14/03/2022

UNIT-1

*) Introduction:-

Hydraulics:-

It is defined as the branch of engineering which deals with water at Rest as the well as in motion.

Classification of Hydraulics

*) Hydro statics → Rest

*) Hydro dynamics → Relationship b/w velocity acculation.

*) Hydro kinematics → motion.

Fluid:-

Fluid is said to be substance with capable of Flowing.

Fluid do not have a deficinite shape

Fluid

- Liquids
  1. water
  2. oil
- Gases
  1. Air
  2. H_2O
  3. CO_2

Properties:-

1. Mass
2. volume
3. Density
4. Specific weight
5. force
6. Specific volume
7. Specific gravity
8. Cohesion
9. adhesion
10. Surface tension
11. Capillarity
12. Compressibility
13. viscocity
14. Vapour pressure.

1. Mass:

$M = \frac{w}{g}$

w = weight

g = gravity

unit = kg

2. Force:-

Force unit = Newton

3. weight:

$w = m \times g$

4. Density:-

$\rho = \frac{mass}{volume}$

water Density 1000 kg/m^3

unit = kg/m^3

5. Specific weight

$$\omega = \rho g$$

6. Specific volume $= \frac{1}{\rho}$

unit $= \frac{m^3}{kg}$

7. Specific gravity:-

$$S = \frac{\text{Specific weight of fluid}}{\text{Specific weight of water}}$$

8. viscosity:-

$\Rightarrow$ 'μ'

unit $\Rightarrow Ns/m^2$

a) kinematic viscosity:-

$$\nu = \frac{\text{viscosity}}{\text{Density}}$$

$$= \frac{\mu}{\rho}$$

unit $= m^2/s$

Dimension and units:-

Length - L

mass - M

Time - T

1. Area (A):

A $\Rightarrow$ l×b = length × breath

unit $\Rightarrow M \times M \Rightarrow m^2$

Dimension $\Rightarrow L \times L = L^2$

2. volume: Length × breath × depth

unit ⇒ Meter × meter × meter

$= m \times m \times m$

$\boxed{V = m^3}$

Dimension $\Rightarrow L \times L \times L = L^3$

3. Specific volume:-

$$= \frac{\text{Volume}}{\text{weight}}$$

$$\Rightarrow \frac{V}{w} \; m^3/N$$

4. velocity (v)

$$V = \frac{\text{Distance}}{\text{Time}} \; m/s$$

unit $= \frac{m}{s} \Rightarrow s$

Dimension : $\frac{L}{T} \Rightarrow LT^{-1}$

5. Accelaration:-

$$a = \frac{\text{velocity}}{\text{time}}$$

unit $= m/s^2$

Dimension $= \frac{L}{T^2} = LT^{-2}$

unit ⇒ $m \times m \Rightarrow m^2$

Dimension ⇒ $L \times L = L^2$

2. volume: Length x breath x depth

unit ⇒ Meter x meter x meter

$= m \times m \times m$

$\boxed{V = m^3}$

Dimension ⇒ $L \times L \times L = L^3$

3. Specific volume:-

$= \frac{\text{Volume}}{\text{weight}}$

$\Rightarrow \frac{V}{w}$ m^3/N

4. velocity (v)

$V = \frac{\text{Distance}}{\text{Time}}$ m/s

unit $= \frac{m}{s} \Rightarrow 5$

Dimension: $\frac{L}{T} \Rightarrow LT^{-1}$

5. Accelaration:-

$a = \frac{\text{velocity}}{\text{time}}$

unit $= m/s^2$

Dimension $= \frac{L}{T^2} = LT^{-2}$

6. Density!

$$\frac{\text{Mass}}{\text{volume}}$$

$$\Rightarrow \frac{kg}{m^3}$$

$$\Rightarrow \frac{M}{L^3} = ML^{-3}$$

7. Discharge:- $\frac{\text{volume}}{\text{Time}}$

$$= \frac{m^3}{s}$$

$$= \frac{L^3}{T}$$

$$= L^3 T^{-1}$$

8. Force:-

Force = mass x acceleration

= m x a

unit = N (or) kN.

9. Pressure:-

$$\Rightarrow \frac{\text{Force}}{\text{Area}} \quad N/m^2$$

unit = $\frac{N}{m^2}$ $N = MLT^2$

$$N = \frac{MLT^2}{L^2}$$

$$\rightarrow ML^{-1}T^{-2}$$

1. Density : $\frac{\text{mass}}{\text{volume}}$

$$Mass = \frac{w}{g} \Rightarrow \frac{9000}{9.81} = 977.43 kg$$

$$Density = \frac{917.43}{1}$$

$$\boxed{= 917.43 kg/m^3}$$

Specific weight :-

$$= \frac{weight}{Volume}$$

$$= \frac{9000}{1}$$

$$SW = 9000 kN/m^3$$

Specific volume :-

$$= \frac{volume}{mass}$$

$$= \frac{1}{917.43} = 1.09 \times 10^{-3}$$

$$= 0.00109 m^3/kg$$

Relative density :-

$$\Rightarrow \frac{\text{specific wgt of liqud}}{\text{specific wgt of water}}$$

$$= \frac{9000}{9810} \rightarrow$$

Constant $\Rightarrow 0.917$

Result:-

(i) Density $\Rightarrow 917.43 kg/m^3$

(ii) spec weight $= 9 kN/m^3$

(iii) spec. volume $= 0.00109 m^3/kg$

(iv) Relative density $= 0.917$.

2.

Given:-

Density $= 837 kg/m^3$

Find:-

(i) spec. weight

(ii) Relative density

(i) spec. wgt $= \frac{weight}{Volume} = \frac{8210.97}{1}$

weight $= m \times g$ $\Rightarrow 8210.97 N/m^3$

$\Rightarrow 837 \times 9.81 \Rightarrow 8210.97 N/m^3$

(ii) Relative density:

$\Rightarrow \frac{\text{Spec. wgt of liquid}}{\text{Spec. wgt of water}}$

$\Rightarrow \frac{8210.97}{9810}$

$\Rightarrow 0.837$

3. The capillary tube of 3mm diameter is deper water. The velcovy of section of water is compton a 75×10^{-6} N/m². the contact water surface is 0%. Calculation rise is the tube.

Given:-

(i) Dia of capillary tube = 3mm $\Rightarrow \frac{9.81\times10^{3}}{109}$

(ii) surface tension $\sigma = 75\times10^{-6}$ N/mm $= 9.81\times10^{-6}$ N/mm²

$\gamma = 9.81\times$ N/m³

(iii) contact angle of water surface $\Rightarrow 0°$

9.81×10^{3}m

To find:-

Capillary Rise in the tube H=?

$$H = \frac{4\sigma\cos\alpha}{\gamma d}$$

$\gamma = 9.81\times10^{3}$ N/m³

$\Rightarrow$

9kN = 9000N

Spec. weight $\gamma = 9.81\times10^{3}$ N/m³

$$H \Rightarrow \frac{4\times75\times10^{-6}\cos0°}{9.81\times10^{-3}\times3}$$

$\Rightarrow$ 10.19mm

Spec. wight = $\frac{\text{weight}}{\text{volume}}$

1. one cubic metre of crude oil weights 19kN. calculate its density, spec, weights Relative density.

2. if a liquid weight 100kN and occupies 4m³ Find its spec. weight, mass, dasity, Relative density, spec. volume

(i) volume = $1m^3$

(ii) weight = 19kN ⇒ $19 \times 10^3 = (1000)$

= 19000N

100×10

$= 100 \times 10$

$= 1000$

(i) Density ⇒ $\frac{mass}{volume}$

mass ⇒ $\frac{w}{g}$

⇒ $\frac{19000}{9.81}$

⇒ 1936

volume = $\frac{1936}{1}$

= 1936.

4. Calculate the capillary rise and fall in a glass tube of 2.5mm diameter when immersed vertically in (a) water, (b) mercury and. Take surface tensions σ = 0.0725 N/m for water and σ = 0.52 N/m for mercury in contact with air. The specific gravity for mercury is given as 13.6 and angle of contact = 130°.

<u>Given:-</u>

Diameter = 2.5 mm $= \frac{2.5}{1000} = 0.0025$ m.

Surface tension (σ) for water (σ) ⇒ 0.0725 N/m

Surface tension (σ) for mercury (σ) ⇒ 0.52 N/m.

Spec. gravity for mercury (γ) ⇒ 13.6

angle of con ~~tact~~ (α) = 130° ⇒ 9810

$$\text{Capillary Rise} = \frac{4\sigma \cos\alpha}{\gamma d}$$

$$\text{Capillary Rise for water} \Rightarrow \frac{4\sigma}{\gamma d}$$

$$\Rightarrow \frac{4 \times 0.0725}{9810 \times 0.0025}$$

$$\Rightarrow 0.0118\text{m}$$

$$\text{Capillary Fall for mercury} = \frac{4\sigma \cos\alpha}{\gamma d}$$

$$= \frac{4 \times 0.52 \times \cos 130°}{13.6 \times 0.0025}$$

=

Measurement of pressure:- (N)

$P = \frac{P \rightarrow \text{Kg}}{A \rightarrow \text{Area}}$

P = intensity of pressure

P = Total pressure (N)

A = cross sectional area (mm^2)

The intensity of pressure of a liquid is the pressure per unit area. It is also known as unit pressure.

Pressure Head of Liquid:-

When pressure is expressed in the units of height of liquid, it is known as pressure head and is measured in metres of liquid column.

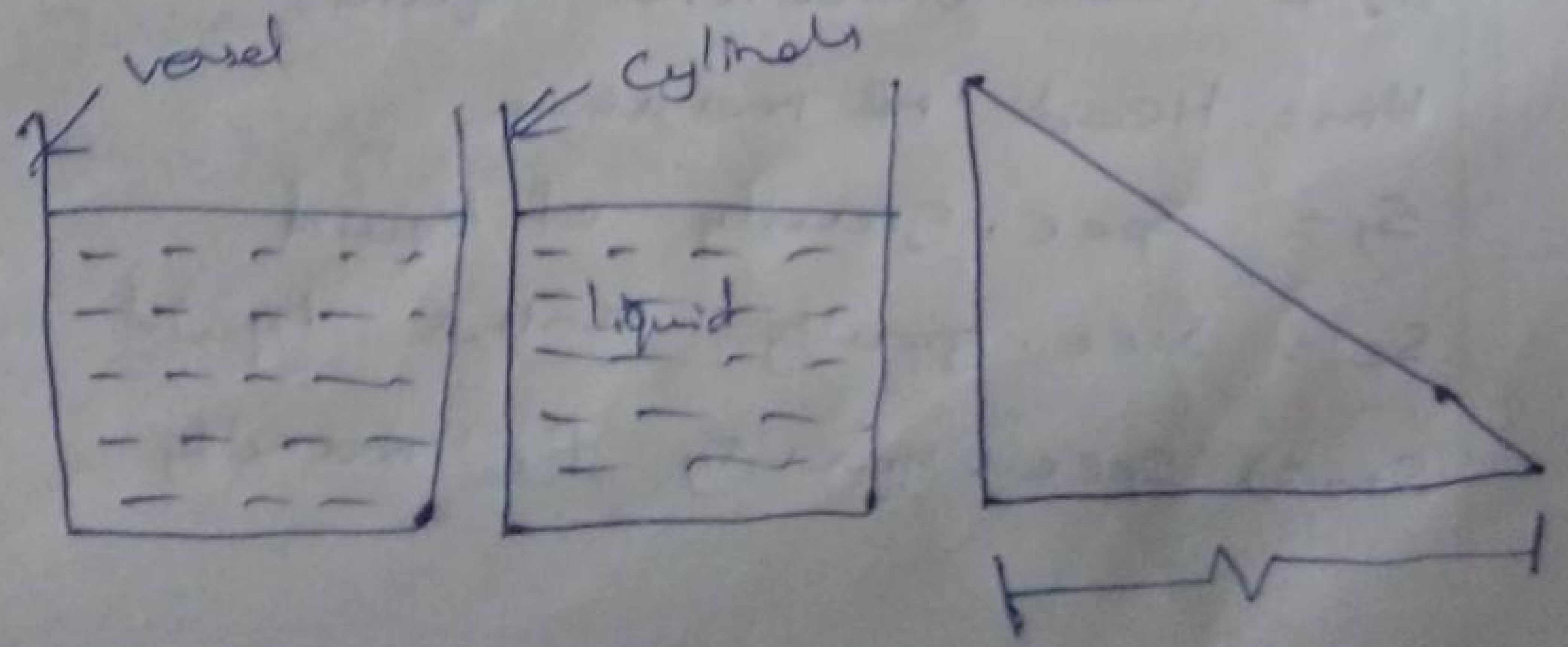
Pressure head, $h = \frac{P}{\gamma}$ m of liquid

Let, h = Pressure head in metres of liquid

P = Intensity of pressure in N/m^2 (or pascal)

γ = Specific wt. of liquid in N/m^3

Conversion from intensity of pressure to pressure head:-



Types of Pressure:-

1. Static Pressure
2. Atmospheric pressure
3. Gauge pressure
4. Vacuum pressure
5. Absolute pressure

$P = \frac{P}{A(mm^2)} \quad N/mm^2$

Static → Reast

kinematic → motion

1. Static pressure:-

The pressure exierted on any opped by a liquid at second Static pressure.

2. Atmospheric pressure:-

Atmospheric is a exerted normal pressure on all shepa with in it confined and its not atmospheric pressure:-

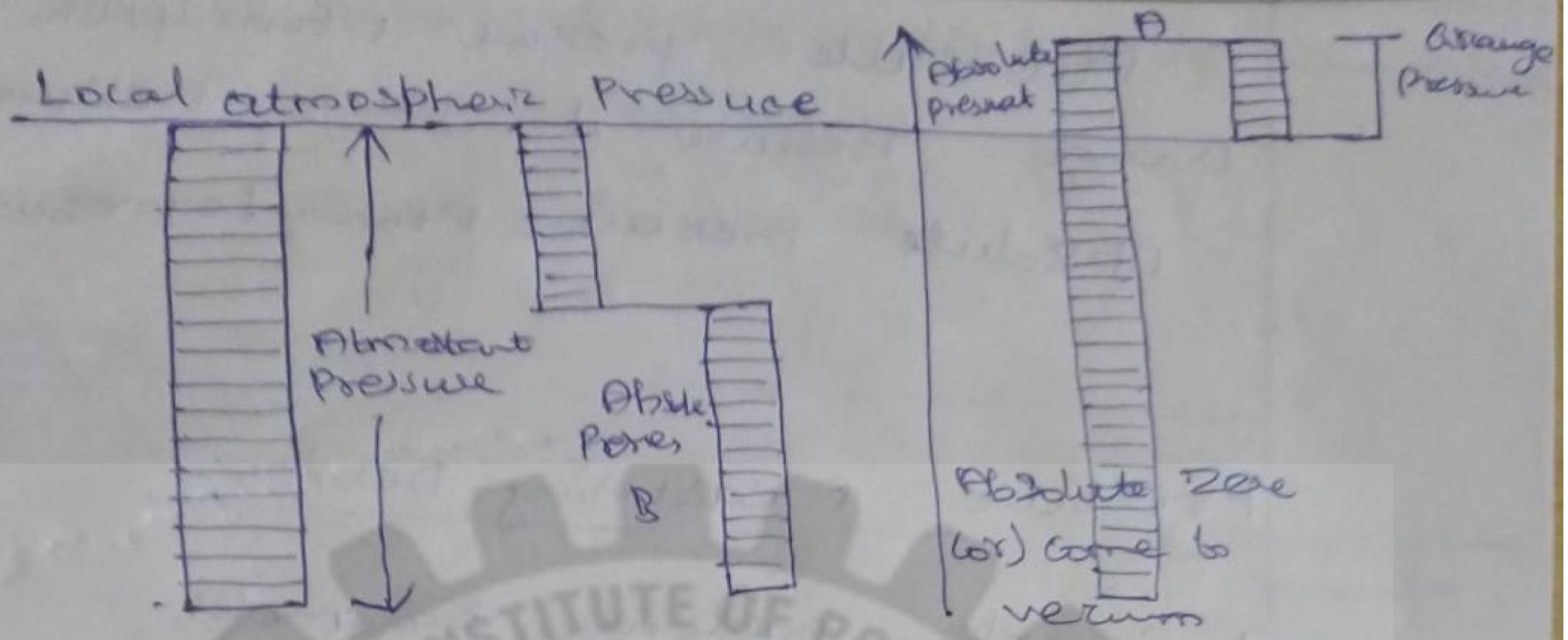
It is measured by barometer

Standard value of atoms. pressure ⇒ 10.4 kN/m^2

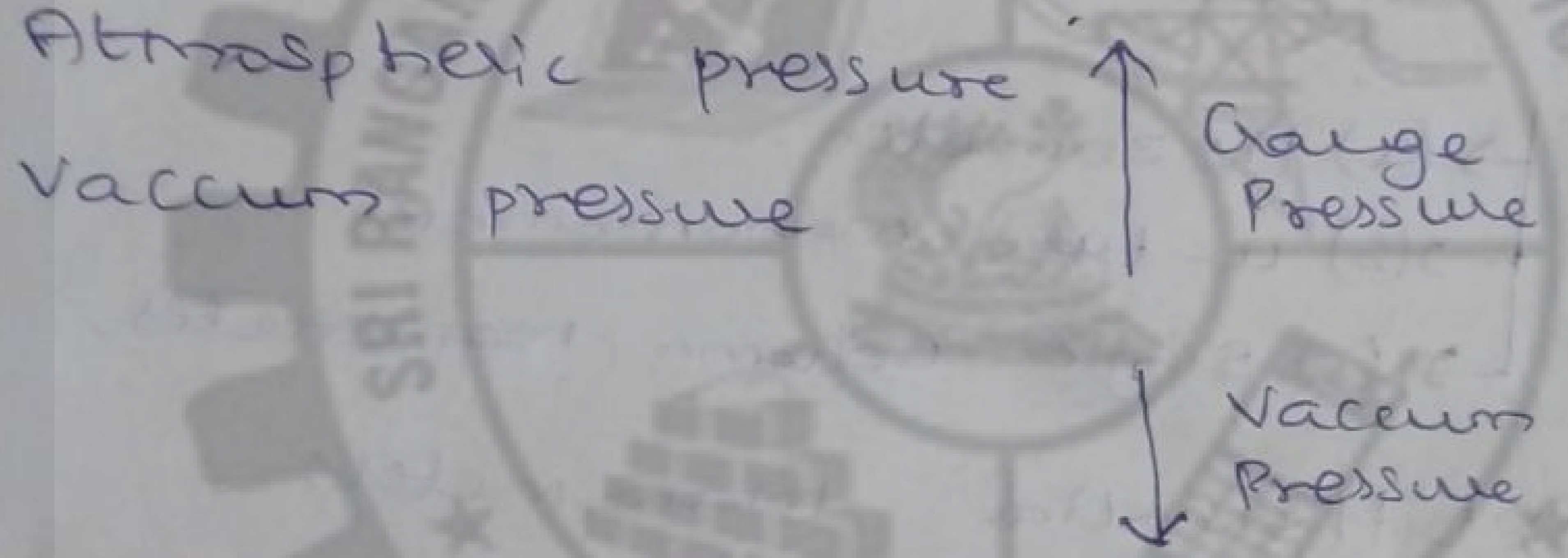
The atmospheric pressure for mercury ⇒

760 mm for metres for water.

