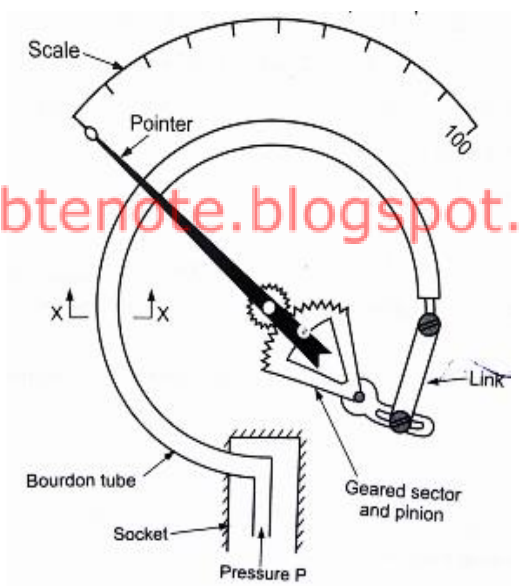
Q-1 Explain Bourdon tube pressure gauge

Introduction

- Bourdon gauge is used to measure pressure differences that are more than 1.2 bars.
- The pressure to be measure is applied to a curved tube, oval in cross section.
- The pressure applied to the tube tends to cause the tube to straighten out, and the deflection of the end of the tube is communicated through a system of levers to a recording needle.
- This gauge is widely used for steam and compressed gases.
- The pressure indicated is the difference between that communicated by the system to the external (ambient) pressure. And is usually referred as the gauge pressure.



Construction and Working

- It consists of a metal tube of elliptical cross-sectional area.
- This tube is bent in the form of a segment of circle and responds to pressure changes.
- One end of the tube is fixed and other end is free to move inward and outward.
- The inward and outward movements of the tube move a pointer with the help of linkage and gear arrangement (rack and pinion) on a dial, which is graduated in pressure scale (bar or N/m^2).

When attached to the source of pressure, the internal pressure causes the tube to expand, thereby inducing circumferential stress. The free end of the tube moves and makes the pointer to move over the dial, and pressure reading is obtained.

Advantages of Mechanical Gauges (Bourdon tube pressure gauge)

1. These pressure gauges give accurate results;
2. They are portable;
3. They costs low;
4. They gives direct reading;
5. They are simple in construction;
6. They can be modified to give an better electrical outputs;
7. They are safe even for high pressure measurement;
8. Accuracy is high especially at high pressure.

Disadvantages:

1. They respond slowly to changes in pressure;
2. They are subjected to hysteresis;
3. They are sensitive to shocks and vibrations;
4. Amplification is a must as the displacement of the free end of the bourdon tube is low;

It cannot be used for precision measurement.

Q-2 **Difference between Simple Manometer and Differential Manometer**

Simple Manometer	Differential Manometer
1. It is used to measure pressure at a point or section of pipe.	**1.** It is used to measure pressure difference between two points or sections of a pipe or two different pipes.
2. Here, one limb is connected to the point , where pressure is to be measured and other end is free or open to atmosphere	2. Here, both ends are connected to the points, whose pressure difference is to be measured.
3. Here, the reading is obtained by measuring the rise of liquid flowing through the pipe in the tube open to atmosphere.	3. Here is reading is obtained by measuring the pressure difference in the level of manometric fluid in the two limbs of U-tube.
4. Examples: Piezometer, simple U-tube manometer.	4. Example: U-tube differential manometer, Inverted U-tube differential manometer.

Define Kinematic viscosity and dynamic viscosity of fluid and write its standard value.

Dynamic Viscosity (μ):- **(01 ½ Marks)**

The dynamic (shear) viscosity of a fluid expresses its resistance to shearing flows, where adjacent layers move parallel to each other with different speeds. The magnitude **(F)** of this force or resistance is found to be proportional to the speed **(u)** and the area **(A)** of each plate, and inversely proportional to their separation **(y).**

$$F = \mu . A \, {du}/{dy}$$

The proportionality factor μ in this formula is the viscosity (specifically, the dynamic viscosity) of the fluid. ***The unit of dynamic viscosity is N-s/m^{2}.***

Kinematic viscosity (ν): **(01 ½ Marks)**

The kinematic viscosity (also called "momentum diffusivity") is the ratio of the dynamic viscosity μ to the density of the fluid. It is usually denoted by the Greek letter nu (ν).

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

In MKS system and SI, the unit of kinematic viscosity in m^2/sec while in CGS units it is written as cm^2/sec.

Define Atmospheric pressure, gauge pressure, vacuum pressure, and absolute pressure. (01 Marks Each)

Pressure on a fluid is measured in two different systems. One is absolute zero or complete vacuum. This is called absolute pressure. The other is pressure measured above the atmospheric pressure. It is called as gauge pressure.

Absolute pressure is the pressure measured with reference to absolute zero line.

Gauge pressure is measured above and with reference to atmospheric pressure.

Vacuum pressure is the pressure measured below the atmospheric line.

Atmospheric pressure: - The pressure which is exerted due to the weight of air above earth's surface.

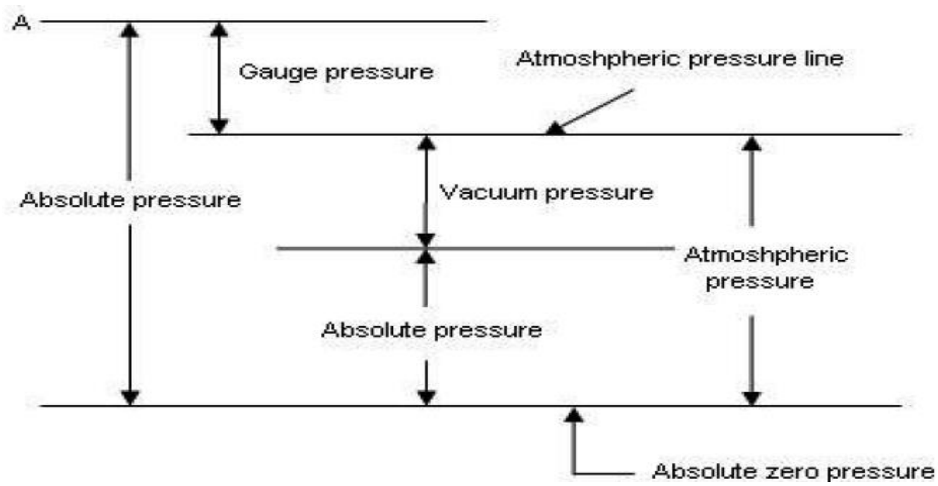
Standard value- 101.3 KN/ m^2 and 760mm of Hg

Figure shows the relation between them….

Mathematically, the absolute pressure is given by…

Pabs = Patm ± Pgauge

Where +ve sign is for gauge pressure is above atmospheric line and –ve sign is for pressure is below atmospheric line.



Explain Surface tension and capillarity.

Surface Tension (σ):- Surface tension is defined as the tensile force acting on the surface of a liquid in contact with gas or on the surface between two immiscible liquid such that the contact surface behaves like membrane under tension.
The magnitude of this force per unit length of the free surface will have the same value as the surface energy per unit area.
In MKS units, it is expressed as kgf/m while SI units as N/m
Example- 1. Spherical shape of drop of water. 2. Insect can easily walk on the surface of liquid due to surface tension

Capillarity:-

Capillary is defined as phenomenon of rise or fall of liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid. The rise of liquid surface is known as ***capillary rise*** while the fall of liquid is known as ***capillary depression***. It is expressed in terms of cm or mm of liquid.

If adhesion is greater than cohesion then capillary rise is there. For example water.
If cohesion is greater than adhesion then capillary fall is there. For example Mercury

Define Mass density, Weight density, Specific volume, Specific gravity.

Mass density: It is defined as the ratio of mass of fluid to volume.

It is denoted by letter 'ρ'.

Mathematically, Mass density (ρ) = $\frac{\text{mass}}{\text{volume}}$

Unit is $\frac{Kg}{m^3}$

Weight density: It is defined as the ratio of Weight of fluid to volume.

It is denoted by letter 'w'.

Mathematically, Weight density (w) = $\frac{\text{Weight}}{\text{volume}}$, $\text{Weight} = \text{m.g}$ ∴ Weight density (w) = $\frac{\text{m.g}}{\text{V}}$

Weight density (w) = ρ.g Unit is $\frac{N}{m^3}$

Specific volume: It is defined as the ratio of volume per unit mass.

Mathematically,

Specific volume = $\frac{Volume}{mass} = \frac{1}{\rho}$ Unit is $\frac{m^3}{Kg}$

Specific gravity: It is defined as the ratio of the specific weight of any fluid to the specific weight of standard fluid (water).

It is denoted by letter 'S'. It is unit less term.

$$S = \frac{w_l}{w_w} \qquad w = \rho.g \qquad \textbf{hence, } S = \frac{\rho_l}{\rho_w}$$

Define Centre of pressure and Total pressure.

Numerical on Centre of pressure and Total pressure for circular surface and isosceles triangle (vertically immersed or inclined to FSL).

