The Shirpur Education Society's

R. C. Patel College of Engineering & Polytechnic, Shirpur

QUESTION BANK OF CHAPTER – 2
FUNDAMENTALS OF FLUID FLOW AND FLOW MEASUREMENT

Program Name: Diploma in Mechanical Engineering
Name of Subject & Code : Fluid Mechanics and Machinery (313309)

Program Code: ME
Semester : THIRD

Instructions: (1) Illustrate your answers with neat sketches wherever necessary.

Q.1.	Two marks questions.	Previous Exam	CO PO Mapping
1.	Define i) Unsteady flow (ii) Laminar	S25-2.b	CO2-TLO2.1-R
2.	State the Bernoulli's theorem.	W25- 1.b S25-1.g	CO2-TLO2.2-R
3.	State Continuity equation and write the expression for it.	W24-1.b	CO2-TLO2.2-R
Q.2.	**Four marks questions.**	**Previous Exam**	**CO PO Mapping**
1.	Explain Bernoulli's theorem with neat sketch. State its two important assumptions.	S25-2..c	CO2-TLO2.2-A
2.	Define the following types of the fluid flow. i) Steady flow ii) Uniform flow iii) Turbulent flow iv) Rotational flow	W25-2b S25-2.b	CO2-TLO2.1-R
3.	A venturimeter is installed in a pipe line of 30 cm diameter. The difference of pressure at entrance and throat read by mercury manometer is 5 cm, when water flows at a rate of 0.05 m3 /sec. If the coefficient for venturimeter is 0.96, determine the diameter of the throat.	W25-2.c	CO2-TLO2.3-A
4.	With neat sketch explain construction and working of pitot tube.	W25-2.d W24-3.d S25-6.b	CO2-TLO2.5-A
5.	An orifice meter with orifice diameter 150 mm is inserted in a pipe of 300 mm diameter. The pressure difference measured by a mercury-oil differential manometer gives a reading of 20 cm of mercury. Find the rate of flow of oil of sp. gravity 0.98 when Cd of meter is 0.6.	S25-4.a	CO2-TLO2.4-A
6.	Interpret turbulent or laminar flow in following situations : (i) Viscous liquid (oil) travelling on smooth surface. (ii) Water falling from top of water fall. (iii) Water flowing at high pressure through pipe. (iv) Glycerin travelling on smooth kitchen floor.	S25-3.d	CO2-TLO2.1-R
7.	A 300 mm × 100 mm Venturi meter has Cd equal to 0.93. The pipe delivers water at the rate of 1000 litre/min. What will be	W24-3.a	CO2-TLO2.3-A

	the pressure difference between inlet and the throat of venturimeter?		
8.	Define hydraulic coefficients Cd, Cv, Cc and state relation between them	W24-3.c	CO2-TLO2.4-R
9.	A venturimeter 30 cm × 15 cm size is inserted in a vertical pipe carring water flowing in the upward direction. A differential mercury manometer is connected to inlet and throat, gives reading of 20 cm. Find the discharge through venturimeter. If the meter coefficient Cd = 0.99.	S25-3.a	CO2-TLO2.3-A
10.	Describe with sketch, construction and working principle of venturimeter.		CO2-TLO2.3-A
11.	Describe the equation for actual discharge through Orifice meter by applying Bernoulli's equation.		CO2-TLO2.4-U
12.	Describe with neat sketch, construction and working principle of orificemeter.	S25-2.d	CO2-TLO2.4-A
	* * *Best of Luck* * *		

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★ Fluid Mechanics & Machinery ★

Chapter 2 :- Fundamentals of Fluid Flow & Flow Measurement.

2.1. Types of Fluid Flows :-

* Types of Flow :-

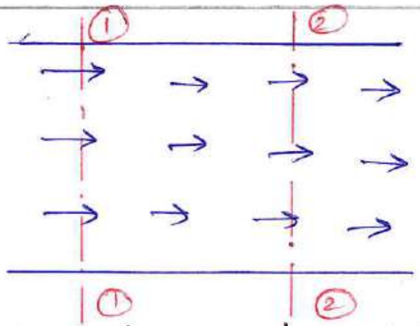
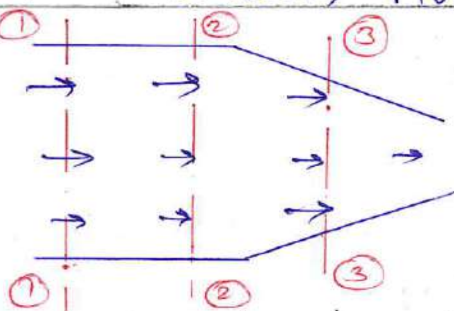
1. Steady & unsteady flow
2. Uniform & Non-uniform flow
3. Laminar & Turbulent flow
4. Rotational & Irrotational flow
5. Compressible & Incompressible flow.
6. 1-D, 2-D & 3-D flow,

1. Steady & unsteady flow :-

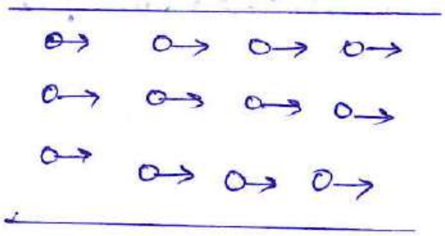
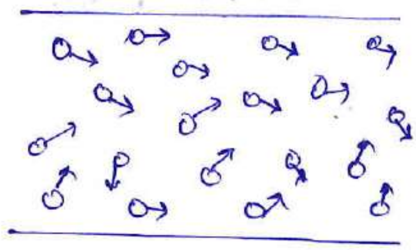
Steady Flow.	Unsteady Flow
◦ Flow properties (velocity, pressure, temp. density) do not change with time,	◦ Flow properties (v, T, P, ρ) change with time.
◦ e.g - water flowing at const. speed in a pipe	◦ e.g. - water flow when valve is opening /closing.
◦ $\frac{dP}{dt}=0, \frac{dv}{dt}=0, \frac{dT}{dt}=0$ $\frac{d\rho}{dt}=0$	◦ $\frac{dv}{dt}\neq 0, \frac{dP}{dt}\neq 0, \frac{dT}{dt}\neq 0$ $\frac{d\rho}{dt}\neq 0$
◦ Same flow at every moment	◦ Flow keeps changing.

