, keeps gives more accurate result than a rectangular notch.

Discharge over a trapizoidal notch or weir:



A trapizoidal notch or weir is a combination of a rectangular and triangular notch or weir. Thus total discharge will be equal to the sum of discharge through rectangular weir + discharge through triangular weir.

Total discharge through trapizoidal weir

= Dischange through triangular porsion (ADF + BCE)

+ Discharge through reclangular porsion (ABCD)

Let us consider,

H = Height of water over the lose.

L = Length of the reclangular porsion of the notch.

C_{d_1} = Co-efficient of dischange for the reclangular porsion.

C_{d_2} = " " " " triangular "

Dischange through reclangular porsion ABCD is given by

$$Q_1 = \frac{2}{3} C_{d_1} \times L \times \sqrt{2g} \times H^{3/2}$$

Dischange through two triangular notches ADF and BCE,

is equal to the discharge through a single triangular

notch of angle θ is given by,

$$Q_2 = \frac{8}{15} \times C_{d_2} \times \tan\frac{\theta}{2} \times \sqrt{2g} \times H^{5/2}$$

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∴ Discharge through trapizoidal notch or weir.

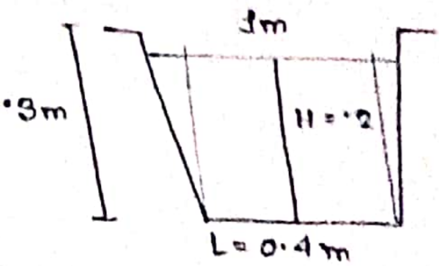
$$Q = Q_1 + Q_2$$

$$= \frac{2}{3} \times C_{d_1} \times L \times \sqrt{2g} \times H^{3/2} + \frac{8}{15} \times C_{d_2} \times \tan \theta/2 \times \sqrt{2g} \times H^{5/2}$$

Prob:

Find the discharge through a trapijoidal notch which is 1m wide at the top, 0·4 m at the bottom and 30 cm is in height. The head of water on the notch is 20 cm. Assume cd for rectangular porsion is 0·62, while triangular porsion is equal to 0·6.

⇒



$$Q = \frac{2}{3} \times 0{\cdot}62 \times \sqrt{2g} \times 0{\cdot}4 \times {\cdot}2^{3/2}$$

$$+ \frac{8}{15} \times 0{\cdot}6 \times 1 \times \sqrt{2g} \times {\cdot}2^{5/2}$$

$$\tan \theta/2 = \frac{0{\cdot}3}{0{\cdot}3} = 1$$

$$= 0{\cdot}091$$

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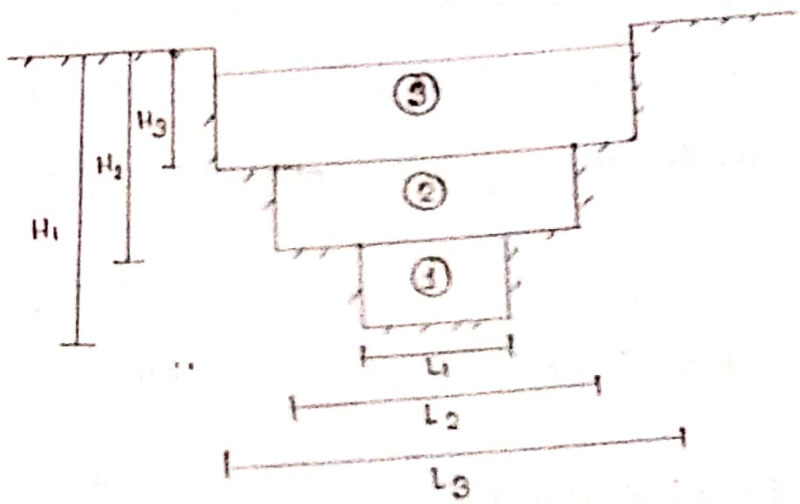
Step, notch or weir: Trapezoidal weir.

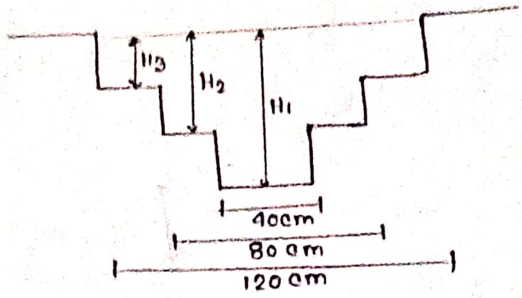
• Discharge over stepped notch.

A stepped notch is a combination of rectangular notches. The discharge through stepped notch is equal to the sum of discharges through different rectangular notches.

Consider a stepped notch as shown in Fig 8.6.