Define Steady flow and unsteady flows

Steady flow: Fluid flow is said to be steady flow, if the flow characteristics such as velocity, density, viscosity pressure, temperature etc. do not change with respect to time.
Example: Flow of water through a tap at a constant rate.

Unsteady flow: A fluid flow is said to be **unsteady flow**, if the flow characteristics such as velocity, density, viscosity pressure, temperature etc. changes with respect to time.
Example: Flow of water when the tap is just open.

Uniform and non-uniform flow

Uniform flow is defined as flow in which the velocity of fluid particles at all sections in given time remains constant with respect to length of direction of flow.
Example: Flow of water in a uniformed diameter pipe, flow of water in an open channel.

In non-uniform flow, the velocity of fluid does not remains constant but goes on changing from section to section.
Example: Flow of water through a converging or diverging pipe**.**

Laminar and Turbulent Flow

Laminar Flow: A flow is said to be **laminar flow**, if fluid particles have a definite path and do not cross each other.
Example: Flow of thick oil. Flow of blood in veins.
Here Reynolds number<2000
It is also called as the flow of low velocity.

Turbulent Flow: A flow is said to be **Turbulent flow**, if fluid particles do not have a definite path and they move in a zigzag way.
Example: Flow of water in river at the time of flood.
Here Reynolds number>4000
It is also called as flow of high velocity.

State the BERNOULLI'S THEOREM with meaning of each term.

Bernoulli's theorem state that, "for a perfect incompressible liquid flowing in a continuous stream, total energy of particle remains same.

This statement is based on the assumption that, there are no losses due to friction in pipe".

Total energy consists of kinetic energy, potential energy, and pressure energy.
Mathematically,

$$Z + \frac{V^2}{2.g} + .\frac{P}{\rho.g} = C$$

Where, Z = Potential Energy

$\frac{V^2}{2.g}$ = Kinetic Energy

$\frac{P}{\rho.g}$ = Pressure Energy

Let us consider a non-uniform pipe (converging) having a section 1-1 and 2-2.
The fluid flow is passing from section 1-1 to section 2-2, i.e. from left to right.
Now by using Bernoulli's theorem, we can write,
Total head at section 1-1 = Total head at section 2-2

$$\frac{P_1}{\rho.g} + \frac{V_1^2}{2.g} + Z_1 = \frac{P_2}{\rho.g} + \frac{V_2^2}{2.g} + Z_2$$

Assumptions and limitations in Bernoulli's Equation

Assumptions:-

- The fluid is ideal i.e. viscosity is zero.
- The flow is steady and continuous.
- The flow is incompressible.
- The flow is one-dimensional i.e. along a stream-line.
- Velocity is uniform over the cross-section and is equal to the mean velocity.
- The forces like gravity force and pressure force are only considered. Effect of viscous force is neglected.
- The flow is irrotational.

Limitations:-

- Only applicable to ideal incompressible flow. In actual practice, fluid is not ideal.
- It is assume that, heat transfer from or to the fluid is zero. Actually, some energy addition or removal may takes place as fluid flows.
- The effect of presence of any mechanical device between two sources is ignored.
- It is assumed that, velocity is uniform. But actually, velocity does not remains constant across the section.

Explain the term Vena-contracta

On the downstream side, the pressure tap is provided quite close to orifice plate at the section, where converging jet of fluid has almost the smallest cross-sectional area resulting in almost maximum velocity of flow and consequently minimum pressure. This place is called as vena-contracta (i.e. section 2-2). Thus vena-contracta is defined as, "the point in the fluid stream, where the diameter of the stream is least and fluid velocity is maximum". Therefore the maximum pressure difference exists between section 1-1 and 2-2, which is measured by differential manometer.

What is Pitot tube? Explain with sketch

- Pitot tube is used to measure the velocity of fluid flowing through the pipe at any point.
- It works on the principle that, "if the velocity of flow at a point becomes zero, there ia an increase in pressure energy". This point is known as stagnation point.
- Pitot tube consists of a glass tube opened at both ends.
- The lower end is bent through 90^0 and facing the upstream direction.
- The liquid rises up in the tube due to the conversion of kinetic energy in to pressure energy.
- The velocity is determined by measuring the rise of liquid in the tube.

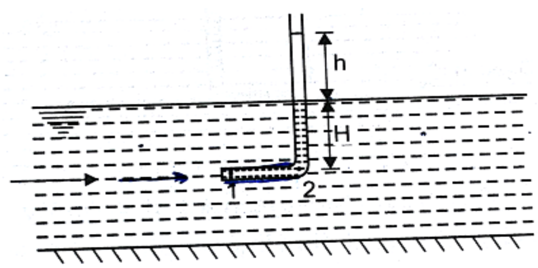


Fig: - Pitot tube

Applying the Bernoulli's equation,

$$\frac{P_1}{\rho.g} + \frac{V_1^2}{2.g} + Z_1 = \frac{P_2}{\rho.g} + \frac{V_2^2}{2.g} + Z_2 \text{...(i)}$$

But here, $V_2 = 0$ and $Z_1 = Z_2$

Also, pressure head at section (1) = $\frac{P_1}{\rho.g}$ = H

And pressure head at section (2) = $\frac{P_2}{\rho.g}$ = (H+h)

So equation (i) becomes,

$$H + \frac{V_1^2}{2.g} + 0 = (H+h) + 0 + 0$$

$$\frac{V_1^2}{2.g} = h$$

$$V_1^2 = 2gh$$

$$V_{th} = \sqrt{2gh}$$

Actual velocity, $V_{act} = C_v \sqrt{2gh}$

Where, Cv = Coefficient of velocity

Note:- The bent end of the pitot tube should be purely facing the direction of flow of liquid, otherwise, there will be error in the reading and calculation.

Define different hydraulic coefficients?

1. **Coefficient of discharge:** It is defined as, "the ratio of actual discharge to theoretical discharge".

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

2. **Coefficient of contraction:** It is defined as, "the area of jet at vena contracta to the area of orifice". If A_2 is the area of jet at vena contracta and A_1 is the area of orifice, then,

$$C_C = \frac{A_2}{A_1}$$

The theoretical value of C_C for sharp edge orifice is equal to 0.611, but in actual practice its value varies from 0.61 to 0.69 and generally taken as 0.64.

3. **Coefficient of velocity:** It is defined as, "the ratio of actual velocity of jet at vena-contracta to theoretical velocity of jet".

$$\mathbf{Cv} = \frac{V_{act}}{V_{th}}$$

$$V_{act} = Cv \times V_{th}$$

$$V_{act} = Cv \sqrt{2gh}$$

- The difference between theoretical and actual values of velocity is mainly due to friction at orifice.
- The value of C_V varies from 0.95 to 0.99 for different orifices. In general, it is taken as **0.98**

Explain Venturimeter.

- Venturimeter is a device used to measure rate of discharge in a pipeline
- It is fixed permanently at different sections of pipeline to know the discharges at those points.

Construction

It consists of following three parts:

b) <u>Convergent cones</u>

- It is a short pipe, which converges from a diameter d_1(diameter of pipe, in which, venturimeter is fitted) to a smaller diameter d_2 (diameter of throat).
- The slope of converging cone is between 1 in 4 or 1 in 5.
- The total angle of converging cone is 21 ± 1^0.

c) <u>Throat</u>

- It a small portion of circular pipe having diameter $d_{2.}$
- Diameter of throat varies between 33% - 75% of main pipe diameter. Preferably is taken as 0.5 times the diameter of pipe i.e. $d_2 = 0.5\ d_1$

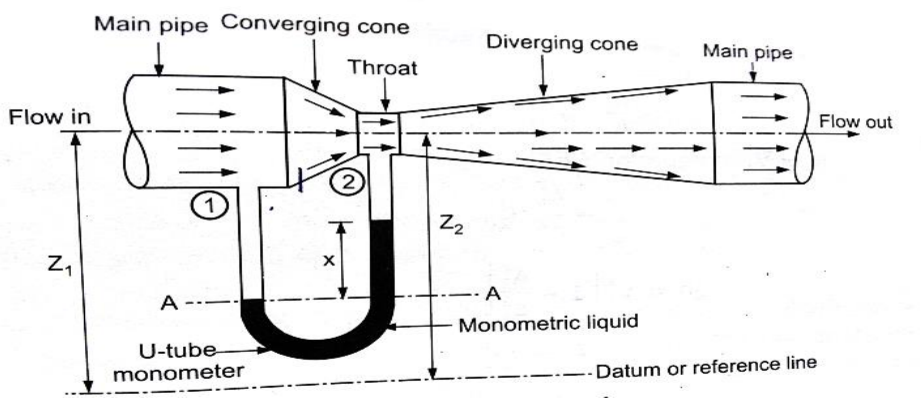
d) <u>Divergent cone</u>

- It is a long pipe, which diverges from a diameter d_2 to the pipe diameter d_1.
- The length of the divergent cone is 3 to 4 times the divergent cone.
- The included angle of divergent cone is $5^0 – 7^0$ (preferably 6^0).