2. Uniform & Non Uniform flow :-

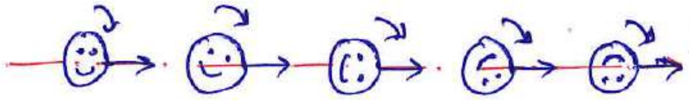
Uniform flow	Non-Uniform flow
◦ velocity is same at every point.	◦ velocity changes from point to point.

Uniform flow	Non-Uniform flow
	
• e.g. Flow in a straight pipe of same diameter.	• e.g. Flow in tapering pipe.
• $\frac{dv}{ds} = 0$	• $\frac{dv}{ds} \neq 0$
• velocity same everywhere	• Different at different places.

J. Laminar & Turbulent flow :-

Laminar flow	Turbulent flow
	
• Fluid moves in smooth layers.	• Fluid moves in irregular, zig-zag motion
• There is no mixing between layers.	• There is mixing & eddies (small whirlpools)
• e.g. - Honey flowing slowly - water flowing slowly in narrow pipe.	• e.g - River flow during flood - smoke coming out fast.
• velocity is low	• velocity is High.

4. Rotational & Irrotational flow :-

Rotational flow	Irrotational flow
 fluid particles rotating	
◦ while moving fluid particles rotate about their own axis.	◦ While moving fluid particles do not rotate.
◦ e.g. - flow of fluid in a rotating tank.	◦ e.g. - flow of fluid in a rectangular wash basin at the drain pipe.

5. Compressible & Incompressible flow :-

Compressible flow	Incompressible flow
◦ A flow in which density of fluid changes during motion	◦ A flow in which density remains constant.
◦ $\rho \neq$ const. (changes with press & temp)	◦ $\rho =$ const.
◦ Mostly occurs in gases	◦ Mostly occurs in liquids.
◦ e.g. gas flow in nozzle.	◦ e.g. oil flow in hydraulic system.

6. 1D, 2D & 3D flow :-

◦ One dimensional (1-D flow) :-

Flow varies in only one direction. velocity depends on one coordinate.

◦ Two dimensional (2-D flow) :

Flow varies in two directions (x & y). Used in surface flows.

- Three dimensional (3-D Flow):

Flow varies in three directions (x, y & z)
Most real life flows.

* Reynold's Number (Re):-

It is a dimensionless number used to predict the type of flow.

It tell us whether flow is laminar or turbulent.

$$Re = \frac{\rho . V . d}{\mu}$$

where,
- Re = Reynold's number
- ρ = density
- V = velocity of fluid
- d = diam. of pipe
- μ = dynamic viscosity.

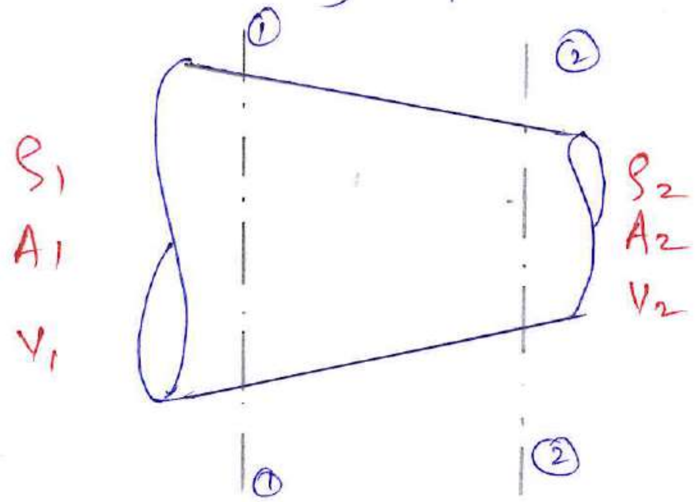
or It is a ratio of inertia force to viscous force.

- Flow classification:

	Reynold's Number	Type of Flow
1.	$Re < 2000$	→ Laminar flow
2.	$2000 < Re < 4000$	→ Transition flow
3.	$Re > 4000$	→ Turbulent flow.

2.2. Continuity Equation & Bernoulli's Theorem:.

* Continuity Equation / Continuity Law:-



It states that, quantity of fluid flowing per second is constant at all cross-section when passing through pipe.

It is based on law of conservation of mass.

Let ρ_1 & ρ_2 = density of fluid at sect ① & ② resp.

A_1 & A_2 = c/s area of pipe at section ① & ②

V_1 & V_2 = velocity of fluid at sect ① & ②

Now, Flow rate $= \rho . A . V$.

According to law of conservation of mass,

Flow rate at sect ①-① = Flow rate at sect. ②-②

$$\rho_1 . A_1 . V_1 = \rho_2 . A_2 . V_2$$

$$\boxed{A_1 V_1 = A_2 . V_2}$$ ... ($\because \rho_1 = \rho_2$) same fluid

$$\therefore \boxed{Q_1 = Q_2}$$ ... ($\because Q = A \cdot V$)

* Discharge / Flow rate / Delivery rate (Q) :-

It is the amount of fluid flowing per second. It is denoted by 'Q'.