⇒ 10.34 m for water.



Gauge Pressure:- → Positive gauge Pressure:-



1. It is diffured. pressure with mesause help mesuring instedrel. It with the Atomospheric presure is datalm. If the pressure above the atmosphere pressure is called Gauge Pressure.

Vaccum pressure:-

Vaccum pressure → Atmospheric pressure - Absolute pressure.

it is diffded pressure below the atmosphere pressure.

5. Absolute pressure:-

Absolute pressure = Atmospheric pressure + Gauge pressure if gauge pressure is positive.

Zero

Absolute pressure = Atmospheric pressure + Gauge Pressure if gauge pressure is negative

Absolute pressure = Atmospheric pressure − Gauge pressure

Pressure measuring Devices:-

1. Simple mercury Barometer.
2. mano meters.
   (i) simple manometers.
      - (a) Piezometer
      - (b) u-tube manomometer
      - (c) single column manometer.
   (ii) Differential manometer:-
      - (a) u tube differential manometer
      - (b) inverted u-tube differential manometer.
3. Mechanical Gauges:-
   (a) Diaphragm Gauge pressure
   (b) Bourdon tube.

Formulas:-

intensity of pressure $p = \frac{P}{A}$ N/mm^2

Pressure head of liquid $h = \frac{p}{\gamma}$ m

$p = \gamma h$ N/m^2

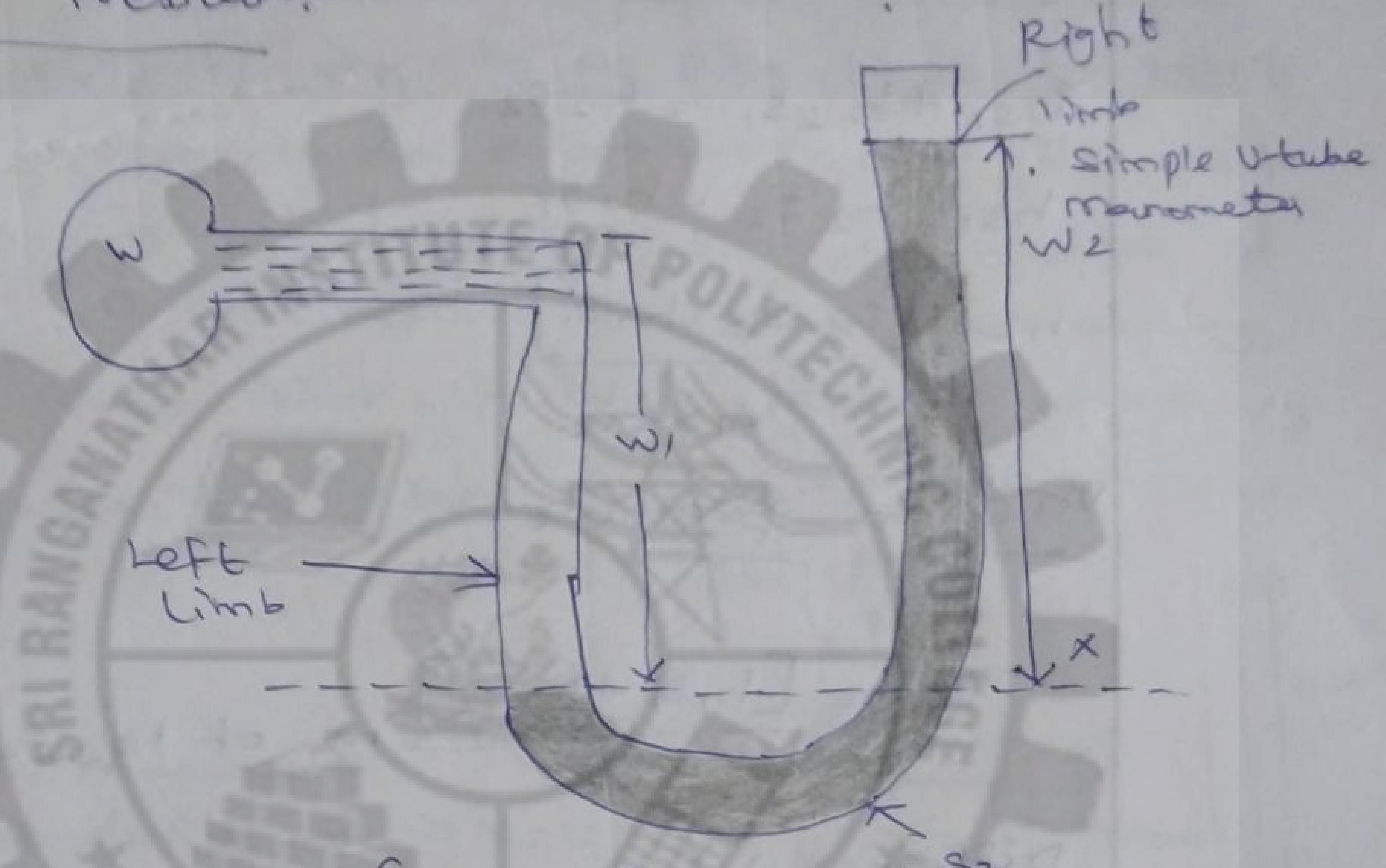
vaccum pressure = Atmospheric pressure − Absolute Pressure

Absolute pressure => Atmospheric pressure ± Gauge pressure

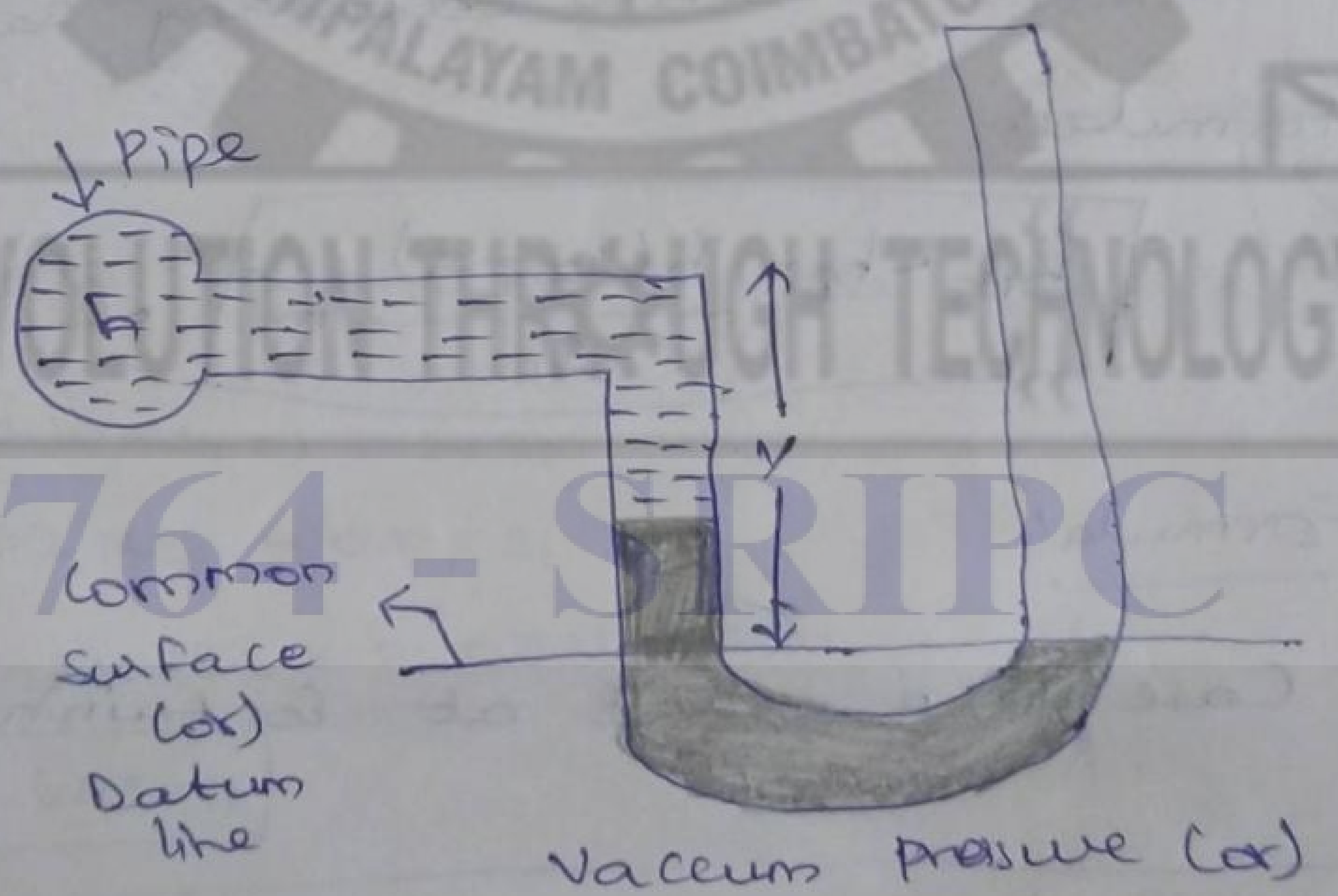
gauge Pressure (+) Positive =>

gauge Pressure (-) Positive =>

Gauge Pressure:



Gauge Pressure (or) Positive pressure



Vaccum pressure (or) Negative pressure.

Formula:-

h = Pressure head in meters

h_1 = height of liquid above x-x line

h_2 = height of heavy liquid above datum

S_1 = Specific gravity of light liquid

S_2 = Specific gravity of heavy liquid

Pressure above x-x in the left colum $[h_1 s_1 + h s_1]$ m of liquid

Pressure above x - x in the Right colum $[h_2 s_2]$ m of liquid

Hence Equating two pressures:-

$h s_1 + h_1 s_1 = h_2 s_2$

$h s_1 = h_2 s_2 - h_1 s_1$

$$h = \frac{[h_2 s_2 - h_1 s_1]}{s_1}$$

Vaccum pressure:-

$$h = \frac{[h_1 s_1 + h_2 s_2]}{s_1} \text{ m of liquid}$$

Differential manometer

Case (1) A and B Containing same liquid

Formula:-

$$\boxed{h_A - h_B = \frac{h(s_2 - s_1)}{s_1} \text{ m}} \text{ of liquid.}$$

Formula:-

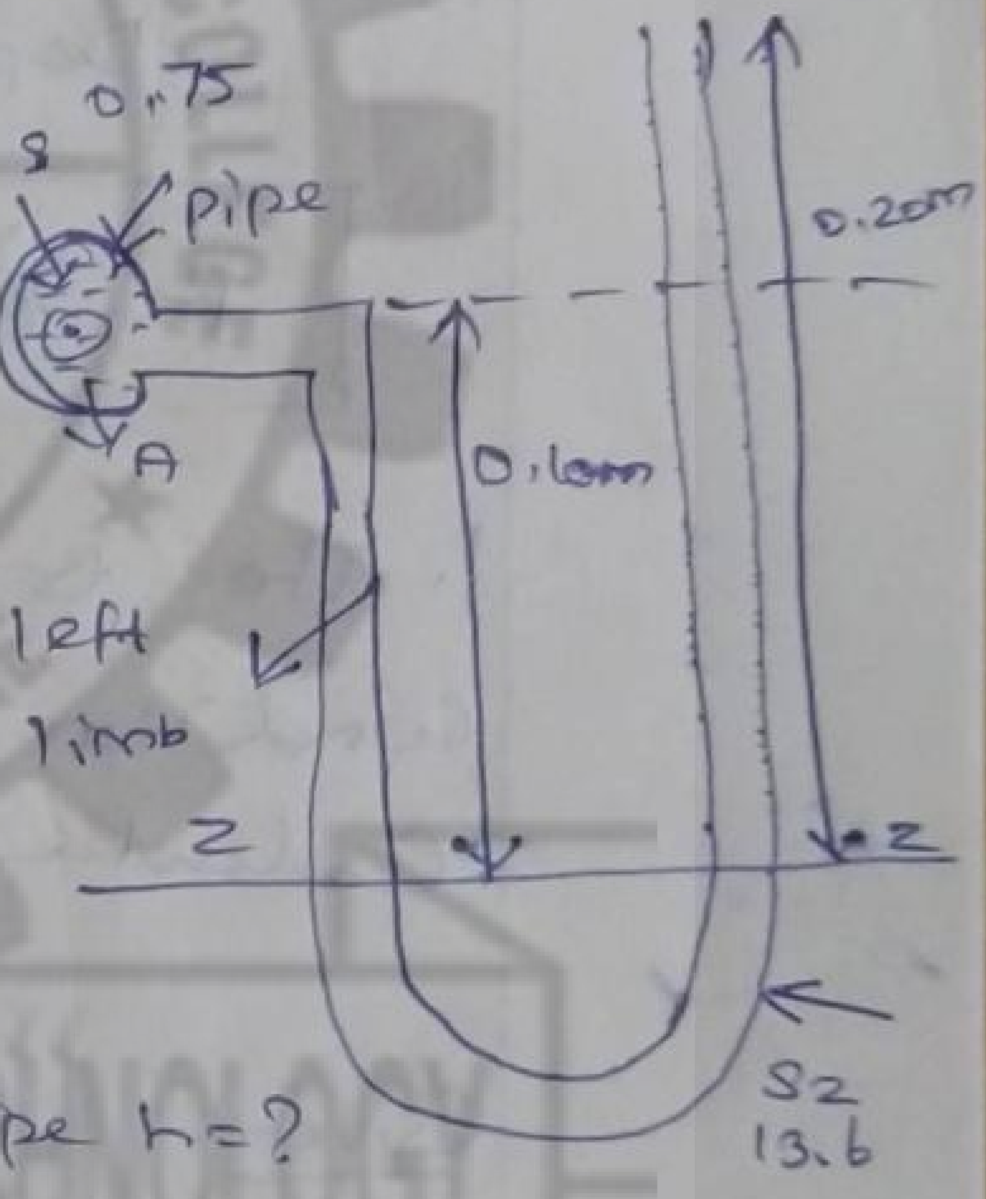
Case (2) A and B at Containing different liquids

$$\boxed{h_A s_1 - h_B s_2 = s_2 h_3 + s_2 h_2 - s_1 h_1} \text{ m of liquid.}$$

micromano meter:-

$$h = s_1 h_2 - s_1 h_1 + \frac{a}{A} h_2 (s_2 - s_1)$$

6. A simple manometer is used to measure the pressure the pressure of oil of relative density 0.75 Flowing in a pipe line. Its right limb is open to the atmosphere. and the left limb is connected to the pipe. The centre of pipe is 0.10m below the level of mercury, in the right limb. If the difference of mercury level in the two limbs is 0.20m, Determine pipe,



Given:-

Simple manometer

Relative density of oil $s_1 = 0.7$

Relative density of mercury = 13.6m

center of the pipe = 0.10m

To find:-

Absolute pressure of oil in the pipe h=?

$H + 0.10 \times S_1 \Rightarrow 0.2 \times S_2$

$H = 0.2 \times S_2 - 0.10 \times S_1$

$\Rightarrow 0.2 \times 13.6 - 0.10 \times 0.75$

$\boxed{H = 2.645\,m}$

Absolute pressure = Atmosphere pressure + gauge pressure

$h \Rightarrow 10.34 + 2.645$

Absolute pressure $\Rightarrow h \Rightarrow 12.985m$

$P = \gamma h$

$= 9.8 \times 10^3 \times 0.75 \times 12985$

$P = 95537.137\ N/m^2$ (or) Pa.

Case (i)

Total pressure on an Immersed Surface Horizontally

γ = Specific weight of liquid ($\gamma_w = 9.81\ kN/m^3$)

A = Area immersed surface in m^2

$\bar{x}$ = Centre of gravity from free liquid surface in m

We know that the total pressure on the surface

P = weight of liquid above the immersed surface

P = Specific weight of liquid × Area of liquid × Depth of liquid.

$$\therefore \boxed{P = \gamma A \bar{x}\ kN}$$

1. The triangles tank 4mm long 2mm wide condition water upo depth of 3.5m. Calculated the pressure of the tank.

Given:-

Length = 4m
wide = 2m
depth $\bar{x}$ => 3.5m

A = L×b
=> 4×2
=> $8m^2$

To find:-

Pressure on the base of tank p = ?

$$\boxed{P = \gamma A \bar{x}}$$

Soln:

$= 9.81 \times 8 \times 3.5$

$= 274.68\ kN$

8. A tank 3m in botom Cortional 1.8m data oil of speific 0.8. Find instape of press. of vertiead the tank.

Given:-

Size of the tank = $3 \times 4 = 12 m^2$

Depth of oil $\bar{x}$ = 1.8m

Specific gravity of oil = 0.8

Specific weight of oil = $0.8 \times 9.81 \Rightarrow 7.84\ kN/m^2$

To find:-

(i) intesity of pressure.