<u>Working</u>

- A U-tube differential manometer is connected to the pipe at the entrance section (before converging section) and other end is connected at the throat. This differential manometer is used for the measurement of pressure.
- When the liquid flows through the venturimeter (converging cone), its flow is accelerated resulting in an increase in velocity. Therefore, the velocity of the liquid at section 2 (throat) becomes higher than that at section 1. This decreases the pressure at section 2.
- When the liquid flows through divergent cone, its flow is decelerated (retarded). As a result of this retardation, the velocity of liquid decreases with a subsequent increase in pressure.

Thus, venturimeter works on the principle of converging pressure energy (head) into kinetic energy by reducing cross-sectional area of flow passage. This gives rise to pressure difference, which is measured by means of U-tube differential manometer.



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Question: <u>Why Divergent cone made 3-4 times longer than the convergent cone.</u>

- In convergent cone, the fluid is accelerated up to throat and in divergent cone; fluid is retarded up to end section of the venturimeter.
- The acceleration of the flowing fluid is allowed to take place rapidly in a relatively smaller length (convergent section), without resulting in appreciable loss of energy.
- However, if the retardation of the flow is allowed to takes place rapidly in small length, then the flowing fluid will not remain in contact with the boundary of the diverging flow

passage or in other words, the flow separates from walls and eddies are formed. This results in excessive energy loss.

- Therefore, in order to avoid the possibility of flow separation and consequent energy loss, the divergent cone is made longer with gradual divergence.
  Since the flow separation may occur in divergent cone of venturimeter, this portion is not used for discharge measurement.

- Venturimeter head is defined as, "piezometric head difference measured and expressed in terms of column of liquid flowing through pipe". It is denoted by as **'h'**.

Thus Venturimeter head = $\left(\frac{P_1}{\rho.g} + Z_1 \right) - \left(\frac{P_2}{\rho.g} + Z_2 \right)$

- **In case of horizontal venturimeter,**

$$Z_1 = Z_2$$

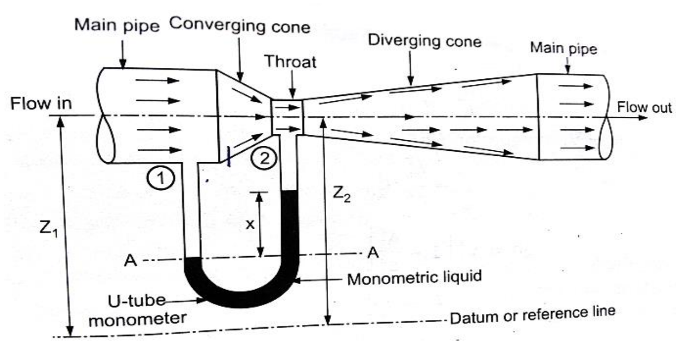
<u>Venturi head (h)</u> = $\frac{P_1}{\rho.g} - \frac{P_2}{\rho.g}$

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

Derive the expression for Discharge with the help of Venturimeter.

Let, d_1 = diameter of pipe

d_2 = diameter of throat



A_1 = Area of pipe at inlet = $\frac{\pi}{4} \times d_1^2$

A_2 = Area of pipe at inlet = $\frac{\pi}{4} \times d_2^2$

x = manometer reading

S_h = Specific gravity of heavier liquid

S = Specific gravity of fluid flowing through the pipe

According to the Bernoulli's theorem

$$\frac{P_1}{\rho.g} + \frac{V_1^2}{2.g} + Z_1 = \frac{P_2}{\rho.g} + \frac{V_2^2}{2.g} + Z_2$$

As $Z_1 = Z_2$,

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

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

But, h = Difference of pressure head = $\frac{P_1}{\rho.g} - \frac{P_2}{\rho.g}$

$$h = \frac{V_2^2}{2.g} - \frac{V_1^2}{2.g}$$

$$2gh = V_2^2 - V_1^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(i)$$

Now applying the continuity equation, we have,

$$Q = A_1 V_1 = A_2 V_2$$

$$V_1 = \frac{A_2}{A_1} \times V_2$$

Put this value of V_1 in equation (i)

$$2gh = V_2^2 - \frac{A_2^2}{A_1^2}.V_2^2$$

$$2gh = V_2^2[1 - \frac{A_2^2}{A_1^2}]$$

$$2gh = V_2^2 . [\frac{A_1^2 - A_2^2}{A_1^2}]$$

$$V_2^2 = [\frac{A_1^2}{A_1^2 - A_2^2}] \times 2gh$$

$$V_2 = \sqrt{\frac{A_1^2}{A_1^2 - A_2^2} \times 2gh}$$

Also, $Q = A_2 V_2$

$$Q = A_2 \times \sqrt{\frac{A_1^2}{A_1^2 - A_2^2} \times 2gh}$$

$$Q_{th} = \sqrt{\frac{A_1^2 . A_2^2}{A_1^2 - A_2^2} \times 2gh}$$

$$Q_{th} = \frac{A_1.A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

But the actual discharge is less than theoretical discharge. Therefore, a new term called as, coefficient of discharge 'C_d' is introduced in the equation and actual discharge is given by,

$$\mathbf{Q_{act} = \frac{C_d.A_1.A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}}$$

Where, C_d = coefficient of discharge.

Generally the value of 'C_d' is taken as 0.98 for venturimeter.

Note: - If, x = Difference of mercury level / manometric liquid in the U-tube manometer then,

1) **Case I: Heavier liquid in manometer**

   $$h = x. [\frac{S_h}{S} - 1]$$

   Where, S_h = Specific gravity of heavier manometric liquid

2) **Case II: Lighter liquid in manometer**

   $$h = x. [1 - \frac{S_L}{S}]$$

   Where, S_L = Specific gravity of lighter manometric liquid.

Q. Continuity Equation or Continuity Theorem

- The continuity equation is based on the principle of conservation of mass.
- It states that **"If no fluid is added or removed from the pipe, then the mass of the fluid per second remains constant at all sections of the pipe"**.
- Consider two cross sectional area of pipe

  Let, A1 = Area of the pipe at section (1)

  V1 = Velocity of fluid at section (1)

  ρ1 = Density of fluid at section (1)

  And A2, V2, ρ2 be the corresponding value at section (2)
- The total quantity of the fluid passing through section (1) = $\rho_1 . A_1 . V_1$

  And the total quantity of the fluid passing through section (2) = $\rho_2 . A_2 . V_2$
- From law of conservation of mass, we have

$$\boldsymbol{\rho_1 . A_1 . V_1 = \rho_2 . A_2 . V_2}$$

This is known as Continuity equation.

- In case of incompressible fluid, $\boldsymbol{\rho_1 = \rho_2}$

Therefore continuity equation reduced to , $\mathbf{A_1 . V_1 = A_2 . V_2}$

Also we have,

Discharge, Q = Area x Average velocity

$\mathbf{Q = A. V}$

Where, A = Area of cross section of the pipe

V = Average velocity of liquid

Therefore, $\mathbf{Q = A_1 . V_1 = A_2 . V_2}$

Write the Darcy's formula for head loss due friction. State the meaning of each term.

- According to the Darcy's Weisbach equation, loss of head due friction is given by,

$$\mathbf{h_f = \frac{4 . f . L . V^2}{2g . d}}$$

Where, f is a function of Reynolds number and is known as Darcy's coefficient of friction.

- Value of 'f' is derived as under,

1. $f = \frac{0.079}{R_e^{0.25}}$, if $R_e > 4000$
2. $f = \frac{16}{R_e}$, if $R_e \leq 2000$

- We have, Reynolds number , $R_e = \frac{V.d}{\upsilon}$,

Where, V = Mean velocity of fluid flowing through pipe in m/sec

d= Diameter of pipe in m.

υ = Kinematic viscosity of fluid in m^2/sec

L = length of pipe

- The value of the Reynolds number decides, whether the flow is laminar or turbulent. In case of circular pipe, if $R_e < 2000$, the flow is said to laminar and if $R_e > 4000$, the flow is said to be turbulent.
- If R_e lies between 2000 to 4000, the flow changes from laminar to turbulent. Reynolds was the first to demonstrate that, transition of flow from laminar to turbulent depends upon,
  1. Increase in velocity
  2. Increase in pipe diameter,
  3. Decrease in viscosity.
- Reynolds number, $R_e = \frac{\rho .V.d}{\mu} = = \frac{V.d}{\vartheta}$ i.e. a dimensionless number [$\vartheta = \frac{\mu}{\rho}$]

  V = velocity of fluid, d = Diameter of pipe, ϑ = kinematic viscosity

$$\mathbf{h_f = \frac{4 .f.L.V^2}{2g.d}}$$ ....Darcy's equation

But, $Q = \frac{\pi}{4} \times d^2 \times V$ $\therefore$ $\boldsymbol{V = \frac{4Q}{\pi.d^2}}$

So, $\mathbf{V^2 = \frac{16\, Q^2}{\pi^2 d^4}}$

Substituting the value $\mathbf{V^2 = \frac{16\, Q^2}{\pi^2 d^4}}$ **in Darcy's equation**

We get $\mathbf{h_f \cong \frac{f.l.Q^2}{3.d^5}}$

Chezy's formula

1. Write Chezy's equation. State the meaning of each term.(S-11,S13)

- If h_f is the loss of head due to friction and L is the length of pipe, then ratio ($\frac{hf}{L}$) is called as head loss per unit length of pipe denoted by i.
- The loss of head due to friction is calculated by using Chezy's formula, which is given by average velocity of fluid as,

$$V = C\sqrt{m.i}$$

Where, **m** = hydraulic mean depth (H.M.D.) $= \frac{\textit{Cross-sectional area of pipe}}{\textit{wetted perimeter}}$

$$\mathbf{m = \frac{A}{P} = \frac{\frac{\pi}{4}d^2}{\pi.d} = \frac{d}{4}}$$

C = Chezy's constant

i = loss of head per unit length of pipe = ($\frac{hf}{L}$)

Explain different Minor losses.