Discharge $\boxed{(Q) = A \cdot V}$ ... m^3/s or lit/s

where A = Area of pipe ... m^2
V = velocity of fluid ... m/s

* Energy Posses by fluid :-

There are three types of energy.
1. Kinetic energy
2. Potential energy
3. Pressure energy.

1. Kinetic Energy (K.E.) :-

It is defined as ability of mass to do work by virtue of its motion.

$$\boxed{K.E. = \frac{V^2}{2g}} \quad \text{---} \quad m$$

where V = velocity of fluid
g = gravitational accln

2. Potential Energy (P.E.) :-

It is defined as ability of fluid to do work by virtue of its position.

$$\boxed{P.E = Z} \quad \text{---} \quad m$$

where Z = height from datum ... m

3. Pressure Energy (P.E.) :-

It is the energy posses by fluid by virtue of its existing pressure.

$$P.E. = \frac{P}{w} = \frac{P}{\rho . g} \quad ---- m$$

where

P = Pressure

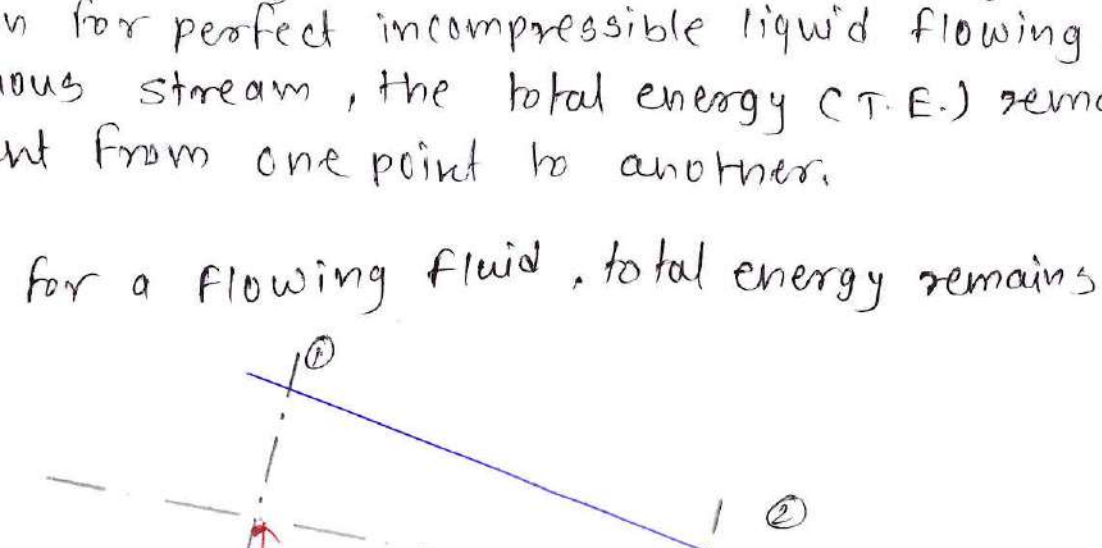
w = weight density

ρ = density

* Bernoulli's Theorem :-

According to Bernoulli's theorem," neglecting friction for perfect incompressible liquid flowing in continuous stream, the total energy (T.E.) remains constant from one point to another.

or for a flowing fluid, total energy remains constant.



$$\frac{V^2}{2g} + \frac{P}{w} + Z = \text{constant}$$

Let us consider nonuniform pipe according to bernoulli's theorem.

Total energy at Sect ① - ① = Total energy at Sect ② - ②

$$T.E_1 = T.E_2$$

$$K.E_1 + PE_1 + PE_1 = KE_2 + PE_2 + PE_2$$

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

* Assumptions in Bernoulli's theorem.

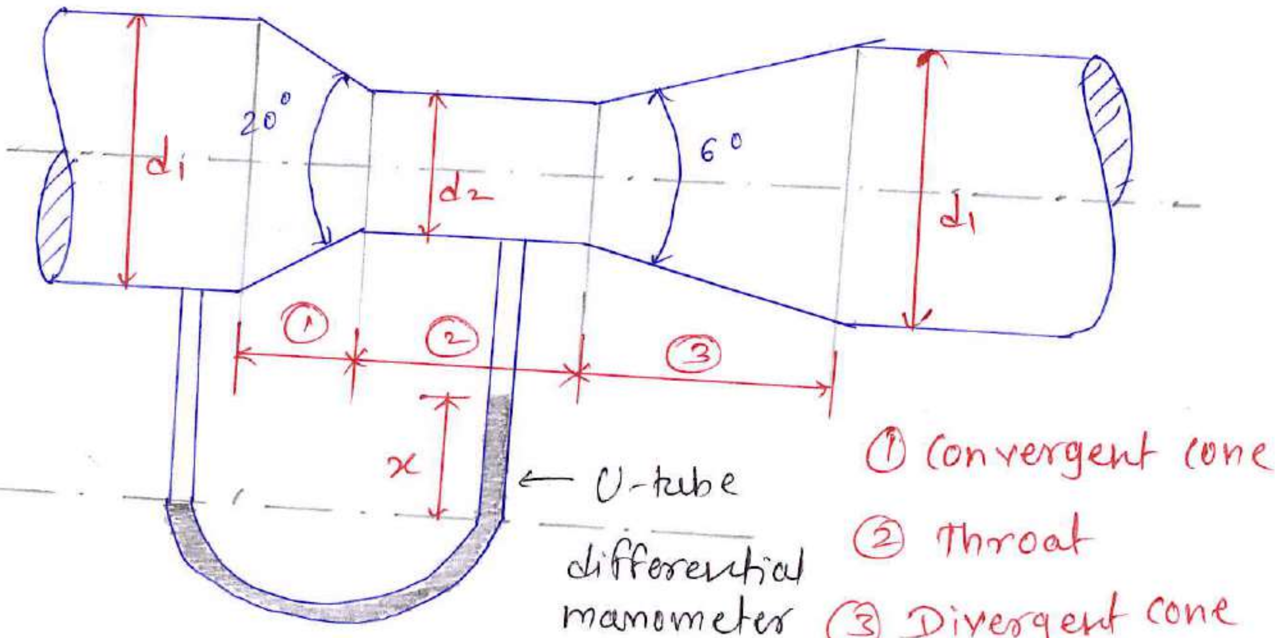
1. Flow is steady
2. Flow is frictionless or Ideal.
3. Fluid is incompressible.
4. Flow occurs along a streamline
5. Flow is irrotational
6. Pressure forces & gravity forces are only considered, viscous forces are neglected.
7. velocity is unifor over the c/s & is equal to mean velocity.

