

$$\text{mm} = 10^{-3} \text{ m}$$

$$\text{cm} = 10^{-2} \text{ m}$$

$$\text{liter} = 10^{-3} \text{ m}^3$$

① Rectangle - CGC → $\frac{1}{2}$
 Area → bd
 ICG → $\frac{bd^3}{12}$

② Triangle - CGC → $\frac{1}{3}$
 Area → $\frac{bh}{2}$
 ICG → $\frac{bh^3}{36}$

③ Circle → CGC → $\frac{d}{2}$

$$\text{Area} \rightarrow \frac{\pi d^2}{4}$$

$$\text{ICG} \rightarrow \frac{\pi d^4}{64}$$

④ Trapezoidal → CGC → $\frac{(a+b)h}{3}$

$$\text{Area} = \frac{(a+b) \times h}{2}$$

$$\text{ICG} = \frac{a^2 + 4ab + b^2}{36(a+b)}$$

$$Q = 0.01 \text{ stroke}$$

$$0.01 \text{ cm}^2/\text{s}$$

$$0.01 \times 10^{-4} \text{ m}^2/\text{s}$$

UNIT- 1

INTRODUCTION

★ Fluid:- Fluid mechanics is that branch of science which deals with the behaviour of the fluid (liquid or gas) at rest as well as in motion.

- static
 - kinematics
 - dynamic.
- This branch of science deals with static kinematic and dynamic aspect of fluid.
 - The study of fluid at the rest is called static fluid.
 - The study of fluid in motion where pressure force are not consider is called kinematics.
 - The study of fluid in motion where pressure force are not consider is called dynamic.

★ Property of Fluid:-

i) Density or mass density:- It is define as the ratio of the mass of fluid to its volume.

- The unit of mass density in SI unit is kg/m^3 .
- It is denoted by ρ

$$\rho = \frac{m}{V} \quad \text{kg/m}^3$$

The value of density of water =

ρ_{water}	1000 kg/m^3
	1 gm/cm^3
ρ_{mercury}	13600 kg/m^3
	13.6 gm/ml

ii) Specific weight or weight density:-

- It is the ratio between weight of fluid to its volume.
- It is denoted by w

i) Specific weight = $\frac{W}{V}$

= $\frac{7}{1000}$

$\frac{1}{1000}$

Specific weight = 7000 N/m^3

Ans.

ii) density :-

We know that $w = \rho g$

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

$\rho = \frac{7000}{9.81} = 713.5 \text{ Kg/m}^3$

Ans.

iii) Specific gravity

$S = \frac{\rho_{\text{liquid}}}{\rho_{\text{water}}}$

$S = \frac{713.5}{1000} = 0.7135$

(unit less)

Ans.

iv) Specific gravity:-

$$S = \frac{\text{weight density of liquid}}{\text{weight density of water}}$$

$S = \frac{\rho_{\text{liquid}}}{\rho_{\text{water}}}$
--

 (Unit less)

Numerical questions:-

1. Calculate the specific weight, density and specific gravity of 1 liter of a liquid which weight 7 N.

Solution

given data

Volume = 1 liter
 $= \frac{1}{1000} \text{ m}^3$

weight = 7 N

$$w_k = \frac{\text{Weight of fluid}}{\text{Volume of fluid}}$$

$$w_k = \frac{W}{V} = \left[\begin{array}{l} W = \text{Weight} \\ V = \text{Volume} \end{array} \right]$$

$$w_k = \frac{\text{mass of fluid} \times \text{Acceleration due to gravity}}{\text{Volume of fluid}}$$

$$w_k = \frac{m}{V} \times g$$

$$w_k = \rho g \quad \text{N/m}^3$$

iii) ~~Specific Volume~~

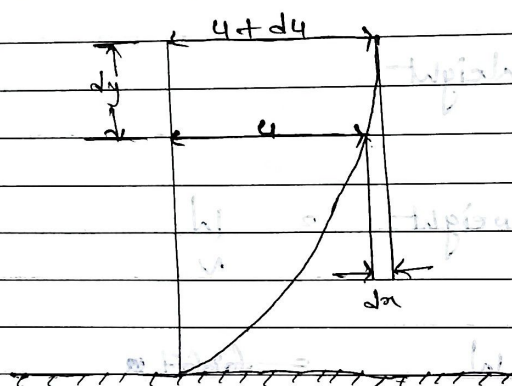
$$= \frac{\text{Volume of fluid}}{\text{mass of fluid}}$$

$$= \frac{1}{\rho}$$

$$= \frac{1}{\rho} \quad \text{m}^3/\text{kg}$$

★ Viscosity :-

- It is defined as a property of a fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid.



- When two layers of fluid at distance dy apart move one over the other at different velocity say u and $u + du$
- The viscosity together with relative velocity call a shear stress acting between the fluid layer.

$$\tau \propto \frac{du}{dy}$$

$$ii) \text{ Specific weight} = \rho_g$$

$$w = \gamma_{00} \times 9.81$$

$$= 6867 \text{ N/m}^3$$

$$iii) \text{ Specific weight}$$

$$\text{Specific weight} = \frac{W}{V}$$

$$6867 = \frac{W}{V} = 6867$$

~~$$6867 = \frac{W}{V}$$~~

$$W = 6867 \text{ N}$$

$$W = 6867 \text{ N}$$

2. Calculate the density, specific weight and weight of 1 liter of petrol of specific gravity 0.7. ii)

Solution

given data

$$\text{Volume} = 1 \text{ liter}$$

$$= \frac{1}{1000} \text{ m}^3$$

$$\text{Specific gravity} = 0.7$$

i) Density ρ

$$\text{Specific gravity} = \frac{\rho_{\text{petrol}}}{\rho_{\text{water}}}$$

$$\rho_{\text{petrol}} = \text{Specific gravity} \times \rho_{\text{water}}$$

$$\rho_{\text{petrol}} = 0.7 \times 1000$$

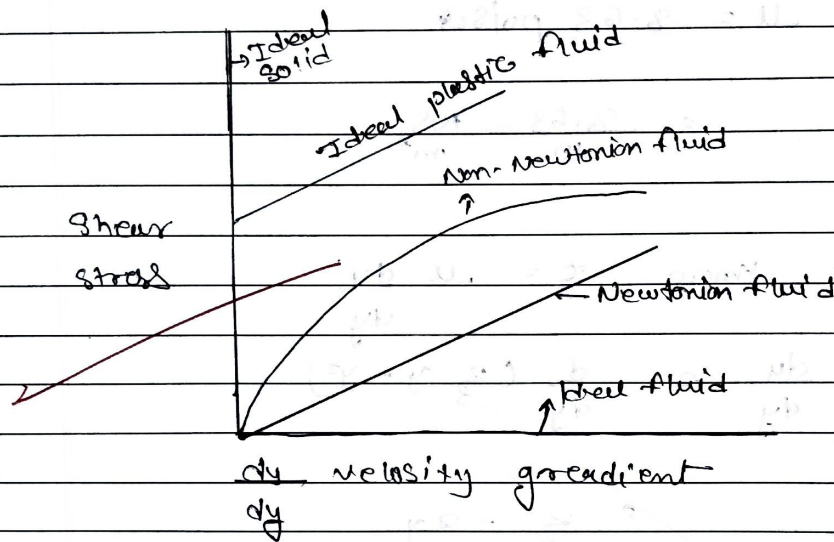
$$\rho_{\text{petrol}} = 700$$

iv) Non-Newtonian Fluid:-

- A real fluid in which the shear stress is not proportional to rate of shear strain. Is known as Non-Newtonian fluid.

v) Ideal Plastic Fluid:-

- A fluid in which shear stress is more than the yield value and shear stress is proportional to the rate of shear strain.



Numerical Question

- If the velocity distribution over a plate is given by $u = \frac{2}{3}y - y^2$ in which u is velocity in m/s at a distance y above the plate determine the shear stress at

$\nu = \frac{\text{dynamic viscosity}}{\text{density of fluid}}$

$\nu = \frac{\mu}{\rho}$	m^2/s
--------------------------	-----------------------

* Types of Fluid

i) Ideal fluid :- A fluid which is incompressible and is having no viscosity is known as ideal fluid.

- Ideal fluid is only an imaginary fluid as all the fluids which exist have some viscosity.

ii) Real fluid :-

- A fluid which possesses viscosity is known as real fluid.

iii) Newtonian fluid :-

- A fluid in which shear stress is directly proportional to the rate of shear strain. (velocity gradient) is known as Newtonian fluid.

$$\tau = \mu \frac{dy}{dx}$$

μ = coefficient of dynamic viscosity

$\frac{dy}{dx}$ = velocity gradient

τ = shear stress

• unit of viscosity =

$$\text{SI unit} = \text{Ns/m}^2 = \text{Pa}\cdot\text{s}$$

(Pascal = N/m^2)

$$1 \text{ Poise} = \frac{1}{10} \frac{\text{Ns}}{\text{m}^2}$$

★ Kinematic Viscosity: It is defined as the ratio of between the dynamic viscosity and density of fluid.

• It is denoted by ν (nu)

(unitary symbol is m^2/s)

Solution

given data.

$$u = 60 \text{ c.m./sec.}$$

$$= 60 \times 0.01 \text{ m/s}$$

$$dy = 0.025 \text{ mm.}$$

$$= 0.025 \times 10^{-3} \text{ m.}$$

$$f = \tau = 2 \text{ N/m}^2$$

$$du = \text{final} - \text{initial}$$

$$= 0.6 - 0$$

$$du = 0.6 \text{ m/s}$$

$$\tau = \mu \frac{du}{dy}$$

$$2 = \mu \times 0.6$$

$$\mu = 2.5 \times 10^{-5}$$

$$\mu = 8.33 \times 10^{-5} \text{ NS/m}^2$$

* A plate of area $1.5 \times 10^6 \text{ mm}^2$ is pulled with a speed of 0.4 m/s relative to another plate located at a distance of 0.15 mm from it. Find the force and power required to maintain this speed. if the fluid separating

$$y=0$$

$$\tau = \mu \left(\frac{dy}{dy} \right)_{y=0}$$

$$\tau = \frac{9.63}{10} \times 0.66$$

$$\tau = 0.5756 \text{ N/m}^2$$

Ans.

$$y=0.15$$

$$\tau = \mu \left[\frac{dy}{dy} \right]_{y=0.15}$$

$$\tau = \frac{9.63}{10} \times 0.15$$

$$\tau = 0.316 \text{ N/m}^2$$

Ans.

- ★ A plate 0.025 mm distant from a fixed plate moves at 60 cm/sec. and requires a force of 2 N/unit area that is 2 N/m² to maintain this speed determine the fluid viscosity between the plate.

$y = 0$ and $y = 0.15$ m. Take dynamic viscosity of fluid as 8.68 poise.

Solution given data

$$u = \frac{2}{3} y - y^2$$

$$y_1 = 0 \text{ m}$$

$$y_2 = 0.15 \text{ m}$$

$$\mu = 8.68 \text{ poise}$$

$$= \frac{8.68}{10} \frac{\text{NS}}{\text{m}^2}$$

We know $\tau = \mu \frac{du}{dy}$

$$\frac{du}{dy} = \frac{d}{dy} \left(\frac{2}{3} y - y^2 \right)$$

$$= \frac{2}{3} - 2y$$

Now

$$y = 0$$

$$\frac{du}{dy} = \frac{2}{3} - 2 \cdot 0$$

$$\frac{du}{dy} = \frac{2}{3}$$

$$\frac{du}{dy} = 0.66$$

Now

$$y = 0.15$$

$$\frac{du}{dy} = \frac{2}{3} - 2 \cdot 0.15$$

$$\frac{du}{dy} = 0.366$$

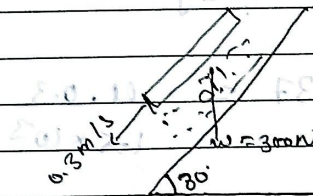
$$\tau = \mu \frac{du}{dy}$$

$$\tau = \frac{1}{10} \times \frac{0.785}{1.5 \times 10^{-3}}$$

$$\tau = 52.33 \text{ N/m}^2$$

* Calculate the dynamic viscosity of an oil which is used for lubrication between a square plate of size $0.8 \text{ m} \times 0.8 \text{ m}$ and inclined plane with angle of inclination 30° as shown in figure. The weight of the square plate is 300 N and it slides down the inclined plane with a uniform velocity of 0.3 m/s . The thickness of oil film is 1.5 mm .

Solution



given data

$$u = 0.3 \text{ m/s}$$

$$dy = 1.5 \text{ mm}$$

$$= 1.5 \times 10^{-3} \text{ m}$$

$$\text{area} = 0.8 \text{ m} \times 0.8 \text{ m}$$

Now power

$$P = F \times u$$

$$P = 400 \times 0.4$$

$$P = 160 \text{ W}$$

* Determine the intensity of shear of an oil having viscosity 1 poise. The oil is used for lubricating the clearance between a shaft of diameter 10 cm and its bearing. The clearance is 1.5 mm and the shaft rotates at 150 rpm.

Solution

Given data

$$\text{Viscosity } (\mu) = 1 \text{ poise}$$

$$= \frac{1}{10} \text{ N s / m}^2$$

$$D = 10 \text{ cm} \\ = 0.1 \text{ m}$$

$$\text{distance } (dy) = 1.5 \text{ mm} \\ = 1.5 \times 10^{-3} \text{ m}$$

$$\text{shaft rotates } (N) = 150 \text{ rpm}$$

$$u = \frac{\pi D N}{60}$$

$$u = \frac{\pi \cdot 0.1 \cdot 150}{60} = 0.785 \text{ m/s}$$

stream has having viscosity as well as

Solution

given data.

$$u = 0.4 \text{ m/s}$$

$$dy = 0.15 \text{ mm}$$

$$= 0.15 \times 10^{-3} \text{ m}$$

$$\text{Area} = 1.5 \times 10^6 \text{ mm}^2$$

$$= 1.5 \times 10^6 \times 10^{-6} \text{ m}^2$$

$$\mu = 1 \text{ poise}$$

$$= \frac{1}{10} \frac{\text{NS}}{\text{m}^2}$$

$$F = \tau \times \text{Area}$$

$$\tau = \mu \frac{du}{dy}$$

$$\frac{du}{dy} = \frac{0.4}{0.15 \times 10^{-3}}$$

$$\tau = \frac{1}{10} \times \frac{0.4}{0.15 \times 10^{-3}}$$

$$= 266.66 \text{ N/m}^2$$

$$\tau = 266.66 \text{ N/m}^2$$

Now force,

$$F = \tau \times \text{Area}$$

$$F = 266.66 \times 1.5 \times 10^6 \times 10^{-6}$$

$$F = 399.99 \text{ N}$$

$$F = 400 \text{ N}$$

* The space between two square plates ^{parallel} plates, is filled with oil. Each side of the plate is 60 c.m. The thickness of the oil film is 12.5 mm. The upper plate which moves at 2.5 m/s. Requires a force of 98.1 N to maintain the speed.

Determine

- i) The dynamic viscosity of the oil in poise.
- ii) the kinematic viscosity of the oil in stokes if the specific gravity of the oil is 0.95.

Solution

given data: -

Each side of square

$$60 = 60 \times 10^{-2}$$

$$\text{Area} = 60 \times 60$$

$$= 3600 \text{ cm}^2 = 0.6 \times 0.6$$

$$= 3600 \times 10^{-2} \text{ m}^2$$

$$dy = 12.5 \text{ mm} \\ = 12.5 \times 10^{-3} \text{ m}$$

$$u = 2.5 \text{ m/s}$$

$$\text{force} = 98.1 \text{ N}$$

* Two horizontal plates are placed 1.25 cm. apart the space between them being filled with oil of viscosity 14 poise. Calculate the shear stress in oil if upper plate is moved with a velocity of 2.5 m/s.

Solution

$$dy = 1.25 \text{ cm.}$$

$$= 1.25 \times 10^{-2} \text{ m}$$

$$u = 2.5 \text{ m/s}$$

$$\mu = 14 \text{ poise}$$

$$= \frac{14}{10} \text{ NS/m}^2$$

$$\tau = \mu \frac{du}{dy}$$

$$\tau = \frac{14}{10} \times \frac{2.5}{1.25 \times 10^{-2}}$$

$$\tau = 28 \text{ N/m}^2$$

$$= 28 \text{ N/m}^2$$

Ans.

$$W = 300 \text{ N}$$

$$F = W \cos 60^\circ$$

$$F = 300 \cos 60^\circ$$

$$F = 150 \text{ N}$$

Now T

$$F = T \times A$$

$$150 = T \times 0.64$$

$$T = \frac{150}{0.64}$$

$$T = 234.37 \text{ N/m}^2$$

Now μ

$$T = \mu \frac{dy}{dy}$$

$$234.37 = \mu \cdot \frac{0.3}{1.5 \times 10^{-3}}$$

$$\mu = 1.171 \text{ N s/m}^2$$

$$= 1.434 \times 10^{-3} \times 100 \text{ c.m/s}$$

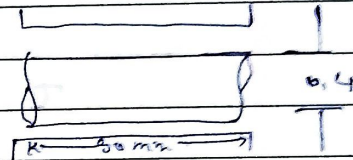
$$= 0.1434 \text{ Stokes}$$

Ans.

★ The dynamic viscosity of an oil used for lubrication between a shaft and sleeve is 6 poise. The shaft is of a diameter 0.4 m and rotates at 190 rpm. Calculate the power in the bearing for a sleeve length of 90 mm. The thickness of the oil film is 1.5 mm

Solution

given data



$$\mu = 6 \text{ poise} = \frac{1}{6} \text{ NS/m}^2$$

$$dy = 1.5 \text{ mm}$$

$$= 1.5 \times 10^{-3} \text{ m}$$

$$\text{rotation (N)} = 190 \text{ rpm}$$

$$D = 0.4 \text{ m}$$

$$P = \frac{2\pi NT}{60} \text{ W}$$

T = Torque

$$T = \frac{F \times D}{2} \text{ N/m}$$

$$F = \tau \times A \text{ N}$$

$$\tau = \mu \frac{dy}{dx}$$

We know

$$\text{Specific gravity} = 0.95$$

$$\text{Specific gravity} = \frac{\text{Soil}}{\text{water}}$$

$$0.95 = \frac{\text{Soil}}{1000}$$

$$\begin{aligned}\text{Soil} &= 0.95 \times 1000 \\ \text{Soil} &= 950\end{aligned}$$

$$\text{Now } V =$$

$$V = \frac{1.3625}{950}$$

$$V = 1.434 \times 10^{-3} \text{ m}^3/\text{s}$$

$$\text{cm}^2/\text{s} = \text{Stokes}$$

$$F = \tau \times A$$

$$\tau = \frac{F}{A}$$

$$\tau = \frac{98.1}{3600 \times 10^{-2}} \quad \frac{98.1}{0.6 \times 0.6}$$

$$\tau = \frac{2.725 \text{ N/m}^2}{272.5 \text{ N/m}^2}$$

Now

$$\tau = \mu \frac{du}{dy}$$

$$272.5 = \mu \frac{2.5}{12.5 \times 10^{-3}}$$

$$\mu = 1.3625 \text{ N s/m}^2$$

$$\mu = 1.3625 \times 10 \text{ poise}$$

$$\text{dynamic viscosity } \mu = 13.62 \text{ poise}$$

viscosity

(2) Kinematic viscosity:-

$$\nu = \frac{\mu}{\rho} \quad \text{m}^2/\text{s}$$

14

given data =

$$du = 0.6 \text{ m/s}$$

$$dy = 1.2 \text{ cm}$$

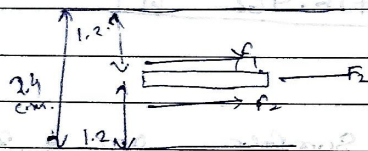
$$1.2 \times 10^{-2} \text{ m}$$

$$0.8 \times 10^{-2} \text{ m}$$

$$\text{Area} = 0.5 \text{ m}^2$$

$$\mu = 8.10 \times 10^{-1} \frac{\text{Ns}}{\text{m}^2}$$

(1)



$$F = \tau \times A$$

$$\tau = \mu \times \frac{du}{dy}$$

$$\tau = 8.10 \times 10^{-1} \times \frac{0.6}{1.2 \times 10^{-2}}$$

$$\tau = 40.5 \text{ N/m}^2$$

$$40.5 \times 0.5 = F$$

$$F = 20.25 \text{ N}$$

Now Power

$$P = \frac{2\pi\eta l}{60}$$

$$P = \frac{2\pi \times 190 \times 36.01}{60}$$

$$P = 736.089 \text{ W}$$

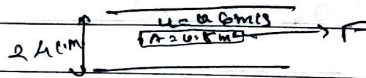
$$P = 716.482 \text{ W}$$

★ Two large plane surface are 2.4 cm apart. The space between the surface is filled with glycerine. what force is required to drag a very thin plate of surface area 0.5 m^2 between the two large plane surface at a speed of 0.6 m/s .
IP

i) The thin plate is in the middle of the two plane surface.

ii) The thin plate is at a distance of 0.6 cm from 1 of the plane surface.

iii) Take dynamic viscosity of glycerine $8.10 \times 10^{-1} \text{ NS/m}^2$



$$T = \frac{4\pi \eta r}{\omega}$$

$$\eta = \frac{\pi D \Delta L}{60}$$

$$\eta = \frac{\pi \times 0.4 \times 100}{60}$$

$$\eta = 3.979 \text{ m/s}$$

$$\tau = \frac{1}{6} \times \frac{3.979}{1.5 \times 10^{-3}}$$

$$\tau = 442.11 \text{ NS/m}^2$$

Now F

$$F = \tau \times A \text{ (area)} \times DL$$

$$F = 1592 \times 0.125 \times 90 \times 10^{-3}$$

$$F = 200.05 \text{ N}$$

Now Torque

$$T = F \times \frac{D}{2}$$

$$T = \frac{180.5}{2} \times \frac{0.4}{2}$$

$$T = 45.125 \text{ Nm}$$

* Compressibility and Bulk modulus :-

i) Compressibility is the reciprocal of the bulk modulus of elasticity.

ii) K (Bulk modulus) = $\frac{\text{Compressive Stress}}{\text{Volumetric strain}}$

iii) Compressibility = $\frac{1}{K}$

* Surface tension and Capillarity

Surface tension :-

It is defined as the ^{surface} tensile force acting on the surface of the liquid in contact with a gas or on the surface between two ~~immiscible~~ immiscible liquids such that the contact surface behaves like a membrane under tension.

SI unit is N/m .

Surface tension of liquid drop :-

$$P = \frac{4\sigma}{d}$$

सर्वर

$$\tau = \frac{dF}{dy}$$

$$\tau = \frac{6.10 \times 10^{-1} \times 0.6}{0.9 \times 10^{-2}}$$

$$\tau = 607.5 \text{ N/m}^2$$

$$F_1 = \tau \times A$$

$$F_1 = 607.5 \times 0.5$$

$$F_1 = 303.75$$

$$F = F_1 + F_2$$

$$F = 303.75 + 303.75 = 151.87$$

$$F = 455.62 \text{ N}$$

A. Con

i) G
m

ii) K

iii) G

A. S

S

J

A

G

F

S

$$F_2 = 40.5 \times 0.5$$

$$F_2 = 20.25$$

$$F_1 + F_2 =$$

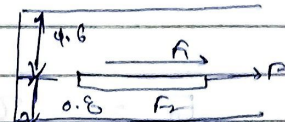
$$20.25 + 20.25$$

$$= 40.5 \text{ N}$$

$$F = 40.5 \text{ N}$$

②

~~$I = \frac{dy}{dy}$~~



$$dy_1 = 0.8 \text{ c.m.}$$

$$= 0.8 \times 10^{-3} \text{ m}$$

$$dy_2 = 1.6 \text{ c.m.}$$

$$= 1.6 \times 10^{-3} \text{ m.}$$

$$F = \tau \times A$$

$$\tau = \frac{8.10 \times 10^7 \times 0.6}{1.6 \times 10^{-3}}$$

$$\tau = 303.75 \text{ N/m}^2$$

$$F_1 = \tau \times A$$

$$F_1 = 303.75 \times 0.5$$

$$F_1 = 151.87 \text{ N}$$

★ Capillarity:-

i) It is defined as a phenomena rise or fall of a liquid surface in a small tube relative to the adjacent general level of liquid when the tube is vertically in the liquid.

ii) The rise of liquid surface is known as capillary rise.

iii) The fall of the liquid surface is known as capillary depression.

iv) It is expressed in terms of cm or mm.

Expression for Capillary rise:-

→ Consider a glass tube of small diameter open at both ends and is inserted in a liquid say water.

→ Let h = height of liquid in the tube

→ Let σ = Surface tension of liquid

→ Let θ = Angle of contact between liquid and glass tube.

then the out side presser calculate the diameter of the droplet of water.