(ii) Total pressure

(i) intensity of pressure:-

$P = \gamma h$

$P = 7.84 \times 1.8$

$\Rightarrow 14.112\ kN/m^2$

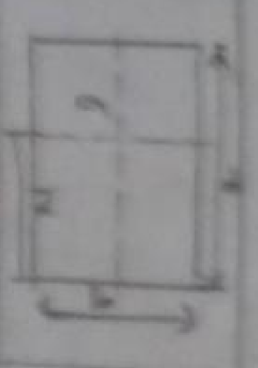
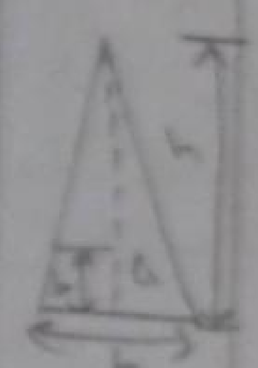
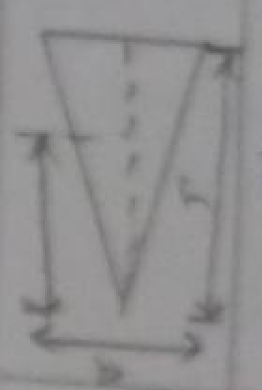
$\Rightarrow 14.112\ kPa$

(ii) Total pressure $= \gamma A \bar{x}$

$P = 7.84 \times 12 \times 1.8$

$= 169.34\ kN$

Geometric properties of some plane figures

plane surface	C.G from base	Area in m^2	Moment of inertia about an axis passing through C.G and parallel to base (I_G) in m^4	Moment of inertia about base (I_B) in m^4
	$\bar{x} = \frac{d}{2}$	bd	$\frac{bd^3}{12}$	$\frac{bd^3}{3}$
	$\bar{x} = \frac{h}{3}$	$\frac{bh}{2}$	$\frac{bh^3}{36}$	$\frac{bh^3}{12}$
	$\bar{x} = \frac{2h}{3}$	$\frac{bh}{2}$	$\frac{bh^3}{36}$	$\frac{bh^3}{12}$
	$\bar{x} = \frac{d}{2}$	$\frac{\pi d^2}{4}$	$\frac{\pi d^4}{64}$	$\frac{5\pi d^4}{64}$

Case (ii)

Total pressure on a vertically immersed Surface

(i) Total pressure $P = \gamma A \bar{x}$

(ii) Depth of centre of pressure $\bar{h} = \frac{I_G}{A\bar{x}} + \bar{x}$

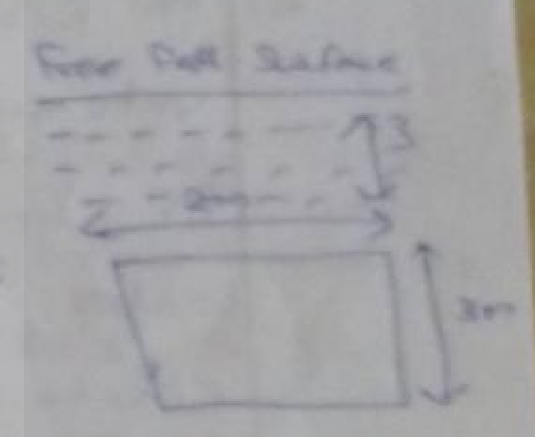
1. The Rectangular plate 2m wide 3m immersed vertically in water with 2m edge parallel 2 and depth of 3m from the water surface. Compute total pressure on the one side of the plate and depth centre of pressure.

Given:-

Rectangular plate immersed vertically

Size of the plate => 2m × 3m

depth => 3m



$\bar{x} = \frac{d}{2} \Rightarrow \frac{3}{2} \Rightarrow 1.5 + 3 = 4.5$

Total pressure:

$P = \gamma A \bar{x}$

$\gamma = 9.81\ kN/m^3$

$A \Rightarrow b \times d = 2 \times 3 \Rightarrow 6m^3$

$P \Rightarrow 9.81 \times 6 \times 4.5 = 264.87\ kN$

depth of center of pressure:-

$$\bar{h} = \frac{I_{GG}}{A\bar{x}} + \bar{x}$$

$$I_{GG} = \frac{bd^3}{12} \Rightarrow \frac{(2)(3)^3}{12} \Rightarrow 4.5\ m^4$$

$$= \frac{4.5}{6 \times 4.5} + 4.5$$

$$\bar{h} \Rightarrow \frac{4.5}{27} \times 4.5 \Rightarrow \boxed{4.667m}$$

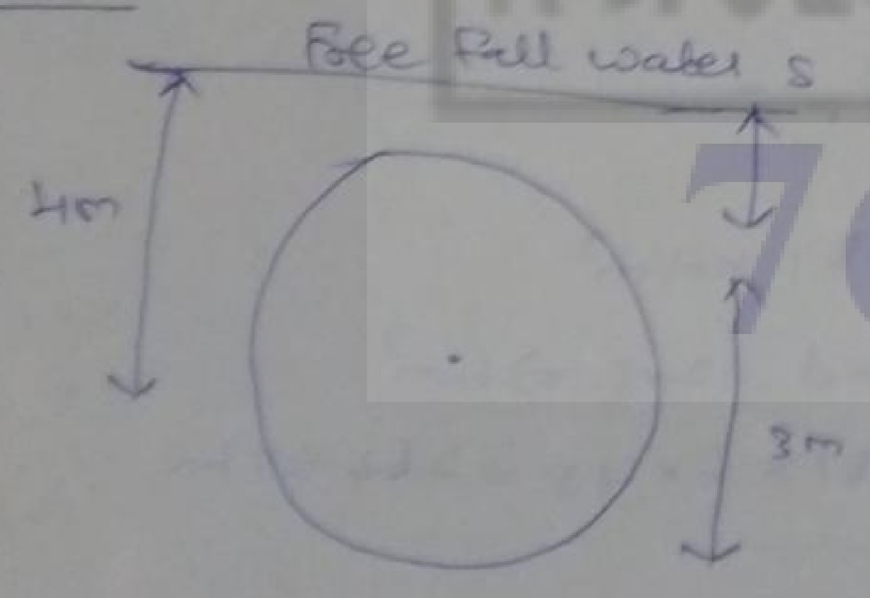
Result:-

(i) Total pressure $P = 264.87 kN$

(ii) depth of center of pressure $h = 4.667m$

2. A circle plate 3mm diameter is placed vertically water so the circle of plated is 4m below the free surface of water. Find the total pressure and depth of circle of pressure on the plate.

Given:-



(i) $P = \gamma A \bar{x}\ kN$

$\gamma = 9.81\ kN/m^3$

$A \Rightarrow \frac{\pi d^2}{4} = \frac{\pi (3)^2}{4} \Rightarrow 7.06m^2$

$\bar{x} \Rightarrow 4m$

$P = 9.81 \times 7.06 \times 4$

$\Rightarrow 277.03 kN$

depth of center of pressure $\bar{h} = \frac{I_{GG}}{A\bar{x}} + \bar{x}$

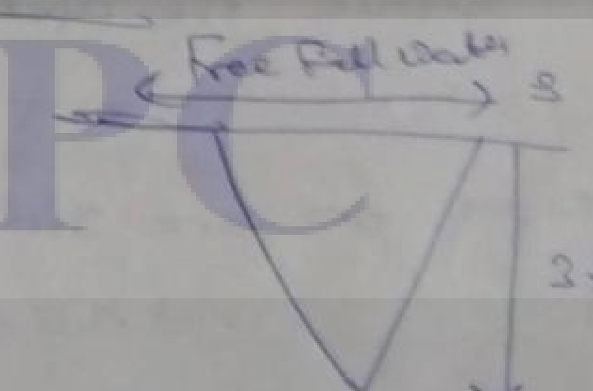
$$I_{GG} = \frac{\pi d^4}{64} = \frac{\pi (3)^4}{64} \Rightarrow 3.98m$$

$$= \frac{3.98}{7.06 \times 4} + 4$$

$$\boxed{h = 4.15m}$$

3. Find the total pressure and depth of centre of pressure when an isoceles triangles plate of 3m base and 3.5m deep the base of the plate is at liquid surface the relative density of liquid is 1.25.

Given data:-



$\gamma = 9.81 \times 1.25$

$= 12.26 kN/m^3$

(i) $P = \gamma A \bar{x}$ kN.

$A = \frac{b\bar{h}}{2} = \frac{3(3.5)}{2} \Rightarrow 5.25 m^2$

$\bar{x} = \frac{h}{3} \Rightarrow \frac{3.5}{3} \Rightarrow 1.166$

$\Rightarrow 1.17 m$

$= 12.26 \times 5.25 \times 1.17$

$= 75.31 kn$

depth of center of pressure $\bar{h} = \frac{I_{GG}}{A\bar{x}} + \bar{x}$

$I_{GG} \Rightarrow \frac{bh^3}{36} \Rightarrow \frac{(3)(3.5)^2}{36} \Rightarrow 3.57 m^4$

Already we know that $A, \bar{x}$

$= \frac{3.57}{5.25 \times 1.17} + 1.17$

$\boxed{h = 1.75m}$

4. A triangular plate 1m base and 1.5m height is immersed in water at an angle of 30° to the free surface of water. The base is paralled to and at a depth of 2m from the free water surface. The apex is below the base.

(i) Resultant pressure on one side of the plate and,

(ii) Depth of centre of pressure.

Given:

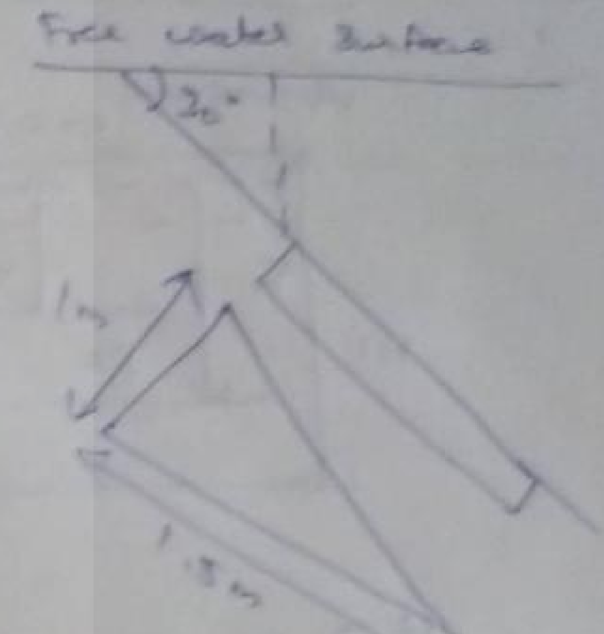
(i) triangular plate

(ii) base = 1m

height = 1.5 m

(iii) immersed in angle 30°

(iv) depth = 2m



Resultant (or) Total Pressure $P = \gamma A \bar{x}$ kN

$\gamma = 9.81 kN/m^3$

$A \Rightarrow \frac{bh}{2} = \frac{1(1.5)}{2} = \frac{1.5}{2} = 0.75 m^2$

$\bar{x} \Rightarrow 2 + \frac{1.5}{3} \times \sin 30°$

$\Rightarrow 2 + 0.5 \times 0.5$

$P = \gamma A \bar{x}$

$= 9.81 \times 0.75 \times 2.25 = 16.55 kN.$

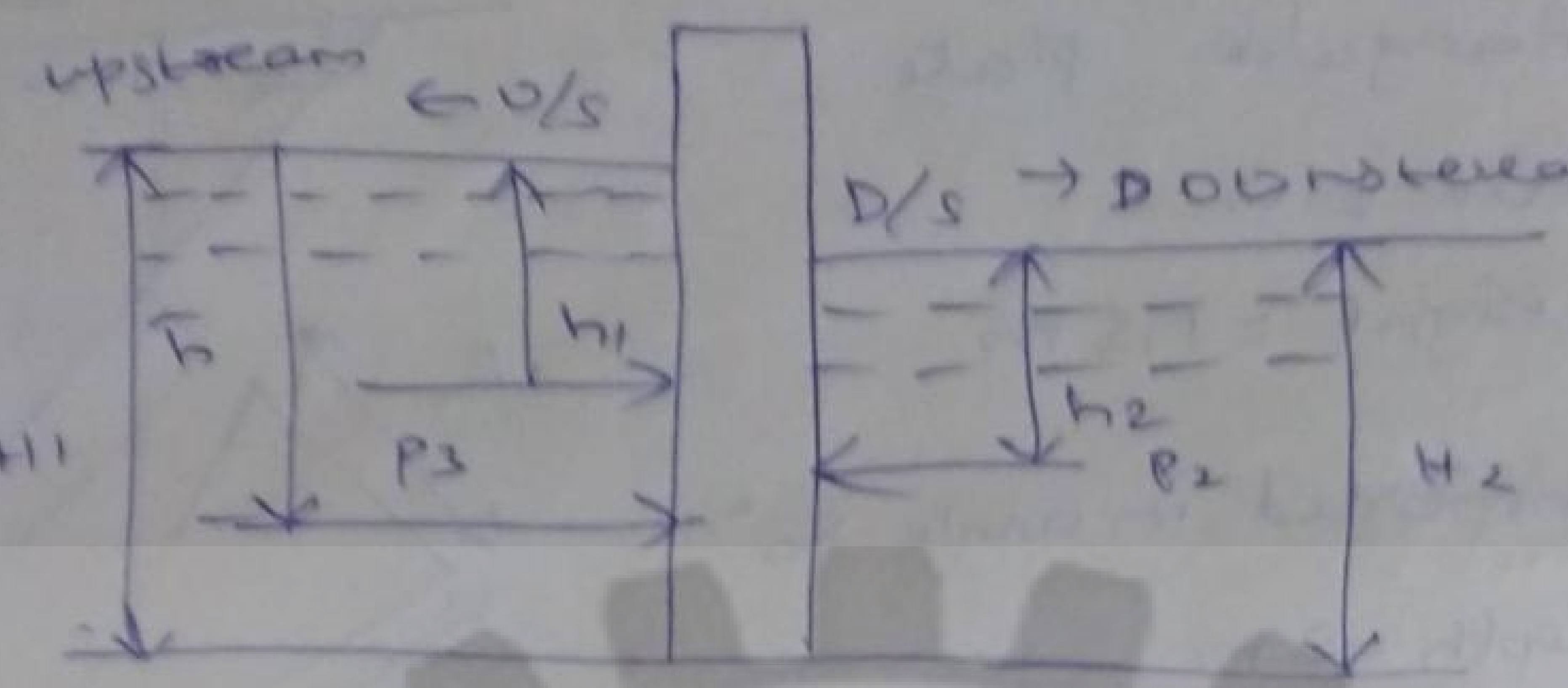
Depth of center of pressure $\bar{h} = \frac{I_{GG} \sin^2\theta}{A\bar{x}} + \bar{x}$

$I_{GG} = \frac{bh^3}{36} = \frac{1(1.5)^3}{36} \Rightarrow 0.093 m^4$

$\bar{h} = \frac{0.093 \sin^2 30°}{0.75 \times 2.25} + 2.25$

$= 2.26 m$

Sluice Gate:



$H_1 \Rightarrow$ Depth of water on upstream side

$H_2 \Rightarrow$ Depth of water on down stream side.

$\bar{x}_1 \Rightarrow$ depth of CG on upstream side

Total pressure on upstream side $P_1 = \gamma A \bar{x}_1$.

Total pressure on up stream side $P_2 = \gamma A \bar{x}_2$

Resultant pressure $= P = P_1 - P_2$ in N

Let,

$\bar{h}_1$ = center of pressure, P_1; $\bar{h}_2$ = center of pressure P_2

$\bar{h}$ = The position of resultant pressure.

Taking moments of pressure about the base

$$P_1(H_1 - \bar{h}_1) - P_2(H_2 - \bar{h}_2) = P(H - \bar{h})$$

$$\bar{h} = \frac{H_1 - P_1(H_1 - \bar{h}_1) - P_2(H_2 - \bar{h}_2)}{P} \text{ meter.}$$

31/03/2022

UNIT-5

Ground water:-

Pumps

well → open well → dia 2m to 9m (20m height)

→ bore well → (15 to 75 cm dia

→ Cavity well → (15 to 30 cm

Shallow well

Deep well

1. Strainer well
2. Cavity type tube well
3. Slotted wells
4. perforated wells.

Yield of open well equation

Derivation:-

Discharge formula for an open well

$Q = A \times V = A.c.h \ m^3/s$.

Q = amount of water percolating into well m^3/s

A = Area in m^2,

V = Mean velocity of water (m/s)

C = Constant for satured soil

h = Depression head in (m).

Test for Yield well:-

(i) Pumping test (or) Constant level test

Darcy's law $Q = KiA$

$= K\left(\frac{S}{L}\right) A$

$\Rightarrow \frac{K}{L} \times A \times S$ $\boxed{K/L = C}$

$Q = C.A.S$

Q = Yield of well, (m^3/s)

A = Area of cross section of well (m^2)

C = a constant

S = depression head (m)

2. Recuperation test:-

$K = 2.303 \frac{A}{T} \log_{10} \frac{H_1}{H_2} \ m^3/sec$

K = Specific capacity of ~~~~ well in cu.m/hr. under head of 1m.

a = area of well in sq.m

h_1 = The difference of water level in the well first after stopage of pumping and the normal water level of the well.

h_2 = The difference of water ~~~~ level in the level after time T and the normal water level of the well.