* Application of Bernoulli's theorem:-

1. Venturimeter } used to measure discharge.
2. Orifice meter }
3. Pitot Tube - used to measure velocity of fluid.

2.3 Construction & working of venturimeter, Coeff of discharge (Cd) :-

* Venturimeter :-



- Construction :

It is a device use for measuring the rate of flow fluid through close pipe. It consist of short converging cone, throat & long diverging cone.

- Working :-

By reducing C/s area of flow a pressure difference gives the quantity of liquid flowing through pipe.

The inlet & outlet of venturimeter is of same diam. (d_1). The converging cone is a pipe of decreasing C/s & divergent cone is gradually increasing C/s area. In betn this throat which is connected to convergent & divergent pipe having uniform diameter (d_2), at inlet & throat press. taps are provided to measure press. difference.

Convergent cone –	Area ↓	Pressure ↓	velocity ↑
Divergent cone –	Area ↑	Pressure ↑	velocity ↓

Let d_1 = diam. at inlet , P_1 = Pressure at inlet

d_2 = diam. at throat , P_2 = Pressure at throat

a_1 & V_1 = area & velocity at inlet

a_2 & V_2 = area & velocity at throat.

Apply Bernoulli's theorem,

$$\therefore TE_1 = TE_2$$

$$KE_1 + PE_1 + PE_2 = KE_2 + PE_2 + PE_2$$

$$\frac{V_1^2}{2g} + \frac{P_1}{w} + z_1 = \frac{V_2^2}{2g} + \frac{P_2}{w} + Z_2 \quad \text{— (1)}$$

As $Z_1 = Z_2$

$$\therefore \frac{V_1^2}{2g} + \frac{P_1}{w} = \frac{V_2^2}{2g} + \frac{P_2}{w}$$

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

$$h = \frac{V_2^2}{2g} - \frac{V_1^2}{2g} \quad \text{— (2)}$$

we know that, continuity eqn

$$a_1 V_1 = a_2 V_2$$

$$V_1 = \frac{a_2 V_2}{a_1} \quad \text{— (3)}$$

$\therefore$ eqn (2) becomes

$$h = \frac{V_2^2}{2g} - \frac{\left(\frac{a_2 V_2}{V_1}\right)^2}{2g}$$

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

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

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

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

Taking square root on both sides.

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

$$V_2 = \frac{a_1 \cdot \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \quad \text{--- (4)}$$

Now find discharge Q.

$$Q = a_2 \cdot V_2$$

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

But above eq^n gives the discharge under ideal cond^n & it is called as theoritical discharge but the actual discharge is less than theoritical discharge.

$$Q_{actual} = Cd \cdot Q_{theoritical}$$

$$\boxed{Q_{act} = \frac{Cd \cdot a_1 \cdot a_2 \cdot \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}}$$

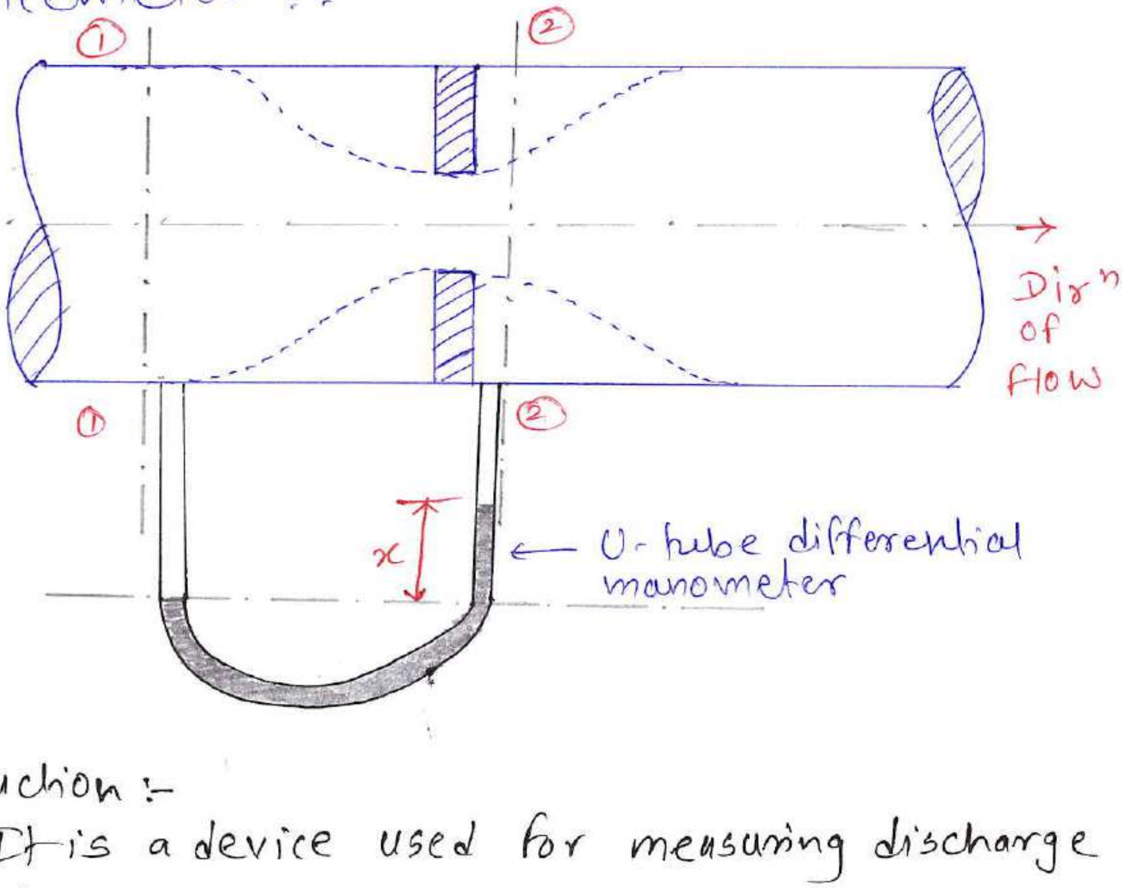
Where, C_d = Coeff. of discharge
h = can be calculated from manometer reading