Soln

given dat

$$\sigma = 0.0725 \text{ N/m}$$

$$P = 0.02 \text{ N/cm}^2 = \frac{0.02}{(10^{-2})^2}$$

$$0.02 \times 10^4 = 4 \times 0.0725$$

d

$$d = \frac{4 \times 0.0725}{0.02 \times (10^{-2})^2}$$

$$\frac{0.02}{(10^{-2})^2} = 4 \times 0.0725$$

d

$$d = 1.445 \times 10^{-3} \text{ m}$$

Ans

* find the surface tension in a shape double of 40 mm diameter. When the inside pressure is 2.5 N/m^2 above at atmospheric pressure.

~~for~~ for

$$d = 40 \text{ mm} \times 10^{-3} \Rightarrow$$

$$P = 2.5 \text{ N/m}^2$$

$$2.5 =$$

$$8 \times 10^{-3}$$

$$2.5 \times 10^3 = 0.64$$

$$= 0.0128$$

P = Pressure intensity in side the drop

d = Diameter of drop

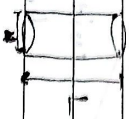
σ = Surface tension of the liquid

Surface tension of Hollow bubble:-

$$P = \frac{8\sigma}{d}$$

Surface tension of liquid jet:-

$$P = \frac{4\sigma}{Ld}$$



$$P = \frac{2\sigma}{d}$$

Numerical

The surface tension of water in contact with air at 20°C is 0.0725 N/m . The pressure inside a droplet of water is 0.02 N/cm^2 greater

* Calculate the capillary rise in a glass tube of 2.5 mm diameter when immersed vertically in water

(ii) mercury

- take $\sigma = 0.0725 \text{ N/m}$ for water and $\sigma = 0.052 \text{ N/m}$ for mercury, in contact with air.

The specific gravity for mercury is given as 13.6 and Angle of contact 130° .

Solution

Given data

$$\text{diameter} = 2.5$$

$$\text{water}(\sigma) = 0.0725 \text{ N/m}$$

$$\text{mercury}(\sigma) = 0.052 \text{ N/m}$$

$$\cancel{h_{\text{mer}} = 40 \text{ cm}}$$
$$89 \text{ g}$$

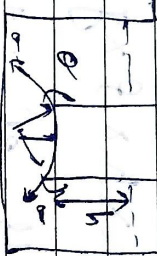
$$h = \frac{4 \times 0.0725 \times \cos 0^\circ}{1000 \times 9.81 \times 2.5 \times 10^{-3}}$$

$$h = \frac{0.2902}{2.4525 \times 10^{-2}}$$

$$h = 0.0118 \text{ m}$$

Depression for Capillary fall:-

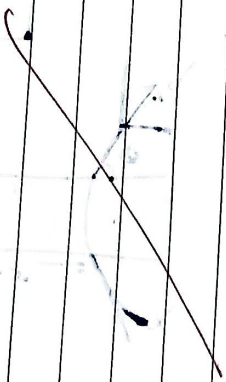
ii)



(1) If the glass tube is dipped in mercury the level of mercury in the tube will be lower than the general level of the outside liquid.



value of θ for mercury and glass tube is 120° .



→ Height of liquid of height h in the tube =

$$= (\text{Area} \times h) \times \rho \times g \text{ (due to gravity)}$$

$$= \frac{\pi}{4} d^2 \times h \times \rho \times g \quad \text{--- (i)}$$

Vertical Component of the Surface Tensile force

$$= (\sigma \times \text{circumference}) \times \cos \theta$$

$$= \sigma \pi d \times \cos \theta \quad \text{--- (ii)}$$

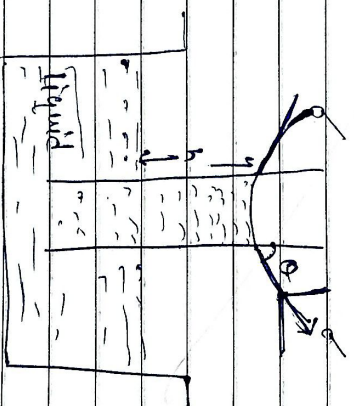
$$\frac{\pi d^2 \times h \times \rho \times g}{4} = \sigma \pi d \times \cos \theta$$

$$h = \frac{4 \sigma \cos \theta}{\rho h d}$$

if $\theta = 0$

$$h = \frac{4 \sigma}{\rho h d}$$

The rise of water is given by



* Calculate the capillary effect in a glass tube of 4 mm diameter, when immersed in water and mercury. $\rho_{\text{water}} = 998.2073575 \text{ N/m}^3$ and $\rho_{\text{mercury}} = 136000 \text{ N/m}^3$. Take density of water = $998.2073575 \text{ kg/m}^3$

~~Ques~~

given data

$$d = 4 \text{ mm}$$

$$= 4 \times 10^{-3} \text{ m}$$

$$\rho_{\text{water}} = 998.2073575 \text{ N/m}^3$$

$$\rho_{\text{mercury}} = 136000$$

$$\rho = 136000$$

$$\rho_{\text{water}} = 998.2073575 \text{ kg/m}^3$$

$$h_{\text{water}} = 4.87$$

$$\rho_{\text{d}} = 998.2073575$$

$$h_{\text{water}} = 4.87 \times 998.2073575$$

$$998.2073575 \times 4 \times 10^{-3}$$

$$h_2 = 4.87 \times 998.2073575 \text{ m}$$

Ans,

← Revision

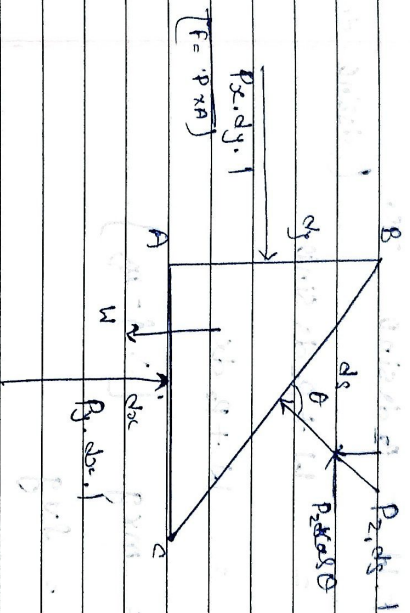
- ① $\tau = \mu \frac{du}{dy}$ N/m^2
- ② $F = I \times A$ N
- ③ $v = \frac{\pi D^2}{4} \times \text{m/s}$
- ④ $P = F \times v$ N/m^2
- ⑤ $P_{\text{water}} = \frac{2 \sigma}{r} \quad \text{ml} / \text{Total (T)} = \frac{F \times D}{2}$
- ⑥ for plate $P = \frac{4 \sigma}{d}$ N/m
- ⑦ for hollow bubble $P = \frac{4 \sigma}{d}$ N/m
- ⑧ for liquids jet, $P = \frac{2 \sigma}{d}$ N/m
- ⑨ $h_{\text{water}} = \frac{4 \sigma}{\rho g d}$
- ⑩ $h_{\text{mercury}} = \frac{4 \sigma \times \cos \theta}{\rho g d}$

h (msec) = $40 \cos(130^\circ)$
of g d

$$h = 4 \times 0.52 \times \cos(130^\circ)$$
$$13600 \times 9.81 \times 0.5 \times 10^3$$

$$h = -0.0004 \text{ m}$$

Consider an arbitrary fluid element in a fluid mass at rest



acted by
sliding
area
surface,

Resolving in
or axis direction factors

$$P \cdot dy \cdot l - P_2 \cdot ds \cdot \cos \theta = 0$$

$$[\because ds \cos \theta = AB = dy]$$

$$P \cdot dy \cdot l - P_2 \cdot dy \cdot l = 0$$

$$P \cdot dy \cdot l = P_2 \cdot dy \cdot l$$

$$P = P_2$$

of
is

$$P_1 = P_2 = P_3$$

Pressure and its measurement:-

$$\text{Pressure} = \frac{F}{A}$$

The ratio of force over Area is known as intensity of pressure or simply pressure and it is represented by P .

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

The force exerted by the surrounding fluid on the area always be perpendicular to the surface,

$$\text{Pressure } F = P \times A$$

The unit of pressure are $\frac{\text{kgf}}{\text{m}^2}$, $\frac{\text{kgf}}{\text{cm}^2}$.

SI units = $\text{N/m}^2 \rightarrow \text{Pascal (Pa)}$

Pascals law:- It states that the pressure or intensity of pressure at a point in static fluid is equal in all direction.

$$h_{\text{massing}} = \frac{4\sigma - \text{cost}}{fgd}$$

$$h = \frac{4 \times 0.51 \times \cos 130^\circ}{13600 \times 9.81 \times 4 \times 10^{-3}}$$

$$h = -2.46 \times 10^{-3} \text{ m}$$

value,

area = 1.47 m²

radius = 0.68 m

area = 1.47 m²

area = 1.47 m²

$$-pA + \left[p + \frac{dp}{dz} \right] dA - dA \cdot dz \cdot \rho g = 0$$

$$-pA + pA + \frac{dp}{dz} dA - dA \cdot dz \cdot \rho g = 0$$

$$\frac{dp}{dz} dA - dA \cdot dz \cdot \rho g = 0$$

$$\frac{dp}{dz} dz = \rho g dz$$

$$\frac{dp}{dz} = \rho g \quad \text{density of fluid}$$

$$dp = \rho g dz$$

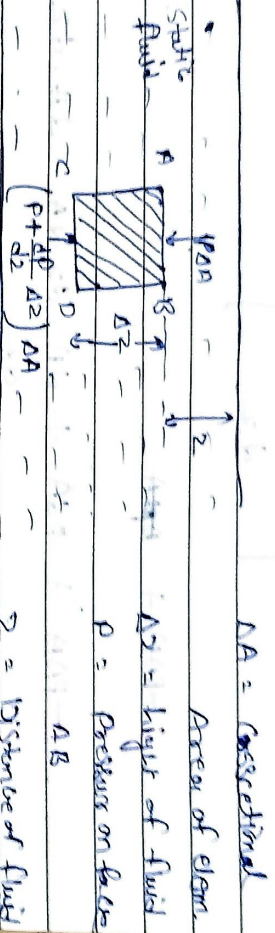
Integration both side

$$\int dp = \int \rho g dz$$

$$p = \rho g z$$

It states that the rate of increase of pressure in vertical direction = weight density of fluid (w).
 (1) is known as hydrostatic law.

Pressure Variation in fluid at rest:-



Resolving y direction forces
forces acting on this fluid element:-

$$- P \Delta A + \left(P + \frac{dP}{dz} \Delta z \right) \Delta A - W = 0$$

$$- P \Delta A + \left(P + \frac{dP}{dz} \Delta z \right) \Delta A - \Delta W = 0$$

$$- P \Delta A + \left(P + \frac{dP}{dz} \Delta z \right) \Delta A - \Delta W = 0$$

$$\left(P + \frac{dP}{dz} \Delta z \right) \Delta A - P \Delta A - \Delta W = 0$$

$$(\Delta A \times \Delta z) = \Delta W / g$$

$$\left(P + \frac{dP}{dz} \Delta z \right) \Delta A - P \Delta A = 0$$

$$\left(P + \frac{dP}{dz} \Delta z \right) \Delta A = P \Delta A$$

$$P + \frac{dP}{dz} \Delta z = P$$

Resolving in direction

$$P_y dx + M - P_2 ds \sin \theta = 0$$

$$[ds \sin \theta = dx]$$

$$P_y dx = M + P_2 ds \sin \theta$$

$$P_y dx = M + P_2 dx$$

$$[M = m \times g \quad [\because g = m]]$$

$$= \int x \times \int y$$

$$= \int x \left[\frac{AB \times AC \times x}{2} \right] \times y$$

$$P_y dx = P_2 dx + \int g \left[\frac{AB \times AC}{2} \right]$$

$$P_y dx = P_2 dx + \int g \left[\frac{dx \times dy}{2} \right]$$

$$[dx \times dy = \text{Neglect}]$$

$$P_y dx = P_2 dx$$

$$[P_y = P_2]$$

So that

$$P_x = P_y = P_2$$

oil 27

$$P = \rho g h$$

$$139240 = 900 \times 9.81 \times h$$

$$h = \frac{139240}{981 \times 900}$$

$$h = 4.44 \text{ m.}$$

A tank of oil of sp. gravity 0.9 is contained in a vessel and at a point the height of oil is 40 m. find the corresponding height of water at the point.

~~Solution~~

Given data

$$\text{Sp. gravity of oil} = 0.9$$
$$\text{height} = 40 \text{ m.}$$

$$P = \rho g h$$

$$P = 900 \times 9.81 \times 40$$

$$P = 353160 \text{ N/m}^2$$

$$\text{for water } P = \rho g h$$

$$353160 = 1000 \times 9.81 \times h$$
$$h = \frac{353160}{1000 \times 9.81}$$

$$h = 36 \text{ m.}$$

for oil

$$P = \rho g h$$

$$P = 800 \times 9.81 \times 0.3$$

$$P = 2354.4 \text{ N/m}^2$$

∴ The pressure intensity at a point in a fluid is given 8.924 N/cm^2 . find the corresponding height of fluid when the fluid is water and all of Sp. gravity 0.9 .

Solution

Given data

$$P = 8.924 \text{ N/cm}^2$$

$$h = ?$$

$$\text{water} = 1000 \text{ kg/m}^3$$

$$\text{oil} = 900 \text{ kg/m}^3$$

water =

$$P = \rho g h$$

$$8924 = 1000 \times 9.81 \times h$$

$$\frac{8924}{9.81 \times 1000} = h$$

$$h = 0.91 \text{ m}$$

$$P = \rho g \left[\frac{e + \frac{P}{\rho g}}{2} \right]$$

P = pressure above the atmospheric pressure
 e = height of the point from free surface
 it also called pressure head

Q. Calculate the pressure due to a column of
 a. 3m of water and all of specific gravity of
 it and mercury of specific gravity 13.6
 density of water 1000 kg/m³.

Given data

$$h = 3 \text{ m}$$

$$\rho_{\text{water}} = 1000 \text{ kg/m}^3$$

$$\text{Sp. gravity of oil} = 0.8$$

$$\text{Sp. gravity of mercury} = 13.6$$

Q. for water

$$P = \rho g h$$

$$P = 1000 \times 9.81 \times 3$$

$$P = 2943 \text{ N/m}^2$$

Q. for mercury

$$P = \rho g h$$

$$P = 13600 \times 9.81 \times 0.3$$

$$= 40024.6 \text{ N/m}^2$$

between liquid interface

$$P = \rho g z_1$$

$$P = 900 \times 9.81 \times 1$$

$$P = 8829 \text{ N/m}^2$$

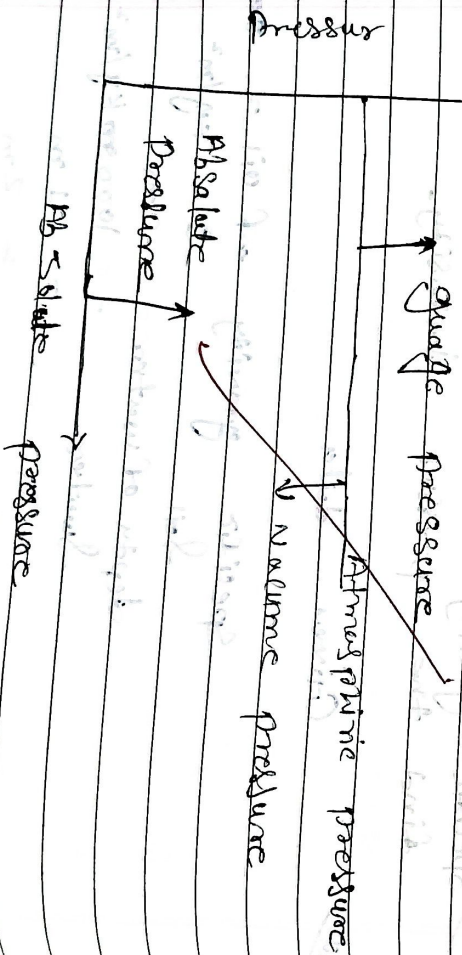
at bottom

$$P = \rho g z_1 + \rho g z_2$$

$$P = 8829 + (1000 \times 9.81 \times 2)$$

$$P = 28449 \text{ N/m}^2$$

* Types of pressures



$$P = 500 \text{ N/m}^2$$

$$P = 31465.40 \text{ N/m}^2$$

Pressure intensity on

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

$$W = \text{Weight}$$

$$W = 31465.40 \times \pi \times (30 \times 10^{-2})^2$$

$$W = 22228.24 \text{ N}$$

4. In open tank water level up to depth of 9m and above it on oil of specific gravity 0.9, for a depth of 1m find the pressure intensity.

Soln

Given data

Specific gravity of oil = 0.9
 $\rho_{\text{oil}} = 900 \text{ kg/m}^3$

Depth of water = 2m

Weight = 1000 kg/m³

$$Z_1 = 1 \text{ m}$$

$$Z_2 = 2 \text{ m}$$

Ex 1 hydraulic press has a of 30 cm diameter at a plunger has cm diameter find the lifted hydraulic pressure when the force applied at the plunger is 50 N.

Soln

Given data

force = 50 N

Hydraulic pressure = 30 cm

Dia. plunger = 4.5 cm

area of plunger = πr^2

$$= \frac{\pi}{4} \times (4.5 \times 10^{-2})^2$$

$$= 0.001590 \text{ m}^2$$

Area of main = πR^2

$$\frac{\pi}{4} \times (30 \times 10^{-2})^2$$

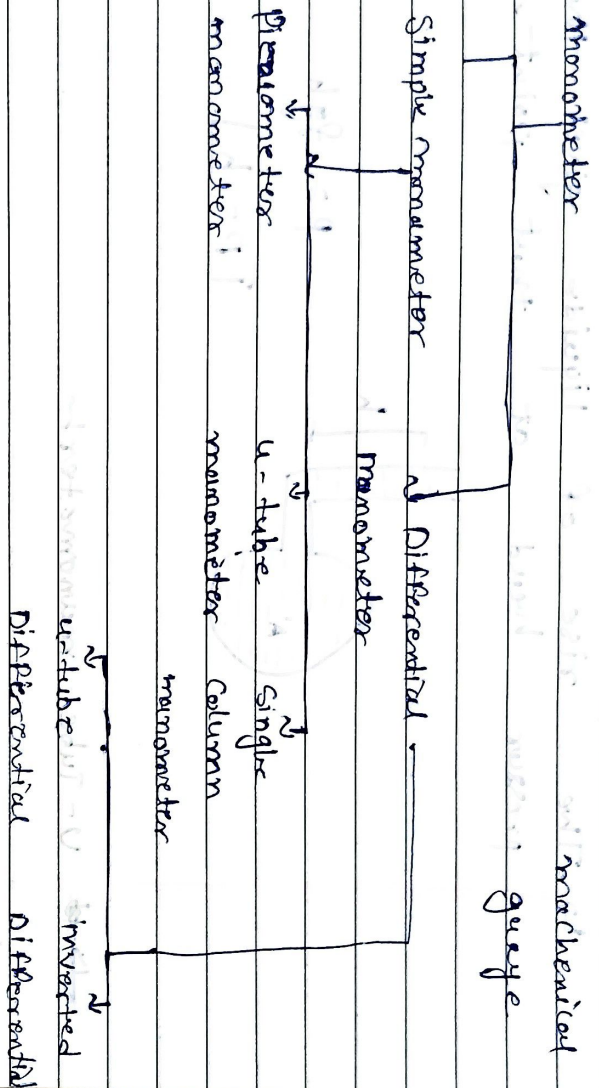
$$\frac{\pi}{4} \times 0.09066 \text{ m}^2$$

Ans

$\therefore$ pressure intensity applied is

$$P = \frac{F}{a}$$

* Measurement of pressure:-



Simple manometer:- It consists of a glass tube having one end connected to a vessel where pressure to be measured and other end remains open to atmosphere.

→ piezo meter:-

↳ It is the simplest form of manometer. used for measuring very pressure.

Problem

Q1

depth = 2.25 m

$$\rho = 1.53 \times 10^3 \text{ kg/m}^3$$

pressure head = 2.25 m of mercury

0.45 m of mercury

specific gravity = 13.6 = 13600 kg/m^3

$$\text{water} = 1000 \text{ kg/m}^3$$

1. Patm pressure = $\rho g z$

$$= 13600 \times 9.81 \times 0.45$$

$$= 100062 \text{ N/m}^2$$

$$P_{\text{water}} = \rho g z$$

$$= 1.53 \times 10^3 \times 9.81 \times 2.25$$

$$= 115086.75 \text{ N/m}^2$$

Both are same

$$P_{\text{atm}} + P_{\text{water}}$$

$$= 100062 + 115086.75$$

$$= 145148.75 \text{ N/m}^2$$

1. Absolute pressure:- It is defined as the pressure which is taken with reference to absolute vacuum pressure.

2. Gauge pressure:- It is defined as the pressure which is taken with the help of instrument in which atmospheric pressure is taken as datum.

3. Vacuum pressure:- It is defined as the pressure below the atmospheric pressure.

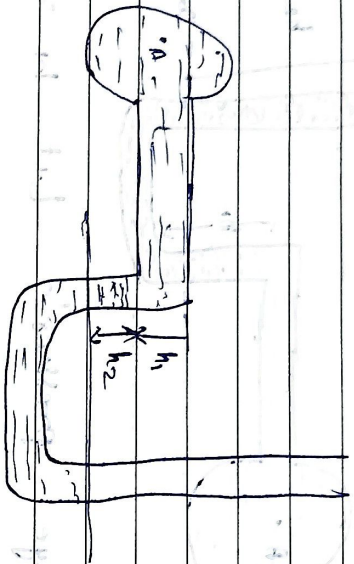
Mathematically:-

$$1. P_{ab} = P_{atmospheric} + P_{gauge}$$

$$2. \text{Vacuum pressure} = P_{atmospheric} - P_{ab}$$

* What are the gauge, partial of the absolute at a point 3m below the free surface of a liquid having a density $1532 \times 10^3 \text{ kg/m}^3$ of the atmosphere is equivalent to a column of mercury the specific gravity of mercury of 13.6 & 1 of water of 1000 kg/m^3 .

↳ For manometer pressure, —



Pressure above datum line on left col.

$$P + \rho g h_1 + \rho g h_2$$

Soln

Pressure above datum line on right column

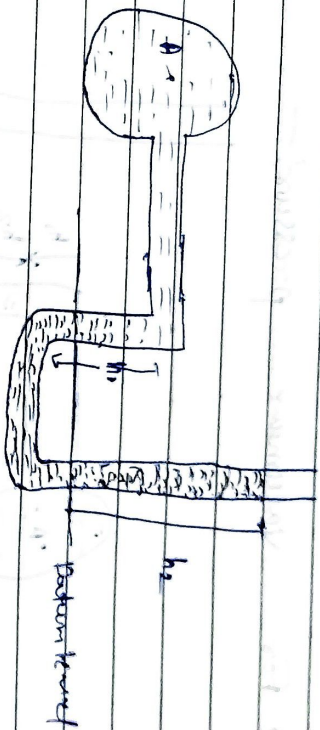
$$= 0$$

Equating

$$P + \rho g h_1 + \rho g h_2 = 0$$

$$P = -\rho g h_1 - \rho g h_2$$

$$P = -[\rho g h_1 + \rho g h_2]$$



For gauge 'pressure' let h_1 = height of light liquid above datum

h_2 = height of heavy liquid above the datum line
 ρ_1 = Specific gravity of light liq.
 ρ_2 = Specific gravity of heavy liq.
 ρ_h = Specific gravity of heavy liq.

Pressure above datum line on left column.

$$= \rho_1 \cdot g \cdot h_1$$

Pressure above datum line on right column.

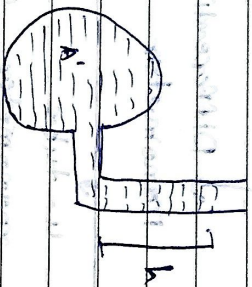
$$= \rho_2 \cdot g \cdot h_2$$

equating:-

$$\rho_1 + \rho_2 \cdot g \cdot h_1 = \rho_2 \cdot g \cdot h_2$$

$$\rho_1 = \rho_2 \cdot g \cdot h_2 - \rho_2 \cdot g \cdot h_1$$

- ↳ One end of this manometer is connected to the point where pressure is to be measured and other end is open to the atmosphere.
- ↳ The rise of liquid gives the pressure head at that point.