Rain water Harvesting:-

Needs of Rain water Harvesting / test

Methods of Rain water Harvesting / test

Sanitary Protection of wells.

Pump:-

mechanical Energy → Hydraulic Energy

Turbine:-

Hydraulic Energy → Mechanical Energy.

Types of Pumps:-

1. Positive displacement Pump.
2. Roto dynamic Pumps.

Positive displacement pumps:-

1. Reciprocating Pump
2. Rotary Pump
   - Gear pumps
   - Vane pumps.

Pump:-

Classification of Pumps

- Positive Displacement Pumps
  - Reciprocating Pumps
    - (i) According to action water
      - Single acting Pump
      - Double acting Pump
    - 2) according to number of cylinder
      - Single cylinder Pump
      - Double cylinder pump
      - triple cylinder pump
    - 3) Air vessels (According to existence of air vessels
  - Rotary Pumps
- Rotodynamic Pipes
  - Centrifugal Pump
  - Propeller Pump
  - Half axial and Screw Pipes

Single acting Reciprocating Pumps:-

D = Diameter of cylinder in metre,

A = Cross Sectional area of the piston (or) Cylinder

(i) $A = \frac{\pi d^2}{4}$

(ii) The actual discharge $\boxed{Q_t = \frac{ALN}{60}\ m^3/sec}$

(iii) Coefficient of discharge $C_d = \frac{Q_a}{Q_t}$

(iv) Theortical weight $W_t = \gamma Q_t$

$W_t = \frac{\gamma ALN}{60}$ N/s.

1. A single acting reciprocating pump has a piston diameter of 160mm and a stroke of 224 mm. If the pump lifts to a total height of 9 m at speed of 25 rpm, determine the power required to derive the pump.

Given:-

Single acting Reciprocating Pump

Piston dia(d) = 160 mm = $\frac{160}{1000}$ ⇒ 0.16 m

Length of Stroke (L) = 230 mm = $\frac{230}{1000}$ = 0.22 m

Height (H) = 9 m

Speed (n) = 25 RPM.

To Find:-

Power Required to deime the pump

$$\boxed{I_p = w_t \cdot H}$$

$$\boxed{w_t \Rightarrow \gamma Q_t}$$

$$Q_t = \frac{ALN}{60}$$

$$A = \frac{\pi d^2}{4}$$

(i) $A = \frac{\pi d^2}{4} = \frac{\pi (0.16)^2}{4} \Rightarrow 0.02\ m^2$

(ii) Theortical discharge:-

$$Q_t = \frac{ALN}{60} = \frac{0.020 \times 0.23 \times 25}{60}$$

$Q_t = 1.916 \times 10^{-3}$

$$\boxed{Q_t = 1.92 \times 10^{-3}\ m^3/s}$$

(iii) Theortical weight $w_t = \gamma \cdot Q_t$

$= 9810 \times 1.92 \times 10^{-3}$

$w_t = 18.84\ N/s$

(iv) Power Required to drive the pump $I_p = w_t \cdot H$

$= 18.84 \times 9$

$$\boxed{I_p = 169.56\ \text{watts (or) Nm/s}}$$

watts (or) Nm/s (or) J

2. A Double acting Reciprocating Pump as piston area of 0.15 m². Stroke length 0.30 m is discharge 2.40 m. cube water per min at 45 RPM, two a Total length 10 m.

Given:-

Double acting Reciprocating Pump

Piston area ⇒ 0.15 m² (A)

Stroke length (L) = 0.30 m

discharging water = 2.40 m³/m.

Speed (n) = 45 rpm.

Total Height (H) = 10 m

To find :-

(i) Percentage of slip S =

(ii) Coefficient of discharge cd =

(iii) Theortical Power P =

(iv) Efficiency of Pump η =

Soln :-

(i) Percentage of slip $S = \frac{Q_{th} - Q_{act}}{Q_{th}} \times 100$

$Q_t \Rightarrow \frac{2ALN}{60} = \frac{2 \times 0.15 \times 0.30 \times 45}{60}$

$Q_{th} \Rightarrow 0.067\ m^3/s$

$Q_{act} \Rightarrow 2.40\ m^3/minute$

23 LPS $\Rightarrow$

$\Rightarrow \frac{23}{1000}$

$\Rightarrow 0.023\ m^3/s$

$Q_{act} \Rightarrow 2.40\ m^3/minute$

$\Rightarrow \frac{2.40}{60} \Rightarrow 0.04\ m^3/s$

$S \Rightarrow \frac{0.067 - 0.04}{0.067} \times 100$

$S = 40.2\%$

(ii) Coefficient of discharge $\boxed{cd = \frac{Q_{act}}{Q_{th}} = \frac{Q_a}{Q_t}}$

$cd \Rightarrow \frac{0.04}{0.067} \Rightarrow 0.597$

$\boxed{cd = 0.597}$

(iii) Theortical Power :-

$OP \Rightarrow \gamma Q_t H = 9810 \times 0.067 \times 10 \Rightarrow$ 6572.7 watts.

$IP \Rightarrow \gamma Q_a H = 9810 \times 0.04 \times 10 \Rightarrow 3924$ watts

3. A Double acting reciprocating as Pump as piston 300mm diameter and stroke length 200mm. If the speed of the RPM and lift is 10mm ditaint the rate by the pump is LPS and power required.

Given :-

Double acting Reciprocating Pump.

$Dia (d) = \frac{300mm}{1000} = 0.3m$

Length of Stroke $L = \frac{200mm}{1000} = 0.2m$

Speed (n) = 30 RPM

Height (H) = 10m

(i) Quantity of water Raised by the Pump

(ii) Power Required.

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Soln:-

(i) $Q_t \Rightarrow \frac{2A\,LN}{60}$

$A = \frac{\pi d^2}{4} = \frac{\pi (0.3)^2}{4} \Rightarrow 0.0706\,m^2$

$Q_t = \frac{2 \times 0.0706 \times 0.2 \times 30}{60}$

$Q_t \Rightarrow 0.01412\,m^3/sec$

Power Required:-

$I_p = W_t \times H$

$W_t = \gamma Q_t$

$W_t = 9810 \times 0.01412$

$\boxed{W_t \Rightarrow 138.517\,N/s}$

$I_p = 138.517 \times 10$

$\boxed{I_p \Rightarrow 1385.17\,Nm/sec}$

$\left.\begin{matrix} Q_t \\ Q_a \end{matrix}\right\}\ m^3/sec$

$\left.\begin{matrix} \%\ \text{of slip} \\ \text{Efficiency} \end{matrix}\right\} - \%$

Cd - no unit

Fundamental Equation or centrifugal Pump:-

(i) Power of the Pump

$\boxed{P = \gamma Q H_m \text{ in watts}}$

P = Power

Q = Discharge In m^3/sec

H_m = Actual head

$H_m = H_s + H_s + H_{Fs} + H_{Fd} + \frac{V_d^2}{2g}$ METERS

Efficiency of centrifugal Pump:-

1. Manometric efficiency
2. Mechanical efficiency
3. overall efficiency

1. Manometric Efficiency:-

$\eta_{mano} = \frac{\text{manometric head}}{\text{Head imparted by impeller to water}}$

2. Mechanical Efficiency (η_m)

$\eta_m = \frac{\text{Power at the impeller}}{\text{Power at the shaft}}$

3. overall Efficiency (η_o)

$\eta_o = \frac{\text{out Put Power of Pump}}{\text{INPut Power of the Pump}} = \frac{OP}{I_p} \times 100$

1. The centrifugal pump is going to lift 4 m³/sec of water per sec, to a height of 5m. If total loss of head is 0.4m. Compute the motor power of the pumper to run the pump, and efficiency of pump motor is 75%.

Given:-

Centrifugal Pump

Quantity of water $Q = 4\,m^3/s$

Height $h = 5m$

Total loss of head $(h_f) = 0.4m$

Efficiency of pump $\eta_e = 75\%$

To Find:-

maximum Power (or) Input Power

Input power $I_{pm} \Rightarrow \frac{\text{output of Pump}}{\text{overall efficiency}}$

Output power $op = \gamma QH$ $\quad H = h + h_f$

$= 5 + 0.40$

$= 9810 \times 4 \times 5.4 \quad = 5.4$

$\boxed{op \Rightarrow 211.896\ kw} = 211.896 \times 10^3 W.$

efficiency $= 75\%$

$= \frac{75}{100} = 0.75$

Input power $I_{pm} = \frac{\text{output Power Pump}}{\text{overall efficiency}} = \frac{211.896}{0.75}$

$I_{pm} \Rightarrow 282.58\,(kw)$

2. The single acting reciprocating pump as a plunger diameter of 500mm and a stroke of 0.40m. The speed of the pump is 60 rpm and the co-efficient of discharge is 0.97. Determine the actual discharge and percentage slip of the pump.

Given:-

Single acting Reciprocating Pump.

$dia\,(d) = 500mm = \frac{500}{1000} = 0.5m$

Stroke length $(L) = 0.40m$.

Speed $(n) = 60\,RPM$

Coefficient of discharge $C_d = 0.97$

To find:-

Actual discharge $(Q_a) =$

Percentage of Slip $(s) =$

(i) Actual discharge $(Q_a) =$

$\boxed{C_d = \frac{Q_a}{Q_{th}}}$

$Q_{th} = \frac{ALN}{60} = \frac{0.196 \times 0.40 \times 60}{60} \Rightarrow 0.0784\,m^3/s$

$A = \frac{\pi d^2}{4} \Rightarrow \frac{\pi (0.5)^2}{4} \Rightarrow 0.196\,m^2$

$0.97 = \frac{Q_a}{0.0784} \Rightarrow Q_a \Rightarrow 0.076048$

$\Rightarrow 0.07605\ m^3/s.$

Percentage of slip $S = \frac{Q_t - Q_a}{Q_t} \times 100$

$\Rightarrow \frac{0.0784 - 0.07605}{0.0784} \times 100$

$\Rightarrow 2.99\%.$

~~A single acting reciprocating pump has a plunger diameter of 500mm and stroke of 400m. The speed of the pump is 50rpm and the coefficient of discharge is 0.97. Determine.~~

~~(a) actual discharge.~~

~~(b) percentage slip of the pump.~~

Given:-

centrifugal pump

Quantity of water $Q = 5\ m^3/s$

~~Height~~ Height $h = 6m$

Total loss of head $(h_f) = 0.30m$

Efficiency of pump $\eta_o = 80\%$.

(4)

3. A centrifugal pump lifts the water at a height of 15m through a pipe of 100m long and of 0.1m dia. The discharge of the pump is 1.8 m^3/minute. If the overall efficiency of the pump is 80%. Find the power required to drive the pump. Assume, f = 0.042.

Given:-

Height = 15m

length of pipe $(l) \Rightarrow 100m$

dia of pipe $(d) = 0.1m$

discharge of pump $(Q) \Rightarrow 1.8\ m^3/min$

$\Rightarrow \frac{1.8}{60} \Rightarrow 0.03\ m^3/sec$

Efficiency $(\eta) = 80\%$.

$F = 0.042$

Sol:

Power Required to drive the motor

$I_P = \frac{\text{output power}}{\text{overall Efficiency}}$

Output power $OP = \gamma Q H$

$\gamma = 9810$

$Q = 0.03\ m^3/sec$

$H = h + h_f$

$= 15 + ?$

$$hf \Rightarrow \frac{fl Q^2}{12 d^5} = \frac{0.048 \times 100 \times (0.03)^2}{12 \times (0.1)^5} \Rightarrow 36m$$

$H = h + hf$

$\boxed{H = 15 + 36 \Rightarrow 51m}$

$op = 9810 \times 0.03 \times 51$

$\boxed{op \Rightarrow 15009.3 \text{ watts}}$

$$I_p = \frac{OP}{\text{Efficiency}} = \frac{15009.3}{0.8} = 18761.63 \text{ Watts}$$

Unit - 3

Flow of Fluids

Type's of Flow:-

1. Steady Flow & unsteady Flow.
2. uniform Flow & non-uniform Flow.
3. Laminar & Turbulent Flow.

1. Steady Flow:-

Fluid Property doesnot change with respect to time. (m^3/s).

2. Unsteady Flow:-

Fluid Property change with respect to time

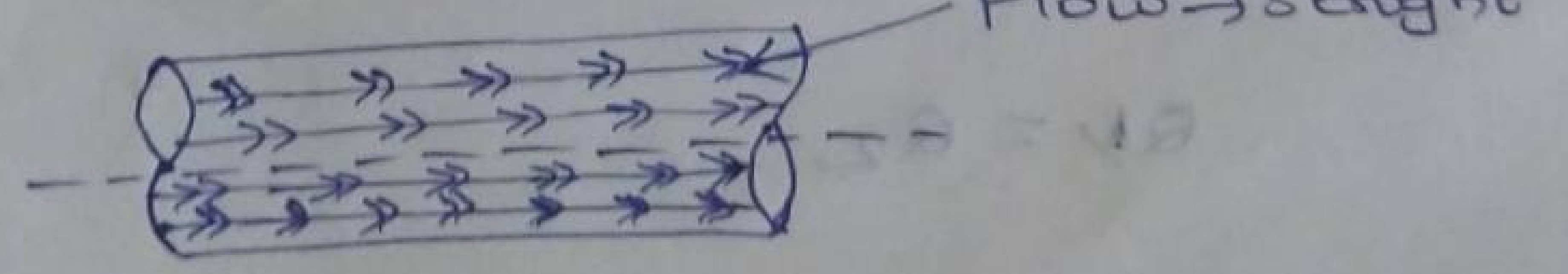
3. uniform Flow:-

velocity of liquid Partical at all section of Pipe is equal.

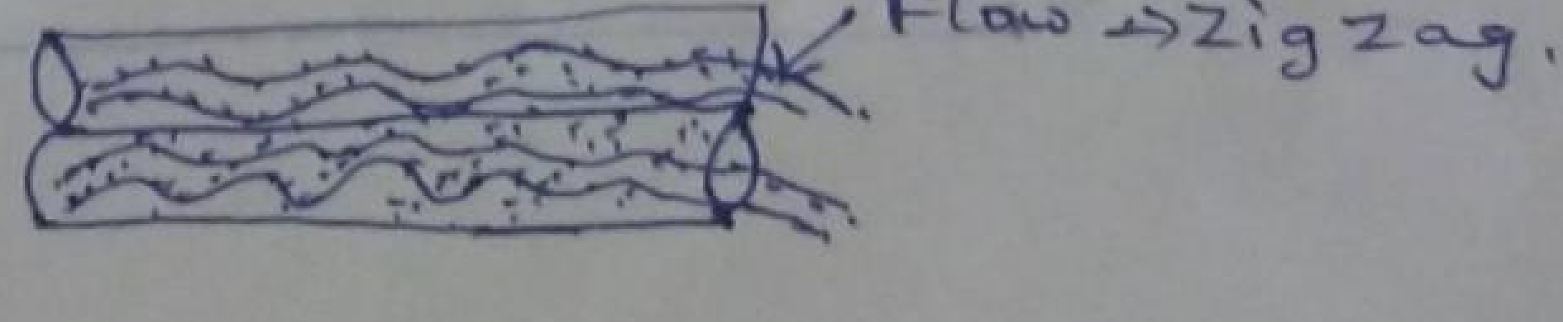
4. non-uniform Flow:-

velocity of liquid Partical at all sectional Pipe is not equal

5. Laminar Flow:-



6. Turbulent Flow:-



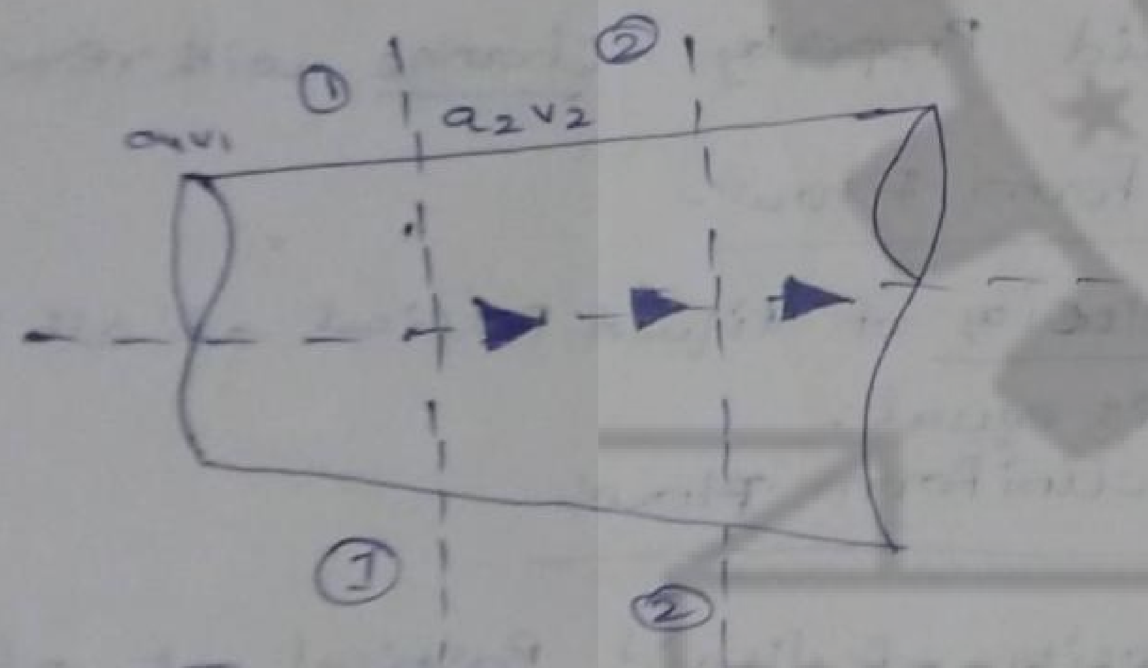
Definitions:- Laminar flow:-

Laminar Flow is type flowing in which the flow patey mood . well difen paths.