$$h = x\left(\frac{S_m}{S_l} - 1\right)$$

Where, x = difference in mercury level
S_m = Sp. gravity of manometric fluid
S_l = Sp. gravity of liquid flowing through pipe.

2.4 Construction & working principle of Orificemeter, Hydraulic coefficients (C_d, C_c, C_v).

* Orificemeter :-



- Construction :-

It is a device used for measuring discharge through pipe. It works on the same principle as that of venturimeter. It consist of flat circular plate which has a circular sharp edge hole called as orifice.

Working :-

Diam. of orifice is 1/2 to 3/4 that of diam of pipe. Pressure difference betn section ① & ② is measured. Orificemeter is economical & reqd less space for fitting. At formation of vena-contracta fluid stream seperates from down stream ~~sound~~ side of orifice plate & form a free flowing jet in the downstream side.

Theoritical discharge (Q_{th}) :

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

Actual discharge (Q_{act}) :

$$Q_{act} = Cd \cdot Q_{th}$$

$$Q_{act} = \frac{Cd \cdot a_1 \cdot a_2 \cdot \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

where Cd = coeff. of discharge.

* Hydraulic Coefficients :-

1. Coefficient of velocity (Cv) :-

It is ratio betn the actual velocity of jet of vena-contracta & theoretical velocity of jet.

$$Cv = \frac{\text{Actual vel. of jet at vena-contracta}}{\text{Theoretical vel. at jet.}}$$

$$Cv = \frac{V_{act}}{V_{th}} \Rightarrow Cv = \frac{V_{act}}{\sqrt{2gh}}$$

2. Coefficient of Discharge (Cd):

It is the ratio of actual discharge to the theoretical discharge.

$$Cd = \frac{Q_{act}}{Q_{th}}$$

3. Coefficient of Contraction (Cc):

It is the ratio of area at vena-contracta to the area of orifice.