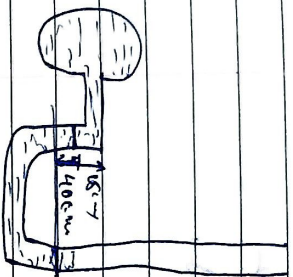
$$P = \rho g h \quad \frac{\text{N}}{\text{m}^2}$$

$$[P = h]$$

↳ Piezometer

- ↳ It consists of glass tube bent in U shape,
- ↳ one end of which is connected to a point at which pressure is to be measured and other end remains open to the atmosphere.
- ↳ The tube generally contains mercury or any other liquid whose specific gravity is greater than the specific gravity of the liquid whose pressure is to be measured.

The other end of the manometer is open to atmosphere, find the vacuum pressure in pipe if the difference of mercury in the two limbs is 40 cm and the height of fluid in the left limb from the center of pipe is 15 cm below.



$$h_2 = 15 \text{ cm}$$

$$15 \times 10^{-2}$$

$$h_2 = 40 \text{ cm}$$

$$40 \times 10^{-2}$$

$$h_1 = 800$$

$$\rho = 13600$$

$$S_1 = 8$$

$$S_2 = 13.6$$

pressure above datum line on left side.

$$P_1 + \rho g h_1 + \rho g h_2$$

$$P + 800 \times 9.81 \times 15 \times 10^{-2} + (13600 \times 9.81 \times 40 \times 10^{-2})$$

$$P + 1177.2 + 53366.4$$

pressure above datum line on right side.

$$= 0$$

Answer

Pressure above the bottom line on left
line

$$= P + \rho gh$$

$$= P + 900 \times 9.81 \times 20 \times 10^{-2}$$

$$= P + 706.32$$

Pressure above the bottom line on
right line

$$\rho gh$$

$$= 1350 \times 9.81 \times 20 \times 10^{-2}$$

$$= 26683.2$$

equation

$$P + 706.32 = 26683.2$$

$$P = 26683.2 - 706.32$$

$$P = 25976.88 \text{ N/m}^2$$

Ans.

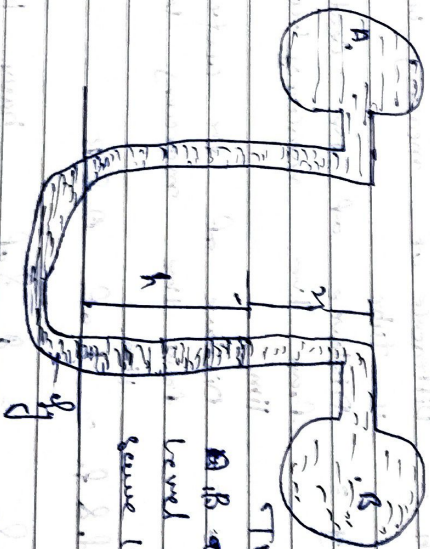
* Simple U-tube manometer containing
mercury is connected to a pipe in
which a fluid at SP gravity 0.8
and having vacuum pressure is flowing



equating

$$P_A + \rho g(h_{\text{top}}) = P_B + \rho g y + \rho g h$$

$$P_A - P_B = \rho g y + \rho g h - \rho g(h_{\text{top}})$$



The two parts are at same level and contain same liquid of ρ

left-right line.

$$P_A + \rho g(h_{\text{top}})$$

right line

$$P_B + \rho g x + \rho g h$$

→ The two points A and B are at different level and also contain liquid of different sp. gr.

→ Two points 'are' connected to the U-tube differential manometer. Let pressure A and B are

Let P_A and P_B

Let h = Difference of mercury level in the U-tube

y = Distance of the center of B from the mercury level in the right limb

x = Distance of the center of A from the mercury level in the left limb

P_A = P_B

~~ρg = ρg of heavy liquid~~

Pressure above D.L. in the left limb

$$= P_A + \rho g (x+y)$$

Pressure above D.L. in the right limb

$$= P_B + \rho g y + \rho g h$$

$$p + 1177.2 + 53366.4 = 0$$

$$p = -53366.4 - 1177.4$$

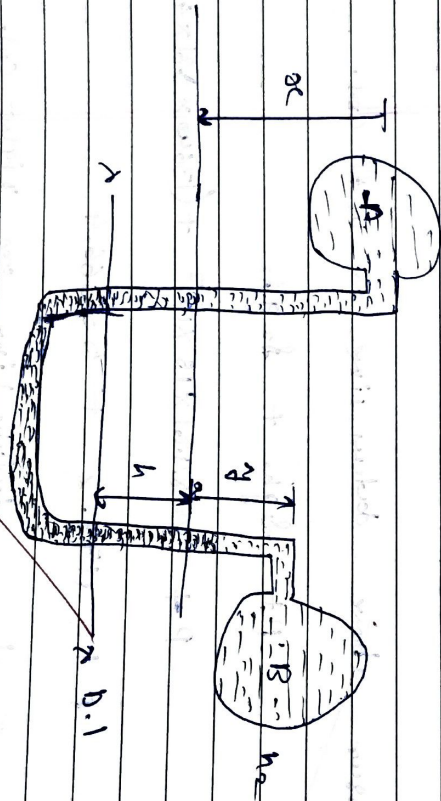
$$p = -(53366.4 + 1177.4)$$

$$p = -54543.8 \text{ N/m}^2$$

Ans.

★ Differential manometer:-

It is a U-tube Differential manometer:-



Two pipes at different level

19656

$$133416h - 800h = 176580 + 1000 - 38100 - 1500$$

$$8829h = 73575$$

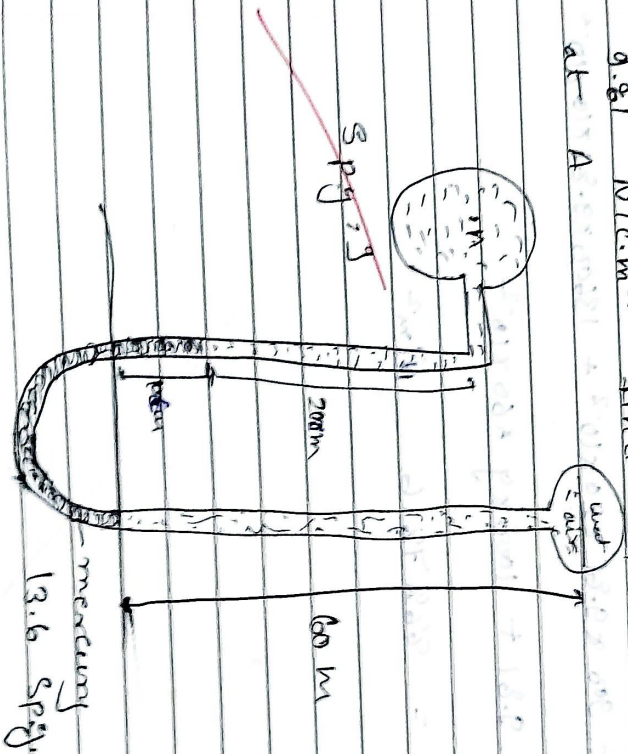
$$133416h = 6905$$

$$124537h = 22563$$

$$h = \frac{0.0563}{124537}$$

$$h = 0.181 \text{ m}$$

A differential manometer is connected at the two points A and B as shown in figure. At B air pressure is 9.81 N/cm² find the absolute pressure at A.



Given data :-

$$1 \text{ kgf} = 9.81 \text{ N}$$

$$\text{SPG (N)} = 1.5 \text{ N/m}^3$$

$$\text{SPG (K)} = 0.9$$

$$\rho_{\text{H}_2\text{O}} = 1 \text{ kgf/cm}^3 = 1 \times 9.81 \times 10^4 \text{ N/m}^3$$

$$\rho_{\text{B}} = 1.8 \text{ kgf/cm}^3 = 1.8 \times 9.81 \times 10^4 \text{ N/m}^3$$

$$\rho_{\text{A}} = 1.5 \times 1000 \text{ kg/m}^3$$

$$\rho_{\text{R}} = 1.9 \times 1000 \text{ kg/m}^3$$

$$\text{LHS} =$$

$$\rho_{\text{A}} + \rho_{\text{R}} g (z_1 + z_2) + \rho_{\text{R}} g h$$

$$\text{RHS} =$$

$$\rho_{\text{B}} + \rho_{\text{B}} g (h + z_2)$$

$$\rho_{\text{A}} + \rho_{\text{R}} g (z_1 + z_2) + \rho_{\text{R}} g h = \rho_{\text{B}} + \rho_{\text{B}} g (h + z_2)$$

$$9.81 \times 10^4 + 1.5 \times 1000 \times 9.81 (5) + 13600 \times 9.81 \cdot h =$$

$$1.8 \times 9.81 \times 10^4 + 1.8 \times 1000 (h + z_2) \times 9.81 (h + z_2)$$

$$98100 + 1500 \times 49.05 + 133416 h =$$

$$176580 + 900h + 1800$$

$$9829h + 17658$$

equating

$$P_A + \rho g(h+x) = P_B + \rho g x + \rho g h$$

$$P_A - P_B = \rho g x + \rho g h - \rho g(h+x)$$

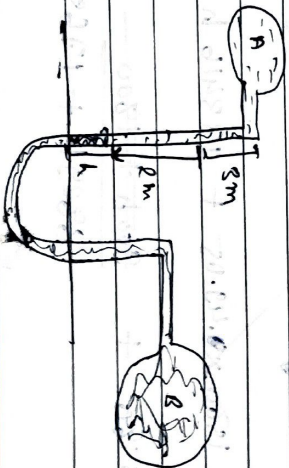
$$P_A - P_B = \rho g x + \rho g h - \rho g h - \rho g x$$

$$P_A - P_B = \rho g h$$

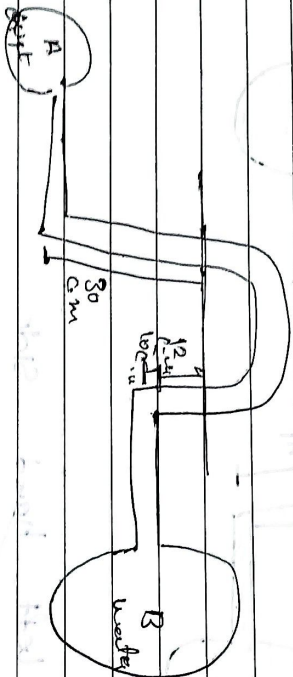
is path
same
condition
of ρ

A Differential manometer is connected at the two points A and B of two pipes as shown in figure.

The pipe A contains liquid of sp. gravity 1.5 while pipe B contains liquid of sp. gravity 0.9. The pressure difference of A and B are 1 kgf/cm^2 and 1.90 kgf/cm^2 respectively. Find the difference in mercury level in the differential manometer.



A water is flowing through two different pipes to which an inverted differential manometer having an oil of sp. g. 0.8 is connected. The pressure head in the pipe A is 9 m of water. Find the pressure in the pipe B. The manometer as shown in figure.



Sol P Sp. g. of oil = 0.8 or 8
 of water = 1000
 height = 1000

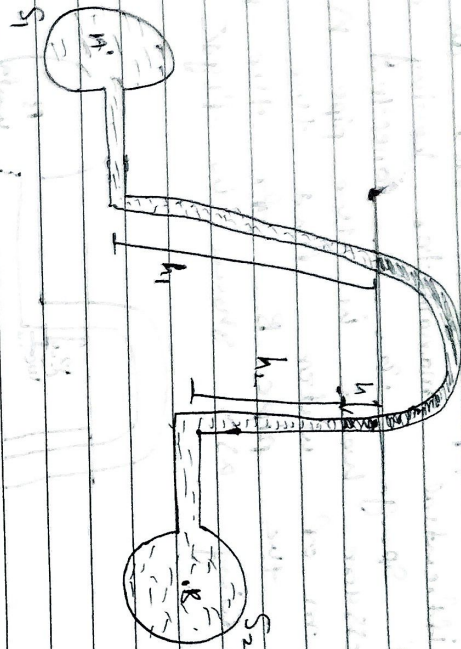
on left $P_A = 894$
 $P_A = 13620$

$P_A = 1000 \times 9.81 \times 30 \times 10^{-2}$

figure

$P_B = 1000 \times 9.81 \times 10 \times 10^{-2} = 980 \times 9.81 \times 10 \times 10^{-2}$

★ Inverted U-Tube Differential Manometer :-



on left hand side :-

~~$$P_1 - \rho g h_1$$~~

on right hand side :-

$$P_2 - \rho g h_2 - \rho g h$$

equating both side

$$P_1 - \rho g h_1 = P_2 - \rho g h_2 - \rho g h$$

$$P_1 - P_2 = -\rho g h_2 - \rho g h + \rho g h_1$$

Solution Given data

$$P_A = ?$$

$$P_B = 9.81$$

$$\rho_A = 900$$

$$\rho_B = 13600$$

$$h = 8$$

LHS =

$$P_A + \rho_A \times g \times 20 \times 10^{-2} + \rho_B \times g \times 10 \times 10^{-2}$$

RHS

$$P_B + \rho_B \times g \times 60 \times 10^{-2}$$

$$P_A + 900 \times 9.81 \times 20 \times 10^{-2} + 13600 \times 9.81 \times 10 \times 10^{-2} =$$

$$9.81 + 1000 \times g \times 60 \times 10^{-2}$$

$$P_A = 28878.6 \text{ N/m}^2$$

HYDROSTATIC

Definition: - It deals with fluids (liquids and gases) at rest.

- These means that they are will be no relative motion between adjacent fluid layer.

- The velocity gradient which is equal to the change of velocity between two adjacent fluid layer divided by the distance between the layers will be

0.

- The shear stress which is equal to velocity = 0

- The force acting on the fluid particle will be

- due to pressure of fluids normal to the surface,
- due to gravity

Total pressure = $P = \rho g h$ → total pressure

~~$h = \frac{P}{\rho g}$~~ → center of pressure

Given data: -

$$\rho_g (\text{oil}) = 0.8$$

$$\rho_{oil} = 800$$

$$P_a - \rho_g h_1 = P_a - \rho_g h_2 - \rho_g h_1$$

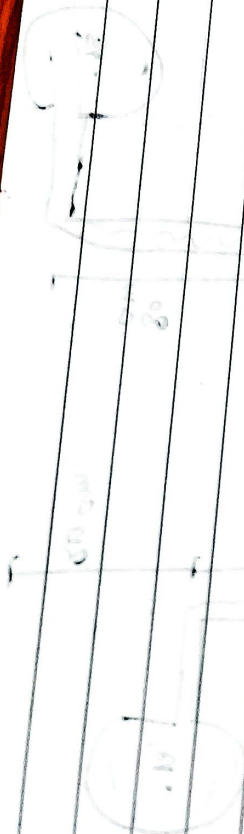
$$P_a - P_a = -\rho_g h_2 = \rho_g h_1 + \rho_g h_1$$

$$= -1000 \times 9.81 \times 30 \times 10^{-2} = 800 \times 9.81 \times 20 \times 10^{-2}$$

$$+ 1000 \times 9.81 \times 30 \times 10^{-2}$$

$$= -1569.6 \text{ N/m}^2$$

~~8/10/23~~

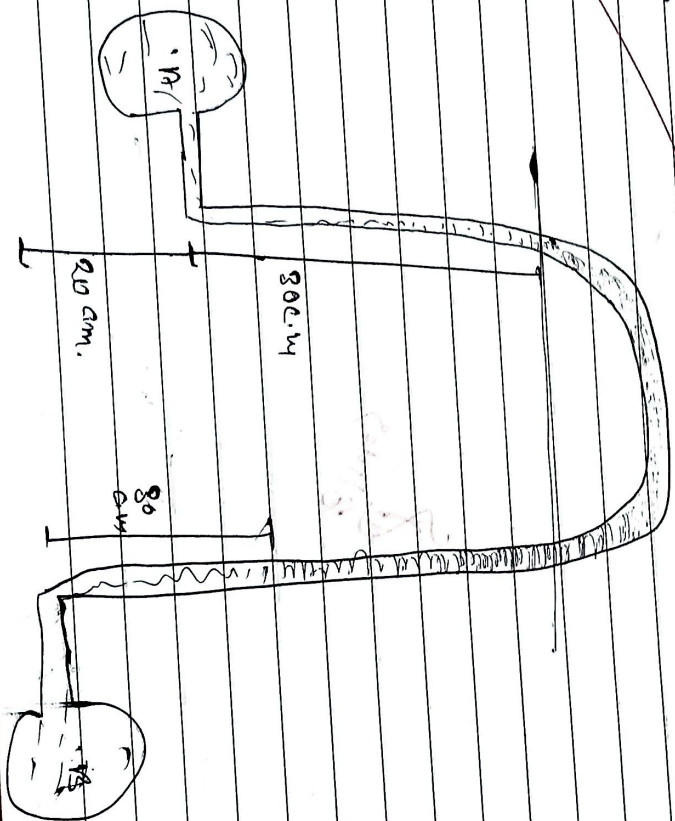


$$P_a - 1000 \times 9.81 \times 30 \times 10^{-2} = P_b - 1000 \times 9.81 \times 10 \times 10^{-2} - 800 \times 9.81 \times 12 \times 10^{-2}$$

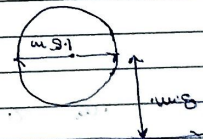
$$19620 - 1000 \times 9.81 \times 30 \times 10^{-2} = P_b - 1000 \times 9.81 \times 10 \times 10^{-2} - 800 \times 9.81 \times 12 \times 10^{-2}$$

$$P_b = 12600 \text{ N/m}^2$$

A inverted differential manometer is connected to two pipes A and B, which convey water. The fluid in manometer is oil of sp. g. $\rho_{oil} = 800$. The pressure difference between A and B.



* Determine the total pressure on a curved plate of diameter 1.5 m, which is placed vertically in water in such a way that the center of the plate is 3 meter below the free surface of water. Find the position of center of pressure also.



here surface

Given data:-
 diameter = 1.5 m
 $A = \frac{\pi d^2}{4} = \frac{\pi \times 1.5^2}{4} = 1.767 \text{ m}^2$
 $h = \frac{d}{2} = \frac{1.5 + 1.5}{2} = 1.5 \text{ m}$
 $F = \rho g A h = 1000 \times 9.81 \times 1.767 \times 1.5 = 25200.296 \text{ N}$
 $F = 25200.296 \text{ N}$

* $T_{\text{total}} = \frac{\rho g A h^3}{3} = \frac{1000 \times 9.81 \times 1.767 \times 1.5^3}{3} = 0.24 \text{ m}^4$

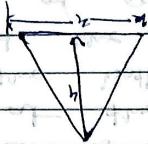
$h^* = \frac{T_{\text{total}}}{A h} = \frac{0.24}{1.767 \times 1.5} = 0.24 \text{ m}$

$h^* = 0.24 \text{ m}$
 $h^* = 0.24 \text{ m}$

$h^* = 0.24 \text{ m}$

$h^* = 0.24 \text{ m}$

* Determine the total pressure and center of pressure on an inclined having plate of base 4 m, and isosceles triangle with height 4 m, when it is immersed vertically in an oil of specific gravity 0.9. The base of the plate coincide with free surface of oil.



Given data:-

A rectangular plate plane surface is 2 meter wide, and 3 meter deep. It lies in vertical plane in water. Determine the total pressure and position of centre of pressure on the plane surface when its upper edge is horizontal and coincides with water surface.

- i) coincide with water surface
- ii) 2 meter below the free surface

① Soln
 Given data:-

$b = 2 \times 3 = 6 \text{ m}^2$
 $h = \frac{2}{2} = 1 \text{ m}$
 $\rho = 1000 \text{ kg/m}^3$

$F = \rho \times b \times h \times g \times \frac{h}{2}$
 $F = 1000 \times 6 \times 1 \times 9.81 \times 1.5$

$F = 930280 \text{ N}$

$h^* = \frac{I_{xx}}{A \times h} + h$
 $I_{xx} = \frac{b \times d^3}{12} = \frac{2 \times 3^3}{12} = 4.5 \text{ m}^4$

$h^* = \frac{4.5}{6 \times 1.5} + 1.5$
 $h^* = 2.5 \text{ m}$

② Cont

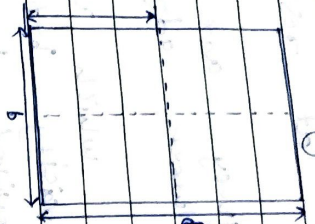
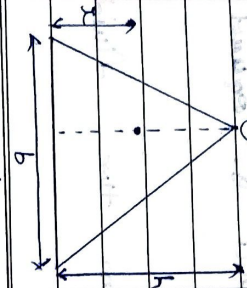
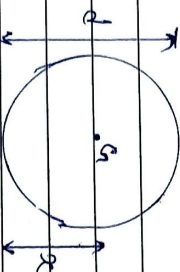
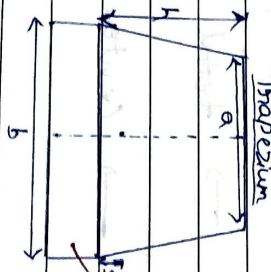
$h = \frac{2}{2} + 2.5 = 1.5 + 2.5 = 4 \text{ m}$

$F = \rho \times b \times h \times g \times \frac{h}{2}$
 $F = 1000 \times 6 \times 4 \times 9.81 \times 2$

$F = 235440 \text{ N}$

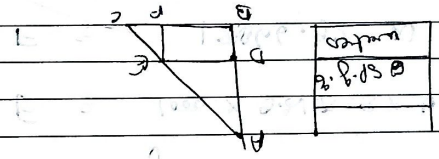
$h^* = \frac{I_{xx}}{A \times h} + h$
 $h^* = \frac{4.5}{6 \times 4} + 4$

$h^* = 4.125 \text{ m}$

Area	Shape	C.G.	I _{xx}	
bd		$x = \frac{d}{2}$	$\frac{bd^3}{12}$	$\frac{bd^3}{3}$
$\frac{bh}{2}$		$x = \frac{h}{3}$	$\frac{bh^3}{36}$	$\frac{bh^3}{12}$
$\frac{\pi d^2}{4}$		$x = \frac{d}{2}$	$\frac{\pi d^4}{64}$	-
$\frac{(a+b)h}{2}$		$x = \frac{(a+b)h}{3}$	$\frac{(a^2+4ab+b^2)h^3}{36}$	$\frac{(a+b)h^3}{3}$

A Tank contain water up to height of 5 m. have the base, and liquid of specific gravity 9 is fill on the top of water up to one meter height. calculate.

i) Total pressure on one side of the Tank
 ii) The position of center of pressure for one side of the tank which is 2 m wide



$$\begin{aligned}
 F_1 + F_2 + F_3 \\
 \text{Pressure intensity on point } P = 0 \quad (h=0) \\
 \text{pressure} \\
 \text{point } B \text{ or } D = \rho g h \\
 = 1000 \times 9.81 \times 1 \\
 = 9848 \text{ N/m}^2 \\
 \text{point } A \text{ or } C = \rho g h_2 + \rho g h_1 \\
 = 1000 \times 9.81 \times 1.5 + 9848 \\
 = 12753 \text{ N/m}^2
 \end{aligned}$$

① $F_1 = \rho g h_1 \times \text{area of } \triangle ADE \times \text{width of tank}$

$$F_1 = \frac{1}{2} \times 9.81 \times 2$$

$$F_2 = \frac{1}{2} \times 9.81 \times 1 \times 2$$

$$F_3 = 9848 \text{ N}$$

② $F_2 = \text{area of } \triangle DEB \times \text{width of tank}$

$$F_2 = 9848 \times 1.5 \times 2$$

③ $F_3 = \text{area of } \triangle EFC \times \text{width of tank}$

$$F_3 = \frac{1}{2} \times 9.81 \times 1.5 \times 2$$

$$F_3 = 2452.5 \text{ N}$$

$$F = F_1 + F_2 + F_3$$

$$F = 9848 + 9848 + 2452.5$$

$$F = 19698.5 \text{ N}$$

Taking a moment of all force about A.
 moment = load $\times$ perpendicular d's.

$$A = \left[\frac{a+b}{2} \right] \times h = \left[\frac{2+4}{2} \right] \times 1 = 3 \text{ m}^2$$

$$h = \left[\frac{2a+b}{3} \right] \times h = \left[\frac{2 \times 2 + 4}{3} \right] \times 1 = 0.444 \text{ m}$$

$$I_{xx} = \left[\frac{a^2 + ab + b^2}{3} \right] \times h^3 = \left[\frac{2^2 + 2 \times 2 \times 4 + 4^2}{3} \right] \times 1^3 = 0.240 \text{ m}^4$$

$$F = \rho g A h$$

$$F = 1000 \times 9.81 \times 3 \times 0.444$$

$$F = 13066.92 \text{ N}$$

$$h^* = \frac{I_{xx}}{A h} + h$$

$$h^* = \frac{0.240}{3 \times 0.444} + 0.444 = 0.444 \times 3$$

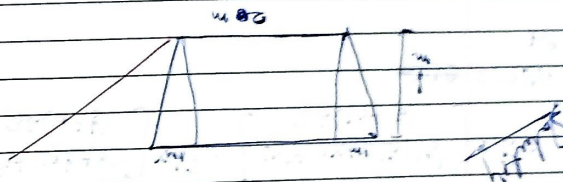
$$h^* = \frac{0.621}{0.444} = 1.4 \text{ m}$$

$$h^* = \frac{I_{xx}}{A h} + h$$

$$h^* = 0.229 \times 4 + 2.769 = 2.969 \text{ m}$$

$$h^* = 3.233 \text{ m}$$

* A trapezoidal channel - 2 m wide at the bottom and 1 m deep has side slopes 1:1, determine the center of pressure on the vertical gate closing the channel when it is full of water



$$a = 2 \text{ m}$$

$$b = 4 \text{ m}$$

$$h = 1 \text{ m}$$

Collision. If the ladder on the outside is left level with the top and back of deck is empty.