Turbulent :- Flow:-

Turbulent flow the define is the type of flow in which the fluid patey mood in the zigzag way.

Equation For continuity of Flow:-



Two cross sections of tapering pipe.

$a_1, a_2 \rightarrow$ cross section area,

$v_1 v_2 \rightarrow$ velocity of flow at sections.

$Q_1 = Q_2$.

$Q_1 = a_1 v_1$

$Q_2 = a_2 v_2$

$\boxed{a_1 v_1 = a_2 v_2}$

$\boxed{Q = a_1 v_1 = a_2 v_2 \ m^3/sec}$

Energy Possessed by a Fluid body:-

1. Potential energy
2. Pressure Energy
3. Kinetic Energy

1. Potential energy:- (or) Potential Head:-

Potential Energy (P.E) = Wz (or) z

Potential Energy per unit weight of liquid $= \frac{Wz}{W} = Z$

Z is called Potential head, (or) datum head (or) static head.

2. Pressure Energy:-

Pressure Energy (or) pressure head.

Pressure Energy at the point $= \frac{P}{\gamma}$ Nm per N of liq-

Pressure Energy per unit weight of the liquid $= \frac{P}{\gamma}$ m of liquid.

The term $\frac{P}{\gamma}$ is termed as pressure head.

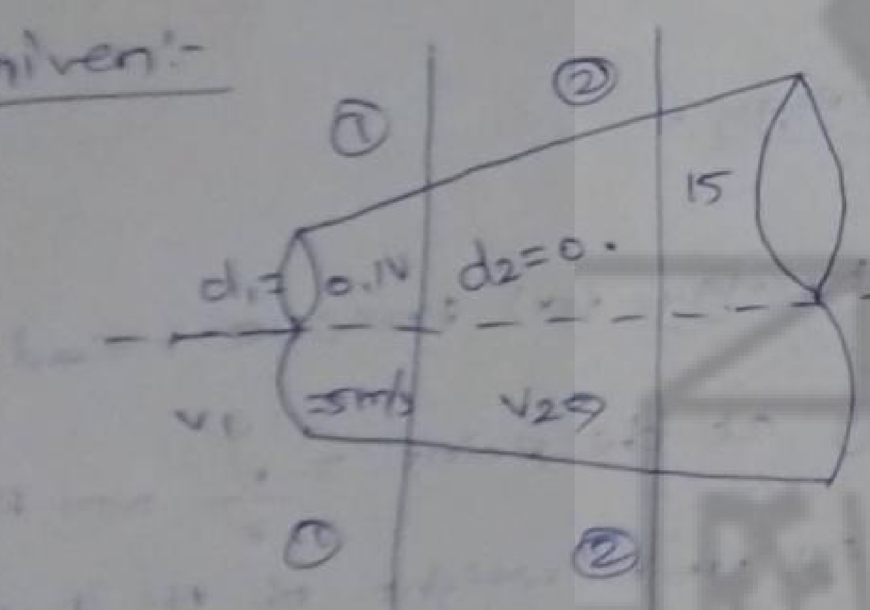
Continuity equation:-

$Q = a_1 v_1 = a_2 v_2 \ m^3/sec$

~~The diameter of the pipe of the section (1) and (2) are 0.15m 0.25m respectively~~

1. The diameters of a pipe at the section (1) and (2) are 0.1m and 0.15m, respectively. Find the discharge through the pipe if the velocity of water flowing through the pipe at section (1) is 5 m/s. Determine also the velocity at section (2).

Given:-



diameter of sec (1) = 0.1m = d_1

velocity of sec (1) = 5 m/s = v_1

diameter of sec (2) = 0.15m = d_2

velocity @ section ② =

Solu:-

$$\boxed{Q = a_1 v_1 = a_2 v_2}$$

Solu:-

We know that $Q = a_1 v_1 = a_2 v_2 \ m^3/s$.

$Q = a_1 v_1 =$

$$a_1 = \frac{\pi d^2}{4} = \frac{\pi (0.1)^2}{4} \Rightarrow 7.85 \times 10^{-3}$$

$$\Rightarrow 0.00785 m^2$$

$Q = 0.00785 \times 5 \Rightarrow 0.03925 \Rightarrow 0.0393 \ m^3/s$.

$Q = a_2 v_2$.

$$v_2 \Rightarrow \frac{Q}{a_2}$$

$$\boxed{\begin{matrix} a = m^2 \\ v = m/s \\ Q = m^3/s \end{matrix}}$$

$$a_2 = \frac{\pi d^2}{4} = \frac{\pi (0.15)^2}{4} = 0.018 \ m^2$$

$$v_2 = \frac{Q}{a_2} = \frac{0.0393}{0.018} \Rightarrow 2.18 \ m/s$$

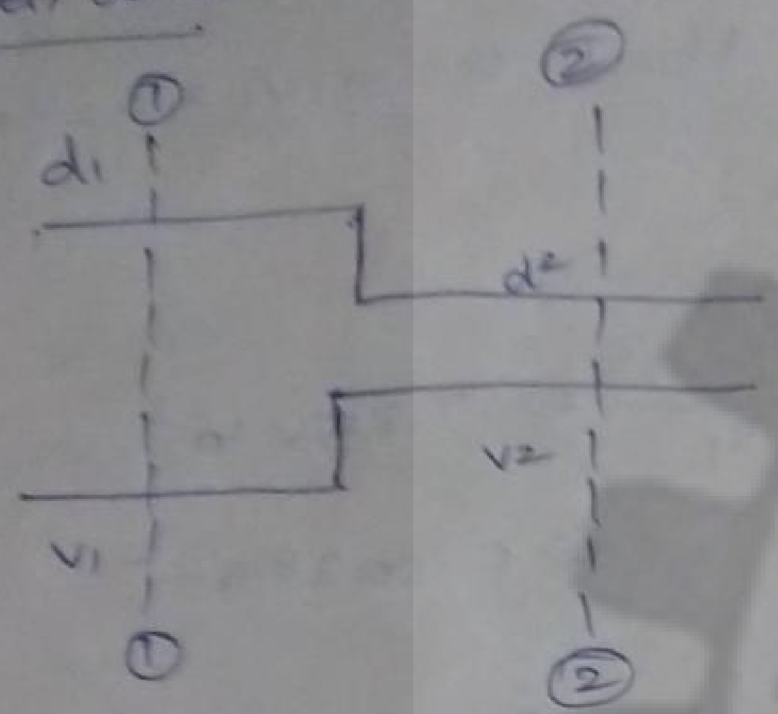
Result:-

discharge $Q \Rightarrow 0.0393 \ m^3/s$

velocity $v_2 \Rightarrow 2.18 \ m/s$.

2. When 2500 liters of water flows per minute through a 0.30 diameter pipe which later reduces to a 0.15m diameter pipe. Calculate the velocities of flow in the two pipes.

Given data :-



Dia $d_1 = 0.30m$

Dia $d_2 = 0.15m$

Discharge $Q = \frac{2500}{lpm}$ $v_1 = ?$

$= \frac{2500}{60 \times 1000}$

$\Rightarrow 0.0416$

$\Rightarrow 0.042 m^3/sec.$

$Q = a_1 v_1 = a_2 v_2$

$Q = a_1 v_1$

$v_1 = \frac{Q}{a_1}$

$a_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.30)^2}{4} \Rightarrow 0.07106 m^2$

$v_1 = \frac{0.042}{0.0706} \Rightarrow 0.595 m/s$

$Q = a_2 v_2$

$v_2 = \frac{Q}{a_2}$

$a_2 = \frac{\pi d_2^2}{4} = \frac{\pi (0.15)^2}{4} \Rightarrow 0.0176 m^2$

$V_2 = \frac{0.042}{0.0176} = \underline{2.386} \ m/s.$

Result :-

velocity @ sec ① ⇒ 0.59 m/s

velocity @ sec ② ⇒ 2.38 m/s

3. A pipe line tapers 100m to 300m dia. The velocity of smaller section 100m/sec. Find the velocity of larger section and discharge

Kinetic Energy & kinetic Head:-

$$\text{Kinetic Energy} = \frac{1}{2} M v^2$$

$$= \frac{1}{2} \frac{W}{g} v^2$$

Kinetic Energy per unit weight of liquid $\Big\} = \frac{Wv^2}{2g} \cdot \frac{1}{W} = \frac{v^2}{2g}$

Here $\frac{v^2}{2g}$ is called kinetic head.

Total Energy of Flowing liquid

Total Energy E = Pressure Energy + kinetic head + Potential Energy.

$$= \left[\frac{P}{\gamma} + \frac{v^2}{2g} + z\right] \text{m of liquid}$$

Total head of flowing liquid

$$H = \left[\frac{P}{\gamma} + \frac{v^2}{2g} + z\right] \text{m of liquid}$$

Bernoulli's theorem:-

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

3. A circular pipe of 250mm diameter carries ~~and~~ an oil of specific gravity 0.8 at the rate of 120 lps and under a pressure of 20kPa. Calculate the total energy in meter at a point which is 4m above the datum line.

<u>Given:-</u>

dia (d) = 250mm $\Rightarrow \frac{250}{1000} = 0.25$

Specific gravity of oil = 0.8

Discharge = 120 lps.

$$Q = \frac{120}{1000} \Rightarrow 0.12 \, m^3/sec.$$

Pressure P = 20 KPa.

H = 4m

$$\text{Total Energy } E = \frac{P}{\gamma} + \frac{v^2}{2g} + z$$

$$\boxed{Q = a \times v}$$

$$v = \frac{Q}{a} \qquad a = \frac{\pi d^2}{4} = \frac{\pi (0.25)^2}{4}$$

$$v = \frac{0.12}{0.0491}$$

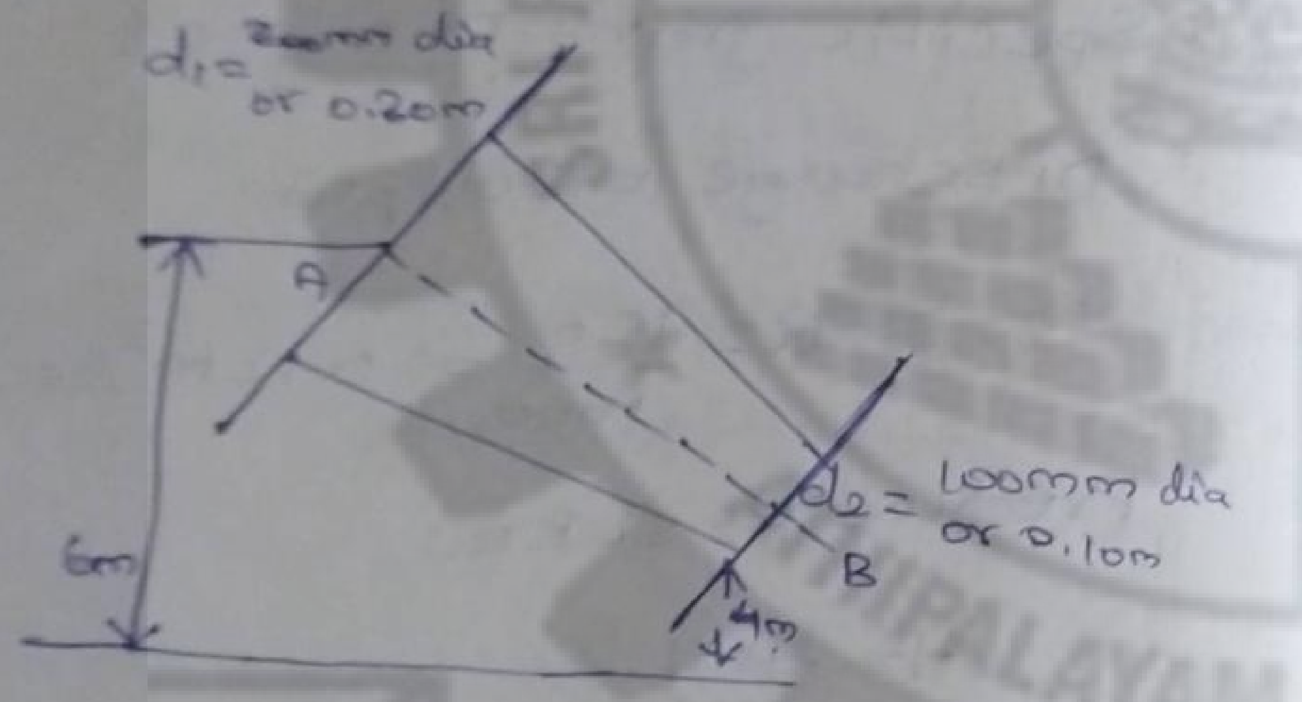
$v \Rightarrow 2.44 \, m/s$

$$\text{Total energy } E = \frac{P}{\gamma} + \frac{v^2}{2g} + z$$

$$\Rightarrow \frac{20 \times 10^3}{0.8 \times 9810} + \frac{(2.44)^2}{2 \times 9.81} + 4$$

$= 6.85\,m$ of oil

4. The water is flowing through a pipe having diameter 0.2m and 0.1m at sections 1 and 2 respectively. The rate of flow through pipe is 35 lps. The section 1 is 6m above datum and section 2 is 4m above datum. If the pressure at section 1 is 39.24 $\times 10^4 N/m^2$, find the pressure at section 2.



Given data:-

dia $d_1 = 0.2m$

dia $d_2 = 0.1m$

$Q = 35$ lps (m^3/sec)

$Q = \frac{35}{1000} \Rightarrow 0.035$

$Z_1 = 6m$

$Z_2 = 4m$

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

To find:- $P_2 = ?$

$Q = a_1 v_1$

$v_1 = \frac{Q}{a_1}$

$Q = \frac{\pi d_1^2}{4}$

$\boxed{a_1 \Rightarrow 0.0314\,m^2}$

$v_1 \Rightarrow \frac{0.035}{0.0314} \Rightarrow \boxed{1.15\,m/s}$

$\boxed{Q = a_2 v_2}$

$v_2 = \frac{Q}{a_2}$

$a_2 = \frac{\pi d_2^2}{4}$

$= \frac{\pi \times (0.1)^2}{4}$

$a_2 \Rightarrow 7.85 \times 10^{-3}$

$\boxed{a_2 \Rightarrow 0.00785\,m^2}$

$v_2 = \frac{0.035}{0.00785}$

$v_2 = 4.458\,m/s$

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

$$\frac{(39.24 \times 10^4)}{9810} + \frac{(1.15)^2}{(2 \times 9.81)} + 6 = \frac{P_2}{9810} + \frac{(4.458)}{2 \times 9.81}$$

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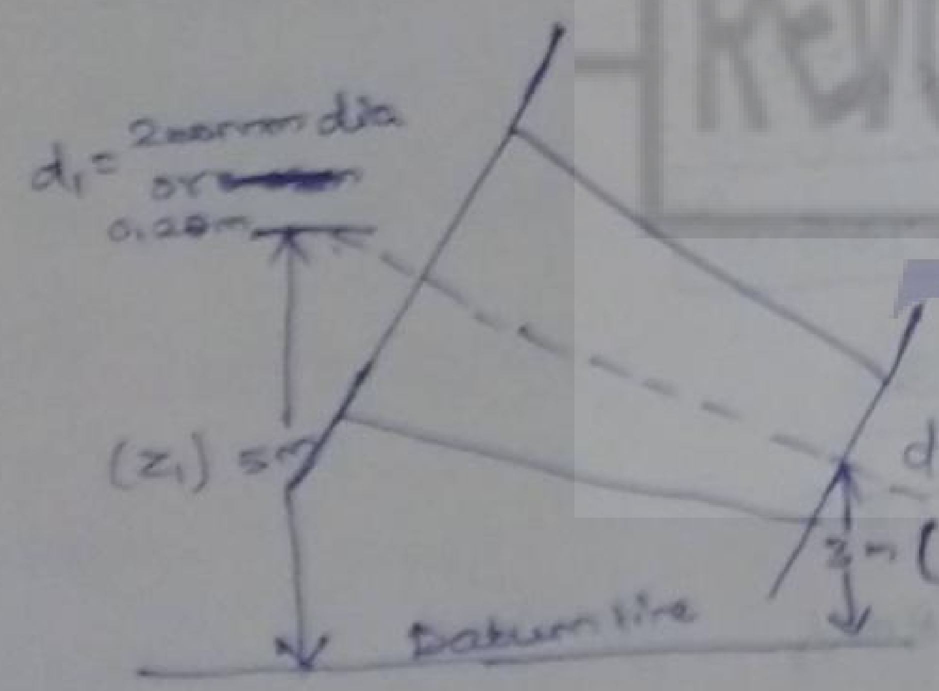
$46.063 = \frac{P_2}{9810} + 5.013$

$46.063 - 5.013 = \frac{P_2}{9810}$

$41.051 = \frac{P_2}{9810}$

$P_2 = 9810 \times 46.051 \Rightarrow 40.27 \times 10^4 \, N/m^2$

The section of a tapering pipe varies from 200mm to 50mm. The larger end is at a height of 5m above the datum. The smaller end is 3m above the datum. The pressure of water at the larger section is 0.4905 Mpa and the velocity of flow at the larger section is 1m/sec. Determine the velocity and pressure at the smaller section.