The loss of head or energy due to friction in a pipe is known as major loss while loss of energy due to change in velocity of flowing liquid in magnitude or direction is called as minor loss of energy. The minor losses are as follows

Explain the different types of minor losses in pipe. (8 marks)

A. Loss of head due to sudden enlargement (Expansion):

- As results of sudden enlargement, liquid flow forming eddies at corners. These eddies causes the loss of head.

Loss of head due to sudden enlargement,

$$\mathbf{h_e = \frac{(V_1 - V_2)^2}{2g}}$$

B. Loss of head due to sudden contraction:

- It is observed that the loss of head due to sudden contraction is not due to contraction but it is due to the sudden enlargement which takes place after vena-contracta.
- Head loss due sudden contraction is

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

If value of h_c is not given then, $\mathbf{h_c = \frac{0.5V_2^2}{2g}}$

Where, V_2 is the velocity of flow at section 2-2.

C. Loss of head at the entrance/inlet of a pipe:

- When the liquid enters from large vessel into a pipe, there occurred a sudden contraction to flow of liquid and this results in the loss of head which is equal to

$$\mathbf{h_{ent} = \frac{0.5V_2^2}{2g}}$$

D. Loss of head at the exit/outlet of a pipe:

- This is the loss head (energy) due to the velocity of liquid at outlet of the pipe, which is dissipated either in the form of a free jet (if outlet of the pipe is free) or it is lost in the tank or reservoir (if outlet of the pipe is connected to the tank or reservoir).
  This loss is denoted by h_o and is given by,

$$\mathbf{h_o = \frac{V^2}{2g}}$$

  Where, V= velocity of liquid at outlet of pipe.

E. **Loss of head due to an obstruction in pipe:**

- Whenever there is an obstruction in a pipe, the loss of energy takes place due to reduction of the area of cross-section of the pipe at the place, where obstruction is present.
- There is a sudden enlargement of the area of the flow beyond the obstruction, due to which, loss of head takes place.
- The loss of head due to an obstruction in a pipe is given by,

$$\mathbf{h_{obs} = \frac{V^2}{2g}\left(\frac{A}{C_c\,(A-a)} - 1\right)^2}$$

Where, a = Area of obstruction in m^2

A = Area of the pipe in m^2

V = Velocity of liquid in pipe in m/sec

C_C = Coefficient of contraction (0.62 or 0.65)

F. Loss of head due to bend in pipe:

- Where there is any bend in a pipe, the velocity of the flow changes due to which, the separation of the flow from the boundary and also formation of eddies takes place. Thus, the energy is lost.
- Loss of head in pipe due to bend is expressed as,

$$h_b = \frac{k.V^2}{2g}$$

Where, h_b = loss of head due to bend in **m**

V = velocity of flow in m/sec

k = coefficient of bend.

The value of k depends on:

a) Angle of bend.
b) Radius of curvature of bend.
c) Diameter of pipe.

G. Loss of head in various pipe fitting:

- The loss of head in various pipe fittings such as valves, coupling etc., is expressed as,

$$h_{pf} = \frac{k.V^2}{2g}$$

Where, V = Velocity of flow in **m/sec**

K = coefficient of pipe fitting

h_{pf} = Loss of head due to pipe fitting

State the laws of fluid friction for Laminar and Turbulent Flow

LAWS OF FLUID FRICTION FOR LAMINAR FLOW

1. The frictional resistance is proportional to the velocity.
2. The frictional resistance is independent of the pressure.
3. The frictional resistance is proportional to the surface area of contact.
4. The frictional resistance varies considerably with temperature.
5. The frictional resistance is independent of the nature of the surface of contact.

LAWS OF FLUID FRICTION FOR TURBULENT FLOW

1. The frictional resistance is proportional to the square of the velocity.
2. The frictional resistance is independent of the pressure.
3. The frictional resistance is proportional to the surface area of contact.
4. The frictional resistance slightly varies with temperature.
5. The frictional resistance is depends of the nature of the surface of contact.
6. The frictional resistance is proportional to the density of the fluid.

POWER TRANSMITTED THROUGH PIPE

$$\mathbf{P = (\rho.g.Q \times (H - h_f)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [h = \mathbf{H - h_f}]$$

$$\mathbf{P = (\rho.g.A.V.\left[H - \frac{4.f.L.V^2}{2gd}\right]} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{[Q = A.\ V]}$$

Condition for maximum power transmission

$$h_f = \frac{H}{3} \quad \text{Or } H = 3h_f$$

EFFICIENCY OF POWER TRANSMISSION

$$\eta = \frac{H - h_f}{H}$$

Do the Numerical on Power Transmission and Venturimeter.

Define HGL and TEL

Hydraulic Gradient Line:-

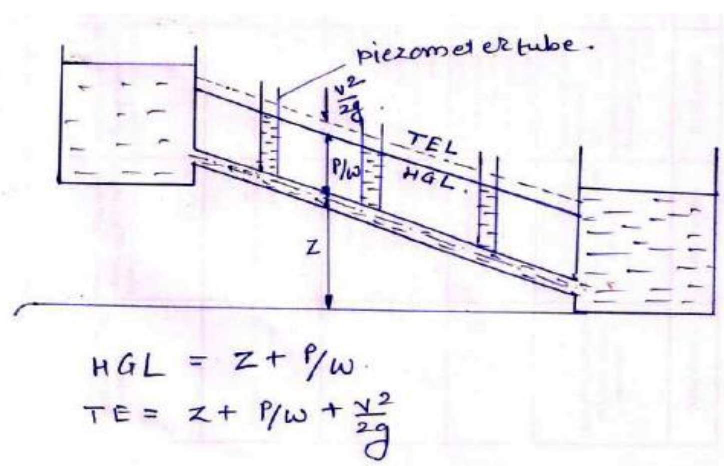
It is defined as the line which gives the sum of pressure head (p/w) and datum head (z) of a flowing fluid in a pipe with respect to some reference line.

The HGL is below the TEL by $\frac{V^2}{2g}$

Total Energy Line (TEL):-

It is defined as the line which gives the sum of pressure head, datum head and kinetic head of a flowing fluid in a pipe with respect to some reference line.

The TEL is above the HGL by $\frac{V^2}{2g}$

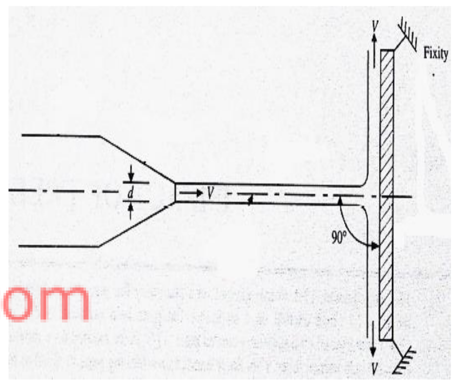


IMPACT OF JET

The liquid comes out in the form of jet from the outlet of a nozzle, which is fitted to a pipe through which the liquid is flowing under pressure. If some plate, which may be fixed or moving, is placed in the path of jet, a force is exerted by the jet on the plate. This force is obtained from Newton's second law off motion or from impulse-momentum equation. Thus impact of jet means force exerted by the jet on a plate which may be stationary or moving. In this chapter the following cases are considered for calculating the force exerted by jet on a plate:

CASE-1: FORCE EXERTED BY JET ON STATIONARY VERTICAL FLAT

Consider a jet of water coming out from nozzle striking on a fixed flat plate kept normal to the jet.



Let, V = velocity of jet;

D = diameter of jet;

m = mass flow rate;

u = velocity of jet after striking in the same direction ∴ u = 0

Therefore force exerted by the jet on the fix plate,

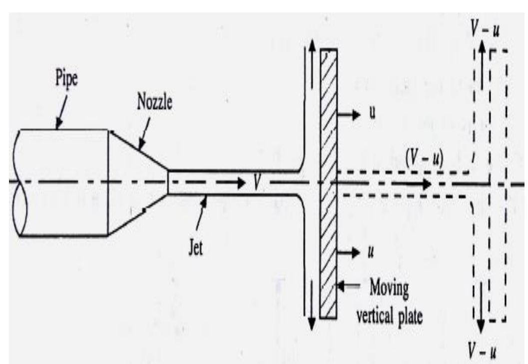
F = mass flow rate × change in velocity (Initial vel. – Final velocity)

$= \rho.a.V \times (V - u) \quad = \quad \rho.a.V^2$ ……………as u = 0 and $\rho = \frac{w}{g}$

$$F = \rho.a.V^2$$ in Newton

As the plate is fixed work done will be zero

IMP CASE-2: IMPACT OF JET ON A MOVING FLATE PLATE



Let, V= velocity of jet;

u= velocity of plate

∴ Velocity of jet relative to the plate = (V-u)

∴ Mass of water striking the plate per second = $\rho.a.(V - u)$

Therefore we can consider that jet is moving with an initial velocity $(V - u)$ relative to the plate.