Given data

$$\begin{aligned} a &= 10 \text{ m} \\ b &= 10 \text{ m} \\ h &= 6 \text{ m} \end{aligned}$$

$$A = \left[\frac{a+b}{2} \right] \times h = \left[\frac{10+10}{2} \right] \times 6 = 78 \text{ m}^2$$

$$h = \left[\frac{2A}{a+b} \right] \times \frac{1}{2} = \left[\frac{2 \times 78}{10+10} \right] \times \frac{1}{2} = 2.76 \text{ m}$$

$$I_{at} = \left[\frac{a^2 + ab + b^2}{3} \right] \times h^3 = \left[\frac{10^2 + 10 \times 10 + 10^2}{3} \right] \times 6^3 = 229.84 \text{ m}^4$$

$$F = \rho g h A$$

$$F = 1000 \times 9.81 \times 2.769 \times 78$$

$$F = 2118493.42 \text{ N}$$

Ans

$$h = \frac{1}{3} = 1.553 \text{ m}$$

$$A = \frac{1}{2} \times 4 \times 1 = 2 \text{ m}^2$$

$$\begin{aligned} F &= \rho g h A \times \dots \\ F &= 1000 \times 9.81 \times 1.553 \times 2 \\ F &= 94152.45 \text{ N} \end{aligned}$$

$$I_{at} = \frac{bh^3}{12} = \frac{4 \times 2^3}{12} = 2.67 \text{ m}^4$$

$$h^* = \frac{I_{at}}{h} = \frac{2.67}{1.553}$$

$$h^* = 1.71 + 1.333 = 1.999 \text{ m}$$

Collision for closing the entrance to a dock is of temporary and 10 m wide at the top and 6 m wide at the bottom and 6 m deep. Find the total pressure and center of pressure on the

Ans

$$D = 3m$$

$$A = \frac{\pi}{4} D^2 = 7.06 m^2$$

$$\sin \theta = \frac{p}{H} \Rightarrow p = H \sin \theta$$

$$H = 1.5 + 1.5 \sin \theta$$

$$W = \frac{\rho g A H}{4} = 3.936$$

for $\theta =$

$$\sin \theta = \frac{H}{3} = 4 - 1.5 = 2.5$$

$$\theta = 0.883$$

$$\sin \theta = 0.883$$

$$h = 1.5 + 1.5 \sin \theta \times 0.883$$

$$h = 2.749 m$$

$$F = \rho g h A$$

$$F = 1000 \times 9.81 \times 2.749 \times 7.06$$

$$F =$$

$$(190391.189 N)$$

$$h^* = D \sin \theta + h$$

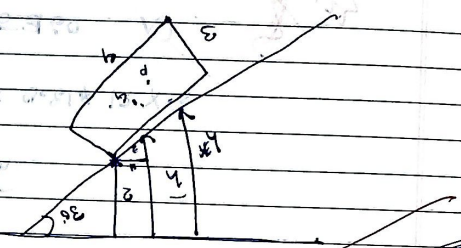
h

$$h^* = 3.936 \sin \theta \times 0.883 = 2.97$$

$$3.06 \times 2.749$$

A rectangular plate surface 3m wide and 4m deep lies in water in such a way that its plane makes an angle of 30° with the free surface of water. Determine the position of center of pressure force and position of water when the upper edge is 2m below the free surface.

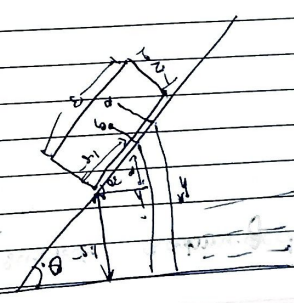
Soln



$$b = 3m$$

$$d = 4m$$

$$\theta = 30^\circ$$



$$h = 2 \text{ m}$$

$$D = 3 \text{ m}$$

$$\theta = 30^\circ$$

$$\sin \theta = \frac{p}{H}$$

$$p = H \sin \theta$$

$$p = 1.5 \sin 30^\circ$$

$$p = 0.75 \text{ m}$$

$$h = p + 1.5$$

$$h = 0.75 + 1.5 = 2.25$$

$$b = 0.25 \text{ m}$$

$$\text{Area} = b \times d = 0.25 \times 3 = 0.75 \text{ m}^2$$

$$I_{CG} = \frac{b d^3}{12} = \frac{0.25 \times 3^3}{12} = 0.5625 \text{ m}^4$$

$$F = \rho g h V$$

$$F = 1000 \times 9.81 \times 2.25 \times 6$$

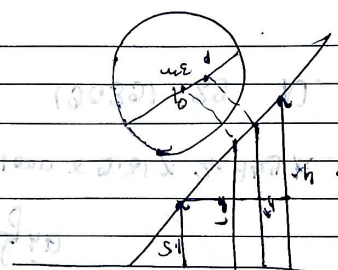
$$F = 132485 \text{ N}$$

$$h^* = \frac{I_{CG} \sin^2 \theta}{h}$$

$$h^* = \frac{0.5625 \sin^2(30^\circ)}{2.25} + 0.25$$

$$h^* = 0.23 \text{ m}$$

* A rectangular plate 3 meter diameter is immersed in water in such a way that its greatest and least depth below the free surface are 4 meter and 1.5 meter respectively. determine the position of the center of pressure and position of the center of pressure.



Inclined plate surface submerged liquid

Vertical

$$F = \rho g h A$$

$$h^* = \frac{I_{xy}}{A h}$$

Inclined

$$F = \rho g h A$$

$$h^* = \frac{I_{xy} \sin \theta}{A h}$$

* Rectangular plane surface 2 meter wide and 3 meter deep. The plane makes an angle of 30° with the free surface of water. Determine the total pressure and position of center of pressure when the upper edge is 1.5 m below the free water surface.

$$F_1 = \text{Area of DBCF} \times \text{width of plate}$$

$$F_1 = 2946.1 \times 0.6 \times 1.5$$

$$F_1 = 2151.48 \text{ N}$$

$$F_2 = \text{Area of EFC} \times \text{width of plate}$$

$$F_2 = \frac{1}{2} \times 536.6 \times 1.5 \times 0.6$$

$$F_2 = 244.97 \text{ N}$$

$$F = F_1 + F_2 + F_3$$

$$F = 536.6 + 2151.48 + 244.97$$

$$F = 1516.39 \text{ N}$$

$$F x h^* = F_1 x h_1 + F_2 x h_2 + F_3 x h_3$$

$$1516.39 h^* = 536.6 \times 0.9 + 2151.48 \times 1.49 + 244.97 \times 0.675$$

$$+ 244.97 \left[\frac{2 \times 0.6 \times 0.9}{3} \right]$$

→ If the fluid particles which flow along stream line do not get rotated about their own axis, it is called irrotational flow.

★ Rate of flow or Discharge (Q)

$$Q = A \times V \quad \text{m}^3/\text{s}$$

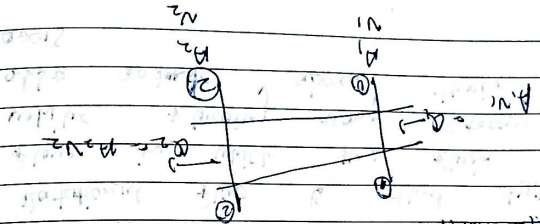
→ It is defined as the quantity of fluid flowing per second through a section of a pipe or a channel.

$$Q = A \times V \quad \text{m}^3/\text{s}$$

A = Cross sectional area of pipe
 V = average velocity of fluid

★ Continuity Equation:-

→ The equation based on the principle of conservation of mass, is called continuity equation.

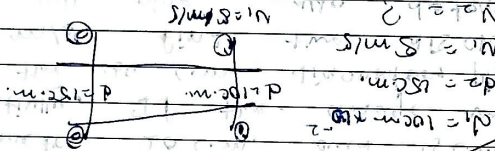


Consider two cross section of pipe. According to law of conservation of mass

$$Q_1 = Q_2$$

$$A_1 V_1 = A_2 V_2$$

★ The diameter of a pipe at the section 1 and 2 are 10 cm. and 15 cm. respectively. find the discharge through the pipe if the velocity of water flowing through the pipe at section 1 is 5 m/s. Find the velocity at section 2.



$$Q_1 = A_1 V_1$$

$$A_1 V_1 = A_2 V_2$$

$$A_1 = \frac{\pi}{4} \times d_1^2 = \frac{\pi}{4} \times 0.1^2 = 0.00785 \text{ m}^2$$

given the dose not along with respect to space.

$$\frac{dv}{ds} = 0 \quad \text{no change}$$

→ Non uniform flow is that type of flow in which the velocity at any given time changes with respect to space

$$\frac{dv}{ds} \neq 0 \quad \text{change}$$

iii) Laminar flow and Turbulent flow:-

→ Laminar flow is defined as that type of flow in which fluid particles move along well define path or stream line and all the stream line are straight and parallel.

→ Turbulent flow is that type of flow in which the fluid particles move in a zig-zag way due to movement of fluid particles in a zigzag way the address formation takes place

→ The type of flow is determined by non dimensional number is called Reynold number

$$Re = \frac{\rho V D}{\mu}$$

Reynold Number is less than 2000 = laminar flow

Reynold Number is more than 2000 = Turbulent flow

Reynold Number is 2000 - 2300 is Transition flow

iv) Compressible and incompressible flow:-

→ Compressible flow is that type of flow in which the density of fluid change from point to point.

$$\rho \neq 0 \quad \text{change} \quad (\text{gas})$$

→ Incompressible flow is that type of flow in which the density is constant for the fluid flow

$$\rho = 0 \quad \text{no change} \quad (\text{liquid})$$

v) Rotational and irrotational flow:-

→ Rotational flow is that type of flow in which the fluid particles rotate about their mass centre while flowing along stream lines.

KINEMATIC OF FLOW

UNIT - 2

It is define as that branch of science which deals with motion of practical without considering the forces causing the motion.

Types of fluid flow

1) Steady and unsteady flow - Steady flow

is define as that type of flow in which the fluid characteristic like velocity, pressure, density etc at a point do not change with time

Steady or unsteady

$\frac{dv}{dt} = 0$ or $\frac{dv}{dt} \neq 0$

$\frac{dp}{dt} = 0$ or $\frac{dp}{dt} \neq 0$

$\frac{d\rho}{dt} = 0$ or $\frac{d\rho}{dt} \neq 0$

→ unsteady flow is that type of flow in which the velocity, pressure or density at a point changes with respect to time

2) Uniform flow and non uniform flow -

Uniform flow is define as that type of flow in which the velocity at any

$$\sin \theta = \frac{H}{L}$$

$$p = H \sin \theta$$

$$p = \rho \sin 30^\circ$$

$$h = p + z$$

$$h = 1.42$$

$$h = 3 \text{ m}$$

$$\text{Area} = \text{box} = 3 \times 4 = 12 \text{ m}^2$$

$$I_a = \frac{b d^3}{12} = \frac{3 \times 4^3}{12} = 16 \text{ m}^4$$

$$F = \rho g h$$

$$F = 1000 \times 9.81 \times 12 \times 3$$

$$F = 35360 \text{ N}$$

$$h^* = \frac{I_a \sin \theta}{h}$$

$$h^* = 16 \sin 30^\circ + 3 = 8.02 \text{ m}$$

dynamic

1. DYNAMIC OF FLUID FLOW

Equation of motion:-

According to Newton's 2nd law of motion

$$F = ma$$

In the fluid flow the following forces are present.

- i) Gravity force. (F_g)
- ii) Pressure force (F_p)
- iii) Force due to viscosity (F_v)
- iv) Force due to turbulence (F_t)
- v) Force due to compressibility (F_c)

Net force

$$F_x = (F_g)_x + (F_p)_x + (F_v)_x + (F_t)_x + (F_c)_x$$

1. If the force due to compressibility is negligible the resulting net force

$$F_x = (F_g)_x + (F_p)_x + (F_v)_x + (F_t)_x$$

(Neglect operation of motion)

2. If F_c is negligible

$$F_x = (F_g)_x + (F_p)_x + (F_v)_x$$

(Neglect operation of motion)

Flow rate

$$V_1 A_1 = V_2 A_2$$

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

$$Q = 1.5 \text{ m}^3/\text{s}$$

$$Q = A \cdot V$$

$$Q = 1.5 = \frac{1}{4} \pi \times 0.2^2 \times V$$

$$1.5 = 0.50 \times V$$

$$V_2 = 1.3$$

$$V_3 = 2.26 \text{ m/s}$$

#

$$Q = AV$$

$$Q = A \cdot V \cdot t$$

$$Q = \frac{V}{t} = \frac{1}{4} \pi \times 0.2^2 \times 2.5$$

$$Q = \frac{1}{4} \pi \times 0.2^2 \times 2.5$$

$$Q = 1.07 \text{ m}^3/\text{s}$$

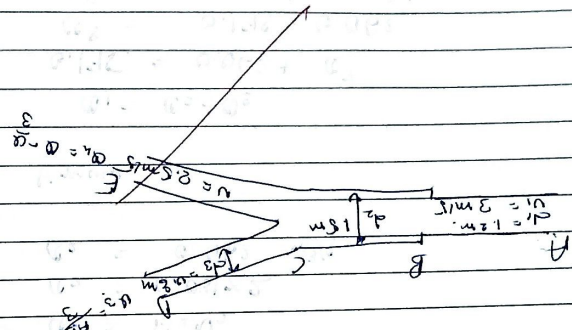
$$Q_3 = A_3 \times V_3$$

$$0.113 = 0.0176 \times V_3$$

$$V_3 = \frac{0.113}{0.0176}$$

$$V_3 = 6.420 \text{ m/s}$$

Water flows through a pipe AB 1.2 meter diameter at 3 m/s and then passes through a pipe BC 1.8 m diameter. At C the pipe branches into branch CD 0.8 m in diameter and carries one third of the flow in AB. The flow velocity in branch CE is 2.5 m/s. Find the volume rate of flow in AB, the velocity in BC, the velocity in CD and the diameter of CE.



$$d_1 = 1.2 \text{ m}$$

$$d_2 = 1.8 \text{ m}$$

$$d_3 = 0.8 \text{ m}$$

$$V_1 = 3 \text{ m/s}$$

$$V_3 = 2.5 \text{ m/s}$$

$$Q_{AB} = A_{AB} \times V_1$$

$$= \frac{\pi}{4} \times d_1^2 \times V_1$$

$$= \frac{\pi}{4} \times 1.2^2 \times 3$$

$$= 3.39 \text{ m}^3/\text{s}$$

The velocity in BC

$$A_1 V_1 = A_2 V_2$$

$$8.39 = \frac{\pi}{4} \times d_2^2 \times V_2$$

$$8.39 = \frac{\pi}{4} \times 1.8^2 \times V_2$$

$$3.89 = 1.767 V_2$$

$$V_2 = \frac{3.89}{1.767}$$

$$V_2 = 2.196 \text{ m/s}$$

* A 30 cm diameter pipe conveying water branches into two pipe of diameter 20 cm and 15 cm. respectively. If the average velocity in the 30 cm diameter pipe is 0.5 m/s. find the discharge in this pipe also determine the velocity of the pipe if the average velocity is 2 m/s.

$$A_2 = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times 0.15^2 = 0.0176$$

$$Q_1 = A_1 V_1 = 0.00985 \times 5$$

$$Q_1 = 0.04925 \text{ m}^3/\text{s}$$

$$A_2 V_2 = A_1 V_1$$

$$V_2 = \frac{A_1 V_1}{A_2} = \frac{0.0176}{0.00985} \times 5$$

$$V_2 = 0.00985 \times 5$$

$$V_2 = 0.0176$$

$$V_2 = 2.230 \text{ m/s}$$

$$Q_1 = Q_2 + Q_3$$

$$0.175 = 0.062 + Q_3$$

$$Q_3 = 0.175 - 0.062$$

$$Q_3 = 0.113 \text{ m}^3/\text{s}$$

like same

$$Q_2 = A_2 V_2$$

$$Q_2 = 0.031 \times 2$$

$$Q_2 = 0.062 \text{ m}^3/\text{s}$$

$$Q_1 = 0.175 \text{ m}^3/\text{s}$$

$$Q_1 = 0.030 \times 2.5$$

$$Q_1 = A_1 V_1$$

$$A_3 = \frac{\pi}{4} \times 0.15^2 = 0.0176 \text{ m}^2$$

$$A_2 = \frac{\pi}{4} \times 0.2^2 = 0.031 \text{ m}^2$$

$$A_1 = \frac{\pi}{4} \times 0.30^2 = 0.070 \text{ m}^2$$

30cm average velocity = 0.5 m/s
15 cm velocity = 2 m/s
20 cm velocity = 2 m/s
Discharge = $Q_1 = Q_2 + Q_3 = ?$

$$D_1 = 30 \text{ cm} \quad D_2 = 20 \text{ cm} \quad D_3 = 15 \text{ cm}$$

$$Q_1 = 0.030 \text{ m}^3/\text{s} \quad Q_2 = 0.062 \text{ m}^3/\text{s} \quad Q_3 = 0.113 \text{ m}^3/\text{s}$$



Solution

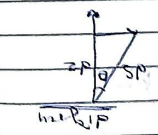
Euler's Equation of motion

$$\frac{1}{\rho} \frac{dp}{dz} + g \frac{dz}{dz} + v \frac{dv}{dz} = 0$$

$$\frac{1}{\rho} \left[\frac{dp}{dz} + g \frac{dz}{dz} + v \frac{dv}{dz} \right] = 0$$

$$\frac{1}{\rho} \frac{dp}{dz} + g \frac{dz}{dz} + v \frac{dv}{dz} = 0$$

$$-\frac{dp}{dz} - \rho g \frac{dz}{dz} - \rho v \frac{dv}{dz} = 0$$



$$-\frac{dp}{dz} - \rho g = \rho v \frac{dv}{dz}$$

$$-\rho \frac{dp}{dz} - \rho g dz = \rho v dv$$

(Integrating by parts)

$$\rho \left[\frac{p}{\rho} + g z + \frac{v^2}{2} \right] = \text{constant}$$

$$\frac{p}{\rho} + g z + \frac{v^2}{2} = \text{constant}$$

$$\frac{p}{\rho} + g z + \frac{v^2}{2} = \text{constant}$$

→ 2 = Potential energy / potential head of datum head.

→ $\frac{v^2}{2g}$ = Kinetic energy / kinetic head
Are lost by head.

→ $\frac{p}{\rho g}$ = Pressure energy per unit weight of fluid. / pressure head

$$\frac{p}{\rho} + \frac{v^2}{2} + g z = \text{constant}$$

dividing by g

$$\frac{p}{\rho g} + \frac{v^2}{2g} + z = \text{constant}$$

$$\int \frac{1}{\rho} \frac{dp}{dz} + \int g \frac{dz}{dz} + \int v \frac{dv}{dz} = 0$$

differentiate

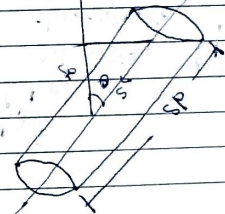
$$\frac{1}{\rho} \frac{dp}{dz} + g \frac{dz}{dz} + v \frac{dv}{dz} = 0$$

Bernoulli's Equation

3 If the flow is assumed to be ideal the viscous force is 0.

$$F_x = (F_g)_x + (F_{vis})_x$$

4 Euler's equation of motion:-



This is equation of motion in which forces due to gravity and pressure are taken into consideration.
Consider a stream line in which flow is taking place in s direction, pressure force $p dA$ in the direction of flow.
ii) Pressure force $(p + dp) dA$ opposite to the direction of flow.

iii) Weight of element $dF_g = m g$

$$p dA - \left[p + \frac{dp}{ds} ds \right] dA - \rho g ds dA \cos \theta = \rho ds dA \frac{dv}{dt}$$

$$\frac{dp}{ds} \frac{ds}{dt} \rightarrow s \& + \left(\text{function of } v \right)$$

$$\rho \frac{dv}{ds} \cdot \frac{ds}{dt} + \frac{dp}{ds} \left[\frac{ds}{dt} \cdot v \right]$$

$$\rho \left[\frac{dv}{ds} \cdot v + \frac{dp}{ds} \right]$$

If flow is steady flow $\frac{dv}{dt} = 0$

$$\rho \frac{dv}{ds} \cdot v$$

$$p dA - \left[p + \frac{dp}{ds} ds \right] dA - \rho g ds dA \cos \theta = \rho ds dA \frac{dv}{dt}$$

dividing by ds

velocity at smaller end and v_2 at larger end respectively. Determine the pressure head at the lower end, flow take place in the downward direction.

Given data

$$z_1 = 2$$

$$z_2 = 0$$

$$v_1 = 5 \text{ m/s}$$

$$v_2 = 2 \text{ m/s}$$

$$h_1 = 2.5 \text{ m}$$

$$h_2 = 0$$

$$h_1 = 0.35 (v_1 - v_2)^2 = 0.160 \text{ m}$$

$$\frac{P_1}{\rho g} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{v_2^2}{2g} + h_1$$

$$\frac{P_1}{\rho g} + 2 + \frac{5^2}{2 \times 9.81} = \frac{P_2}{\rho g} + 0 + \frac{2^2}{2 \times 9.81} + 0.160$$

$$\frac{P_1}{\rho g} = 5.41 \text{ m}$$

A pipe line carrying oil of S.G. 0.87 changes in diameter from 200 mm diameter at a position A. To 50 mm diameter at a position B, which is 4 m higher level. If the pressure at A and B

Given data

$$d_1 = 400 \text{ mm}$$

$$d_2 = 400 \times 10^{-3} \text{ m}$$

$$v_1 = 0.5 \text{ m/s}$$

$$P_1 = 29.43 \text{ N/cm}^2 = 29.43 \times 10^4 \text{ N/m}^2$$

$$P_2 = 22.56 \text{ N/cm}^2 = 22.56 \times 10^4 \text{ N/m}^2$$

$$z_1 = 2.5 \text{ m}$$

$$z_2 = 3.0 \text{ m}$$

$$h_1 = 2$$

$$\frac{P_1}{\rho g} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{v_2^2}{2g} + h_1$$

$$\frac{29.43 \times 10^4}{1000 \times 9.81} + 2.5 + \frac{0.5^2}{2 \times 9.81} = \frac{22.56 \times 10^4}{1000 \times 9.81} + 3.0 + \frac{v_2^2}{2 \times 9.81} + h_1$$

$$h_1 = 4.926 \text{ m}$$

A vertical tube of length 2 meter is fixed vertically with its smaller end upward. The velocity of flow at smaller end is 5 m/s while at the lower end it is 2 m/s. The pressure head at the smaller end is 0.5 m of liquid. The loss of head in the tube is $0.35 (v_1 - v_2)^2$. v_1 is the

ASSUMPTIONS

- ~~Bernoulli's Equation for Real Fluid:-~~

$\Delta E =$ loss of energy between point 1 & 2

No. 127 m/s

~~$$0.04 = 1 \times 0.2^2 \times v_2$$~~

$$P_0 + P_1 + P_2 + P_3 = 1$$

$$\begin{array}{r} 0.4758 \\ + 0.659 \\ \hline 1.1348 \end{array}$$

$$25.0121 = 10.0\% + 22$$

~~21-21-21 25.01-10.09~~

$$\frac{2^2 \div 2}{2} = 11.93 \text{ m}$$

* The water is flowing through a pipe have in diameter 100 cm and 100 cm. at section one and two respectively. The rate of flow through pipe is 35 l/s. The section one is 6 m above datum and section two is 4 m above datum. If the pressure at section one is 39.24 N/cm². Find the intensity of pressure at section two.