$$Cc = \frac{a_{venacontracta}}{A_{theoretical}}$$

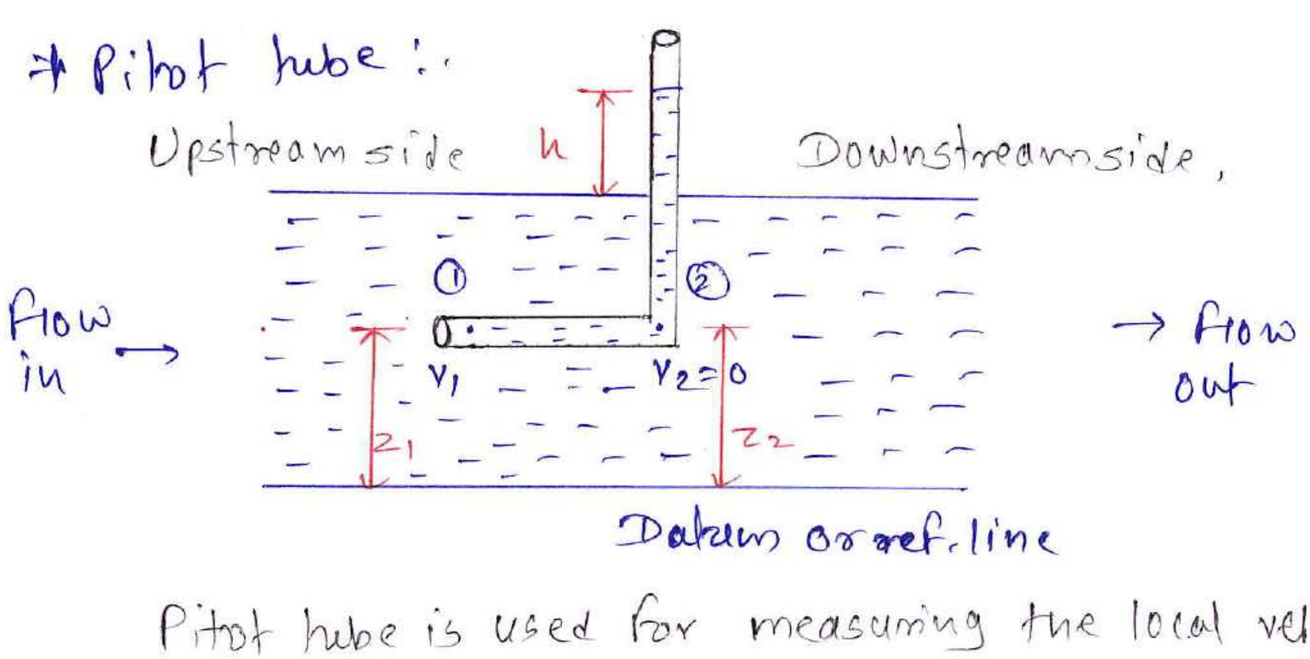
$$Cc = \frac{A_{act}}{A_{th}}$$

* Relation betn Cd, Cc & Cv:

$$Cd = Cv \cdot Cc$$

2.5 Construction & working of Pitot tube:

* Pitot tube:



Pitot tube is used for measuring the local velocity of flow at any point in a pipe or channel.

Its working principle is if velocity of flow at a point becomes zero, there is increase in pressure energy. In its simplest form, it is a glass tube bent at right angle as shown in fig.

The lower end is bend through 90° is facing the upstream dir^n. The liquid rises up in the tube due to the conversion of kinetic energy into pressure energy.

Piezometer tube gives pressure head & pitot tube gives pressure & velocity head.

The velocity is determined by measuring the rise (h) of liquid in the tube as shown in fig.

$$\text{Actual velocity} = \boxed{V = C_V \cdot \sqrt{2gh}}$$

The bent end of pitot tube should be facing the dir^n of flow of liquid otherwise there will error in calculation.

* Numerical on Continuity Eqⁿ & Bernoulli's Theorem *

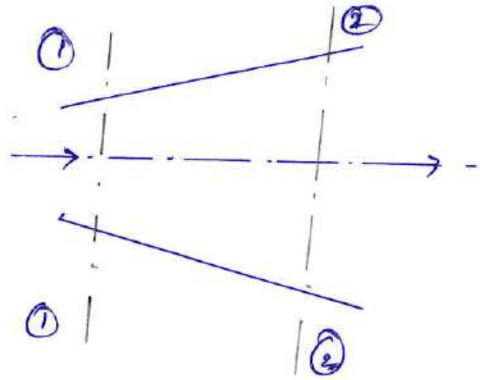
1. A conical pipe having end diam. 100 mm & 150 mm is used to supply oil. find discharge through pipe. The velocity of oil flowing through pipe at smaller diam. side is 5 m/s. Also, find velocity at larger end side.
(S-16)

→ Given data :

$d_1 = 100$ mm $= 0.1$ m

$d_2 = 150$ mm $= 0.15$ m

$V_1 = 5$ m/s



Now $a_1 = \frac{\pi}{4} \cdot d_1^2 = \frac{\pi}{4} \times (0.1)^2 = 7.853 \times 10^{-3}$ m²

$a_2 = \frac{\pi}{4} \cdot d_2^2 = \frac{\pi}{4} \cdot (0.15)^2 = 0.01767$ m²

1. Now find velocity head at sect ②

By continuity eqⁿ

$$a_1 V_1 = a_2 V_2$$

$$V_2 = \frac{7.853 \times 10^{-3} \times 5}{0.01767}$$

$$\boxed{V_2 = 2.22 \text{ m/s}}$$

∴ velocity head $= \frac{V_2^2}{2g} = \frac{(2.22)^2}{2 \times 9.81} = 0.25$ m

2. Rate of discharge :

$Q = a_1 V_1 = 7.853 \times 10^{-3} \times 5 = 0.039$ m³/s

or

$Q = a_2 V_2 = 0.01767 \times 2.22 = 0.039$ m³/s

2. A 30 cm diam pipe carrying water, branches into two pipes of 20 cm & 15 cm diam. If the mean velocity in 30 cm pipe is 2.5 m/s, find the discharge in the pipe. Also, find velocity in 15 cm pipe, if mean velocity in 20 cm pipe is 2 m/s. (W-14)

→ Given data:

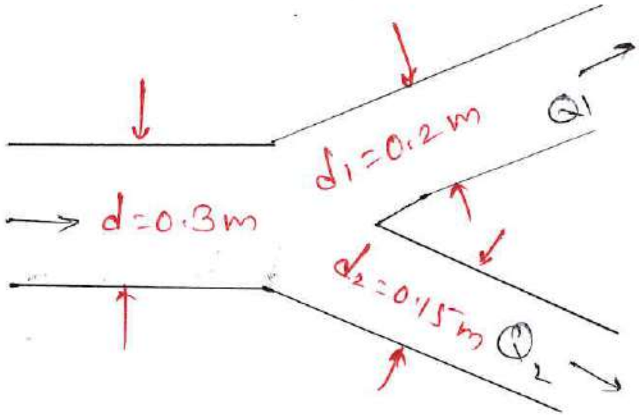
$d = 30\,cm = 0.3\,m$

$d_1 = 20\,cm = 0.2\,m$

$d_2 = 15\,cm = 0.15\,m$

$V = 2.5\,m/s$

$V_1 = 2\,m/s$



area $a_1 = \frac{\pi}{4} \cdot d_1^2 = \frac{\pi}{4} \cdot (0.2)^2 = 0.03141\,m^2$