Given:-

dia$(d_1) \Rightarrow 200mm = 0.2m$

dia$(d_2) \Rightarrow 50mm = 0.05m$

$z_1 = 5m$

$z_2 = 3m$

$v_1 = 1m/s$

$P_1 = 0.4405 MPa$

To find:-

$v_2 = ?$

$P_2 = ?$

$Q = a_1 v_1 = a_2 v_2$

$Q = a_2 v_2$

$\boxed{v_2 = \frac{a}{a_2} \times v_1}$

$\boxed{Q = a_1 v_1}$

$a_1 = \frac{\pi d_2^2}{4} = \frac{\pi (0.2)^2}{4} \Rightarrow 0.03m^2$

$a_2 = \frac{\pi d_2^2}{4} = \frac{\pi (0.05)^2}{4} \Rightarrow 1.96 \times 10^{-3} = 0.00196m^2$

$v_2 = \frac{0.0314}{0.0196} \times 1$

$v_2 = 16m$

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

$\frac{490.5 \times 10^3}{9810} + \frac{(1)^2}{2 \times 9.8} + 5 = \frac{P_2}{9810} + \frac{(16)^2}{2 \times 9.81} + 3$

$55.05 = \frac{P_2}{9810} + 16.04$

$$55.05 - 16.04 = \frac{P_2}{9810}$$

$$39.01 = \frac{P_2}{9816}$$

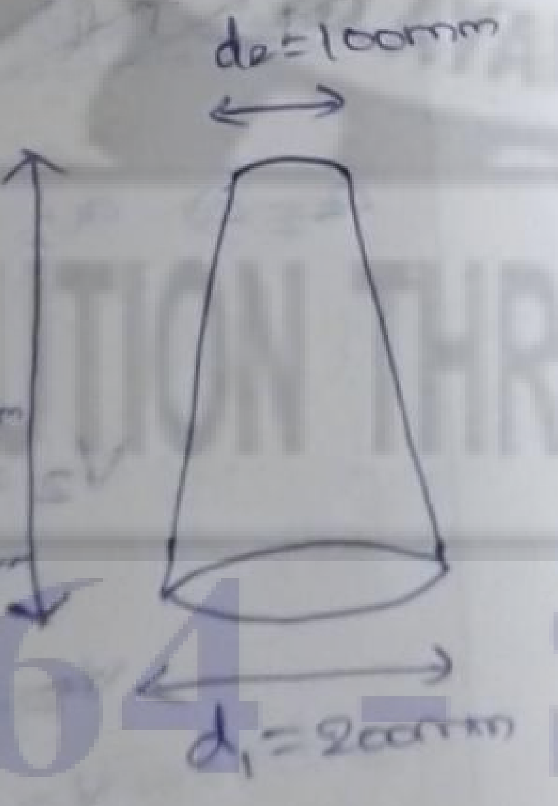
$P_2 = 39.01 \times 9810 \Rightarrow 382.68 \times 10^3 m/s_q$

Result:-

$V_2 = 16 m/s$

$P_2 = 382.6 \times 10^3 pa$

The discharge through a vertical water pipe 100mm diameter at top and 200mm diameter at bottom is 78.54 lps. If the diameter at bottom is intensity of pressure at the bottom is 98.1×10^3 pa and the length of the pipe is 1m. Find (i) The velocity at the top (ii) The velocity at the bottom and (iii) The pressure at the top.



Given data:-

Top dia of the pipe $d_2 = 100mm$

Bottom dia of the pipe $d_1 = 200mm$

Discharge $Q = 7854$ lps

$= \frac{7854}{1000}$

Pressure at bottom $P_1 \Rightarrow 98.1 \times 10^3 pa$.

Length of pipe $z_1 = 1m$ $z_2 = 0$.

To Find:-

(i) velocity @ the top V_1

(ii) velocity @ top V_2

(iii) Pressure @ P_2.

Sol:-

$\boxed{Q = a_1 V_1 = a_2 V_2}$

$Q = a_1 V_1$ $\qquad V_1 = \frac{Q}{a_1}$

$a_1 = \frac{\pi d_1^2}{4}$ $\qquad V_1 = \frac{0.0785}{0.0314}$

$a_1 = \frac{\pi (0.2)^2}{4}$ $\qquad V_1 = 2.5 m/s$

$a_1 \Rightarrow 0.0314 m^3$

$a_2 = \frac{\pi d_2^2}{4} = \frac{\pi (0.1)^2}{4} \Rightarrow 0.00785 m^2$

$V_2 = \frac{Q}{a_2} = \frac{0.07854}{0.00785} \Rightarrow 10 m/s$.

$$\boxed{\begin{aligned} V_1 &= 2.5 m/s \\ V_2 &= 10 m/s \end{aligned}}$$

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

$$\frac{98.1 \times 10^3}{9810} + \frac{(2.5)^2}{2 \times 9.81} + 0 = \frac{P_2}{9810} + \frac{(10)^2}{2 \times 9.81} + 1.$$

$$10 + 80.65 = \frac{P_2}{9810} + 5.09 + 1$$

$40.65 + \frac{P_2}{9810} + 6.09$

$40.65 - 6.09 = \frac{P_2}{9810}$

$34.56 = \frac{P_2}{9810}$

$P_2 = 339.03 \times 10^3$ Pa

Practical Application of Bernoulis theorm:-

1. venturimeter
2. orificemeter
3. pitot tube
4. nozzels
5. orifice
6. mouth piece.

Formula For venturimeter:-

discharge Formula for venturimeter $\Big\}$ $Q = k \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}}$

orificemeter discharge $\Big\}$ $\Rightarrow Q = k \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gH} \, (m^3/s)$

k = co-efficient of venturimeter

a_1 = area of cross-section at enlarged end

a_2 = area of cross-section at throat in m^2

V_1 = velocity of flow at enlarged end in m/s

V_2 = velocity of flow at throat in m/s

Q = Quantity of liquid flowing in m^3/sec

g = acceleration due to gravity in m/sec^2

H = Difference of pressure head b/w enlarged end and throat in metre of liquid.

8. The actual head difference at entrance and throat of the venturimeter by using simple piezometer tube at two point is 1.75m of water. The diameter of the pipe and the throat of the meter are 0.15m and 0.05m respectively. Find the discharge through the meter. Assume co-efficient of meter K = 0.98.

venturimeter:-

$$Q = K \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gH} \; m^3/sec$$

Given:-

Dia of pipe d_1 = 0.15m

Dia of throat d_2 = 0.05m

Co-efficient of meter K = 0.98

Difference of head H = 1.75m

To find:-

discharge (Q)

Sol:-

$$Q = K \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gH}$$

$$a_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.15)^2}{4} \Rightarrow 0.0176\,m^2$$

$$a_2 = \frac{\pi d_2^2}{4} = \frac{\pi (0.05)^2}{4} \Rightarrow 1.963 \times 10^{-3}$$

$$\Rightarrow 0.00196$$

$$Q = 0.98 \frac{0.0176 \times 0.00196}{\sqrt{(0.0176)^2 - (0.00196)^2}} \sqrt{2 \times 9.81 \times 1.75}$$

9. An orificemeter consisting of 100mm diameter orifice in a 250mm diameter pipe has co-efficient of 0.65. The pipe delivers oil of specific gravity 0.9. If the differential gauge reads 900 mm of mercury calculate the rate of flow in lps.

Orificemeter:-

Diameter of pipe $d_1 \Rightarrow$ 250mm

Diameter of orifice $d_2 \Rightarrow$ 100mm

Coefficient of meter $K = 0.65$

Specific gravity of oil $= 0.9$

Differential gauge reads ~~H~~ $\Rightarrow$ 900mm $\Rightarrow$ 0.9m

Specific gravity of mercury $\Rightarrow$ 13.6

$$Q = K \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gH} \ (m^3/s)$$

$$a_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.25)^2}{4} \Rightarrow 0.049\,m^2$$

$$a_2 = \frac{\pi d_2^2}{4} \Rightarrow \frac{\pi (0.1)^2}{4} \Rightarrow 7.853 \times 10^{-3}$$

$$= 0.007853\,m^2$$

$$H = h\left(\frac{S_m - S_o}{S_o}\right) \Rightarrow 0.9\left(\frac{13.6 - 0.9}{0.9}\right) \Rightarrow 12.7\,m$$

$$Q = 0.65 \cdot \frac{0.049 \times 0.00785}{\sqrt{(0.049)^2 - (0.00785)^2}} \times \sqrt{2 \times 9.81 \times 12.7}$$

10. An orificemeter is fitted in a pipe line of 500mm diameter to carry oil of relative density 0.9. A diaphragm of 200mm diameter is fitted to it. The deflection of an oil in differential manometer is 0.3m. The co-efficient of the meter is 0.82. Determine (i) The pressure head (ii) Discharge in lpm.

Given data:-

dia of pipe $d_1 = 500mm = \frac{500}{1000} = 0.05m$

Diaphragm $d_2 = 200mm = \frac{200}{1000} = 0.2m$

Relative density of oil $= 0.9\ (S_o)$

Relative density of mercury $= 13.6\ (S_m)$ (constant)

Deflection of mercury $h = 0.3m$

Co-efficient of meter $K = 0.82$

To Find :-

(i) Pressure head (H) = ?

(ii) Discharge (Q) = ?

(i) $H = h\left(\frac{S_m - S_o}{S_o}\right)$

(ii) $Q = K \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gH}$.

(i) Pressure Head

$H = h\left(\frac{S_m - S_o}{S_o}\right)$

$= 0.3\left(\frac{13.6 - 0.9}{0.9}\right)$

$H \Rightarrow 4.23m$

(ii) Discharge $Q = K \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gH}$

$a_1 = \frac{\pi d_1^2}{4} \Rightarrow \frac{\pi(0.5)^2}{4} \Rightarrow 0.1963m^2$

$a_2 = \frac{\pi d_2^2}{4} \Rightarrow \frac{\pi(0.2)}{4} \Rightarrow 0.031m^2$

$Q = K \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gH}$

$\Rightarrow 0.82 \frac{0.1963 \times 0.031}{\sqrt{(0.1963)^2 - (0.031)^2}} \times \sqrt{2 \times 9.81 \times 4.23}$

$\Rightarrow 0.82 \frac{6.08 \times 10^{-3}}{\sqrt{0.03853369 - 9.61 \times 10^{-4}}} \times \sqrt{82.9926}$

$\Rightarrow 0.82 \frac{6.08 \times 10^{-3}}{0.19383934} \times 9.1027442$

$Q \Rightarrow 0.235 m^3/sec$:-

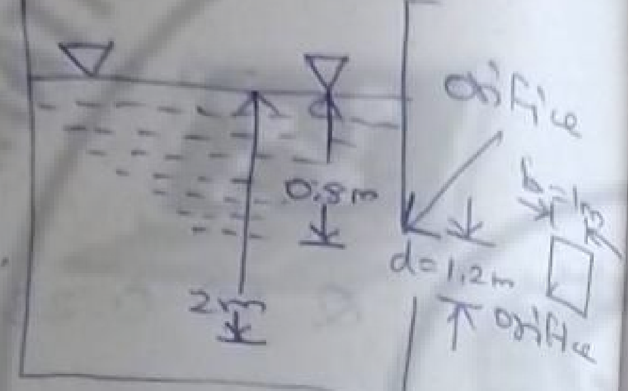
Flow through Mouthpiece & orifices:-

Classification for orifices:-

1. Based on size → 1) Small orifice 2) Large orifice
2. Based on shape → 1) circular 2) [illegible] 3) Triangular
3. Based on from →
4. Based on nature [illegible] → 1) Fully [illegible] (or) [illegible] orifice
2. [illegible] [illegible] orifice

5. A rectangular orifice 1m wide and 1.2m deep is discharging water from a vessel. The top edge of the orifice is 0.8m below the water surface in the vessel. Calculate the discharge through the orifice if $c_d = 0.6$

Rectangular orifice



$$Q = \frac{2}{3} c_d b \sqrt{2g}\left[H_2^{3/2} - H_1^{3/2}\right] m^3/sec.$$

Given:-

width = 1m

depth = 1.2m

$c_d = 0.6$

$H_1 = 0.8m$

$H_2 \Rightarrow 0.8 + 1.2 = 2m$

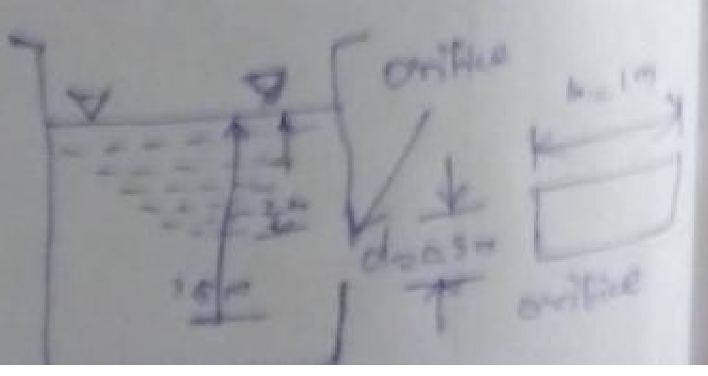
$$\Rightarrow \frac{2}{3} \times 0.6 \times 1 \times \sqrt{2 \times 9.81}\left[(2)^{3/2} - (0.8)^{3/2}\right]$$

$$\Rightarrow 0.4 \times 4.429 \left[4 - 0.256\right]$$

$$\Rightarrow 1.7716 \times \left[2.105\right]$$

$$\Rightarrow 3.729 m^3/s$$

6. A large vertical orifice is 1m wide and 0.3m deep. The surface of water is 1.2m above the upper edge of the orifice. Determine the discharge, if the co-efficient of discharge is 0.62.



Rectangular orifice

$$Q = \frac{2}{3} c_d b \sqrt{2g}\left[H_2^{3/2} - H_1^{3/2}\right] m^3/sec$$

Given:-

width = 1m

depth = 0.3m

cd = 0.6

$H_1 = 1.2m$

$H_2 = 1.2 + 0.3 \Rightarrow 1.5m$

Soln:-

Discharge of orifice, $Q \frac{2}{3} c_d b \sqrt{2g}\left[H_2^{3/2} - H_1^{3/2}\right]$

$$Q = \frac{2}{3} \times 0.62 \times 1 \times \sqrt{2 \times 9.8}\left[(1.5)^{3/2} - (1.2)^{3/2}\right]$$

$$= 0.9568 m^3/s$$

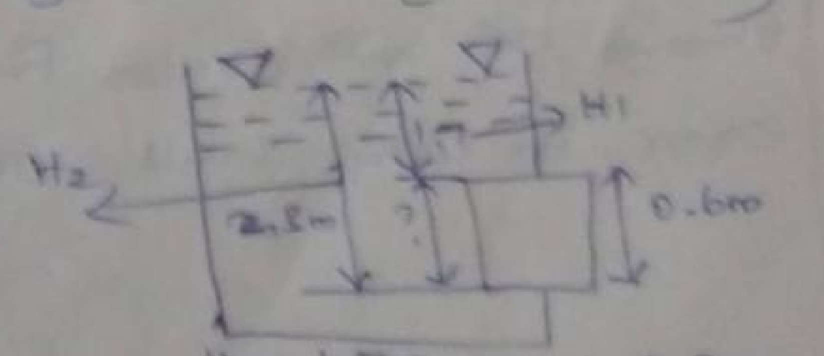
~~7. A rectangular large orifice 2m wide and 0.6 deep in a~~

7. A rectangular orifice in the side of a large tank is 2m broad and 0.6m deep. The depth of water on the upstream side above the top edge is 1.7m, if the orifice discharges freely into atmosphere, calculate (i) The discharge, using large orifice formula (ii) The discharge, using small orifice formula. Take cd = 0.6 in both the cases.

Rectangular orifice:-

Small orifice $Q = c_d a \sqrt{2gH}$

large orifice $Q = \frac{2}{3} c_d b \sqrt{2g}\left[H_2^{(3/2)} - H_1^{(3/2)}\right]$



$H_2 = 1.7 + 0.6 \Rightarrow 2.3m$

largeorifice Formula:-

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

$$= \frac{2}{3} \times 0.6 \times 2 \times \sqrt{2 \times 9.81}\left[(2.3)^{3/2} - (0.8)^{3/2}\right]$$

$$= 0.8 \times 4.42\left[3.488 - 2.216\right]$$

$$= 3.536\left[1.272\right]$$

$$\boxed{Q \Rightarrow 4.997\ m^3/s}$$

Small orifice $Q = C_d a \sqrt{2gH}$

$Q = C_d a \sqrt{2gH}$

$a = 2m$

$C_d = 0.6$

$g = 9.81$

$H = 1.7 + \frac{0.6}{2} \Rightarrow$

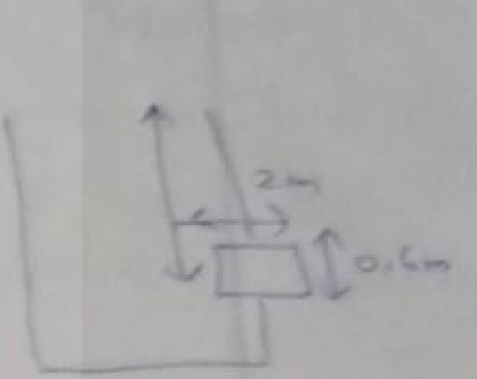
$Q = 0.6 \times 2 \times 0.6 \sqrt{2 \times 9.81 \times 2}$

$Q = 4.507\ m^3/s$.

A Rectangular large orifice 2m wide and 0.60m deep in a vertical side of a vessel has its edge 1.70m below the constant water level in the vessel. Assuming $C_d = 0.60$. Calculate the rate of flow through the orifice. Also find out the percentage error in using small orifice formula.