Solution

Given data

at dia section = 100 cm = 1 m.

dia section = 100 cm = 1 m.

datum at section = 4 m.

pressure at section = 39.24 N/cm²

rate of flow = 35 l/s

take $\rho_{\text{water}} = 1000 \text{ kg/m}^3$

$$Q = A_1 V_1 = A_2 V_2$$

$$0.035 = \frac{\pi}{4} \times 1^2 \times V_1 = \frac{\pi}{4} \times 1^2 \times V_2$$

$$V_1 = 1.11 \text{ m/s}$$

$$Q = A_2 V_2$$

$$0.035 = \frac{\pi}{4} \times 1^2 \times V_2$$

$$V_2 = 4.45 \text{ m/s}$$

$$P + \frac{\rho V^2}{2} + \rho z = P_2 + \frac{\rho V_2^2}{2} + \rho z_2$$

$$P + \frac{1000 \times 1.11^2}{2} + 1000 \times 4 = P_2 + \frac{1000 \times 4.45^2}{2} + 1000 \times 4$$

$$P + 616.5 = P_2 + 1980.5$$

$$P_2 = P - 1364$$

$$39.24 + 1.11^2 + 4 = P_2 + 4.45^2 + 4$$

$$39.24 + 1.11^2 + 4 = P_2 + 19.80 + 4$$

$$39.24 + 1.11^2 + 4 = P_2 + 23.80$$

$$P_2 = 39.24 + 1.11^2 + 4 - 23.80$$

$$P_2 = 16.55 \text{ N/cm}^2$$

$$P_2 = 16.55 \text{ N/cm}^2$$

* Water flowing from a pipe having di. 80 mm and 200 mm at the bottom and upper end respectively. The bottom and upper end of the bottom end is 24.525 N/cm² and the pressure at upper end is 9.81 N/cm². determine the difference in datum head. If the rate of flow through pipe is 40 l/s.

Solution

Given data

di = 80 mm = 0.08 m.

db = 200 mm = 0.2 m.

$P_1 = 24.525 \text{ N/cm}^2$

$P_2 = 9.81 \text{ N/cm}^2$

$Q = 40 \text{ l/s}$

$\rho = 1000 \text{ kg/m}^3$

0.80 of the central velocity. Find the discharge through the pipe if the difference between two orifice is 100 mm of water. Take coefficient of orifice = 0.98.

Soln given data

dia meter = 80 mm

$= 80 \times 10^{-3} \text{ m}$

mean velocity = 0.8 central velocity

$h(\text{pressure head}) = 60 \text{ mm}$

$= 60 \times 10^{-3} \text{ m}$

$C_v = 0.98$

$C_d = 0.98$

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

$A = \frac{\pi}{4} \times (80 \times 10^{-3})^2$

$A = 0.07 \text{ m}^2$

$N = C_v \sqrt{2gh}$

$V = 0.98 \times \sqrt{2 \times 9.81 \times 60 \times 10^{-3}}$

$V = 1.063 \text{ m/s}$

Find the velocity of the flow of oil through a pipe when the difference of mercury level in a differential U-tube manometer connected to the two tapping of pipe is 100 mm. Take coefficient of pipe is 0.98 and Sg of oil = 0.8.

Soln given data

$x = 100 \text{ mm}$

$S_g = 0.8$

$C_v = 0.98$

$C_d = 0.98$

$C_v = 0.98 \times 0.98$

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

$V = 0.8 \times 1.063$

mean value = 0.8 x V

$C_d = 0.98$

$C_d = 0.98 \times 1.063$

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

Applying Bernoulli's equation at point 1 & 2

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

As $z_1 = z_2$ datum is same

$$v_2 = 0$$

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

We know

$$P = \rho gh$$

$$P_1 = \rho gh$$

$$P_2 = \rho gH$$

Same point

$$P_2 = \rho gH + \frac{\rho v^2}{2g}$$

$$\frac{P}{\rho g} = H + \frac{v^2}{2g}$$

Putting the value

$$H + \frac{v^2}{2g} = H + h$$

$$h = \frac{v^2}{2g}$$

$$v = \sqrt{2gh}$$

This is theoretical velocity. Actual velocity is given by

$$v_{\text{actual}} = C_v \sqrt{2gh}$$

C_v = coefficient of velocity

$$h = \frac{25g}{2g} = 1.25m$$

C_v = difference of mercury level
 $S_g = 13.6$ of heavy liquid
 $s_l = 1$ of lighter liquid

* A pitot static tube placed in the center of a stream has a centre pointing up stream and other perpendicular to it. The mean velocity in the pipe is

are 9.81 N/cm^2 and 5.886 N/cm^2 respectively
 and the discharge is 200 L/s determine
 the loss of head and direction of
 flow.

$$\text{dia (A)} = 200 \text{ mm} \\
= 200 \times 10^{-3} \\
\text{dia (B)} = 500 \text{ mm} \\
= 500 \times 10^{-3}$$

$$P_1 = 9.81 \text{ N/cm}^2 \\
= 9.81 \times 10^4 \text{ N/m}^2 \\
P_2 = 5.886 \text{ N/cm}^2 \\
= 5.886 \times 10^4 \text{ N/m}^2$$

$$h_1 = 200 \times 10^{-3} \text{ L/m}^3 \text{ (m}^3/\text{s)}$$

$$Q = A_1 V_1$$

$$Q = A_2 V_2$$

$$200 \times 10^{-3} = \frac{\pi}{4} \times (200 \times 10^{-3})^2 \times V_1$$

$$V_1 = 6.36 \text{ m/s}$$



1) It is a device used for measuring the velocity of flow at any point in a pipe or a channel.
 It is based on the principle that if the velocity of flow at a point becomes 0 the pressure there increases due to conversion of kinetic energy into pressure energy.

PITOT TUBE

$$h_t = 2.60 \text{ m}$$

$$P_1 + \frac{1}{2} \rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho V_2^2 + \rho g h_2 \\
98100 + 0 + 0 = 58860 + 0 + 1.01^2 \times \frac{\rho}{2} + h_t$$

$$V_2 = 1.01 \text{ m/s}$$

$$Q = A_2 V_2 \\
= \frac{\pi}{4} \times (500 \times 10^{-3})^2 \times 1.01$$

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

$$Q = a_2 V_2$$

also known

$$V_2 = \frac{a_1}{a_2} \times \sqrt{2gh} \times \sqrt{a_2^2 - a_1^2}$$

$$V_2 = \sqrt{2gh} \times \frac{a_1}{a_2} \times \sqrt{a_2^2 - a_1^2}$$

$$V_2^2 = 2gh \times \left[\frac{a_1^2}{a_2^2} \times (a_2^2 - a_1^2) \right]$$

$$h = \frac{V_2^2}{2g} \left[\frac{a_2^2}{a_1^2} \times (a_2^2 - a_1^2) \right]$$

$$h = \frac{V_2^2}{2g} \left[1 - \frac{a_1^2}{a_2^2} \right]$$

$$h = \frac{V_2^2}{2g} \times \frac{a_2^2 - a_1^2}{a_1^2}$$

$$h = \frac{V_2^2}{2g} \times \frac{a_2^2 - a_1^2}{a_1^2}$$

Case-3

A horizontal venturimeter with inlet and throat diameter, 30cm and 15cm. Respectively is used to measure the flow of water. The reading of differential manometer connected to the inlet and the throat is 20 cm. of mercury. determine the rate of flow. Take $\rho = 0.98$

$h = 20$	$h = 1 - 51$	50
$98 = \text{sp. g. of water}$	$98 = \text{sp. g. of liquid}$	$80 = \text{sp. g. of liquid}$

Case-2:- If the differential manometer contains liquid which is lighter than the liquid flowing through the pipe

$$h = x \left[\frac{S_2}{S_1} - 1 \right] \left[\frac{80}{50} \right]$$

Case-1:- Let the differential manometer contains a liquid which is heavier than the liquid flowing through the pipe.

$$Q_{\text{actual}} = C_d \times a_1 \times \frac{a_2}{a_1} \times \sqrt{2gh} \times \sqrt{a_2^2 - a_1^2}$$

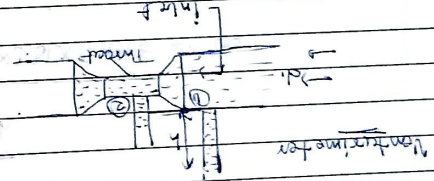
UNIT - 3 FLUID MEASUREMENT

VENTURIMETER:-

A venturimeter is a device used for measuring the rate of flow of a fluid flowing through a pipe.

- It consists of three parts
- (i) A short converging part
 - (ii) Throat
 - (iii) Diverging part

It is based on the principle of Bernoulli's equations



Consider a venturimeter fitted in a horizontal pipe.

- Let d_1 = diameter at inlet
 P_1 = pressure at section (1)
 V_1 = velocity of fluid at section (1)
 a_1 = Area of section (1)
 d_2 , P_2 , V_2 , a_2 are corresponding values at section (2)

Applying Bernoulli's at sec. 1 and 2

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

[$z_1 = z_2$ because horizontal pipe]

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

$$P_1 - P_2 = \frac{\rho}{2} (V_2^2 - V_1^2)$$

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

$$P_1 - P_2 = h$$

$$h = \frac{V_2^2 - V_1^2}{2g}$$

Applying continuity equation

$$a_1 V_1 = a_2 V_2$$

or putting the value of V_1

A submarine moved horizontally in sea and has its axis 15 m below the surface of water. A pitot tube properly placed just in front of the submarine and along its axis is connected to the two limbs of a U-tube containing mercury. The difference of mercury level is found to be 170 mm. Find the speed of submarine assuming that ρ of mercury is 13.6 and ρ of water with respect of fresh water is 1.026.

$$h = x \left[\frac{\rho}{\rho_0} - 1 \right]$$

$$h = \left[\frac{13.6}{1.026} - 1 \right] \times 0.17$$

$$h = 1.6 \text{ m}$$

$$V = \sqrt{2gh}$$

$$V = 0.98 \sqrt{2 \times 9.81 \times 1.6}$$

$$V = 5.49 \text{ m/s}$$

Solution

Given data =

$$x = 170 \text{ mm}$$

$$= 170 \times 10^{-3} \text{ m}$$

$$\rho = 13.6$$

$$\rho_0 = 1$$

$$h = x \left[\frac{\rho}{\rho_0} - 1 \right]$$

$$h = 0.17 \left[\frac{13.6}{1} - 1 \right]$$

$$h = 2.063 \text{ m}$$

$$V = \sqrt{2gh}$$

$$V = \sqrt{2 \times 9.81 \times 2.063}$$

$$V = 6.46 \text{ m/s}$$

Submarine speed

$$= 6.39 \times 60 \times 60$$

$$= 23600$$

$$= 23 \text{ km/hr}$$

Ans

Given data

$\rho = 13.6 \text{ N/cm}^3$

$d_1 = 20 \text{ cm}$

$d_2 = 10 \text{ cm}$

$h = 30 \text{ cm of mercury}$

$CD = .96$

$Q_1 = \frac{1}{4} \pi d_1^2 \cdot v_1 = \frac{1}{4} \pi (20)^2 \cdot 4.0134$

$Q_2 = \frac{1}{4} \pi d_2^2 \cdot v_2 = \frac{1}{4} \pi (10)^2 \cdot 15.6$

$Q_1 = \frac{1}{4} \pi d_1^2 \cdot v_1 = \frac{1}{4} \pi (20)^2 \cdot 4.0134$

$Q_2 = \frac{1}{4} \pi d_2^2 \cdot v_2 = \frac{1}{4} \pi (10)^2 \cdot 15.6$

$h = x \left[\frac{54}{50} - 1 \right]$

$h = 30 \left[\frac{13.6}{13.6} - 1 \right]$

$h = 936 \text{ cm}$

$Q = cd \times \frac{a_1 \times v_1}{\sqrt{a_2^2 - a_1^2}} \times \sqrt{2 \times 9.81 \times 336}$

$Q = 0.96 \times \frac{814.15^2 \times 96.53}{\sqrt{814.15^2 - 96.53^2}} \times \sqrt{2 \times 9.81 \times 336}$

$Q = 67644.92 \text{ cm}^3/\text{s}$



$h = 40 \text{ cm}$

1000×9.81

$h =$

$\rho = 13.6 \text{ N/cm}^3$

$\frac{13.6 \times 10^4}{1000 \times 9.81}$

$= 17.99 \text{ m}$

$= 180 \text{ m}$

$P_2 = -3.6 \times 10^4 \times 13.6$
(- vacuum pressure)

$P_2 = -4$

P_2

$h =$

P_2

$h = 180 \text{ m} - (-4)$

$h = 22 \text{ m}$

$$Q = C_d \times a_0 \times \frac{a_1}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$$

$$Q = 0.95 \times 0.14 \times \frac{78.53}{\sqrt{78.53^2 - 36.53^2}} \times \sqrt{2 \times 9.81 \times 400}$$

$$Q = 7041.29 \text{ cm}^3/\text{s}$$

A horizontal venturimeter with inlet dia = 20 cm and throat dia = 10 cm is used to measure the flow of oil of sp gr 0.98. The oil is flowing freely in the venturimeter. Find the reading of the oil mercury differential manometer.

Given data

$$\begin{aligned} d_1 &= 20 \text{ cm} \\ d_2 &= 10 \text{ cm} \\ \rho &= 0.98 \times 1000 \text{ kg/m}^3 \\ Q &= 60 \text{ L/s} \\ C_d &= 0.98 \end{aligned}$$

$$C_d = C_d a_0 \times \frac{a_1}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$$

$$60 \times 10^{-3} = 0.98 \times 0.0314 \times \frac{0.0785}{\sqrt{0.0785^2 - 0.0314^2}} \times \sqrt{2 \times 9.81 \times h}$$

$$h = 2.941 \text{ m}$$

$$h = C \left[\frac{S_0}{S_1} - 1 \right]$$

$$2.9412 = C [13.6 - 1]$$

$$C = 0.1963$$

A horizontal venturimeter with inlet dia = 20 cm and throat dia = 10 cm is used to measure the flow of water. The pressure at inlet is 17.65 N/cm² and the vacuum pressure at the throat is 30 cm of mercury. Find the discharge of water through the venturimeter. $C_d = 0.98$

slide 14

Given data:

$$d_1 = 30 \text{ cm.}$$

$$d_2 = 15 \text{ cm.}$$

$$d_3 = 20 \text{ cm.}$$

$$C_d = 0.98$$

$$Q_1 = 0.070 \text{ m}^3/\text{s}$$

$$Q_2 = 0.017 \text{ m}^3/\text{s}$$

$$Q_3 = 0.010 \text{ m}^3/\text{s}$$

$$C_d = 0.98$$

$$h = 20 \times 10^{-2} \text{ m}$$

$$h = 15 \times 10^{-2} \text{ m}$$

$$h = 10 \times 10^{-2} \text{ m}$$

$$h = 5 \times 10^{-2} \text{ m}$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

$$h = 2.052$$

dry

$$Q = 0.120 \text{ m}^3/\text{s}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

$$Q = 0.98 \times 0.017 \times 0.017 \times \sqrt{2 \times 9.81 \times 10^{-2}}$$

slide 15

A oil of spg. 0.8 is flowing through a venturimeter having inlet diameter 20 cm. and throat diameter 10 cm. the oil mercury difference in venturimeter shows a reading of 25 cm. calculate the discharge of oil through the horizontal venturimeter. take $C_d = 0.98$

$$d_1 = 20 \text{ cm.}$$

$$d_2 = 10 \text{ cm.}$$

$$d_3 = 20 \text{ cm.}$$

$$d_4 = 10 \text{ cm.}$$

$$d_5 = 20 \text{ cm.}$$

$$d_6 = 10 \text{ cm.}$$

$$d_7 = 20 \text{ cm.}$$

$$d_8 = 10 \text{ cm.}$$

$$d_9 = 20 \text{ cm.}$$

$$d_{10} = 10 \text{ cm.}$$

$$d_{11} = 20 \text{ cm.}$$

$$d_{12} = 10 \text{ cm.}$$

$$d_{13} = 20 \text{ cm.}$$

$$d_{14} = 10 \text{ cm.}$$

$$d_{15} = 20 \text{ cm.}$$

$$d_{16} = 10 \text{ cm.}$$

$$d_{17} = 20 \text{ cm.}$$

$$d_{18} = 10 \text{ cm.}$$

$$d_{19} = 20 \text{ cm.}$$

$$d_{20} = 10 \text{ cm.}$$

$$h = 25 \left[\frac{S_o}{S_L} - 1 \right]$$

$$h = 25 \left[\frac{13.6}{1} - 1 \right]$$

$$h = 25 \left[\frac{13.6}{1} - 1 \right]$$

$$h = 25 \left[\frac{13.6}{1} - 1 \right]$$

$$h = 25 \left[\frac{13.6}{1} - 1 \right]$$

$$h = 25 \left[\frac{13.6}{1} - 1 \right]$$

$$h = 25 \left[\frac{13.6}{1} - 1 \right]$$

Question Paper

2023

* A circular plane surface is 4 m diameter. Its top surface lies 3 m below the free surface of the water. Calculate the total pressure and center of pressure on the plate if the plate is vertically placed.

Solution Given data

diameter = 4 m

top surface lies 3 m below the free surface

Area of circle = $\frac{\pi}{4} d^2$

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

$$= 12.56 \text{ m}^2$$

Position of CG = $\frac{d}{2}$

$$= \frac{4}{2}$$

$$= 2 \text{ m} + 3 \text{ m}$$

$$= 5 \text{ m}$$

Position of CG = $\frac{\pi}{4} d^4$

$$= \frac{\pi}{4} \times 4^4$$

$$= 12.56 \text{ m}^4$$

Total pressure

$$F = \rho g A h$$

$$F = 1000 \times 9.81 \times 0.1256 \times 2.55 = 3119.52 \text{ N}$$

$$F = 3119.52 \text{ N/m}^2$$

Ans

Center of pressure

$$h^* = 2.54 + 5$$

$$= 7.54$$

$$h^* = 12.56 + 2.5$$

$$12.56 \times 8$$

$$= 100.48 \text{ m}$$

Ans

The right limb of simple U-tube manometer containing mercury is open to the atmosphere, while the left limb is connected to a pipe in which a fluid of sp. g. 0.9 is flowing. The center of pipe is 10 cm below the level of mercury in right limb. Find the pressure of fluid flowing in pipe if the difference of mercury level in two limb is 20 cm.

10000

$$Q = 13737.22 \text{ cm}^3/\text{s}$$

$$Q = 0.64 \times 706.85 \times 176.91 \times \sqrt{2 \times 9.81 \times 9.65} \times \sqrt{(706.85)^2 - (176.91)^2}$$

$$Q = C_d \times A_2 \times \sqrt{2g \times \frac{h_1^2 - h_2^2}{1 - \left(\frac{A_2}{A_1}\right)^2}}$$

$$h = 705 \text{ cm}$$

$$h = 50 \left[\frac{13.6}{0.9} - 1 \right]$$

$$h = 50 \left[\frac{80}{80} - 1 \right]$$

$$d_1 = 30 \text{ cm}, d_2 = 15 \text{ cm}, \rho = 0.64, \text{spg} = 0.9$$

$$Q_1 = \frac{A_1}{A_2} \times 30^2 = 706.85$$

$$Q_2 = \frac{A_2}{A_1} \times 15^2 = 176.91$$

★ An orifice meter with orifice dia. 15 cm is inserted in a pipe of 30 cm dia. The pressure difference measured by mercury sits of the orifice meter gives a reading of 50 cm of mercury fluid the rate of flow of oil spg 0.9

$$Q = 0.068 \text{ m}^3/\text{s}$$

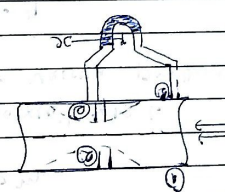
$$Q = 0.6 \times 0.0314 \times 0.0035 \times \sqrt{(0.0314)^2 - 10.0035^2}$$

$$Q = C_d \times A_2 \times \sqrt{2g \times \frac{h_1^2 - h_2^2}{1 - \left(\frac{A_2}{A_1}\right)^2}}$$



$Q = C_d \times a_1 \times v_1$
 $Q = C_d \times a_2 \times v_2$
 $C_d = \text{Coefficient of discharge}$

$$Q = C_d \times a_1 \times v_1 = C_d \times a_2 \times v_2$$



It is a device used for measuring the rate of flow of a fluid through a pipe.

* ORIFICE METER

$$Q = 0.1150 \text{ m}^3/\text{s}$$

$$Q = 0.1650 \text{ m}^3/\text{s}$$

$$Q = 0.1150 \times 0.00395 \times \sqrt{0.0124} = 0.00465 \text{ m}^3/\text{s}$$

$$Q = 0.1650 \times 0.00395 \times \sqrt{0.0124} = 0.0061 \text{ m}^3/\text{s}$$

$$h = 10 \text{ m}$$

$$h = \frac{19.62 \times 10^4}{9.81 \times 10^4}$$

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

$$Q = \frac{P_1}{\rho g} \times d_1^2 = \frac{P_2}{\rho g} \times d_2^2 = 0.00785 \text{ m}^2$$

$$Q = \frac{P_1}{\rho g} \times d_1^2 = \frac{P_2}{\rho g} \times d_2^2 = 0.00314 \text{ m}^2$$

$$d_1 = 20 \text{ cm}$$

$$d_2 = 10 \text{ cm}$$

$$P_1 = 9.81 \text{ N/cm}^2$$

$$P_2 = 9.81 \text{ N/cm}^2$$

Given data

The An orifice meter with a pipe of 20 cm dia. The pressure gauge fitted up stream and down stream of the orifice meter gives reading of 19.62 N/cm² and 9.81 N/cm² respectively. $C_d = 0.6$ find the rate of water through pipe.

After integrate

It gives equation of motion.

$$\frac{dp}{\rho} + g dz + v dv = 0$$

$$\int \left[\frac{dp}{\rho} + g dz + v dv \right] = 0$$

$$\frac{dp}{\rho} + g dz + v dv = 0$$

$$-\frac{dp}{\rho} - g dz = v dv$$

$$dz = \frac{v dv}{g}$$



$$-\frac{dp}{\rho} - g dz = v dv$$

$$-\frac{dp}{\rho} - g dz = v dv$$

dividing by dz

$$-\frac{dp}{\rho} - g = v \frac{dv}{dz}$$

After integrate

$$\frac{dp}{\rho}$$

velocity head.

$$\frac{v^2}{2}$$

pressure head.

$$\frac{p}{\rho g}$$

pressure head.

Bernoulli equation

$$\frac{p}{\rho} + \frac{v^2}{2} + \frac{p}{\rho g}$$

$$\frac{p}{\rho} + \frac{v^2}{2} + \frac{p}{\rho g}$$

dividing by g

$$\frac{p}{\rho g} + \frac{v^2}{2g} + \frac{p}{\rho g}$$

$$\int \frac{dp}{\rho} + g dz + v dv = 0$$

* State the limitation of Bernoulli's theorem and its definition.

$$h^* = 41.52 \text{ m}$$

$$h^* = 20.83 + 41.0 \times 4$$

$$h^* = 30.1 + h$$

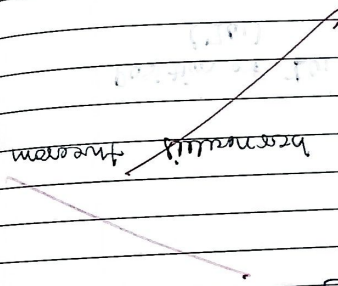
center of pressure

$$F = 32400 \text{ N/m}^2$$

$$F = 1000 \times 9.81 \times 10 \times 4$$

$$F = \rho g h$$

Force pressure



$$P_A - P_B - \rho g \sin \theta \cdot ds = \rho \cdot ds \cdot \frac{dv}{dt}$$

$$P_A - P_B - \rho g \sin \theta \cdot ds = \rho \cdot ds \cdot \frac{dv}{dt}$$

$$Q = v \cdot ds$$

$$Q = v \cdot ds + \frac{dv}{dt} \cdot ds \quad \text{When the fluid is steadily flow so } \frac{dv}{dt} = 0$$

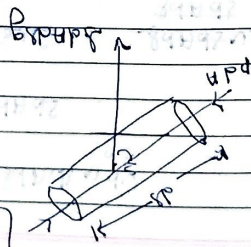
$$Q = v \cdot ds + \frac{dv}{dt} \cdot ds \quad \left[\frac{dQ}{dt} = v \right]$$

$$Q = v \cdot ds$$

$$P_A - P_B - \rho g \sin \theta \cdot ds = \rho \cdot ds \cdot \frac{dv}{dt}$$

$$F = m \cdot a$$

like know



$$P_A - P_B - \rho g \sin \theta \cdot ds = \rho \cdot ds \cdot \frac{dv}{dt}$$

* A rectangular plane surface is 2m wide and 5m deep. It lies in vertically plane in water. Determine the total pressure and position of center of pressure. On the plane surface when its upper edge is horizontal and 1.5m below the water surface.