Practice Problem # 17



Soln:

$C_d = 0.62$

$L_1 = 40$ cm

$L_2 = 80$ cm

$L_3 = 120$ cm

$Q_1 = \frac{2}{3} C_d \times L_1 \times \sqrt{2g} \left[H_1^{3/2} - H_2^{3/2} \right]$

$H_1 = 50 + 30 + 15 = 95$ cm

$H_2 = 50 + 30 = 80$ cm

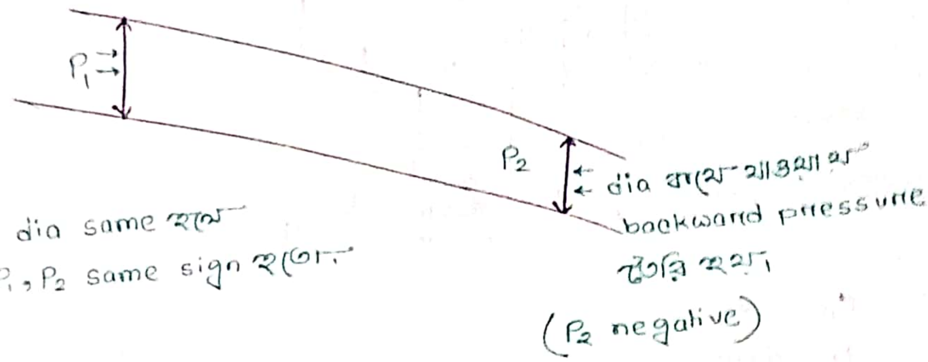
$H_3 = 50$ cm

* Cipolletti weir or notch
* Broad crested weir, narrow crested weir.
* Ogee weir, ogee notch. ⟶ defination + figure.

23/02/2020

Lecture : 1 and 2

Derivation of Bernouli's eq^n

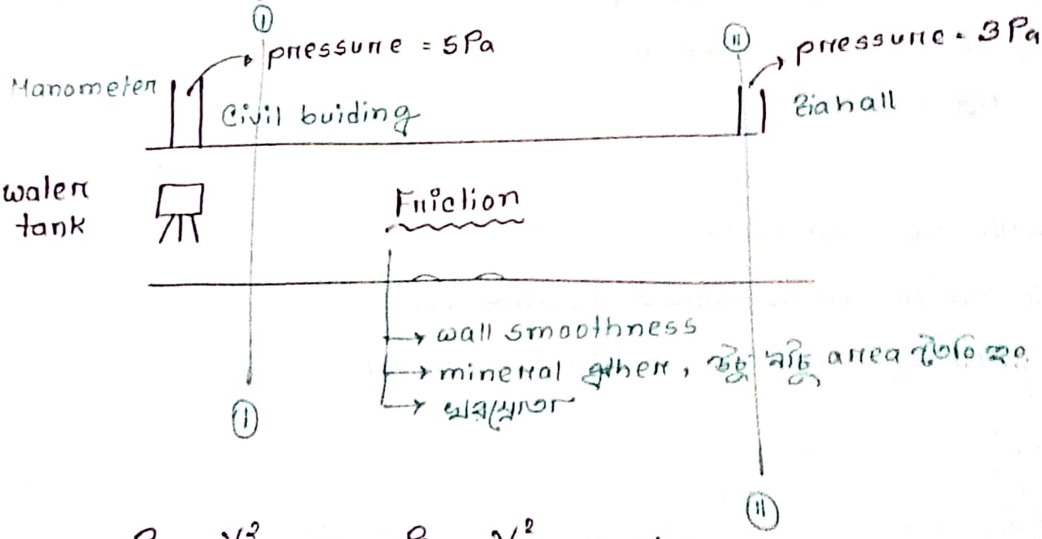


dia same হলে P_1, P_2 same sign হতো

Assumption.

Assignment → 6.4, 3

Bernoulli's eq^n for real fluid:



$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_f$$

ρ = sg × পানির ঘনত্ব

□ Practicle application of B.E.

□ Venturimeter.
- → convergent
- → Divergent
- → throat

□ Expression for rate of flow through venturimeter

head lose $h = \frac{P_1 - P_2}{\rho g}$

$$Q_{th} = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

Prac Prob # 4

02/03/2020

Lecture : 4 and 5

Pilot Tube:

velocity measurement.

Working of pilot tube:

Theory of pilot tube:

Q: → Arrangements of pitot tube: → 4 টা figure

Assignment: → 6.27, 6.45, Rajput (page- 311), prob-6, prob-7, (Raj)-32[illegible])
prob-8

Free liquid jet: → আগুন লাগলে যে nozzle use করে পানি ছোড়া হয়

trajectory path **

Eqn of a free liquid jet.

Maximum Height attained by jet.