Also the final velocity in the direction of jet is zero.

F = mass flow rate × change in velocity (Initial vel. – Final velocity)

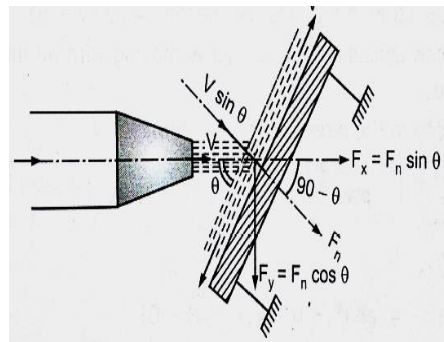
$= \rho . a . (V - u) \times [(V - u) - 0] \ldots\ldots\ldots\ldots$ (Final velocity in the direction of jet is zero)

$$F = \rho . a . (V - u)^2$$

$$(\text{The work done}) = (\text{Force}) \times \left(\begin{matrix}\text{The distance through which body} \\ \text{moves in the direction of force}\end{matrix}\right)$$

Work done = $\rho . a . (V - u)^2 \times u$

CASE-3: IMPACT OF JET ON AN INCLINED FIXED PLATE



Consider a jet of water striking on a fixed inclined plate at an angle θ,

We know that;

$$F = (\rho . a . V^2)$$

- Let a jet of water striking an inclined stationary flat plate with velocity V;
- Therefore, mass of water striking per second = $\rho . a . V$
- If the plate is smooth, and if it assumed that, there is no loss of energy due to impact of jet, and then the jet will leave the plate after striking with velocity 'V' equal to initial velocity.
- Now, let us find out the force exerted by the jet in the direction normal to the plate. Let F_n be this force.
- If θ = Angle between the jet and plate, then,
  Component of velocity of jet before striking in the direction normal to plate = V. sin θ.
- Also, velocity of jet in the direction normal to plate after striking = 0
- Therefore, $F_n = \left(\begin{matrix}\text{mass of water} \\ \text{striking per second}\end{matrix}\right) \times (\text{initial velocity} - \text{Final velocity})$
  $= \rho . a . V \times [V . \sin\theta - 0] = \rho . a . V^2 . \sin\theta$
- This force can be resolved into two mutually perpendicular components i.e. along two perpendicular directions, one in the direction of jet (F_x) and other perpendicular to the direction of jet (F_y).
  Force in the direction of jet, $F_x = (F_n . \sin\theta) = \rho . a . V^2 . \sin\theta \times \sin\theta$

$$F_x = \rho . a . V^2 . \sin^2\theta$$

Force in the direction normal to the jet, $F_y = F_n . \cos\theta = \rho . a . V^2 . \sin\theta . \cos\theta$

IMP CASE-4 IMPACT OF JET ON AN INCLINED PLATE MOVING IN THE DIRECTION OF JET

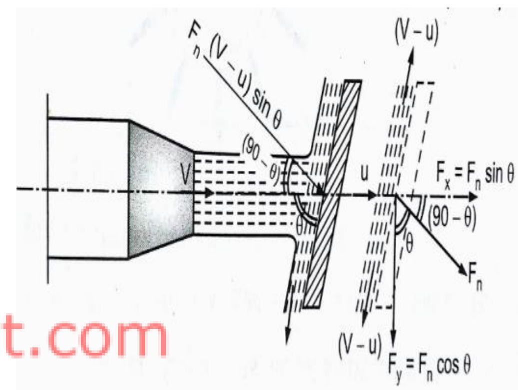
Let, V= velocity of jet

u= velocity of plate

∴ Velocity of jet relative to the plate = (V-u)

∴ Mass of water striking the plate per second $= \rho . a . (V - u)$

- If the plate is smooth, and if it assumed that, there is no loss of energy due to impact of jet, and then the jet will leave the inclined plate after striking with velocity '(V-u)
- Let us find out the force exerted by the jet of water in the direction normal to the plate. Let this force be $\mathbf{F_n}$
- Component of velocity of jet before striking in direction normal to the plate $= (V - u) . \sin\theta$
- Velocity of jet after striking in direction normal to the plate = 0
- Therefore, $\mathbf{F_n} = \left(\text{Mass of water striking per second}\right) \times (\text{Initial velocity} - \text{Final velocity})$
- $\mathbf{F_n} = \rho . a . (V - u)[(V - u)\sin\theta - 0] = \rho . a . (V - u)^2 . \sin\theta$



- This normal force $\mathbf{F_n}$ can be resolved into two mutually perpendicular components, i.e. along two perpendicular directions, one in the direction of jet $(\mathbf{F_x})$ and other perpendicular to the direction of jet (F_y).
- $\mathbf{F_x} = F_n . \sin\theta = [\rho . a . (V - u)^2 . \sin\theta] . \sin\theta = \boldsymbol{\rho . a . (V - u)^2 . \sin^2\theta}$
- $\mathbf{F_y} = F_n . \cos\theta = [\rho . a . (V - u)^2 . \sin\theta] . \cos\theta = \boldsymbol{\rho . a . (V - u)^2 . \sin\theta . \cos\theta}$.
- Also work done per second by the jet on the plate,
- **W.D** $= \mathbf{F_x \times u = \rho . a . (V - u)^2 . \sin^2\theta . \times u}$ **in** $\mathbf{\frac{N.m}{sec}}$ **or** $\mathbf{\frac{Joule}{sec}}$ **or watts.**

CHAPTER5
Hydraulic Turbines

Explain the significance or function of draft tube in reaction turbine

Give the classification of Hydraulic Turbines

Differentiate between impulse and reaction turbine

CHAPTER 6

Centrifugal Pump

Q(1)State the functions of impeller and casing in centrifugal pump

Q(2)State the suction head and delivery head of centrifugal pump

Q(3)Differentiate between centrifugal pump and reciprocating pump

Q(4)State static head and manometric head of centrifugal pump

Q(5)Explain with neat sketch construction and working of centrifugal pump

Q(6)Explain the necessity of priming in centrifugal pump. Explain different methods of priming

What are multistage pumps? What are their advantages?

State the types of impeller used in centrifugal pump.state their uses.

What are the different types of casing used in centrifugal pump?

Explain with neat sketch working of Jet pump

Reciprocating Pump

Explain the working of single acting Reciprocating pump with a suitable diagram.

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ble acting Reciprocating pump with a suitable diagram.

and negative slip of a Reciprocating pump

What is an Air vessel? List down its advantages

Show effect of acceleration and friction on ideal indicator diagram individually

AGNEL POLYTECHNIC, VASHI

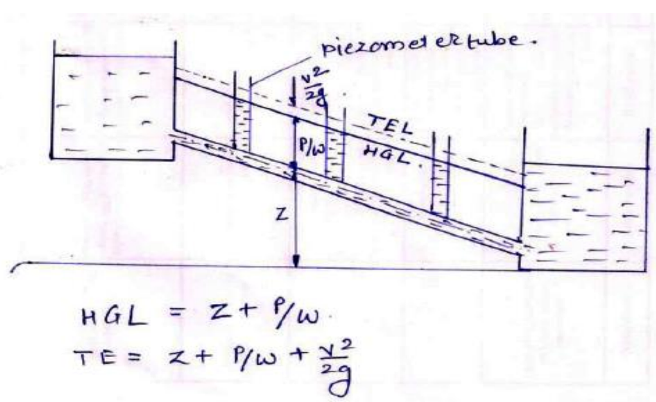
Model Answer Winter -2018

Unit Test 1

Subject: Fluid Mechanics and Machinery

Q.No	C. O.		Questions	Marks
			Attempt the following.	
1.	CO1	a	**Define Kinematic viscosity and dynamic viscosity of fluid and write its standard value.** **Dynamic Viscosity (μ):-** **(01 ½ Marks)** The dynamic (shear) viscosity of a fluid expresses its resistance to shearing flows, where adjacent layers move parallel to each other with different speeds. The magnitude **(F)** of this force or resistance is found to be proportional to the speed **(u)** and the area **(A)** of each plate, and inversely proportional to their separation **(y).** $$F = \mu . A \, {du}/{dy}$$ The proportionality factor μ in this formula is the viscosity (specifically, the dynamic viscosity) of the fluid. ***The unit of dynamic viscosity is N-s/m$^{2.}$*** **Kinematic viscosity (v):** **(01 ½ Marks)** The kinematic viscosity (also called "momentum diffusivity") is the ratio of the dynamic viscosity μ to the density of the fluid. It is usually denoted by the Greek letter nu (ν).	**03**