Rectangular orifice:

Small orifice $Q = C_d a \sqrt{2gH}$



Percentage Error

$Q_{large} - Q_{small} \Rightarrow 4.4997 - 4.507$

$\Rightarrow 0.01\ m^3/s$

Percentage Error $= \frac{0.01}{4.4997} \times 100$

$\Rightarrow 0.222\%$

large orifice formula:-

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

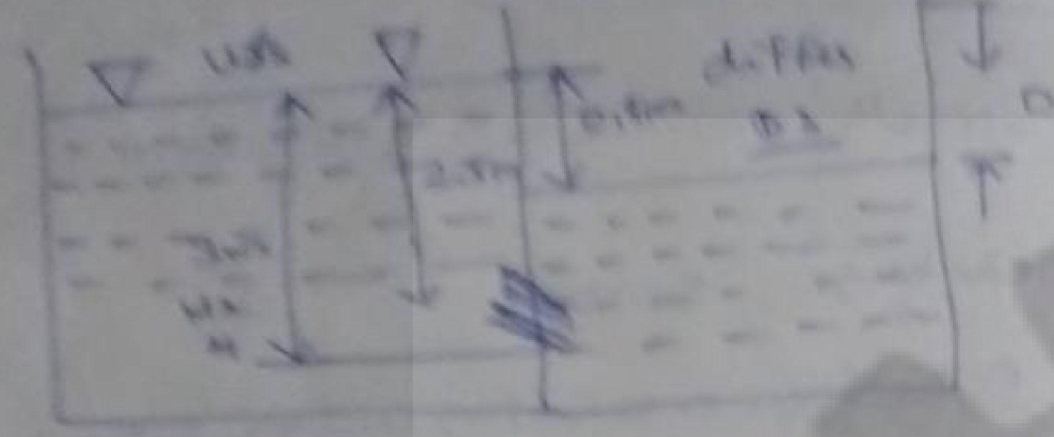
$$= \frac{2}{3} \times 0.6 \times 2 \times \sqrt{2 \times 9.81}\left[(2.3)^{3/2} - (0.8)^{3/2}\right]$$

$$= 0.8 \times 4.42\left[3.488 - 2.216\right]$$

$$= 3.536\left[1.272\right]$$

$$\boxed{Q = 4.997\ m^3/s}$$

9. A fully drowned orifice of breadth 2m has the difference of water level between the sides of the orifice as 0.5m. The heads of water from top and bottom of the orifice are 2.5m and 3m respectively. Find the discharge through the orifice if $C_d = 0.60$



<u>Given data</u>:-

Breadth of orifice = 2m

Difference in water level = 0.5m

Height of water from top of orifice H_1 = 2.5m

H_2 = 3m

C_d = 0.60

<u>Sol</u>:

$Q = C_d\, b(H_2 - H_1)\sqrt{2gH}$

$= 0.60 \times 2(3-2.5)\sqrt{2\times 9.81\times 0.5}$

$\boxed{Q = 1.68\ m^3/s}$

~~A partially submerged orifice in the side of a large tank is rectangular in shape 1.2m broad and 0.6m deep. If the water level on one side of orifice is~~

<u>Formulas</u>:-

1. Loss of head due to sudden enlargement (h_e)

$$h_e = \frac{(V_1 - V_2)^2}{2g} \text{ metre of liquid}$$

2. Loss of head due to sudden contraction (h_c)

$$h_c = \frac{V_2^2}{2g}\left[\frac{1}{C_c} - 1\right]^2 \text{ metre of liquid}$$

3. Loss of head due to obstruction (h_o)

$$h_o = \frac{V^2}{2g}\left[\frac{A}{C_c(A-a)} - 1\right] \text{ metre of liquid.}$$

2. A horizontal pipe 200mm diameter is suddenly contracted to 1500mm diameter. The discharge through the pipe is 0.012 m^3/sec. Take C_c as 0.60. Find loss of head due to sudden contraction

<u>Given</u>:

d_1 = 200mm = 0.2m

d_2 = 150mm = 0.15m

discharge Q = 0.012 m^3/sec C_c = 0.60

Find: Loss of head due to sudden contraction

<u>Sol</u>:-

Loss due to to sudden contraction

$$h_c = \frac{V_2^2}{2g}\left[\frac{1}{C_c} - 1\right]^2$$

$Q = A_1V_1 = A_2V_2$

$Q = A_2V_2$

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

$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi(0.15)^2}{4}$

$A_2 \Rightarrow 0.0177 m^2$

$V_2 = \frac{0.012}{0.0177}$

$\boxed{V_2 \Rightarrow 0.678 m/s}$

loss of head due to sudden contraction:-

$$h_c = \frac{V_c^2}{2g}\left[\frac{1}{c_c} - 1\right]^2$$

$$= \frac{(0.678)^2}{2\times 9.81}\left[\frac{1}{0.62} - 1\right]^2$$

$$\boxed{h_c = 0.015m}$$

3. Water is flowing through a horizontal pipe of diameter 200mm at a velocity of 0.3m/sec. A circular solid plate of diameter 150mm is placed in the pipe to obstruct the flow. Find the loss of head due of obstruct in the pipe. If $c_c = 0.62$

Given data:

D = 200mm = 0.2m

V = 0.3m/sec

d = 150mm

$c_c = 0.62$

To Find:

loss of head due to obstructed to the pipe

$$h_o = \frac{V^2}{2g}\left[\frac{A}{c_c(A-a)} - 1\right]^2$$

$$A = \frac{\pi D^2}{4} = \frac{\pi(0.2)^2}{4} \Rightarrow 0.0314m^2$$

$$a = \frac{\pi d^2}{4} = \frac{\pi(0.15)^2}{4} \Rightarrow 0.017m^2$$

$$h_o = \frac{(0.3)^2}{2\times 9.81}\left[\frac{0.0314}{0.62(0.0314 - 0.017)} - 1\right]^2$$

4. The velocity of water in a pipe 200mm dia is 5m/sec. The length of pipe is 450m. Find loss of head due to friction take F = 0.032

Given:-

Darcy's formula

dia(d) = 200m = 0.2m

velocity (v) = 5m/sec

length (l) = 450m

F = 0.032

$$hf = \frac{flv^2}{2gd}$$

$$= \frac{0.032\times 450\times(5)^2}{2\times 9.81\times(0.2)} \Rightarrow 91.74m$$

$$V^2 = c^2 m i$$

$$V^2 = c^2 \frac{A}{P}\frac{hf}{l}$$

$$A = \frac{\pi d^2}{4},\ P = \pi d$$

$$v^2 = c^2 \times \frac{\pi d^2}{4}\ \frac{hf}{l}$$

$$v^2 = c^2 \times \frac{\pi d^2}{4\pi d} \times \frac{hf}{d}$$

$$\boxed{v^2 \Rightarrow \frac{c^2 d h_f}{4l}}$$

major energy - Losses

1. Darchy's weisbach Formula (or) [Friction losses]

$$\boxed{\text{velocity } h_f = \frac{flv^2}{2gd}}$$

$$\boxed{\text{Discharge } h_f = \frac{flQ^2}{12d^5}}$$

2. Chezy's equation For velocity :-

$$\boxed{v = c\sqrt{mi}} \ (m/sec)$$

c - Chezy's Constant (50 to 60)

5. A pipe line 300mm dia and 400m long Connects two reservoirs discharge through the pipe is 191 lps. Taking the Friction Factor as 0.02 determine loss of head.

Given:-

Darchy's Formula

Dia (d) = 300mm = 0.3m

length (l) = 400m,

discharge (Q) = 191 lps (m^3/s)

$$= \frac{191}{1000}$$

$Q = 0.191 m^3/sec$

$F = 0.02$

$$h_f = \frac{flQ^2}{12d^5} = \frac{0.02 \times 400 \times (0.191)^2}{12 \times (0.3)^5}$$

$\Rightarrow 10m$

6. Two reservoirs are conneted by a 500mm dia 2000m long pipe line. The difference of water levels between the two reservoirs is 20m. Calculate the discharge take F = 0.024 Neglect minor losses.

Given:-

Dia (d) = 500mm = 0.5m

length (l) = 2000m.

difference in water level $h_f = 20m$

$F = 0.0248$ $\quad Q = h_f$

discharge : ?

$$h_f = \frac{flQ^2}{12d^5}$$

$$Q^2 = \frac{h_f 12 d^5}{fl}$$

$$Q^2 = \frac{20 \times 12 (0.5)^5}{0.0248 \times 2000}$$

$Q^2 =$

$Q = 0.389$ Cumsec

$Q = 389$ lps.

7. A 150mm diameter and 300m long pipe connects two reservoirs. The difference in water levels in the two reservoirs is 4m. Taking Chezy's constant as 60, determine the velocity of flow in the pipe.

Given:-

Chezy's

Dia (d) = 150mm => 0.15m

length (l) = 300m

Chezy's Constant's = 60

difference in water level hf = 4m.

Find:-

velocity of flow:-

$v = C\sqrt{mi}$

$C = 60$

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

$= \frac{\frac{\pi d^2}{4}}{P}$

$= \frac{\frac{\pi d^2}{4}}{\pi d} \times \frac{1}{\pi d}$

$= \frac{\cancel{\pi} d^{\cancel{2}}}{4 \cancel{\pi} \cancel{d}}$

$m = \frac{d}{4}$

$m = \frac{0.15}{4} \Rightarrow 0.0375m$

$i = \frac{hf}{l} = \frac{4}{300} = 0.013$

$v = C\sqrt{mi}$

$= 60\sqrt{0.0375 \times 0.013}$

$\boxed{v = 1.32 \text{ m/sec}}$

head loss due

$v^2 = \frac{c^2 d hf}{4l}$.

8. water flows through a 150mm diameter and 60m long pipe with a velocity of 2.5m/sec. find the loss of head, using Darcy's formula and chezy's formula. Take F = 0.02 & C = 60.

Given:-

dia = 150mm = 0.15m

length (l) = 60m

velocity = 2.5m/sec.

Take f = 0.02

C = 60.

(i) loss of head using Darchy's formula.

(ii) loss of head using Chezy's formula.

(i) Loss of head using Darchy's formula

$hf = \frac{flv^2}{2gd}$

$\Rightarrow \frac{0.02 \times 60 \times (2.5)^2}{2 \times 9.81 \times 0.15}$

$hf \Rightarrow 2.55m$.

(ii) Loss of head using Chezy's

$$v^2 = \frac{c^2 d h_f}{4l}$$

$$h_f = \frac{4lv^2}{c^2 d}$$

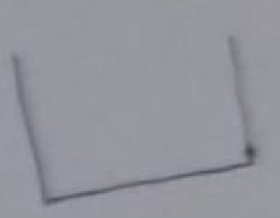
$$h_f = \frac{4\times 60\times (2.5)^2}{(60)^2\times(0.15)}$$

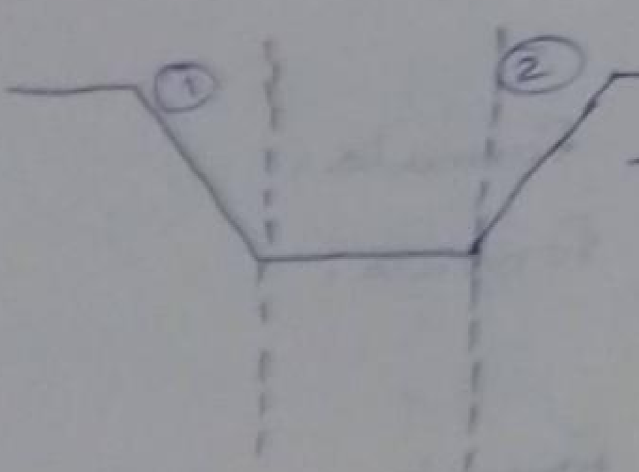
$h_f = 2.78\text{m}$

Unit - III

Flow Through Notches

1.  V-notch

2.  → ~~Rectangle~~ Rectangular notch

3. 

→ Trapezoidal Notch

~~A rectangular notch 2m wide is discharging under a constant head of 0.4m. Find the discharge if the co-efficient of discharge is 0.62.~~

Given:

(i) Triangular Notch:-

$$\boxed{Q = \frac{8}{15} C_d \sqrt{2g}\tan\frac{\theta}{2} H^{5/2}}\ \text{m}^3/\text{sec}$$

(ii) Rectangular Notch:-

$$\boxed{Q = \frac{2}{3} C_d b \sqrt{2g} H^{3/2}}\ \text{m}^3/\text{sec}$$

(iii) Trapezoidal Notch:-

$$\boxed{Q = \frac{2}{3} C_d b \sqrt{2g} H^{3/2} + \frac{8}{15} C_d \sqrt{2g}\tan\frac{\theta}{2} H^{5/2}}\ \text{m}^3/\text{s}$$

1. A rectangular notch 2m wide is discharging under a constant head of 0.4m. Find the discharge, if the co-efficient of discharge is 0.62

Given:-

Rectangular notch

Breath = 2m (b)

Constant Head (H) = 0.4m

cd = 0.62

$$\boxed{Q = \frac{2}{3} C_d b \sqrt{2g} H^{3/2}}\ (\text{m}^3/\text{sec})$$

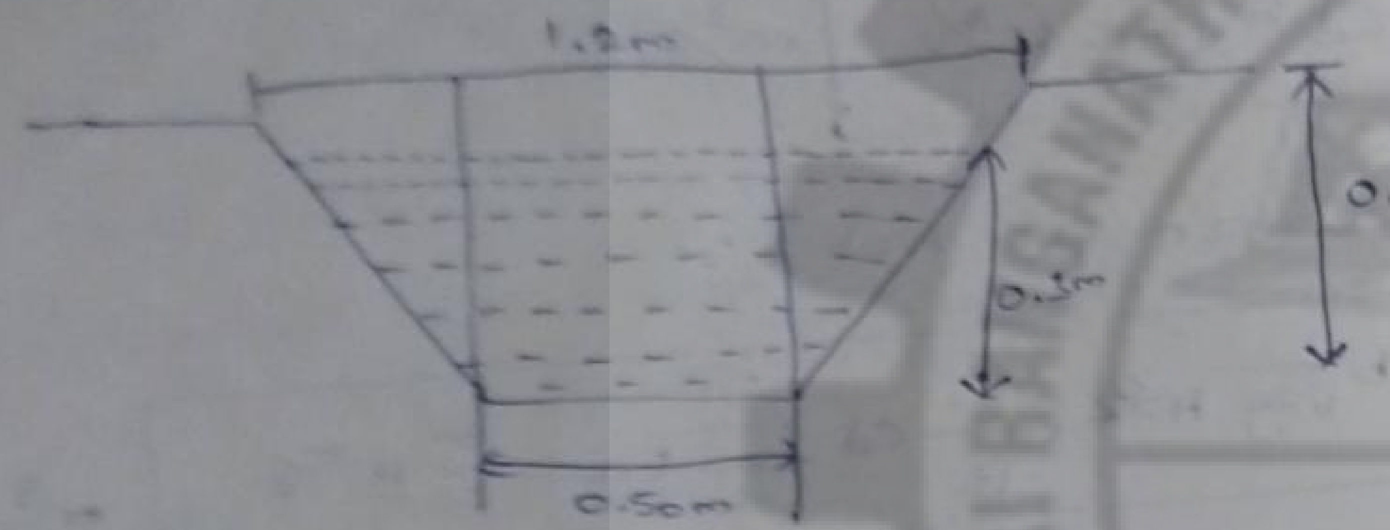
$$Q = \frac{2}{3}\times 0.62\times 2\times\sqrt{(2\times 9.81)}\times(0.4)^{3/2}$$

$Q = 0.926\ \text{m}^3/\text{sec}$

5. A trapezoidal notch is 1.2m wide at the top and 0.50m at the bed. The height is 0.4m. Determine the discharge through the notch when the head of water is 0.3m. Take Cd as 0.60.

Given:

Trapezoidal Notch



Given:-

Top width (B) = 1.2m

Bed (or) Bottom width (b) = 0.5m

Height = 0.4m

Height of water (H) = 0.30m

cd = 0.60

Sol:

$$Q = \frac{2}{3} Cd b \sqrt{2g} H^{3/2} + \frac{8}{15} cd \sqrt{2g} \tan\frac{\theta}{2} H^{5/2}$$

$$\tan\frac{\theta}{2} = \frac{(1.2-0.5)/2}{0.4}$$

$$\tan\frac{\theta}{2} = 0.875$$

$$Q = \frac{2}{3} \times 0.60 \times 0.5 \sqrt{(2\times 9.81)} \times (0.3)^{3/2} + \frac{8}{15} \times 0.6 \times 0.875 \times \sqrt{2\times 9.81} \times (0.3)^{5/2}$$

$$= 0.205 m^3/s.$$

3. Water flows over a rectangular notch of 1 metre breadth over a depth of 160mm. Then the same quantity of water passes through a triangular right-angled notch. Find the depth of water through the notch. Take the coefficients of discharge for the rectangular and triangular notch as 0.62 and 0.60 respectively.

Rectangular Notch:-

Breath (b) = 2m

Constant Head (H) = 0.4m

cd = 0.60

$$\boxed{Q = \frac{2}{3} cd\, b \sqrt{2g}\, H^{3/2}}$$

$$= \frac{2}{3} \times 0.60 \times 2 \sqrt{(2\times 9.81)} \times (0.4)^{3/2}$$

Q =>

Given:-

$Q = 21.5 m^3/min$

$= \quad m^3/sec$

$= \frac{21.5}{60}$ 1 min = 60sec

$Q \Rightarrow 0.358 m^3/sec$

cd = 0.62

$H = b/2 = \frac{1}{2} b = 0.5b$

b = ?

$$Q = \frac{2}{3} Cd\, b \sqrt{2g}\, H^{3/2}$$

$$0.358 = \frac{2}{3} \times 0.62 \times b \times \sqrt{(2\times 9.81)}\, (b/2)^{3/2}$$

$$0.358 = 0.648\, b^{5/2}$$

$$b^{5/2} = \frac{0.358}{0.648}$$

$$b = (0.55)^{2/5}$$

$$\boxed{b = 0.78m}$$

4. A triangular notch is discharging under a head of 0.5m. If the angle of the notch is 120° and Cd is 0.60, calculate the discharge through the notch.

Triangular Notch:-

Given:-

Head of Notch (H) = 0.5m

Angle of Notch (θ) = 120

cd = 0.60.