$a_2 = \frac{\pi}{4} \cdot d_2^2 = \frac{\pi}{4} \cdot (0.15)^2 = 0.01767\,m^2$

$a = \frac{\pi}{4} \cdot d^2 = \frac{\pi}{4} \cdot (0.3)^2 = 0.07068\,m^2$

1. Now find discharge

$Q = a \cdot V = 0.07068 \times 2.5$

$$\boxed{Q = 0.1767\,m^3/s}$$

2. Now find velocity in ② pipe i.e. $d_2 = 15\,cm$

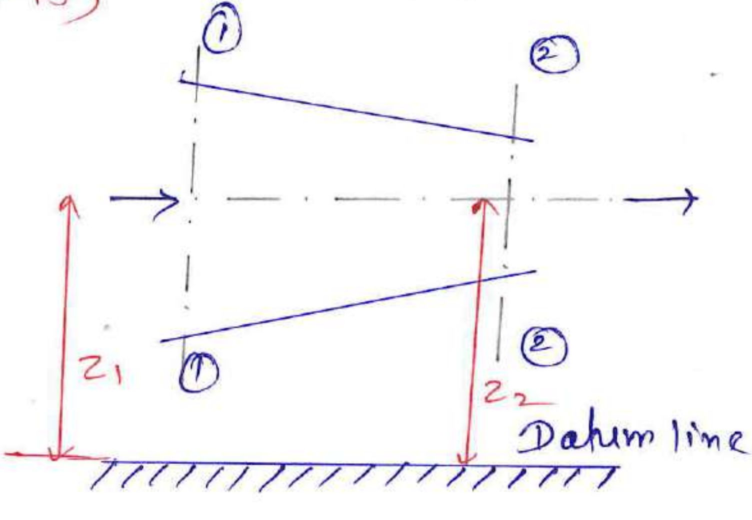
$Q = Q_1 + Q_2$

$Q = a_1 V_1 + a_2 V_2$

$0.1767 = (0.03141 \times 2) + (0.01767 \times V_2)$

$$\boxed{V_2 = 6.44\,m/s}$$

3. Discharge through a horizontal tapering pipe is 0.06 m3/s. The diam. at the inlet & outlet are 250 mm & 200 mm resp. If the water enters the pipe at a pressure of 9.81 bar, Calculate the outlet pressure. (S-13)



→ Given data:

$Q = 0.06 \; m^3/s$

$d_1 = 250 \; mm = 0.25 \; m$

$d_2 = 200 \; mm = 0.2 \; m$

$P_1 = 9.81 \; bar$
$= 9.81 \times 10^5 \; N/m^2$

Now area $a_1 = \frac{\pi}{4} \cdot d_1^2 = \frac{\pi}{4} \cdot (0.25)^2 = 0.04908 \; m^2$

$a_2 = \frac{\pi}{4} \cdot d_2^2 = \frac{\pi}{4} \cdot (0.2)^2 = 0.03141 \; m^2$

Now from continuity eqn. $\Rightarrow Q = a_1 V_1 = a_2 V_2$

$V_1 = \frac{Q}{a_1} = \frac{0.06}{0.04908} = 1.2224 \; m/s$

$V_2 = \frac{Q}{a_2} = \frac{0.06}{0.03141} = 1.9098 \; m/s$

As pipe is horizontal $z_1 = z_2$

Now Apply Bernoulli's theorem

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

$$\frac{9.81 \times 10^5}{9810} + \frac{(1.2224)^2}{2 \times 9.81} = \frac{P_2}{9810} + \frac{(1.9098)^2}{2 \times 9.81}$$

$P_2 = 979922.87 \; N/m^2$

$P_2 = 9.79922 \times 10^5 \; N/m^2$

* Numericals on Venturimeter, orificemeter & Pitot tube *

4. An orificemeter with orifice diam, 150mm is inserted in a pipe of 300 mm diam. The pressure difference measured by a mercury-oil differential manometer gives a reading of 20cm ~~diam~~ of mercury. Find the rate of flow of oil of sp. gravity 0.98, when cd of meter is 0.6. (S-25)

→ Given data:

$d_1 = 300 \text{ mm} = 0.3 \text{ m}$

$d_2 = 150 \text{ mm} = 0.15 \text{ m}$

$x = 20 \text{ cm} = 0.2 \text{ m}$

$S_o = 0.98$, $S_m = 13.6$, $C_d = 0.6$

$Q = ?$

Now find h, =>

$$h = x\left(\frac{S_m - 1}{S_e}\right) = 0.2\left(\frac{13.6}{0.98} - 1\right)$$

$\therefore$ $h = 2.575$ m of oil

Now find area a_1 & a_2

$$a_1 = \frac{\pi}{4} \cdot d_1^2 = \frac{\pi}{4} \cdot (0.3)^2 = 0.07069 \text{ m}^2$$

$$a_2 = \frac{\pi}{4} \cdot d_2^2 = \frac{\pi}{4} \cdot (0.15)^2 = 0.01767 \text{ m}^2$$

Now find discharge (Q) :

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

$$= \frac{0.6 \times 0.07069 \times 0.01767 \times \sqrt{2 \times 9.81 \times 2.575}}{\sqrt{(0.07069)^2 - (0.01767)^2}}$$

$$\boxed{Q = 0.0779 \approx 0.078 \ m^3/s}$$

5. A 300 mm × 100 mm venturimeter has Cd equal to 0.93. The pipe delivers water at the rate of 1000 lit/min. What will be the pressure difference betⁿ inlet & throat of venturimeter? (W-24)

→ Given data :