			$$\nu = \frac{\mu}{\rho}$$ In MKS system and SI, the unit of kinematic viscosity in m^2/sec while in CGS units it is written as cm^2/sec.	
	CO2	b	**State the Bernoulli's theorem and write the equation.** **Bernoulli's Equation:-** **(01 ½ Marks)** "For a perfect incompressible liquid, flowing in a continuous stream, the total energy of a particle remains the same, while the particle moves from one point to another." This statement is based on the assumption that there are no losses due to friction in the pipe. **(01 ½ Marks)** $$\frac{P}{w} + \frac{V^2}{2g} + z = Constant$$ **Where,** $\frac{P}{w} = Pressure\ Energy$ $\frac{V^2}{2g} = Kinetic\ Energy$ *Z= Potential Energy*	**03**
	CO3	c	**State the Darcy's equation for frictional losses with meaning of each terms used in it.** When a fluid is flowing through a pipe, the fluid experiences some resistance due to which some energy or head of the fluid is lost. This loss of energy or head is classified as i) Major loss ii) Minor losses Major loss can be calculated by using Darcy's equation. **(01 ½ Marks)** $$h_f = \frac{4flv^2}{2gd}$$ Where f - Darcy's friction factor L – Length of Pipe V- Velocity of flow d- Diameter of pipe h_f- Head loss due to friction **(01 ½ Marks)** **OR** **Explain HGL and TEL.** **Hydraulic Gradient Line:-** It is defined as the line which gives the sum of pressure head (p/w) and datum head (z) of a flowing fluid in a pipe with respect to some reference	**03**

			line. **(01 Marks)** **Total Energy Line (TEL):-** It is defined as the line which gives the sum of pressure head, datum head and kinetic head of a flowing fluid in a pipe with respect to some reference line. **(01 Marks)** **Figure-1:- Representation of Hydraulic Gradiant Line and Total Energy Line** 	
2.			**Attempt the following.**	
	CO2	a	**Define steady and unsteady flow with example.** **OR** **Define laminar and turbulent flow with examples.**	**04**
	CO3	b	**List the major and minor losses in flow through pipe.** When the liquid is flowing through a pipe, the liquid experiences some resistance due to which some of the energy of liquid is lost. There are two	**04**

			types of losses. **Major Losses In Pipes(Head lost due to Friction):-** 1. Darcy's Formula for Frictional Losses. 2. Chazy's equation for frictional Losses. **(02 Marks)** **Minor losses in pipes (any FOUR)** -Loss of head due to sudden enlargement. -Loss of head due to sudden contraction. -Loss of head at the entrance of a pipe. -Loss of head at the exit of a pipe. -Loss of head due to an obstruction in a pipe. -Loss of head due to bend in a pipe. -Loss of head due to various pipe fitting. **(02 Marks)**	
3.			**Attempt any two of the following.**	
	CO1	a	**Define Atmospheric pressure, gauge pressure, vacuum pressure, and absolute pressure.** **(01 Marks Each)** Pressure on a fluid is measured in two different systems. One is absolute zero or complete vacuum. This is called absolute pressure. The other is pressure measured above the atmospheric pressure. It is called as gauge pressure. ***Absolute pressure*** is the pressure measured with reference to absolute zero line. ***Gauge pressure*** is measured above and with reference to atmospheric pressure. ***Vacuum pressure*** is the pressure measured below the atmospheric line. ***Atmospheric pressure: -*** The pressure which is exerted due to the weight of air above earth's surface. ***Standard value- 101.3 KN/ m^2 and 760mm of Hg*** Figure shows the relation between them…. Mathematically, the absolute pressure is given by… **Pabs = Patm ± Pgauge** Where +ve sign is for gauge pressure is above atmospheric line and –ve sign is for pressure is below atmospheric line.	**04**

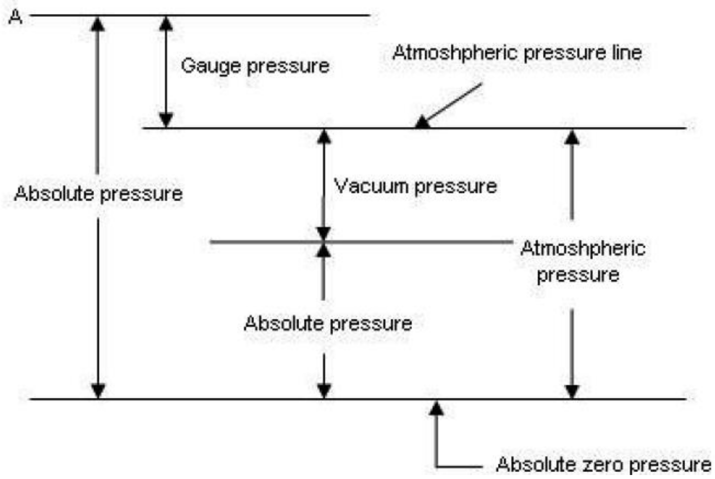
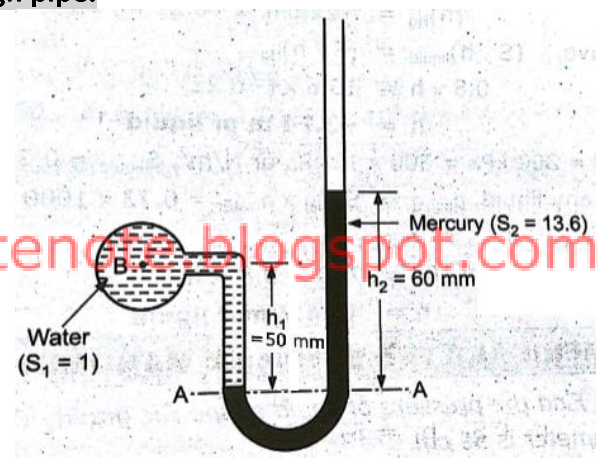


Figure-2 :- Relationship between pressures.

CO1 | b | 04

A simple manometer is shown in fig. Calculate the pressure of water flowing through pipe.



Given:-

S_1=1

S_m=13.6

h_1=50mm =0.05m

h_2= 60mm = 0.06m

Find out:-

P_B=? N/m^2

Solution:-

a) **Pressure on the left hand side of Manometer.**

$h_B + S_1 \times h_1 = 0$

$h_B + 1 \times 0.05 = 0$ --------------------------(1)

b) **Pressure on the right hand side of Manometer.**

$S_m \times h_2 = 0$

$13.6 \times 0.06 = 0$ --------------------------(2) **(01 Marks)**

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...ng pressure equation (1) and (2)

... + 1 x 0.05 = 13.6 x 0.06

... = 13.6 x 0.06 -1 x 0.05

h_B = 0.766 m of Water **(02Marks)**

$P_B = w \times h_B$

$P_B = 9.81 \times 1000 \times 0.766$ (***Weight Density H_2O = 9.810 N/m^3***)

P_B = 7514.46 N/m^2

P_B = 7.51445 KN/m^2 **(01Marks)**

Alternate Method

∴Pressure on L.H.S. of Manometer = Pressure on R.H.S. of Manometer

$\therefore P_B + \rho_1 \times g \times h_1 = \rho_m \times g \times h_2$ **(01 Marks)**

$\therefore P_B = \rho_m \times g \times h_2 - \rho_1 \times g \times h_1$ **(01 Marks)**

$\therefore P_B = (13.6 \times 1000 \times 9.81 \times 0.06) - (1 \times 1000 \times 9.81 \times 0.05)$

$\therefore P_B = (8004.96) - (490.5)$ **(01 Marks)**

∴P_B = 7514.46 N/m^2

∴P_B = 7.51446 KN/m^2 **(01 Marks)**

OR

Explain Surface tension and capillarity.

Surface Tension (σ):- Surface tension is defined as the tensile force acting on the surface of a liquid in contact with gas or on the surface between two immiscible liquid such that the contact surface behaves like membrane under tension. The magnitude of this force per unit length of the free surface will have the same value as the surface energy per unit area. In MKS units, it is expressed as kgf/m while SI units as N/m. **(02Marks)**

Capillarity:-

Capillary is defined as phenomenon of rise or fall of liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid. The rise of liquid surface is known as ***capillary rise*** while the fall of liquid is known as ***capillary depression***. It is expressed in terms of cm or mm of liquid. **(02Marks)**

(MODEL ANSWER)