Triangular Notch

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

$$Q = \frac{8}{15} \times 0.60 \sqrt{(2\times9.81)} \times \tan\frac{120}{2} \times (0.5)^{5/2}$$

$$= \frac{8}{15} \times 0.60 \sqrt{(2\times9.81)} \times \tan 60 \times (0.5)^{5/2}$$

$$\Rightarrow 0.434 \, m^3/s.$$

5. The discharge through a right angled V-notch was found to be 60lpm. Under a constant head of 0.09m. Find the coefficient of discharge of the notch.

$\theta = 90°$

$H = 0.09m$

$Q = \frac{60 lpm}{} \; m^3/sec$

$= \frac{60}{1000\times60} = 1\times10^{-3}$

$= 0.001 \, m^3/sec$

$$\Rightarrow \frac{8}{15} cd \sqrt{2g} \tan\frac{\theta}{2} H^{5/2}$$

$$0.001 = \frac{8}{15} \times cd \times \sqrt{(2\times9.81)} \times \tan\frac{90°}{2} \times (0.09)^{5/2}$$

$\times \tan 45° = 1$

cd = 0.001

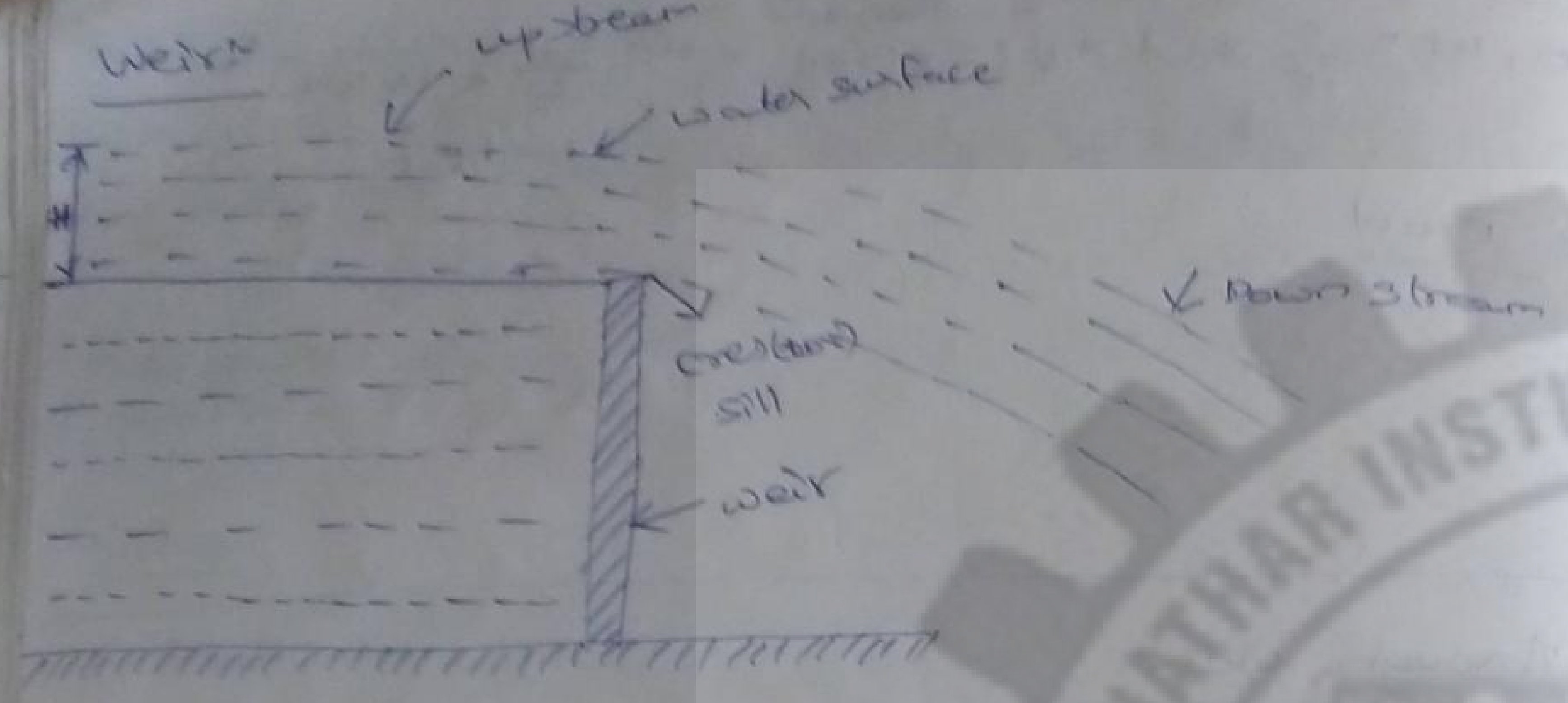
cd =

Flow Through weir:-

Classification of weir

1. According to shape of opening:-
   - (a) Rectangular weir
   - (b) triangular weir
   - (c) trapezoidal weir
2. According to nature of crest:-
   - (a) Sharp-crested weir
   - (b) ogee-shaped weir
3. According to crest width:-
   - (a) Narrow crested weir
   - (b) Broad crested weir
4. According to nature of discharge:-
   - (a) ordinary weir
   - (b) submerged (or) drowned weir

Weir:-



Formula:-

1. Rectangular weir:-

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

2. Trapezoidal weir:-

$$Q = \frac{2}{3} C_d L \sqrt{2g}\, H^{3/2} + 3/2 + \frac{8}{15} C_d \sqrt{2g} \tan\frac{\theta}{2} H^{5/2}$$

3. Rectangular weir with end contraction:-

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

$$\boxed{Q = 2/3\, C_d (L_e - 0.2H) \sqrt{2g}\, H^{3/2}}$$

4. Cippoletti weir:-

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

5. Basin's Formula for discharge over a cipplotti weir:-

cipplotti weir

$$\boxed{Q_a = 1.84\, L H^{3/2}}$$

6. Cipplottic Formula for discharge over a cipplottic weir:-

$$\boxed{Q_a = 1.86\, L H^{3/2}}$$

7. Narrow crested weir:-

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

8. Broad crested weir:-

$$Q = C_d L h \sqrt{2g(H-h)}$$

where, $h = 2/3\, H$.

$Q_{max} = 1.71\, C_d L H^{3/2}$

9. Drowned (or) submerged weir:-

$$Q = Q_{free} + Q_{sub}.$$

$$Q_{free} = \frac{2}{3} C_d L \sqrt{2g}\, (H-h)^{3/2}$$

$$Q_{sub} = C_d L H \sqrt{2g(H-h)}$$

10. Sharp crested weir:-

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

11. Ogee weir:-

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

12. Contracted weir:-

$$Q = 1.84\,(L - 0.1n\,H)(H)^{3/2}$$

13. Suppressed weir:-

$$Q = 1.84\, L H^{3/2}$$

14. Stepped weir:-

$Q = Q_1 + Q_2 + Q_3 \; m^3/sec.$

$Q_1 = \frac{2}{3} C_d L_1 \sqrt{2g} (H_1)^{3/2}$

$Q_2 = \frac{2}{3} C_d L_2 \sqrt{2g} \left[H_2 - H_1^{3/2}\right]$

$Q_3 = \frac{2}{3} C_d L_3 \sqrt{2g} \left[H_3^{3/2} - H_2^{3/2}\right]$

---

1. Find the discharge of water flowing over a rectangular weir of 2m length when the constant head over the notch is 300mm. Take $C_d = 0.60$.

Given:-

Rectangular weir

Length $= 2m (L)$

Constant head $H = 300mm$

$(H) \Rightarrow 0.3m$

$C_d = 0.60$

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

$\Rightarrow 2/3 \times 0.60 \times 2 \sqrt{2 \times 9.81} (0.3)^{3/2}$

$Q \Rightarrow 0.582 \; m^3/sec.$

2. A rectangular channel 2.3m wide has a discharge of 250 litres per second, which is measured by a right-angled V-notch weir. Find the position of the apex of the notch from the bed of the channel, if the maximum depth of water is not exceed 1.2m. Take $C_d = 0.62$.

Given:-

Rectangular channel.

wide $(b) = 2.3m$

discharge $(Q) = 250$ lps $= \frac{250}{1000}$

$= 0.25 \; m^3/sec$

Depth of water in channel $= 1.2m$.

$C_d = 0.62$

Angle $\theta = 90°$

To find:- Position of Apex = Depth of water - Height of channel.

Solu:

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

$0.25 = \frac{8}{15} \times 0.62 \sqrt{2 \times 9.81} \tan\frac{90°}{2} \times H^{5/2}$

$H^{5/2} = \frac{0.25}{1.464} \quad H = [0.170]^{2/5} = H = 0.493$

Position of Apex = Depth of water - height of channel

$= 1.2m - 0.493$

$= 0.707m.$

---

1. Cippoletti weir
2. Narrow crested weir
3. Sharp crested weir

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

7. Water is flowing over a Cippoletti weir whose length of the crest is 2m, compute the discharge if the head of water above the crest is 0.64m. Assume $C_d = 0.62$.

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Cippoletti weir:-

length (L) = 2m

Head (H) = 0.64m

$C_d = 0.62$

To find:- (Q) discharge

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

$= \frac{2}{3} \times 0.62 \times 2 \times \sqrt{2 \times 9.81}\, (0.64)^{3/2}$

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

$Q = 1.875\ m^3/sec.$

8. A narrow-crested weir of 10 metres long is discharging water under a constant head of 420mm. Find the discharge over the weir in lps. Assume coefficient of discharge as 0.623.

Narrow crested weir:-

Given:-

Length (L) = 10m

Head => 420mm = 0.42m

$C_d = 0.623$

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

$= \frac{2}{3} \times 0.623 \times 10 \times \sqrt{2 \times 9.81} \times (0.42)^{3/2}$

$Q = 5.007\ m^3/sec.$

$= 5007 \times 1000$

$= 5007$ lps

9. In a laboratory experiment, water flows over a sharp-crested weir 200mm long under a constant head of 75mm. Find the discharge over the weir in litres/sec. If $C_d = 0.6$.

Sharp-crested weir:-

Length (L) $= \frac{200mm}{1000} = 0.2m$

Head (H) $= \frac{75\ mm}{1000} = 0.075m$

$C_d = 0.6$

To find:-

Discharge in litre/sec.

Solution:-

$Q = \frac{2}{3} C_d L \sqrt{2g}\, H^{3/2} = \frac{2}{3} \times 0.6 \times 0.2 \times \sqrt{2 \times 9.81} \times (0.075)^{3/2}$

$= 7.27 \times 10^{-3}$

$= 0.0072\ m^3/sec \times 1000$

$= 7.2$ lps.

10. A 45m long broad crested weir has 0.5m of water above its crest. Find the maximum discharge over the weir. Take $C_d = 0.62$

Broad crested weir:-

L = 45m

H = 0.5m

$C_d = 0.62$

$\boxed{Q = 1.71\, C_d\, L \times H^{3/2}}$

$= 1.71 \times 0.62 \times 45 \times (0.5)^{3/2}$

$\boxed{Q \Rightarrow 16.80\ m^3/sec.}$

Unit - 5

Flow Through open channels → Natural (or) Artificial passage in which water flows with a free surface.

. steady flow → velocity of flow, Rate of flow do not change with respect to time.

. unsteady flow → velocity of flow, Rate of flow change with respect to time.

. uniform flow → velocity of flow, depth of flow, slope of channel remain constant

. non-uniform flow → velocity of flow, depth of flow, slope of channel do not remain constant

. Laminar flow → Each fluid partical has a definite path.

→ → → → →

. Turbulent flow → Partical does not have a definite Path. It moves in zig zag way.

Important:-

a) Area (A)

b) wetted Perimeter (P)

c) Hydraulic mean depth $(m) = \frac{A}{P}$.

Formula:-

(i) For Rectangular section:-

$A = bd\,(m^2)$

$P = b + 2d$

$m = \frac{A}{P} = \frac{bd}{b+2d}$ (m)

(ii) For a Trapezoidal section:-

$A = (b+nd)\,d \quad (m^2)$

$P = b + 2d\sqrt{n^2+1}$

$m = \frac{A}{P} = \frac{(b+nd)d}{b+2d\sqrt{n^2+1}}$

(iii) For a circular section:-

$A = \frac{\pi d^2}{4}\,(m^2)$

$P = \pi d\,(m)$

$m = \frac{A}{P} = \frac{\pi d^2}{4\pi d} = d/4$ (m)

(Discharge Formula):-

(i) Chezy's Formula:-

$Q = A \times V$

$\therefore V = C\sqrt{mi}$

$\boxed{Q = AC\sqrt{mi}}$

(ii) Bazins Formula:-

$C = \frac{157.6}{1.81 + \frac{K}{\sqrt{m}}}$

Manning's Formula:-

$Q = A\,m\,m^{2/3}\,i^{1/2}\,(m^3/sec)$

1. A rectangular channel is 5m wide and 3m deep. The bed fall is 1 in 1000. Find the discharge when it is running full. Take chezy's constant as 6.55

Unit - 5

Flow Through open channels → Natural (or) Artificial Passage in which water flows with a free surface

1. Steady flow → velocity of flow, Rate of flow do not change with respect to time.

2. unsteady flow → velocity of flow, Rate of flow change with respect to time.

3. uniform flow → velocity of flow, depth of flow, slope of channel remain constant

4. non-uniform flow → velocity of flow, depth of flow, slope of channel do not remain constant

5. Laminar flow → Each fluid partical has a definite path.

→ → → → →

6. Turbulent flow → partical does not have a definite path. It moves in zig zag way.

Important:-

a) Area (A)

b) wetted perimeter (P)

c) Hydraulic mean depth $(m) = \frac{A}{P}$

Formula:-

(i) For Rectangular section:-

$A = bd\,(m^2)$

$P = b + 2d$

$m = \frac{A}{P} = \frac{bd}{b+2d}$ (m)

(ii) For a Trapezoidal section:-

$A = (b+nd)d\ (m^2)$

$P = b + 2d\sqrt{n^2+1}$

$m = \frac{A}{P} = \frac{(b+nd)d}{b+2d\sqrt{n^2+1}}$

(iii) For a circular section:-

$A = \frac{\pi d^2}{4}\ (m^2)$

$P = \pi d\ (m)$

$m = \frac{A}{P} = \frac{\pi d^2}{4\pi d} = d/4\ (m)$

(Discharge Formula):-

(i) Chezy's Formula:-

$Q = A \times V$

$\therefore V = C\sqrt{mi}$

$\boxed{Q = AC\sqrt{mi}}$

(ii) Bazins Formula:-

$C = \frac{157.6}{1.81 + \frac{K}{\sqrt{m}}}$

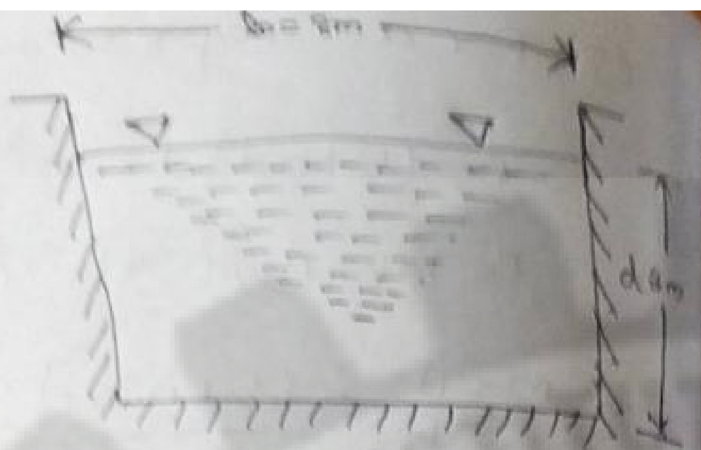
Mannings Formula:-

$Q = A\, m^{2/3}\, i^{1/2}\ (m^3/sec)$

1. A rectangular channel is 8m wide and 3m deep. The bed fall is 1 in 1000. Find the discharge when it is running full. Take Chezy's constant as 0.55

Given data:-

1. Rectangular channel:-



$b = 8m$

$d = 3m.$

Slope (i) = 1 in 1000 = $\frac{1}{1000}$

$C = 0.55$

To find:- (Q) discharge.

$Q = AC\sqrt{mi}$ → Slope

Area, Chezy's, Hydraulic mean depth

$A \Rightarrow b \times d \Rightarrow 8 \times 3 \Rightarrow 24 m^2$

$P = b + 2d \Rightarrow 8 + 2(3) = 14$

$m = A/P = \frac{24}{14} \Rightarrow 1.714$

$Q = 24 \times 0.55 \sqrt{1.714 \times 1/1000}$

$= 54.72 m^3/sec$

3. A rectangular channel 1.2m wide and 1m deep has longitudinal slope 1 in 3000 using Bazin's formula determine the discharge through the channel. K = 1.54.

Rectangular channel:-

$b = 1.2m$

$d = 1m$

Slope (i) = 1 in 3000 = $\frac{1}{3000}$

$K = 1.54$

Discharge: (Q)

$$C = \frac{157.6}{1.81 + \frac{K}{\sqrt{m}}}$$

$A \Rightarrow b \times d \Rightarrow 1.2 \times 1 = 1.2 m^2$

$P = b + 2d \Rightarrow 1.2 + 2(1) = 3.2m$

$m = \frac{A}{P} = \frac{1.2}{3.2} \Rightarrow 0.375m.$

$$C = \frac{157.6}{1.81 + \frac{1.54}{\sqrt{0.375}}}$$

$C \Rightarrow 36.44$

$Q = AC\sqrt{mi}$

$= 1.2 \times 36.44 \sqrt{0.375 \times \frac{1}{3000}}$

$\Rightarrow 0.489 m^3/sec.$

4. A trapezoidal channel is 8m wide at bottom. The side slopes are 1:1. The bed fall is 0.5m per km. Taking Chezy's constant as 60, find the discharge through the channel when the depth of flow is 2m.