$d_1 = 300$ mm $= 0.3$ m , $Cd = 0.93$

$d_2 = 100$ mm $= 0.1$ m $Q = 1000$ lit/min

Now 1st convert Q into m^3/s

$$Q = 1000 \text{ lit/min} = \frac{1000 \times 10^{-3}}{60} = 0.01667 \ m^3/s$$

Now find area

$$a_1 = \frac{\pi}{4} \cdot d_1^2 = \frac{\pi}{4} \cdot (0.3)^2 = 0.07069 \ m^2$$

$$a_2 = \frac{\pi}{4} \cdot d_2^2 = \frac{\pi}{4} \cdot (0.1)^2 = 0.007854 \ m^2$$

we know that.

$$Q_{act} = \frac{Cd \cdot a_1 \cdot a_2 \cdot \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

$$0.01667 = \frac{0.93 \times 0.07069 \times 0.007854 \times \sqrt{2 \times 9.81 \times h}}{\sqrt{(0.07069)^2 - (0.007854)^2}}$$

$$h = 0.287 \text{ m of water}$$

Now find press. difference.

we know that $h = \frac{P}{\omega}$

$\therefore P = h \cdot \omega$

$= 0.287 \times 9810$

$$P = 2.82 \times 10^3 \ N/m^2$$

$$P = 2.82 \ kPa$$

6. A venturimeter 30 cm x 15 cm size is inserted in a vertical pipe carrying water flowing in the upward dirn. A differential mercury manometer is connected to inlet & throat, gives reading of 20 cm. find the discharge through venturimeter, If the meter coeff. Cd = 0.99

(S-25)

→ Given data:

$d_1 = 30$ cm $= 0.3$ m , $S_m = 13.6$

$d_2 = 15$ cm $= 0.15$ m , $S_e = 1$

$Cd = 0.99$

$x = 20\,cm = 0.2\,m$

Now find (h) =>

$$h = x\left(\frac{S_m}{S_l} - 1\right)$$

$$= 0.2\left(\frac{13.6}{1} - 1\right)$$

$$\boxed{h = 2.52 \text{ m of water}}$$

Now find area a_1 & a_2

$$a_1 = \frac{\pi}{4} \cdot d_1^2 = \frac{\pi}{4} \cdot (0.30)^2 = 0.07069\ m^2$$

$$a_2 = \frac{\pi}{4} \cdot d_2^2 = \frac{\pi}{4} \cdot (0.15)^2 = 0.01767\ m^2$$

Now find discharge (Q)

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

$$= \frac{0.99 \times 0.07069 \times 0.01767 \times \sqrt{2 \times 9.81 \times 2.52}}{\sqrt{0.07069^2 - 0.01767^2}}$$

$$Q = 0.127\ m^3/s$$

or $Q = 127$ lit/s

7. A venturimeter is installed in a pipeline of 30 cm diam. The difference of pressure at entrance & throat read by mercury manometer is 5 cm, when water flows at a rate of 0.05 m^3/s. If the coeff. for venturimeter is 0.96, determine the diam of throat.

(W-25)

→ Given data.

$d_1 = 30\ cm = 0.3\ m.$

$Q = 0.05\ m^3/s$

$x = 5\ cm = 0.05\ m$

$C_d = 0.96$

$d_2 = ?$

Now find $h \Rightarrow \ h = x\left(\frac{S_m}{S_e} - 1\right) = 0.05\left(\frac{13.6 - 1}{1}\right)$

$$\boxed{h = 0.63\ m \text{ of water}}$$

$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} \cdot (0.3)^2 = 0.07069\ m^2$

$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.63} = 3.516\ m/s$

Now $$Q = \frac{C_d \cdot a_1 \cdot a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

$$0.05 = \frac{0.96 \times 0.07069 \times a_2 \times 3.516}{\sqrt{(0.07069)^2 - a_2^2}}$$

$$0.05 = \frac{0.2385\, a_2}{\sqrt{0.004997 - a_2^2}}$$

$$a_2 = 0.0150\ m^2$$

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

$$d_2^2 = \frac{4 \times 0.0150}{\pi}$$

$$d_2 = 0.138\ m$$

$$d_2 = 13.8\ cm$$

8. A pitot tube is inserted into a water stream having velocity 2.3 m/s. It has gauge difference of 30 mm on the water mercury manometer, find the Coeff. of velocity. (S-15, W-17)

→ Given data.

$V = 2.3\ m/s$

$x = 30mm = 0.03\ m$

$S_m = 13.6$

$S_l = 1$

Now first find (h)

$$h = x\left(\frac{S_m}{S_l} - 1\right)$$

$$= 0.03\left(\frac{13.6}{1} - 1\right)$$

$$h = 0.378\ m$$

We know that.

$$V_{act} = C_v \cdot \sqrt{2gh}$$

$$C_v = \frac{V_{act}}{\sqrt{2gh}}$$

$$= \frac{2.3}{\sqrt{2 \times 9.81 \times 0.378}}$$

$$\boxed{C_v = 0.8445}$$

9. Find the velocity of an oil flowing through a pipe, when the difference of mercury level in a differential U-tube manometer connected to two tappings of the pitot tube is 100 mm. Take S.G. of oil as 0.8 & coeff. of pitot tube as 0.98. (S-13)

→ Given data;

$x = 100 \text{ mm} = 0.1 \text{ m}$

$S_{oil} = 0.8$

$S_m = 13.6$

$C_v = 0.98$

Now find h,

$$h = x\left(\frac{S_m}{S_o} - 1\right)$$

$$= 0.1\left(\frac{13.6}{0.8} - 1\right)$$

$$\boxed{h = 1.6 \text{ m}}$$

velocity of oil $V = C_v \cdot \sqrt{2gh}$

$= 0.98 \cdot \sqrt{2 \times 9.81 \times 1.6}$

$$V = 5.49 \text{ m/s}$$