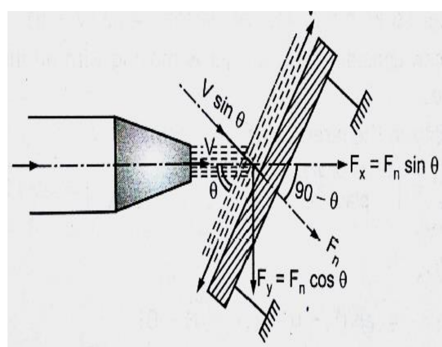
AGNEL POLYTECHNIC, VASHI

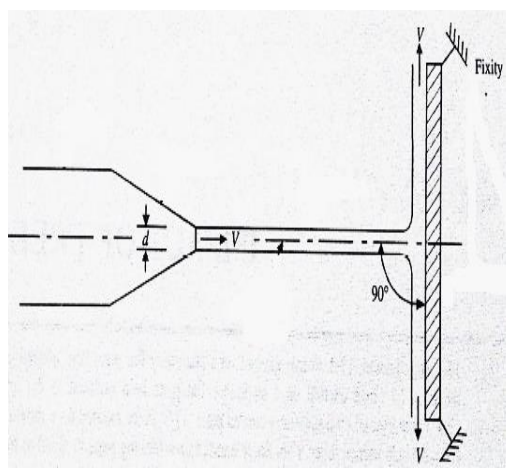
Unit Test 2

Course Code: - ME-4G (A&B) Subject Fluid Mechanics and Machinery

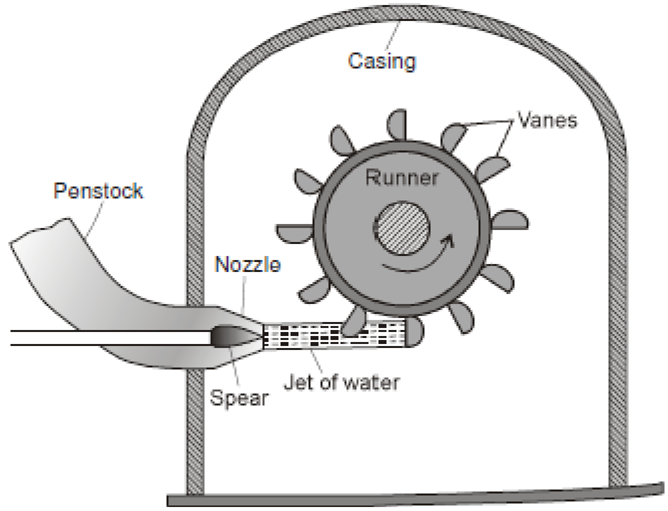
Time: **1 hour**

Marks: **25**

Q.No	C. O.		Questions	Marks
		A)	**Attempt any two of the following.**	3x2=6
		a	**What is impact of jet? Write the formula for force exerted when plate is fixed**. The liquid comes out in the form of jet from the outlet of a nozzle, which is fitted to a pipe through which the liquid is flowing under pressure. If some plate, which may be fixed or moving, is placed in the path of jet, a force is exerted by the jet on the plate. **This force is obtained from Newton's second law off motion or from impulse-momentum equation. Thus impact of jet means force exerted by the jet on a plate which may be stationary or moving**. **force exerted when plate is fixed**(F) = mass flow rate × change in velocity (Initial vel. – Final velocity) $= \rho.a.V \times (V - u) \quad = \quad \rho.a.V^2$ ……………as u = 0 and $\rho = \frac{w}{g}$ $F \quad = \quad \rho.a.V^2$ in Newton 	
1.	CO4	b	**Find the force exerted by jet when it strikes on a flat inclined fixed plate.** Consider a jet of water striking on a fixed inclined plate at an angle θ, We know that; $F = (\rho.a.V^2)$ • Let a jet of water striking an inclined stationary flat plate with velocity V; • Therefore, mass of water striking per second = $\rho.a.V$ • Now, let us find out the force exerted by the jet in the direction normal to the plate. Let F_n be this force.  • If θ = Angle between the jet and plate, then,	

			Component of velocity of jet before striking in the direction normal to plate = V. sin θ. • Also, velocity of jet in the direction normal to plate after striking = 0 • Therefore, $F_n = \begin{pmatrix} \text{mass of water} \\ \text{striking per second} \end{pmatrix} \times$ (initial velocity − Final velocity) $= \rho.a.V \times [V.\sin\theta - 0] = \rho.a.V^2.\sin\theta$ • This force can be resolved into two mutually perpendicular components i.e. along two perpendicular directions, one in the direction of jet (F_x) and other perpendicular to the direction of jet (F_y). Force in the direction of jet, $F_x = (F_n.\sin\theta) = \rho.a.V^2.\sin\theta \times \sin\theta$ $F_x = \rho.a.V^2.\sin^2\theta$ Force in the direction normal to the jet, $F_y = F_n.\cos\theta = \rho.a.V^2.\sin\theta.\cos\theta$	
		c	**A jet of water 95 mm diameter is moving with a velocity of 25 m/s, strikes a stationary plate. Find the normal force on plate when plate is normal to jet.** **Given data- d=95 mm=0.095m, V=25 m/s** Area of jet $= \frac{\pi}{4} \times d^2 = \frac{\pi}{4} \times 0.095^2 = 0.007084\, m^2$ $F = \rho.a.V^2$ F= $1000 \times 0.007084 \times 25^2$ **F= 4427.890 N** 	

		B)	**Attempt the following**	3x1=3
	CO5	c	**Define Slip and state the condition for negative Slip.** The actual discharge of pump is generally less than the theoretical discharge due to leakage. Slip of a pump is defined as the difference between the theoretical discharge and actual discharge of the pump. $$\text{Slip} = Q_{th} - Q_{actual}$$ Slip is expressed in percentage as follows; $$\text{Percentage slip} = \frac{Q_{th} - Q_{actual}}{Q_{th}} \times 100$$ **Negative Slip** If actual discharge is more than the theoretical discharge, the slip of the pump will become negative and the slip is called as negative slip. The reason for negative slip to occur is short delivery pipe, higher rpm. of pump and long suction pipe. **Or** **Define i) Suction Head ii) Delivery Head iii) Manometric Head related to Centrifugal pump**. **i. Suction head (hs):** It is the vertical height of the Centre line of centrifugal pump above the water surface in the tank or sump from which water is to be lifted. **ii. Delivery head (hd):** The vertical distance between the Centre line of the pump and water surface in the tank upto which water is to be delivered is known as delivery head. **iii) Manometric head (Hm):** The manometric head is defined as the head against which the centrifugal pump has to work.	
2.			**Attempt any two of the following.**	**4x2=8**
	CO5	a	**Explain with neat sketch construction and working of Pelton wheel turbine.** This turbine is a tangential flow impulse turbine. This turbine is used when high head more than 300 m, is available in reservoir and operates at low specific speed less than 60 rpm.	



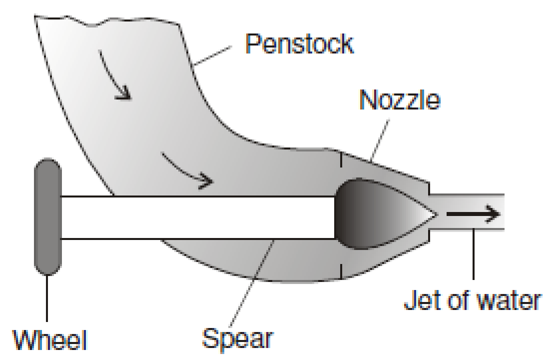
Pelton turbine

Working

In this turbine, water strikes the bucket (vanes) along the tangent of the runner. The energy available at the inlet of turbine, is kinetic energy only, which rotates the turbine and so electrical energy is produced. The pressure at inlet and outlet of turbine is atmospheric. The kinetic energy is produced when water from reservoir flows through the penstock and out through the nozzle. The nozzle converts pressure into kinetic energy of water flowing through the penstock. To stop rotation of turbine, the breaking jet which falls on the vanes of turbine in reverse direction is used.

The main parts of Pelton wheel turbine are:

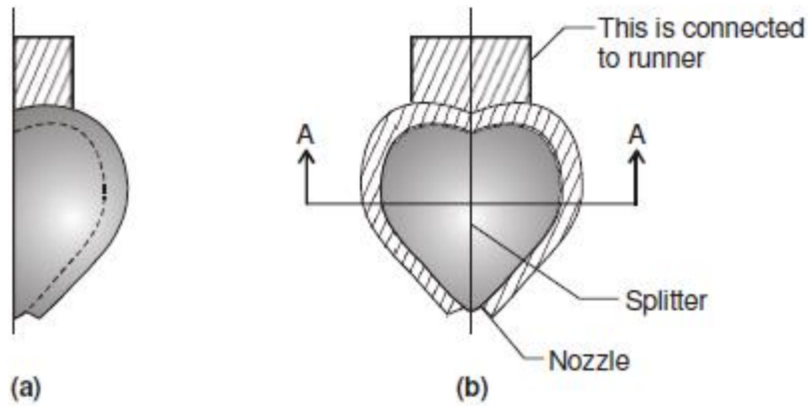
i. Nozzle and flow regulating arrangement



Nozzle with a spear to regulate flow

The amount of water striking the bucket (vanes) of the runner, is controlled by providing sphere in the nozzle as shown in figure.

ii. Runner with bucket



A circular disk with number of buckets evenly spaced on its periphery constitutes runner of Pelton wheel. The shape of the bucket is doubled hemispherical cup or bowl. Each bucket is divided into two symmetrical parts by a dividing wall which is known as splitter. The jet of water strikes on splitter. The splitter divides jet into two equal parts and jet comes out at the outer edge of the bucket. The buckets are made up of cast iron, cast steel, bronze or stainless steel.