Solution
Given data:-

Size of rectangle = 2×5
= 10 m^2

Distance from free surface to rectangle = 1.5m.

Area

Area of surface = 2×5

(m)

= 10 m^2

Position of C.G. (G) = $\frac{d}{2} = 1.5$

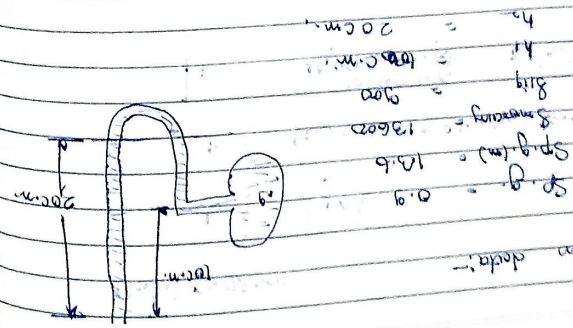
= $\frac{5}{2} = 2.5$

= 2.5 m

Position of T.C. = $\frac{h}{3} = \frac{5}{3}$

= 1.67

= 20.83 m^4



Solution
Given data:-

S.G. = 0.9
S.G. (L) = 13.6
S.G. (R) = 13.6

Height = 900
Height = 100 cm

Height = 20 cm

Pressure above the datum line on left limb

P.L. S.G.

P.L. $900 \times 9.81 \times 10 \times 10^{-3}$

P.L. 20×9.81

Pressure above the datum line on right limb

S.G.

$13.6 \times 9.81 \times 20 \times 10^{-2}$

26.6832

Equation

P.L. $26.6832 = 26.6832$

P.L. $26.6832 = 26.6832$

3) Coefficient of discharge: C_d

$$C_d = \frac{\text{Actual Discharge}}{\text{Theoretical Discharge}}$$

$$C_d = \frac{\text{Actual Area} \times \text{Actual Velocity}}{\text{Theoretical Area} \times \text{Theoretical Velocity}}$$

$$C_d = C_v \times C_c$$

* The head of water over and orifice of diameter is 10m. Find the actual discharge and actual velocity of the jet at $C_v = 0.98$ and $C_c = 0.6$

Soln Given data

$$d = 10 \text{ mm}$$

$$H = 10 \text{ m}$$

$$C_d = 0.6$$

$$C_v = 0.98$$

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

$$Q = \frac{\pi}{4} \times (10 \times 10^{-3})^2 \times V$$

$$Q = 0.00125 \text{ m}^3/\text{s}$$

$$C_v = \frac{V}{\sqrt{2gh}}$$

$$0.98 = \frac{V}{\sqrt{2 \times 9.81 \times 10}}$$

$$\sqrt{2 \times 9.81 \times 10}$$

$$V = 13.72 \text{ m/s}$$

$$Q = 0.00125 \times 13.72$$

$$Q = 0.0171 \text{ m}^3/\text{s}$$

$$C_d = \frac{Q_{\text{act}}}{Q_{\text{theor}}}$$

$$Q_{\text{theor}}$$

$$Q_{\text{act}} = 0.0171 \times 0.6$$

$$Q_{\text{act}} = 0.01$$

$$C_d = \frac{Q_{\text{act}}}{Q_{\text{theor}}}$$

$$Q_{\text{theor}}$$

$$Q_{\text{act}} = \frac{\pi}{4} \times d^2 \times V \times C_d$$

$$Q_{\text{act}} = \frac{\pi}{4} \times (10 \times 10^{-3})^2 \times V \times C_d$$

$$Q_{\text{act}} = 0.0171 \text{ m}^3/\text{s}$$

Vena contracta - The area of jet liquid passes on decreasing and at a section is called the area is minimum. This section is called vena contracta.

Applying Bernoulli equation at Sec. (A) & (B)

$$\rho \left(z_1 + \frac{v_1^2}{2g} \right) + \frac{\rho}{2g} = \rho \left(z_2 + \frac{v_2^2}{2g} \right) + \frac{\rho}{2g}$$

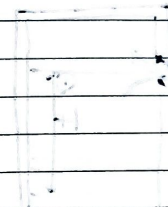
$z_1 = z_2 = \text{height of same level}$

$$\rho \left(\frac{v_1^2}{2g} \right) = \rho \left(\frac{v_2^2}{2g} \right) + \frac{\rho}{2g}$$

$$\left[\frac{v_1^2}{2g} - \frac{v_2^2}{2g} \right] = \frac{1}{g}$$

$$\frac{v_1^2}{2g} - \frac{v_2^2}{2g} = \frac{1}{g} \quad v_1 = 0 \quad (\text{slow velocity})$$

$$H + 0 = 0 + \frac{v_2^2}{2g}$$



$$v_2 = \sqrt{2gh}$$

This is theoretical velocity. Actual velocity will be less than this value.

Hydraulic Coefficient

1) Coefficient of velocity (C_v)

$C_v = \frac{\text{Actual velocity at vena contracta}}{\text{Theoretical velocity}}$

$$C_v = \frac{V}{\sqrt{2gh}}$$

C_v varied from 0.95 to 0.99 generally the value of $C_v = 0.98$

2) Coefficient of contraction (C_c)

$C_c = \frac{\text{Area of jet}}{\text{Area of orifice}}$

$C_c = \frac{\text{Area of jet at vena contracta}}{\text{Area of orifice}}$

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

* ORIFICE & MULTIPLE

* ORIFICE:- Orifice is a small opening of any cross-section [Circular, Triangular, Rectangular etc.] on the side or at the bottom of a tank. Through which a fluid is flowing.

* CLASSIFICATION OF ORIFICE

The orifice are classified on the basis of their size, shape, nature of discharge and shape of upstream edge.

i) The orifice are classified as:-

- 1) Circular orifice
- 2) Triangular orifice
- 3) Rectangular orifice
- 4) Square orifice

Depending upon their cross-sectional area

ii) The orifice are classified as:-

- 1) Sharp edged orifice
- 2) Bell mouth orifice

Depending upon the shape of upstream edge

iii) The orifice are classified as:-

- 1) Free discharge orifice
- 2) Submerged orifice

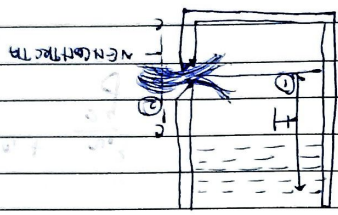
Depending upon the nature of discharge

iv) The orifice are classified as small orifice or large orifice.

NOTE:- ORIFICE AS WELL AS MOUTH PIECE ARE USED FOR MEASUREMENT THE RATE OF FLOW OF FLUID.

* FLOW THROUGH AND ORIFICE:-

i) Consider a tank fitted with a circular orifice in one of its side.



$$Q = \frac{\pi}{4} \times (1.5)^2 \times 1.1$$

$$Q = \frac{1.46 \times 1}{25}$$

$$Q = 0.090 \text{ m}^3/\text{s}$$

$$C_d = \frac{Q}{Q \times \sqrt{2gh}}$$

$$C_d = \frac{0.07}{0.0028 \times \sqrt{2 \times 9.81 \times 10}}$$

$$C_d = 0.64$$

$$C_v = \frac{\sqrt{2gh}}{C_d}$$

$$C_v = \frac{4.3}{\sqrt{14 \times 9.81 \times 10}}$$

$$C_v = 0.96$$

Ans

$$C_v = C_d$$

$$C_v$$

$$C_v = 0.64$$

$$0.96$$

$$C_v = 0.66$$

Ans

4 Flow Through Large Orifice

If the head of liquid is less than 5 times the depth of orifice, the orifice is called large orifice.

5 Discharge through large rectangular orifice.

Let

H_1 = Height of liquid above the top edge of orifice

H_0 = Height of liquid above bottom edge of orifice

b = breadth of orifice

d = depth of orifice = $H_0 - H_1$

C_d = Coefficient of Discharge

Consider an elementary horizontal strip of depth

dh at a depth of h below the free surface of liquid

Soln

Given data

$$H = 10 \text{ cm}$$

$$d = 20 \text{ cm}$$

$$R = 100 \text{ cm}$$

$$C_d = 0.60$$

A jet of water issuing from a sharp edged orifice under a constant head of 10 cm. at a certain point, has the horizontal and vertical coordinates measured from the vena contracta as 20 cm and 10.5 cm. respectively. Find the value of C_v also find the value of C_c if $C_d = 0.60$.

C_v	C_c
C_d	

3) Determination of Coefficient of contraction

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

2) Determination of Coefficient of velocity

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

($Q = \text{area of orifice}$)

$$C_v = \frac{V}{\sqrt{2gH}}$$

Given data

$$H = 10 \text{ cm}$$

$$d = 20 \text{ cm}$$

$$R = 100 \text{ cm}$$

$$C_d = 0.60$$

The head of water over an orifice of dia 20 mm is 10 cm. The water coming out from orifice is collected in a container. The rise of water level of orifice is 1 cm in 25 sec. also the coordinates of a point on the jet measured from vena contracta are 20 cm horizontal and 10.5 cm vertical. Find the coefficient C_d and C_v .

$$C_c = 0.61$$

$$C_v = \frac{0.60}{0.975}$$

$$C_v = 0.61$$

$$C_v = \frac{0.60}{0.975}$$

$$C_v = \frac{V}{\sqrt{2gH}}$$

$$V = 4.429 \text{ m}^3/\text{s}$$

$$V = 2 \times 9.81 \times 1$$

$$\frac{V}{2} = \sqrt{2gh}$$

$$d = 0.0031 \text{ m}^2$$

$$= \sqrt{\frac{1}{2} (20 \times 10^3)^2}$$

$$C_d = \frac{1}{\sqrt{2}} \times (d/g)^{1/2}$$

$$C_d = C_c \times C_v$$

$$C_d = 2$$

$$Q_{act} = 0.85 \text{ m}^3/\text{s}$$

$$H = 1 \text{ m}$$

$$d_{jet} = 20 \text{ mm}$$

Solution

The head of water over the center of orifice is 1 m. The actual discharge through the orifice is 0.85 m³/s. Find the coefficient of discharge.

$$Q_{act} = C_d \times 0.0147$$

$$Q_{th} =$$

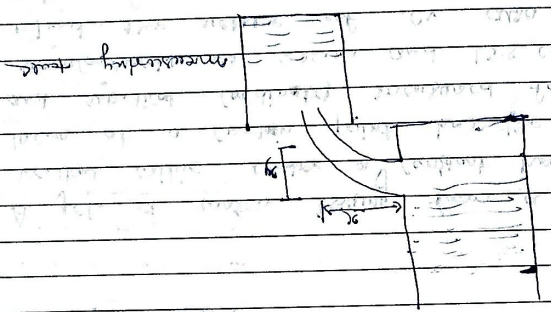
$$C_d =$$

$$V = 4.429 \text{ m}^3/\text{s}$$

$$V = 2 \times 9.81 \times 1$$

$$\frac{V}{2} = \sqrt{2gh}$$

Q = Area of measuring tank x Height of water in measuring tank



① Determination of coefficient of discharge

Experiment for Determination of Hydraulic Coefficient

$$C_d = 0.65$$

$$C_d = \frac{0.0013}{0.0013} = 1$$

$$Q_{th} = 0.0013 \text{ m}^3/\text{s}$$

$$Q_{act} = 0.0031 \times 4.429$$

The notch is a small size while the weirs are bigger size.
The notch is generally made of metallic stay plate, while weir is made of concrete or masonry structure.

Weirs are a structure placed in an open channel over which the flow occurs.

NOTCHES - Notches is a device used for measuring the rate of flow of liquid through a small channel, or a tank.

NOTCHES AND WEIRS

$$H = 4.156 \text{ m}$$

$$0.62 \times 0.00196 \times \sqrt{2 \times 9.81}$$

$$0.90 = 2 \times 1.227 (\sqrt{H} - \sqrt{H_1})$$

$$cd \cdot a \cdot \sqrt{2g}$$

$$T = 2A (\sqrt{H} - \sqrt{H_1})$$

$$H = \frac{2}{\sqrt{2}} \times 1.227 = 1.227 \text{ m} \quad \frac{Q = \frac{1}{2} \times 0.5^2}{(50 \times 10^{-3})^2} = 0.00196$$

$$H_1 = 5 \text{ m}$$

$$1.5 \times 60 \text{ s}$$

$$T = 1.5 \text{ m}$$

$$cd = 0.62$$

$$2 \times 50 \times 10^3 \text{ m}$$

$$d = 50 \text{ mm}$$

$$dT = 1.25 \text{ m}$$

Given data

A circular tank of diameter 125 m. Contain water up to height of 5 m. An orifice of 50 mm diameter is provided at bottom. If $cd = 0.62$ find the height of water above the orifice after 1.5 minutes.

$$T = 107.83 \text{ sec}$$

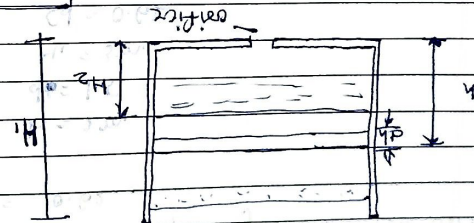
$$T = \frac{2 \times 12.5 \times \sqrt{5}}{0.62 \times 0.00196 \times \sqrt{2 \times 9.81}}$$

$$cd \cdot a \cdot \sqrt{2g}$$

$$T = 2A \sqrt{H}$$

Case - 2

* Time of emptying a tank through an orifice at its bottom.



$$T = \frac{2A\sqrt{H_1}}{C_d \cdot a \cdot \sqrt{2g}}$$

$$T = \frac{2A\sqrt{H_1}}{C_d \cdot a \cdot \sqrt{2g}}$$

A = Area of the tank
 a = Area of the orifice
 H_1 = Initial height of the liquid
 H_2 = Final height of the liquid
 T = Time in seconds for the liquid to fall from H_1 to H_2

* A circular tank of diameter, 4m radius is provided with an orifice of diameter, 5m at the bottom. Find the time taken by water.

- ① To find from 5m to 0m
 ② for completely emptying tank. Take $C_d = 0.6$

Given data:-

diameter of tank = 4m
 $H_1 = 5m$
 $C_d = 0.6$

Area of tank = $\frac{\pi}{4} \times (4)^2 = 12.56 m^2$
 a of orifice = $\frac{\pi}{4} \times (0.5)^2 = 0.196 m^2$

$$T = \frac{2A\sqrt{H_1}}{C_d \cdot a \cdot \sqrt{2g}}$$

$$T = \frac{2 \times 12.56 \sqrt{5}}{0.6 \times 0.196 \times \sqrt{2 \times 9.81}}$$

$$T = 39.63 \text{ sec.}$$

Area of ship = $b \times d$

Theoretical velocity of water through a ship

$$= \sqrt{2gh}$$

Discharge through ship $ds = \text{Area} \times \text{Theor. velocity}$

$$ds = c_d \times b \times d \times \sqrt{2gh}$$

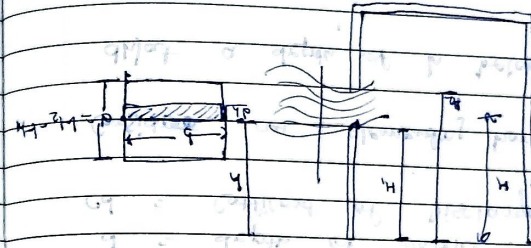
Integrating above equation

$$\int ds = \int c_d \times b \times d \times \sqrt{2gh} \, dh$$

$$Q = c_d \times b \times d \times \sqrt{2g} \int_{H_2}^{H_1} \sqrt{h} \, dh$$

$$Q = c_d \times b \times d \times \sqrt{2g} \left[\frac{h^{3/2}}{3/2} \right]_{H_2}^{H_1}$$

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



→ find the discharge through a rect. orifice 2m wide and 1.5m deep fitted in the tank it

3m above the top edge of the orifice

take $c_d = 0.62$

$b = 2m$

$d = 1.5$

$H_1 = 3m$

$c_d = 0.62$

$H_2 = 4.5$

$H_2 = 6.45m$

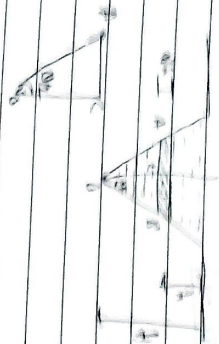
$$Q = \frac{2}{3} \times c_d \times b \times d \times \sqrt{2g} \left[H_1^{3/2} - H_2^{3/2} \right]$$

$$Q = \frac{2}{3} \times 0.62 \times 2 \times \sqrt{2 \times 9.81} \left[4.5^{3/2} - 3^{3/2} \right]$$

$$Q = 15.92 \, m^3/s$$

Ans

* Discharge over triangular notch or weir



$$\tan \frac{\theta}{2} = \frac{AC}{OC} = \frac{AC}{(H-h)}$$

$$AC = \tan \frac{\theta}{2} (H-h)$$

$$AB = 2 AC = 2 \tan \frac{\theta}{2} (H-h)$$

$$\text{Area strip} = \text{width} \times \text{height} = 2 \tan \frac{\theta}{2} (H-h) \times dh$$

$$\text{Area Vels.} = \int \text{Area strip} \times \text{velocity}$$

$$Q = \int \text{Area strip} \times \text{velocity} = \int 2 \tan \frac{\theta}{2} (H-h) \times \sqrt{2gh} \times dh$$

Integrating

$$Q = 2 \tan \frac{\theta}{2} \times \sqrt{2g} \times \int_0^H (H-h) \sqrt{h} dh$$

* Find discharge over a triangular notch of angle 60° when the head over the V-notch is 0.3 m. Assume $C_d = 0.6$

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

Given data

$$H = 0.3 \text{ m}$$

$$C_d = 0.6$$

$$\theta = 60^\circ$$

$$Q = \frac{2}{15} \times \frac{0.6}{15} \times \tan \frac{60^\circ}{2} \times \sqrt{2 \times 9.81} \times (0.3)^{5/2}$$

$$Q = \frac{0.6}{15} \times \frac{0.6}{15} \times \tan 30^\circ \times \sqrt{19.62} \times (0.3)^{5/2}$$

$$Q = 0.017 \text{ m}^3/\text{s}$$

* Water flows over a triangular weir 1 m wide at a depth of 150 mm, and after weir passes through a triangular right angle weir take $C_d = 0.6$ and triangular weir also and 59 mm. Find the depth over the triangular weir.

Solution

Given data

$$L = 6 \text{ m}$$

$$H = 2$$

$$d = 6$$

$$Q = 2000 \text{ L/s}$$

* Determine the weight of rectangular wire of length 6m. to be laid on the top of a rectangular channel. The maximum depth of water on the up slope side of the wire is 1.2m and discharge is 2000 L/s. $d = 6$

$$Q = 0.562 \text{ m}^3/\text{s}$$

$$Q = \frac{3}{2} \times 0.6 \times \sqrt{2 \times 9.81} \times 2 \times 10.8^{3/2}$$

$$Q = \frac{3}{2} \times 0.6 \times \sqrt{2 \times 9.81} \times L \times H^{3/2}$$

$$= 0.3 \text{ m}$$

$$= 300 \times 10^{-3} \text{ m}$$

$$H = 300 \text{ mm}$$

$$L = 2 \text{ m}$$

Solution

$$Q = \frac{3}{2} \times 0.6 \times \sqrt{2 \times 9.81} \times 6 \times H^{3/2}$$

$$H = 0.186 \text{ m} / 0.322 \text{ m}$$

$$H_0 = H_1 - H$$

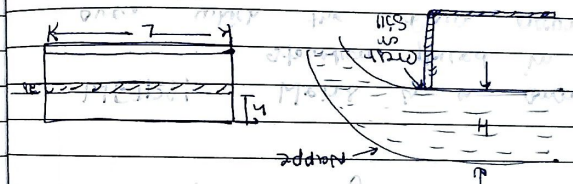
$$H_0 = 1.8 - 0.328$$

$$H_0 = 1.472 \text{ m}$$

1. Nappe or Vein - The sheet of water following through a notch or over a wire is called a nappe or vein.

2. Crest or Sill - The bottom edge of notch or a top of wire over which the water flows, is known as the sill.

Discharge over a rectangular notch



Rectangular notch at crest
C/S. of crest
\$H\$ = head of water over the crest
\$L\$ = length of the notch or wire

area of strip = \$t \times dx\$

theoretical velocity = \$\sqrt{2gh}\$

for strip

discharge = area \$\times\$ theoretical velocity

The total discharge \$Q\$ =

$$Q = \int_H^0 cd \times \sqrt{2gh} \times t \times dx$$

$$Q = cd \times \sqrt{2g} \times t \times \int_H^0 \sqrt{h} \times dh$$

$$Q = cd \times \sqrt{2g} \times t \times \int_H^0 h^{1/2} \times dh$$

$$Q = cd \times \sqrt{2g} \times t \times \left[\frac{h^{3/2}}{3/2} \right]_H^0$$

$$Q = \frac{2}{3} cd \times \sqrt{2g} \times t \times H^{3/2}$$

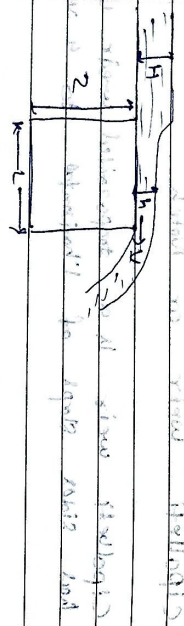
\$\therefore\$ find the discharge of water flowing over a rectangular notch of 2m length when the constant head over the notch is 300 mm take \$cd = 0.6\$.

$$Q = \frac{2}{3} \times 6 \times \sqrt{2g} \times 1 \times 1.62^{\frac{3}{2}}$$

$$Q = \frac{2}{3} \times 6 \times 1.62 \times \sqrt{2 \times 9.81} \times 1 \times 1.62^{\frac{3}{2}}$$

$$Q = 8.661 \text{ m}^3/\text{s}$$

* Discharge over a broad crest weir



A weir having a crest height H is known as broad crest weir.

Let H = height of water above crest

L = length of crest

h = head of water over weir

V = velocity of flow over the weir

If H is greater than h

It is called broad crest weir

Applying Bernoulli's equation

$$\frac{V^2}{2g} + h = \frac{V^2}{2g} + 0$$

$$V^2 = 2gh$$

$$V = \sqrt{2gh}$$

$$Q = C_d \times L \times h \times \sqrt{2gh}$$

$$Q = C_d \times L \times h \times \sqrt{2gh} = \frac{2}{3} C_d L \sqrt{2g} h^{\frac{3}{2}}$$

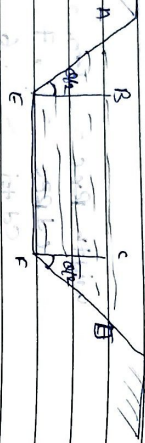
$$\frac{dQ}{dh} = 0$$

$$\frac{d}{dh} \left(\frac{2}{3} C_d L \sqrt{2g} h^{\frac{3}{2}} \right) = 0$$

$$\frac{2}{3} C_d L \sqrt{2g} \times \frac{3}{2} h^{\frac{1}{2}} = 0$$

$$C_d \times L \times \sqrt{2g} h^{\frac{1}{2}} = 0$$

Discharge over a trapezoidal notch or weir



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

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

* Find the discharge of a trapezoidal notch which is 1m wide at the top and 0.4m at the bottom and is 0.62m in height. The breadth of water on the notch is 20cm, estimate cd for Rect portion 0.62 while for triangular portion 0.60.

Solution

top = 1m, width
bottom = 0.4m,
height = 0.62m

$$H = 0.62m = 0.3m$$

$$\tan \theta = \frac{0.3}{0.3}$$

$$\tan \theta = 1$$



If velocity of approach considered
 $Q = \frac{2}{3} \times cd \times \sqrt{2g} \left[(H + h_a)^{3/2} - h_a^{3/2} \right]$
 $V_a = \frac{Q}{A} \text{ m/s} \quad h_a = \frac{V_a^2}{2g} \text{ m}$

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

$$Q = \frac{2}{3} \times 0.62 \times \sqrt{2 \times 9.81} \times 0.4 \times 10^{3/2} + \frac{8}{15} \times 0.62 \times \sqrt{2 \times 9.81} \times 10^{5/2}$$

$$Q = 0.090 \text{ m}^3/\text{s}$$

Ans.

* Cipolletti weir or notch

Cipolletti weir is a trapezoidal weir which has side slopes of 1 horizontal to 4 vertical.

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

* Find the discharge over a Cipolletti weir of length 2m when the head over the weir is 1m. Take $cd = 1.62$

Solution

Given data:

$$cd = 1.62$$

$$L = 2 \text{ m}$$

$$H = 1 \text{ m}$$

Depth

Given data

Rec wide = 1m

$H_{rec} = 150 \text{ mm}$

150×10^{-3}

$= 0.15 \text{ m}$

$C_{d, rec} = 0.62$

$C_{d, tri} = 0.59$

$\theta = 90^\circ$

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

$$Q = 0.106 \text{ m}^3/\text{s}$$

for triangular

$$Q = C_d \times \frac{2}{3} \times \tan \frac{\theta}{2} \times \sqrt{2g} \times H^{5/2}$$

$$Q = 0.106 = \frac{0.59 \times 2}{15} \times \tan \frac{90}{2} \times \sqrt{2g} \times H^{5/2}$$

$$H = 0.356 \text{ m}$$

Ans

Water flows through a triangular pipe angle weir first and then over a rectangular weir of 1m width, the discharge coefficient of the triangular and rectangular weir are 0.62 & 0.59 respectively. If the depth of water

over the triangular weir is 360mm find the depth of water over the rectangular weir.

Depth

width Rec = 1m = 1

$C_{d, rec} = 0.7$

$C_{d, tri} = 0.6$

$H_{tri} = 360 \text{ mm}$

$\theta = 90^\circ$

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

$$Q = \frac{0.6 \times 2}{15} \times \tan \frac{90}{2} \times \sqrt{2g} \times H^{5/2}$$

$Q = 0.110 \text{ m}^3/\text{s}$

for rec

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

$$0.110 = \frac{2}{3} \times \frac{0.7 \times \sqrt{2g} \times 1 \times H^{3/2}}{15}$$

$$H = 0.14 \text{ m}$$

UNIT - 4

① Darcy's formula

$$h_f = \frac{4fLV^2}{2gd}$$

L = length of pipe
 d = diameter of pipe
 V = velocity of flow

$$f = \frac{16}{Re}$$

$$Re < 2000$$

$$f = \frac{0.079}{Re}$$

$$Re > 4000$$

$$Re = \frac{VD}{\nu}$$

② Chezy's formula

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

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

$$i = \frac{h_f}{L}$$

* find the head lost due to friction in a pipe of diameter 300mm and length 50 m through which water is flowing at a velocity of 3 m/s using

① Darcy's formula

② Chezy's formula

for which $C = 60$, take $\nu = 0.01 \text{ stokes}$

* Discharge over a narrow Crested weir

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

* Q over an ogee weir

Ogee weir is the crest of the weir
ribbed up to maximum height of 0.115H

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

$$Q = C_d \times L \times \sqrt{\frac{H^3}{g} \left(\frac{2}{3} \right)}$$

$$Q = C_d \times L \times \sqrt{\frac{2g}{9} \left[\frac{4}{3} H^3 - \frac{2}{27} H^3 \right]}$$

$$= C_d \times L \times \sqrt{\frac{2g}{9} \left[\frac{4}{3} H^3 - \frac{2}{27} H^3 \right]}$$

$$= C_d \times L \times \sqrt{2g} \times 0.3849 H^{3/2}$$

$$Q = 1.705 \times C_d \times L \times H^{3/2}$$

If velocity approach is consider

$$Q = 1.705 \times C_d \times L \times \left[(H + h_a)^{3/2} - h_a^{3/2} \right]$$

- ★ A broad crested weir of 50 m length has 50 cm height of water above it crest. Find the maximum discharge take $C_d = 0.60$
- ① Neglect velocity approach
- ② If the velocity of approach is to be taken consideration find the maximum discharge when the channel has a cross section area of 50 m² on the up stream site.

given data

$$L = 50 \text{ m}$$

$$H = 11.5 \text{ m}$$

$$C_d = 0.60$$

$$A = 50 \text{ m}^2$$

$$Q = 1.705 \times C_d \times L \times H^{3/2}$$

$$Q = 1.705 \times 0.60 \times 50 \times (0.5)^{3/2}$$

$$Q = 18.08 \text{ m}^3/\text{s}$$

$$V_a = \frac{Q}{A} = \frac{18.08}{50}$$

$$V_a = 0.361 \text{ m/s}$$

$$h_a = \frac{V_a^2}{2g} = \frac{(0.361)^2}{2 \times 9.81} = 0.00664 \text{ m}$$

$$Q = 1.705 \times 0.60 \times 50 \times \left[(0.5 + 0.00664)^{3/2} - (0.00664)^{3/2} \right]$$

$$Q = 18.41 \text{ m}^3/\text{s}$$

$$Q = AV$$

$$0.3 = \frac{\pi}{4} \times d^2 \times V$$

$$V = 4.24 \text{ m/s}$$

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

$$Re = \frac{0.3 \times 4.24}{14 \times 10^{-4}}$$

$$Re = 91800$$

$$f = \frac{16}{Re} = \frac{16}{91800} = 1.74 \times 10^{-4}$$

$$f = \frac{0.039}{91800} = 4.25 \times 10^{-5}$$

$$hf = \frac{4fLV^2}{2gd}$$

$$hf = 4 \times 4.25 \times 10^{-5} \times 50 \times (4.24)^2$$

$$hf = 0.308$$

$$h = 3.61 \text{ m}$$

An oil of sp. g. 0.7 is flowing through a pipe of diameter 30mm at the rate of 500 L/s. Find the head lost due to friction and power required to maintain the flow for a length of 100m take $\lambda = 0.29$ stokes.

$$\text{Sp. g. of oil} = 0.7$$

$$\text{dia} = 30 \text{ mm}$$

$$Q = 500 \text{ L/s}$$

$$Q = 0.5 \text{ m}^3/\text{s} = 0.5 \text{ m}^3/\text{s}$$

$$\text{We know } Q = AV$$

$$0.5 = \frac{\pi}{4} \times (0.03)^2 \times V$$

$$V = 7.07 \text{ m/s}$$

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

$$Re = 0.3 \times 7.07$$

$$Re = 2137.003$$

Find the diameter of a pipe of length 200m when the rate of flow of water through the pipe is 200 l/s and the head loss due to friction is 4m. Take the value of $C = 50$.

Given data

$$L = 200 \text{ m}$$

$$Q = 200 \text{ l/s} = 0.2 \text{ m}^3/\text{s}$$

$$V = \frac{Q}{A} = \frac{0.2}{\frac{\pi}{4} d^2}$$

$$h_f = 4 \text{ m}$$

$$C = 50$$

$$L = 200 \text{ m}$$

$$L = 200 \text{ m}$$

$$L = 200 \text{ m}$$

$$L = 200 \text{ m}$$

$$L = 200 \text{ m}$$

$$V = 0.2 \text{ m/s}$$

$$Q = 200 \text{ l/s}$$

$$Q = 200 \text{ l/s}$$

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

$$Q = 200 \text{ l/s}$$

$$d = 0.032 \text{ m}$$

$$Q = 200 \text{ l/s}$$

$$Q = 200 \text{ l/s}$$

$$d = 0.05 \text{ m}$$

A crude oil of kinematic viscosity $4 \text{ cm}^2/\text{s}$ is flowing through a pipe of diameter 20mm at the rate of 200 l/s. Find the head lost due to friction for a length of 50m of the pipe.

Given data

$$V = 4 \text{ cm}^2/\text{s}$$

$$V = 4 \times 10^{-4} \text{ m}^2/\text{s}$$

$$d = 20 \text{ mm}$$

$$d = 0.02 \text{ m}$$

$$Q = 200 \text{ l/s}$$

$$Q = 0.2 \text{ m}^3/\text{s}$$

$$L = 50 \text{ m}$$

Shedule

Given data:

$$\begin{aligned} \text{dia} &= 300 \text{ m} \\ &= 0.3 \text{ km} \\ v &= 0.3 \text{ mile} \\ &= 0.01 \times 10^4 \text{ m}^2/\text{s} \end{aligned}$$

Density

$$\begin{aligned} \rho &= 5 \times 10^3 \\ &= 0.01 \times 10^4 \end{aligned}$$

$$\rho = 0.00000$$

$$\rho = 2.4 \times 10^3$$

$$\rho = 0.003$$

$$\rho = 0.000000884$$

$$\begin{aligned} \rho &= 0.000000884 \\ &= 0.25 \times 10^3 \end{aligned}$$

Area

$$A = \pi r^2$$

$$A = 4 \times 0.000000884 \times 2.5 \times 10^3$$

$$A = 0.000000884$$

$$h_f = 2.58 \times 10^5$$

$$= 0.00002681$$

Cherry

$$v = \sqrt{m}$$

$$m = 1$$

$$h_f = 4.6 \times 10^5$$

$$2.9 \times 10^5$$

$$h_f = 4.6 \times 10^5 \times 50 \times 10^3$$

$$= 0.000000884 \times 0.03$$

$$h_f = 1.004 \times 0.98$$

Cherry

$$N = \sqrt{m}$$

$$m = \frac{d}{y} = \frac{0.3}{4} = 0.075$$

$$3 = 0.075 \times 4$$

$$1 = 0.038$$

$$j = \frac{h_f}{L} = \frac{0.038 \times 4}{50}$$

$$h_f = 1.65$$

$$Re = \frac{\rho V D}{\mu}$$

$$Re = \frac{1000 \times 1.90}{6 \times 10^{-3}}$$

$$Re = 31666.67$$

$$f = \frac{16}{Re}$$

$$f = 0.000506$$

$$h_f = \frac{f L V^3}{2 g D}$$

$$h_f = \frac{0.000506 \times 500 \times (1.90)^3}{2 \times 9.81 \times 0.006}$$

$$h_f = 463.66 \text{ m}$$

$$P = \frac{\rho g Q h_f}{1000}$$

$$P = \frac{1000 \times 9.81 \times 463.66}{1000}$$

$$Re = \frac{\rho V D}{\mu}$$

$$Re = \frac{1000 \times 1.90 \times 0.006}{6 \times 10^{-3}}$$

$$Re = 19000$$

$$f = \frac{0.079}{(Re)^{1/4}}$$

$$f = 0.0051$$

$$h_e = \frac{4 \times (5.11 \times 10^{-3}) \times 500 \times (1.90)^2}{2 \times 9.81 \times 0.006}$$

$$P = \frac{\rho g Q h_e}{1000}$$

$$P = 4.97 \text{ kW}$$

MINOR ENERGY (HEAD) LOSSES

1) loss of head due to sudden enlargement

$$h_e = \frac{(V_1 - V_2)^2}{2g}$$

2) loss of head due to sudden contraction

$$h_e = 0.375 \frac{V_2^2}{2g}$$

Water is flowing through a pipe diameter 200mm with a velocity of 3 m/s. Find the head lost due to friction for a length of 5 m. If the coefficient of friction is given by $f = \frac{0.02}{Re}$. The kinematic viscosity of water $\nu = 0.01 \text{ stokes}$

Soln
Given data.

diameter = 200mm

Velocity = 3 m/s

L = 5 m

$f = \frac{0.02}{Re}$

$\nu = 0.01 \times 10^{-4} \text{ m}^2/\text{s}$

$Re = \frac{Dv}{\nu}$

$Re = \frac{0.2 \times 3}{0.01 \times 10^{-4}}$

$Re = 600000$

$f = \frac{0.02}{600000}$

$f = 3.33 \times 10^{-8}$

$Re = 600000$

$f = 3.33 \times 10^{-8}$

hf = 4.48 x 10⁻² m

29d

hf = 4.48 x 10⁻² x 5 = 0.224 m

2.298 x 10⁻²

hf = 0.330 m

0.990 m

hf = 0.990 m

* Oil of Sp. g = 0.8 and viscosity = 0.06 poise is flowing through a pipe of diameter 200mm at the rate of 60 L/s. Find the head lost due to friction for a 50m length of pipe. Find the power required to maintain this flow.

Sp. g = 0.8
D = 200 mm = 0.2 m
Q = 60 L/s = 0.06 m³/s
L = 50 m
μ = 0.06 poise = 0.06 x 10⁻¹ Pa.s = 0.006 Pa.s

Sp. g = 0.8

Q = 60 L/s = 0.06 m³/s

L = 50 m

μ = 0.06 poise

hf = 4.48 x 10⁻² m

0.06 m³/s = π × (0.2)² × v

v = 1.90 m/s

$$F = 0.039$$

$$73137.93$$

$$F = 1060 \times 10^6$$

$$F = 4.80 \times 10^3$$

$$h_f = 461.47$$

$$29d$$

$$h_f = 4 \times \frac{f \times 0.0081 \times 10^3}{2 \times 0.81 \times 0.3} \times 1000 \times (7.0 \times 10^{-3})^2$$

$$2 \times 0.81 \times 0.3$$

$$h_f = 163.98 \text{ m}$$

$$P = \frac{f \times 0.0081 \times 10^3}{2 \times 0.81 \times 0.3} \times 1000 \times (7.0 \times 10^{-3})^2$$

$$1000$$

$$P = 300 \times 0.81 \times 0.5 \times 163.98$$

$$1000$$

$$P = 553.79$$

$$560.27$$

$$h_f = 163.98 \text{ m}$$

$$h_f = 163.98 \text{ m}$$

Calculate the discharge through a pipe

of diameter 200 mm, when the difference of pressure head between the two end of

a pipe is 50 cm. apart by a meter of water

find the value of f if 0.009 in the

formula

Given data

$$d = 200 \text{ mm}$$

$$L = 50 \text{ m}$$

$$P_1 - P_2 = 0.009 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$h_f = 4 \text{ m}$$

Head loss due to sudden contraction

$$h_c = \frac{v_2^2}{2g} \left[\frac{A_1}{A_2} - 1 \right]^2$$

$$h_c = \frac{v_2^2}{2g} \left[\frac{A_1}{A_2} - 1 \right]^2$$

$$h_c = 0.375 \frac{v_2^2}{2g}$$

$$h_c = 0.5 \frac{v_2^2}{2g}$$

$$h_c = k \frac{v_2^2}{2g}$$

A horizontal pipe of diameter 50mm is suddenly contracted to a diameter of 25mm. The pressure intensity in the large and smaller pipe is given by 13.74 N/cm^2 & 11.772 N/cm^2 respectively find the loss of head due to contraction if $C_c = 0.62$ also after minor loss of flow of water

$$P_1 = 4.453 \text{ kN}$$

$$1000$$

$$P_2 = 4.453 \times 1.816$$

$$P_2 = 8.081$$

$$P_2 = 129546.49 \text{ N/m}^2$$

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

$$h_c = 1.816 \text{ m}$$

$$h_c = \frac{v_2^2}{2g} (1.95 - 1.95)^2$$

$$h_c = \frac{v_2^2}{2g} (1.95 - 1.95)^2$$

$$v_2 = 1.989$$

$$0.25 = \frac{4}{\pi \times (0.4)^2} \times v_2$$

$$A_1 v_1 = A_2 v_2$$

The rate of flow of water through a horizontal pipe is 0.25 m/s in suddenly enlarged of pipe which is 200 mm in diameter. The pressure intensity in the small pipe is 11.732 N/cm² determine

- (1) Loss of head due to sudden enlargement
- (2) Pressure intensity in the large pipe.
- (3) Power lost due to enlargement

Given data

$d_1 = 200 \text{ mm}$
 $d_2 = 400 \text{ mm}$
 $V_1 = 0.25 \text{ m/s}$
 $P_1 = 11.732 \text{ N/cm}^2$
 $P_2 = 11.732 \times 10^4 \text{ N/m}^2$

$$0.25 = \frac{V_1}{A_1}$$

$$0.25 = \frac{V_1}{\frac{\pi}{4} (0.2)^2 \times V}$$

$$A = A_1$$

$$0.01 \times \frac{V_1}{V_2} = \frac{V_2}{V_1} \times (4V_1 - V_2)^2$$

$$V_2 = 0.191 \text{ m/s}$$

$$A = AV_1 = \frac{\pi}{4} \times (0.2)^2 \times V_1$$

$$0.01 = \frac{V_1}{V_2} \times (4V_1 - V_2)^2$$

$$V_1 = \frac{\frac{\pi}{4} \times (0.2)^2 \times V_1}{\frac{\pi}{4} \times (0.2)^2 \times V_2}$$

$$V_1 = \frac{A_1 \times V_2}{A_2}$$

$$A_1 V_1 = A_2 V_2$$

We know

* find the loss of head when a pipe of diameter 200 mm is suddenly enlarged to a diameter 400 mm. rate of flow of water through a pipe is 250 L/s.

Soln

$$d_1 = 200 \text{ mm}$$

$$= 0.2 \text{ m}$$

$$d_2 = 400 \text{ mm}$$

$$= 0.4 \text{ m}$$

$$Q = 250 \text{ L/s}$$

$$= 0.25 \text{ m}^3/\text{s}$$

$$Q = A_1 V_1$$

$$0.25 = \frac{\pi}{4} \times (0.2)^2 \times V_1$$

$$V_1 = 7.95 \text{ m/s}$$

$$Q = A_2 V_2$$

$$0.25 = \frac{\pi}{4} \times (0.4)^2 \times V_2$$

$$V_2 = 1.98 \text{ m/s}$$

$$h_c = \frac{(V_1 - V_2)^2}{2g}$$

$$h_c = \frac{(7.95 - 1.98)^2}{2 \times 9.81}$$

$$h_c = 1.816 \text{ m}$$

* At a sudden enlargement of a water main from 240 mm to 480 mm, the hydraulic gradient rises by 10 mm. estimate the rate of flow.

Soln

given data.

$$d_1 = 240 \text{ mm}$$

$$d_2 = 480 \text{ mm}$$

$$h = 10 \text{ mm}$$

$$Q = ?$$

We know

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

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

$$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} = \frac{V_2^2}{2g} + h_c$$

$$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} = \frac{V_2^2}{2g} + \frac{(V_1 - V_2)^2}{2g}$$

$$0.01 + \frac{V_2^2}{2g} = \frac{V_2^2}{2g} + \frac{(V_1 - V_2)^2}{2g}$$

$$P_1 - P_2 = \frac{\rho_2}{2g} + \frac{v_2^2}{2g} + h_c$$

$$\frac{P_1 - P_2}{\rho_2} = \left[\frac{v_2^2}{2g} + \frac{v_1^2}{2g} + h_c \right]$$

$$P_1 - P_2 = \rho_2 \left[\frac{v_2^2}{2g} + \frac{v_1^2}{2g} + h_c \right]$$

$$P_1 - P_2 = 0.999 \times 10^4 \times 0.2 \times 4$$

Loss of Head at the entrance of a pipe

$$h_f = \frac{v^2}{2g}$$

Loss of head at the exit of a pipe

$$h_o = \frac{v^2}{2g}$$

$$h_o = \frac{v^2}{2g} \left[\frac{1}{2} - 1 \right]^2$$

$$v_o = 0.519 \text{ m/s}$$

$$v_o = \frac{1}{2} \times 1.038 \text{ m/s}$$

$$v_o = 0.519 \text{ m/s}$$

$$h_o = \frac{v^2}{2g} \left[\frac{1}{2} - 1 \right]^2$$

$$h_o = 0.330 \text{ m}$$

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

$$P_1 + \frac{v_1^2}{2g} = P_2 + \frac{v_2^2}{2g} + 0.330$$

$$1.038 \times 10^4 + 0.145 = P_2 + 0.145 + 0.330 \times 10^4$$

$$V_1 = 1.697 \text{ m/s}$$

$$Q = A \cdot V = 0.03 \text{ m/s} / \text{sec} \cdot 6$$

$$Q = 0.18 \text{ m}^3/\text{s}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

$$d = 1.5 \text{ mm}$$

A 150 mm diameter pipe reduced in diameter abruptly to 100 mm. If the pipe carries water at 300 l/s calculate the pressure loss across the contraction take the $C_c = 0.6$

$$C_c = 0.6$$

$$0.215 = \frac{1}{\sqrt{1 + \frac{K}{C_c^2}}}$$

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

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$h_c = 0.215 \text{ m}$$

$$\frac{1.3 \times 10^4}{0.25 \times 10^4} + \frac{2.9 \times 10^4}{1.1 \times 10^4} + \frac{2.9 \times 10^4}{2.9 \times 10^4} = 5.2$$

~~$$\frac{P_r}{\sqrt{N}} + \frac{P_p}{\sqrt{N}} = \frac{P_r}{\sqrt{N}} + \frac{P_p}{\sqrt{N}}$$~~

0.25 N_2

$$\frac{1}{\sqrt{N}} \rightarrow 0$$

④ Principles of management

$$P_1 + \frac{P_2}{\sqrt{3}} + \frac{P_3}{\sqrt{3}} = \frac{P_2}{\sqrt{3}} + \frac{P_3}{\sqrt{3}}$$

$i = 0$
 $i = 24$

Q. 2 0.62

$$p_2 = \frac{1}{2} \frac{m}{m_0} \frac{v}{c} \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

0.25 m
p. 13.934 m/10m3
N/A

$m_{\text{OSC}} = 0.9$
 $m_{\text{SO}} = 0.9$
 $m_{\text{OS}} = 0.9$

Handwritten text at the bottom of the page: "Mongolian People's Republic" and "Ulaanbaatar".

$$p_1 = 13.734 \times 10^4 \text{ N/m}^2$$

$d_1 = 18.5 \text{ m}$
 $d_2 = 2.25 \text{ m}$

ac. assembly
the same thing

Q. If in the previous question the ratio of water is 300 L/s other data

1. 2. 3. 4.

$$a = \frac{\pi \cdot 0.25^2 \times 5.46}{268} = 0.00268 \text{ m}^3/\text{s}$$

$$a_2 = A_2 \sin \theta_2 \quad \text{and} \quad \theta_2 = 50^\circ$$

~~4 = 0.669 m~~

$$h_c = N^2 \cdot 0.375 = 0.569$$

$$N_2 = 5.92 \times 10^{21} \text{ molecules}$$

$$14 + 0.0031 = 14.0031$$

Figure 4

Consider

① মিনার লব্ধি সীমিত
② মাল্টিপলি মিনার

$H = 12m$

~~मसुदा =~~

2	30m
---	-----

3 = 210 m

$$d_1 = 302 \text{ mm}$$

Mr. J. C. Smith

$$13 = 4.50 \text{ mm}$$

$\frac{1}{2} \times 100 = 50$

370000 21.8

$$\frac{p_c}{\frac{1}{2} \pi n} + \frac{p_c}{\frac{1}{2} \pi n} + \frac{p_c}{\frac{1}{2} \pi n} + \frac{p_c}{\frac{1}{2} \pi n} + \frac{p_c}{\frac{1}{2} \pi n} = H$$
$$\frac{P}{N} + \frac{P}{N} + \frac{P}{N}$$
$$\begin{aligned} A_1 &= \frac{1}{\sqrt{2}} (P_1^2 + P_2^2) \\ A_2 &= \frac{1}{\sqrt{2}} (P_1^2 - P_2^2) \\ A_3 &= \frac{1}{\sqrt{2}} (P_1^2 + P_2^2) \\ A_4 &= \frac{1}{\sqrt{2}} (P_1^2 - P_2^2) \end{aligned}$$
$$A_1 V_1 = A_2 V_2$$
~~$$V_1 = \Delta_1 \times V_2 = 0.00025 \times 2.556 \times 10^{-2} = 0.000642 V_2$$~~
$$A^2 v_2 = A^3 v_3$$

$\sqrt{g}$

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

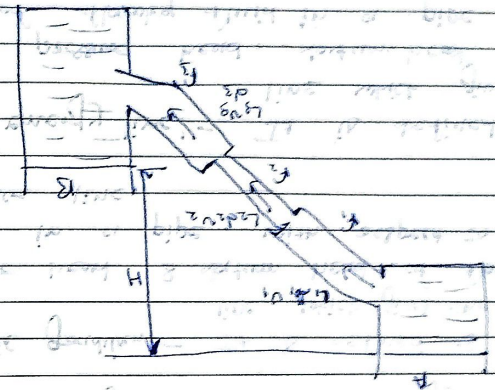
$$10 = 2.5 \times 0.442 \sqrt{z} + 4 \times 0.005 \times 0.442 \sqrt{z} - 1 + 0.001 \times 2 \times 0.8$$
$$+ 5x^2 + 4x + 130x + 0.0052x^3 + 9.81x^2 \times 2$$
$$(v_2 - 0.248v_1)^2 + 4 \times 0.0049 \times 0.248^2 v_1^2$$
$$+ 0.24 \times 10^2$$
~~$$5 \times 2.5 \times 10^{-3} \times \frac{4.9 \times 10^{-4}}{2} = 21$$~~
$$12 = 0.0049v_1^2 + 0.19v_1 + 0.025v_2^2 + 0.90v_2$$
$$+ (u_2 - 0.24u_2) + 0.03u_2 + 0.003u_2$$
$$V_2 = 2.86$$

respect to same reference line.

Flow through pipes in series or flow through compound pipe

Pipe in series in a compound pipe are defined as the pipe of different length and different diameter connected end to end to form a pipe line.

Let
 l_1, l_2, l_3 = length of pipe 1, 2, 3,
 u, v, w = velocity of pipe 1, 2, 3
 d_1, d_2, d_3 = diameter of pipe 1, 2, 3
 f_1, f_2, f_3 = coefficient of friction
 H = difference of water level in the two tanks.



$$Q = A_1 v_1 = A_2 v_2 = A_3 v_3$$

The difference in liquid surface level = Sum of the total head loss in the pipe

$$H = \frac{8 f_1 l_1 v^2}{g d_1^5} + \frac{8 f_2 l_2 v^2}{g d_2^5} + \frac{8 f_3 l_3 v^2}{g d_3^5} + \frac{v^2}{2g}$$

$$+ \frac{4 f_2 l_2 v^2}{g d_2^5} + \frac{v^2}{2g}$$

Neglect all minor losses

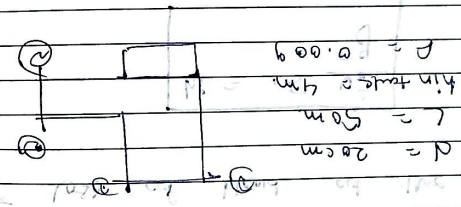
$$H = \frac{8 f_1 l_1 v^2}{g d_1^5} + \frac{8 f_2 l_2 v^2}{g d_2^5} + \frac{8 f_3 l_3 v^2}{g d_3^5}$$

$$\text{Let } f_1 = f_2 = f_3 = f$$

$$\frac{4 f}{g} \left[\frac{l_1 v^2}{d_1^5} + \frac{l_2 v^2}{d_2^5} + \frac{l_3 v^2}{d_3^5} \right]$$

* The difference in water surface level in two tanks which are connected by three pipe in series of length 300 m, 130 m, 820 m. & of dia. 30 mm, 20 mm, 40 mm respectively. & coefficient of friction are 0.005, 0.0052, 0.0048 respectively.

* Determine the rate of flow of water through a pipe of dia 20 cm and length 50 m when the one end of the pipe is connected to a tank and other end of pipe is open to the atmosphere. The pipe is horizontal and the height of water in the tank is 4 meter above the center of the pipe. Consider our minor losses and take $f = 0.009$ in the formula $h_f = \frac{4fLV^2}{2gd}$.



late km

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_{\text{all losses}}$$

$$0 + 0 + 4 = 0 + \frac{V_2^2}{2g} + 0 + h + h_f$$

$$V_2 = 2V$$

Hydraulic Gradient & Total energy line
 Hydraulic gradient - It is defined as the line which gives the sum of pressure head & velocity head of flowing fluid in a pipe with respect to some reference line.
 Total energy line - It is defined as the line which gives the sum of pressure head, velocity head & kinetic head of flowing fluid in a pipe with respect to some reference line.

$$h_f = \frac{4fLV^2}{2gd}$$

$$h_f = \frac{4 \times 0.009 \times 50 \times V^2}{2 \times 9.81}$$

$$h_f = 0.09 V^2$$

$$4 = \frac{V^2}{2g} + 0.09 V^2 + 0$$

$$4 = \frac{V^2}{19.62} + 0.09 V^2$$

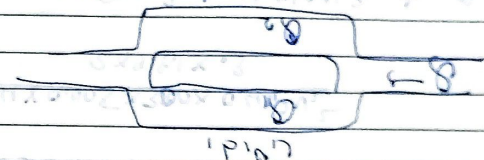
$$4 = V^2 \left(\frac{1}{19.62} + 0.09 \right)$$

$$4 = V^2 (0.051 + 0.09)$$

$$4 = V^2 (0.141)$$

$$V^2 = \frac{4}{0.141}$$

$$V = 5.33 \text{ m/s}$$



Consider a main pipe which divides in to two or more branches & again join together down stream to form a single pipe then the branch pipe & outlet connected in parallel.

The discharge through the main pipe is increased by connecting pipe in parallel.

* Flow through parallel pipe

$$Q = Q_1 + Q_2 = 0.24 \times 0.354 = 0.0849$$

$$V_1 = 0.849$$

$$Q = 0.111$$

$$Q = 0.105 \times 0.84$$

$$Q = 0.100 \text{ m}^3/\text{s}$$

$$L_1 = 2000 \text{ m}, d_1 = 1 \text{ m}$$

$$L_2 = 2000 \text{ m}, d_2 = 0.5 \text{ m}$$

$$Q = 3 \text{ m}^3/\text{s}, f = 0.005$$

given data

A main pipe divides in to two parallel pipes which again joins one pipe as shown in figure. The length & diameter for the first parallel pipe are 2000 m & 1 m respectively, while the length & diameter of second parallel pipe are 2000 m & 0.5 m. The rate of flow in each pipe is total flow in the parallel pipe is 3 m³/s. The coefficient of friction for each parallel pipe is same and equal to 0.005.

$$\frac{L_1 V_1^2}{2g d_1} = \frac{L_2 V_2^2}{2g d_2}$$

$$K \frac{L_1 V_1^2}{2g d_1} = K \frac{L_2 V_2^2}{2g d_2}$$

$$f = f$$

$$\frac{L_1 V_1^2}{2g d_1} = \frac{L_2 V_2^2}{2g d_2}$$

$$16 = 1.024 v_2^2 + 0.058 v_2^2 + 1.019 v_2^2 + 0.193 v_2^2$$

$$16 = 1.294 v_2^2$$

$$v_2 = 3.54$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$16 = 1.294 v_2^2$$

$$12 = 0.199V_1^2 + 0.901V_2^2 + 0.031V_2^2$$

$$V_2 = 3.257$$

$$V_1 = 4.42 \times 3.257$$

$$V_1 = 14.39$$

$$Q = A_1 V_1$$

$$Q = 0.160 \text{ m}^3/\text{s}$$

Three pipes of 40mm, 20mm, 30mm dia have length of 40m, 20m, 30m respectively they are connected in series to make compound pipe. The end of two compound pipe are connected with two tanks whose diff. of water level is 16m. If $f = 0.005$ for the pipe. determine the discharge through the compound pipe. Neglecting first @ second minor loss & 8 then including them.

$$d_1 = 40\text{mm} \quad l_1 = 40\text{m}$$

$$d_2 = 20\text{mm} \quad l_2 = 20\text{m}$$

$$d_3 = 30\text{mm} \quad l_3 = 30\text{m}$$

$$f = 0.005$$

$$H = 16$$

$$H = \frac{5V_1^2}{2g} + \frac{5V_2^2}{2g} + \frac{5V_3^2}{2g} + \frac{4f l_1 V_1^2}{2g d_1} + \frac{4f l_2 V_2^2}{2g d_2} + \frac{4f l_3 V_3^2}{2g d_3}$$

$$\frac{(V_1 - V_2)^2}{2g} + \frac{4f l_1 V_1^2}{2g d_1} + \frac{4f l_2 V_2^2}{2g d_2} + \frac{4f l_3 V_3^2}{2g d_3}$$

$$H = \frac{4f l_1 V_1^2}{2g d_1} + \frac{4f l_2 V_2^2}{2g d_2} + \frac{4f l_3 V_3^2}{2g d_3}$$

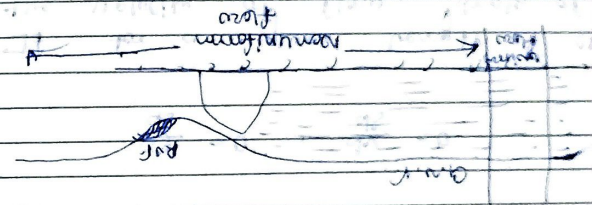
$$12 = 4 \times 0.005 \times 30 \times \frac{0.442 V_2^2}{2 \times 9.81 \times 0.03} + 2 \times 9.81 \times 0.8$$

$$4 \times 0.005 \times 2 \times 170 \times \frac{V_2^2}{2 \times 9.81 \times 0.02} + 2 \times 9.81 \times 0.2$$

$$4 \times 0.0049 \times 0.10 \times \frac{0.442 V_2^2}{2 \times 9.81 \times 0.01} + 2 \times 9.81 \times 0.4$$

If the depth of flow in a channel changes gradually over a long length of channel it is called CUF.

2. CUF :-



If a depth of flow in which a small change in depth of flow changes abruptly over a small length of channel.

① RUF :-

- * 1. Rapidly varied flow. (RUF)
- * 2. Gradually varied flow (GVF)

1. Depth :-

② Non uniform is classified in two types.

$Re < 1 \rightarrow$ sub critical
 $Re = 1 \rightarrow$ critical
 $Re > 1 \rightarrow$ super critical

$D = \frac{A}{T}$
 $A =$ wetted area to the top
 $T =$ top width of channel

$V =$ mean velocity of flow
 $D =$ hydraulic depth of channel

$Fr = \frac{V}{\sqrt{gD}}$
 $Fr =$ Froude number

4. Sub critical, critical, super critical

* The flow in open channel is said to be laminar if Re is less than 500 or less.
 * Turbulent - If Re is more than 5000 the flow is said to be turbulent in open channel.

③ Laminar flow & turbulent flow

UNIT-5 Flow in open channel

→ Flow in open channel is defined as the flow of liquid with a free surface.

→ A free surface is a surface having constant pressure, such as atmospheric pressure.

Classification of flow in channel

1) Steady Flow and unsteady flow.

If the flow characteristics such as depth of flow, velocity of flow, rate of flow at any point in open channel flow do not change with respect to time flow is said to be steady flow.

$$\frac{dV}{dt} = 0, \frac{dA}{dt} = 0, \frac{dV}{dt} = 0$$

If the flow characteristics such as rate of flow, velocity of flow, rate of flow at any point in

2. UNIFORM FLOW AND NON UNIFORM FLOW

→ Open channel flow changes with respect to time flow is said to be unsteady flow.

$$\frac{dV}{dt} \neq 0, \frac{dA}{dt} \neq 0, \frac{dV}{dt} \neq 0$$

* If for a given length of channel, the velocity of flow, depth of flow, slope of the channel and cross-section do not remain constant. The flow is said to be uniform.

$$\frac{dV}{dt} = 0, \frac{dA}{dt} = 0, \frac{dV}{dt} = 0$$

* If for a given length of channel, the velocity of flow, depth of flow, slope of the channel and cross-section do not remain constant. The flow is said to be non uniform.

$$\frac{dV}{dt} \neq 0, \frac{dA}{dt} \neq 0, \frac{dV}{dt} \neq 0$$

$Q_1 = Q_2$
 $A_1 V_1 = A_2 V_2$
 $1.11 \times 2.18 = 2.41 \text{ m/s}$
 $V_1 = 2.41 \text{ m/s}$
 $V_2 = 2.18 \text{ m/s}$
 $Q = Q_1 + Q_2$
 $Q = \frac{4}{\pi} \times 1.11^2 \times 2.18 + \frac{4}{\pi} \times 0.8^2 \times V_2$
 $3 = \frac{4}{\pi} \times 1.11^2 \times 2.18 + \frac{4}{\pi} \times 0.8^2 \times V_2$
 $3 = 3.41 + 0.8^2 \times V_2$
 $0.8^2 \times V_2 = 3 - 3.41$
 $0.64 \times V_2 = -0.41$
 $V_2 = \frac{-0.41}{0.64} = -0.64 \text{ m/s}$
 $Q_1 = Q_2$
 $A_1 V_1 = A_2 V_2$
 $1.11 \times 2.18 = 2.41 \text{ m/s}$
 $V_1 = 2.41 \text{ m/s}$
 $V_2 = 2.18 \text{ m/s}$
 $Q = Q_1 + Q_2$
 $Q = \frac{4}{\pi} \times 1.11^2 \times 2.18 + \frac{4}{\pi} \times 0.8^2 \times V_2$
 $3 = \frac{4}{\pi} \times 1.11^2 \times 2.18 + \frac{4}{\pi} \times 0.8^2 \times V_2$
 $3 = 3.41 + 0.8^2 \times V_2$
 $0.8^2 \times V_2 = 3 - 3.41$
 $0.64 \times V_2 = -0.41$
 $V_2 = \frac{-0.41}{0.64} = -0.64 \text{ m/s}$

$Q_1 = Q_2$
 $A_1 V_1 = A_2 V_2$
 $1.11 \times 2.18 = 2.41 \text{ m/s}$
 $V_1 = 2.41 \text{ m/s}$
 $V_2 = 2.18 \text{ m/s}$
 $Q = Q_1 + Q_2$
 $Q = \frac{4}{\pi} \times 1.11^2 \times 2.18 + \frac{4}{\pi} \times 0.8^2 \times V_2$
 $3 = \frac{4}{\pi} \times 1.11^2 \times 2.18 + \frac{4}{\pi} \times 0.8^2 \times V_2$
 $3 = 3.41 + 0.8^2 \times V_2$
 $0.8^2 \times V_2 = 3 - 3.41$
 $0.64 \times V_2 = -0.41$
 $V_2 = \frac{-0.41}{0.64} = -0.64 \text{ m/s}$
 $Q_1 = Q_2$
 $A_1 V_1 = A_2 V_2$
 $1.11 \times 2.18 = 2.41 \text{ m/s}$
 $V_1 = 2.41 \text{ m/s}$
 $V_2 = 2.18 \text{ m/s}$
 $Q = Q_1 + Q_2$
 $Q = \frac{4}{\pi} \times 1.11^2 \times 2.18 + \frac{4}{\pi} \times 0.8^2 \times V_2$
 $3 = \frac{4}{\pi} \times 1.11^2 \times 2.18 + \frac{4}{\pi} \times 0.8^2 \times V_2$
 $3 = 3.41 + 0.8^2 \times V_2$
 $0.8^2 \times V_2 = 3 - 3.41$
 $0.64 \times V_2 = -0.41$
 $V_2 = \frac{-0.41}{0.64} = -0.64 \text{ m/s}$

$$\begin{array}{r} 10 \\ 20 \\ \hline 30 \end{array}$$

Diksha Feb 5, 2026, 12:54

$$Q = A \times V$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

$$Q = 1.44 \times 10^3$$

* Empirical formula for value of C

1) Bazin's formula:-

$$C = \frac{149}{1 + K \sqrt{N}}$$

K = Bazin's constant
 m = Hydraulic radius / Hydraulic depth

2. Chezy's formula:-

$$C = \frac{47.5}{1 + \frac{23 + 0.00155}{\sqrt{N}}}$$

N = Kutter's constant

3. Manning's formula

$$C = \frac{1.49}{N}$$

N = Manning's Constant

* find the discharge through a rectangular channel 0.5m wide having depth of water 1.5m and bed slope as 1 in 2000. the value of $K = 2.36$ in Bazin's formula



$$b = 0.5$$

$$d = 1.5$$

$$K = 2.36$$

$$A = b \times d = 0.5 \times 1.5 = 0.75 \text{ m}^2$$

$$P = b + 2(d) = 0.5 + 2(1.5)$$

$$P = 3.5 \text{ m}$$

$$C = \frac{1.49}{N} = \frac{1.49}{2.36} = 0.631$$

* Find the bed slope of trapezoidal channel through the channel is $30 \text{ m}^3/\text{s}$ when the depth of water 3m and side slope $3:4$ where the discharge is $30 \text{ m}^3/\text{s}$.



Given data
 $d = 3 \text{ m}$
 $b = 6$
 $c = 7.5$
 $d = 3$
 $e = 2.25 \text{ m}$
 $f = 3 \times 3$
 $g = 2.25 \text{ m}$
 $h = 30 \text{ m}^3/\text{s}$

$$A = \left[\frac{a+b}{2} \right] \times h = \left[\frac{6+10.5}{2} \right] \times 3 = 24.75 \text{ m}^2$$

Perimeter = $AB + BC + CD + DE + EF + FG + GH + HI + IJ + JK + KL + LM + MN + NO + OP + PQ + QR + RS + ST + TU + UV + VW + WX + XY + YZ + ZA$

$$AD = \sqrt{AE^2 + DE^2}$$

$$AB = 9.75 \text{ m}$$

Perimeter = $3.75 + 6 + 3.75$

$$= 6 + 2 \times 3.75$$

$$= 13.5 \text{ m}$$

$$= 13.5 \text{ m}$$

$$30 = 24.75 \times 3 \times \sqrt{13.5}$$

$$\sqrt{24.75 \times 13.5} = 30$$

$$24.75 \times 13.5 = 30$$

Squaring both side

$$24.75 \times 13.5 = 30$$

$$900 \times 13.5$$

$$612.56 \times 4900 \times 24.75$$

$$12150$$

$$74286214$$

$$74286214$$

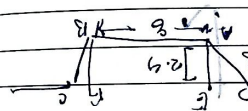
$$6114.25$$

$$\text{Side slope} = \frac{1}{3}$$

$$L = 50$$

$$d = \text{depth of water} = 2.4 \text{ m}$$

$$b = 6 \text{ m}$$



Given data

Find the discharge through a trapezoidal channel of width 6m & side slope of 1 horizontal to 3 vertical the depth of water is 2.4m and the bed of channel is 1 in 4000

$$K = 3.903 \text{ m}^{3/2}$$

$$Q = AV$$

$$A = K \sqrt{S}$$

$$Q = K \sqrt{S}$$

$$Q = AV$$

$$Q = 20.96 \text{ m}^3/\text{s}$$

$$Q = 21.12 \times 50 \times \sqrt{\frac{21.12}{13.04} \times \frac{1}{4000}}$$

$$m = \frac{b}{p}$$

$$p = 13.04 \text{ m}$$

$$\text{Perimeter} = AB + BC + [AD + DC] = 6 + 2.4 + [2.52 + 2.52]$$

$$AB = 2.52 \text{ m}$$

$$AD = \sqrt{2.4^2 + 3^2}$$

$$AD = \sqrt{AC^2 + DC^2}$$



$$A = [6 + 2.4] \times 2.4 = 21.12 \text{ m}^2$$

$$Q = AV = 20.96 \text{ m}^3/\text{s}$$

$$Q = AV$$

$$Q = AV$$

$$\text{Hydraulic radius} = \frac{\text{Area}}{\text{Perimeter}}$$

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

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

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

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

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

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

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

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

Ans

$$Q = 10.32 \text{ m}^3/\text{s}$$

$$Q = 8 \times 50 \times \sqrt{1 \times 1}$$

$$Q = 400 \text{ m}^3/\text{s}$$

$$m = \frac{2}{3}$$

$$h = 1.5 \text{ m}$$

$$C = 50$$

$$S = 1/1500$$

Given data

A rectangular channel of width 4m is having bed slope of 1 in 1500 find the maximum discharge through the channel. Take value of $C = 50$.

$$M = \frac{P}{A} = \frac{b^3 d}{b^2 d} = \frac{b d}{d} = b$$

$$\text{Economic Rectangular channel} = b = 2d$$

Most economic section of channel.

$$b = 2d$$

$$1400 = 324 \times 1301.04 \times 18 \times 11.2$$

$$400 \times 11.2$$

$$324 \times 1301.04 \times 18$$

$$4480$$

$$7587665.29$$

$$1 =$$

$$7587665.29$$

$$4480$$

$$1 = \frac{1693.67}{4480}$$

Ad

$$AD = \sqrt{AC^2 + DC^2}$$

$$AD = \sqrt{8^2 + 2^2}$$

$$AD = 8.60$$

$$A = \left[\frac{a+b}{2} \right] \times h = \left[\frac{4+8}{2} \right] \times 3 = 18 \text{ m}^2$$

$$P = b + 2 \times \text{radius} \times \pi \times 3$$

$$P = 4 + 2(3.60)$$

$$P = 11.2 \text{ m}^2$$

$$\frac{1}{11.2} \times \left[\frac{16}{0.03} \right]^{11.2}$$

$$\textcircled{2} = AD$$

$$\textcircled{2} = A \times C \text{ m}^2$$

$$00 = 16 \times 3607 \times 18 \times 11.2$$

$$00 = 3 \times 3$$

$$00 = 5 \times 1$$

$$C = \frac{1}{N} \text{ m}^6$$

$$C = 1 \times \left[\frac{3}{5} \right]^{1/6}$$

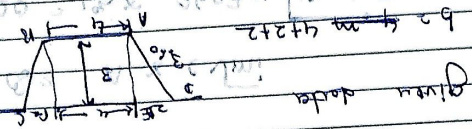
$$C = 0.853$$

$$Q = AV$$

$$Q = 3 \times 0.53 \times \sqrt{\frac{3}{5} \times \frac{5}{4} \times 8000}$$

$$Q = 3.976 \text{ m}^3/\text{s} \text{ Ans.}$$

Find the bed slope of trapezoidal channel of bed width 4m. depth of water 3m. side slope of 2:1 when the discharge is 20 m³/s. Chezy coefficient $N = 0.03$ is taken minimum.



$$b = 4 \text{ m}$$

$$d = 3 \text{ m}$$

$$N = 0.03$$

$$Q = 20 \text{ m}^3/\text{s}$$

$$N = 0.03$$

$$Q = 20 \text{ m}^3/\text{s}$$

$$N = 0.03$$

$$Q = 20 \text{ m}^3/\text{s}$$

Find the discharge through a trapezoidal channel of width 2m. having bed slope 1 in 1000. The depth of flow is 1.5m. Take the value of $N = 0.012$.

$$Q = 3.37 \times 0.53 \times \sqrt{\frac{3}{5} \times \frac{5}{4} \times 2000}$$

$$Q = 3.37 \times 0.53 \times \sqrt{\frac{3}{5} \times \frac{5}{4} \times 2000}$$

$$Q = AV$$

like known

$$P = 2 + 2 \times 1.5 = 5 \text{ m}$$

$$A = 2 \times 1.5 + 1 \text{ m}^2$$

$$N = 0.012$$

$$Q = 20 \text{ m}^3/\text{s}$$

$$d = 1.5$$

$$b = 2$$

given data

$$\frac{hd}{2} = \frac{d \times 1.1}{2}$$

$$b + d = 2 \times d \times 1.1$$

$$b + d = 2.2 \times d$$

$$b = (2.2 \times d) - d$$

$$b = 2.2d - d$$

$$b = 1.236d$$

Area of trapezoid

$$A = \frac{(b + 2nd + b) \times d}{2}$$

$$A = \frac{(2b + 2nd) \times d}{2}$$

$$A = \frac{2(b + nd) \times d}{2}$$

$$A = (b + nd) \times d$$

$$40 = (1.236 + \frac{1}{2}d) \times d$$

$$d = 4.80$$

$$b = 1.236 \times d$$

$$b = 1.236 \times 4.80$$

$$b = 5.93$$

$$m = \frac{1}{2} \times \frac{4.80}{2} = 2.4$$

$$Q = A \times c \times \sqrt{m}$$

$$Q = 40 \times 50 \times \frac{\sqrt{2.4}}{1500}$$

$$Q = 80 \text{ m}^3/\text{s} \quad \text{Ans}$$

★ PUMP

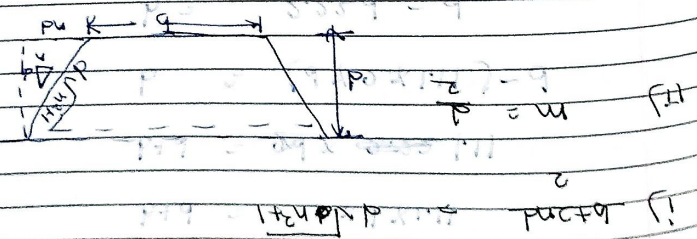
Definition:- Hydraulic machine which converts the mechanical energy into hydraulic energy are called pump.

★ Centrifugal pump:- The hydraulic energy is in the form of pressure energy if the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid. The hydraulic machine is called Centrifugal pump.

Solution
 Rectangular channel carried water at full rate of 400 cfs when bed slope is 1 in 2000 find the most economical dimension of the channel if $C = 50$.
 given data

$Q = 400 \text{ cfs}$
 $S = 1 \text{ in } 2000$
 $C = 50$
 $A = b \times d$
 $P = b + 2d$
 $R = \frac{A}{P}$
 $A = b \times d$
 $P = b + 2d$
 $R = \frac{A}{P}$
 $A = 400 \times 10^{-3} = 0.4 \times 10^3$
 $d = 0.57$
 $b = 1.14$

Most economical Trapezoidal channel



* A trapezoidal channel has side slope of 1:2 (horizontal to vertical) and rate of the slope of bed is 1 in 2000 the area of the section is 400 m² find the dimension of the section if it is the most economical determine the $\frac{Q}{A}$ of the most economical section if $C = 50$

Solution
 (1) side slope = 1:2
 $A = 400 \text{ m}^2$
 $C = 50$
 $S = 1 \text{ in } 2000$
 $b + 2nd = \frac{400 \times 10^3}{d}$
 $b + 2nd = \frac{400 \times 10^3}{d}$