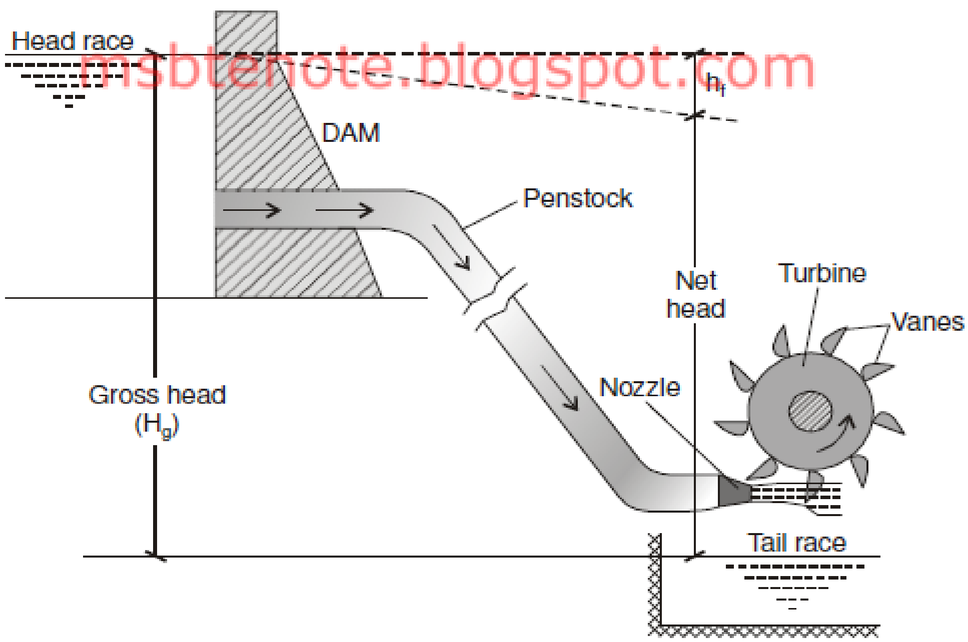
iii. Casing: The function of the casing is to prevent the splashing of water and to discharge water to tail rate. It also acts as a safeguard against accidents. It is made up of cast iron and fabricated steel plate. It doesn't perform any hydraulic function.

iv. Breaking jet: Breaking jet falls on the back of the vane, to stop rotating turbine. This jet of water is called breaking jet.

b **Compare impulse turbine with reaction turbine.**

	Impulse Turbine	Reaction Turbine
i.	The energy available at the runner of turbine is kinetic energy only.	Energy available are both K.E. and pressure energy at the inlet of turbine.
ii.	The water flows through nozzle and falls on the buckets, which are fixed to the outer periphery of the wheel.	The water is guided by blades to flow over moving vanes.
iii.	The pressure on water is atmospheric.	The velocity and pressure both vary as water passes through the runner.
iv.	Nozzle is fitted at the end of penstock. Casing has no hydraulic function to do.	Penstock is connected directly to casing. Casing is of spiral type.
v.	e.g., Pelton wheel turbine.	e.g., Francis turbine, Kaplan turbine.
vi.	The wheel should not run full of water.	The wheel must run full of water.
vii.	It is possible to regulate flow without loss.	It is not possible to regulate flow without loss.

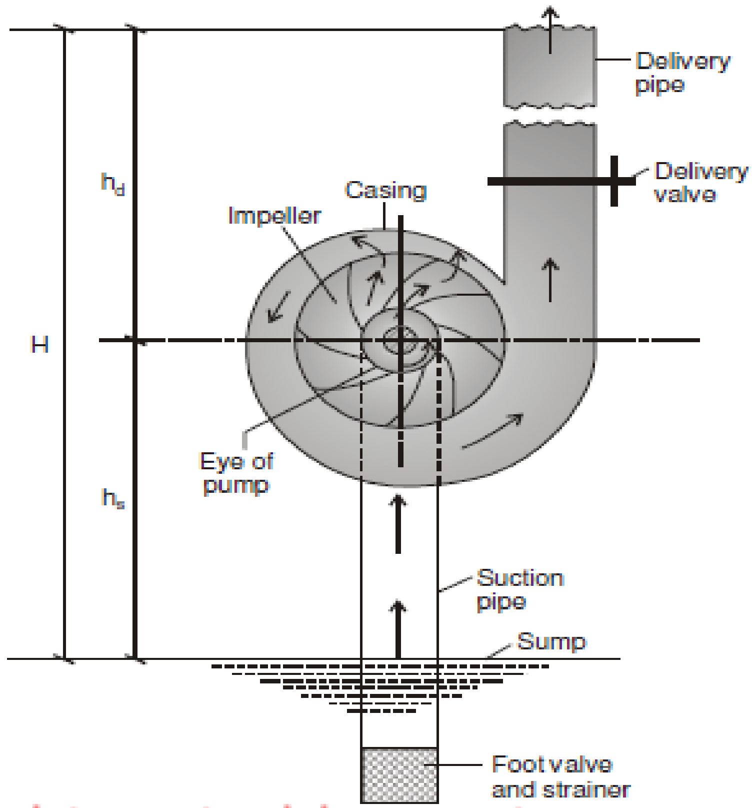
c **Draw neat labeled diagram of Hydraulic Power plant layout.**

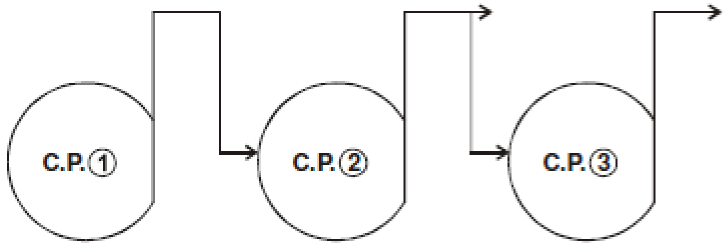


Layout of a hydro-electric power plant

Attempt *Any Two* of the following.

CO6	a	**Draw a neat labeled diagram of centrifugal pump**.	**04**

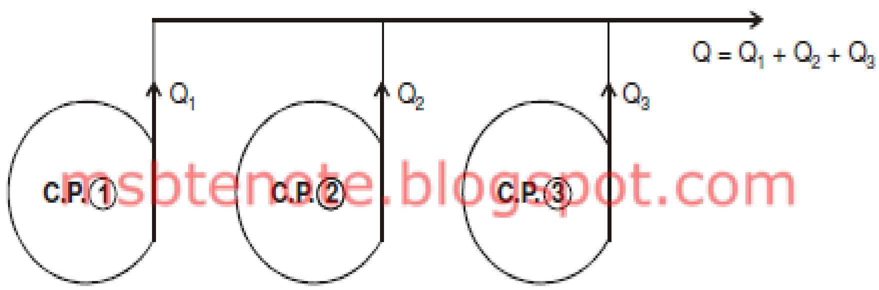
3.			 **Main parts of a centrifugal pump**	
		b	**Explain with neat sketch the construction and working of multistage pump.** If the centrifugal pump consists of two or more impellers, the pump is called multistage centrifugal pump. The impeller may be mounted on same shaft or different shafts. **Multi staging is done for two purposes**: i. To produce a high head i.e. pressure ii. To discharge large quantity of liquid. The high head is generated by connecting centrifugal pump in series. While to get high discharge pumps are connected in parallel. **i. Multistage centrifugal pump to get high head (series arrangement)**	**04**



Total head = n □□Hm
where, n: number of impellers / pump
Hm: head developed by each impeller or pump

To get high head the impellers can be mounted on the same shaft or output of one pump is connected to second pump and second pump is to third pump and so on.

ii. Multistage centrifugal pump for high discharge (Parallel arrangement):



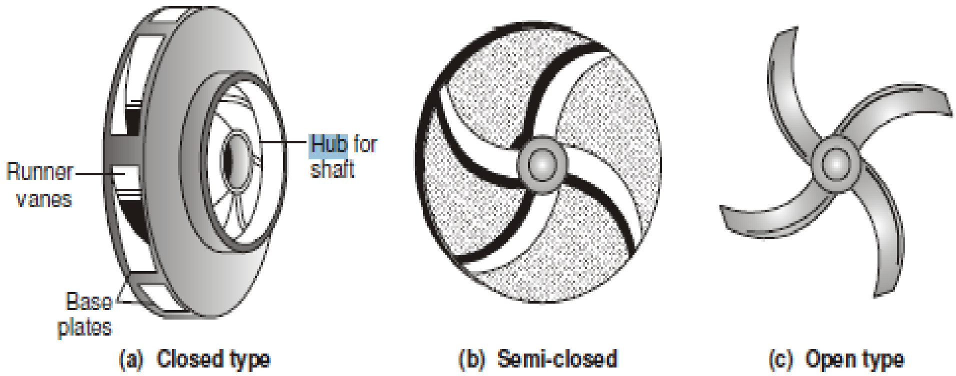
Total discharge = Q = Q1 + Q2 + Q3 + ...+ Qn
In parallel arrangement, to get high discharge, all the pumps output is connected to the common discharge line, i.e., pipe.

c

Explain any two types of impellers with neat sketch.

04

Impeller
The rotating part of centrifugal pump is called as impeller. It consists of series of backward curved vanes. The impeller is mounted on shaft which is connected to the shaft of an electric motor with the help of coupling. There are three types of impellers.



a. Closed type impeller: In this impeller the vanes or blades are inserted in the closed walls from both sides. It provides better guidance for liquid and has higher efficiency. **Uses:** Used when the liquid is clean and free from impurities and debris.

b. Semi-closed impeller: The vanes or blades are closed from only one side by the wall of the material. **Uses:** It is used for pumping water or liquid containing debris and impurities to some extent such as sewage water, machine tool lubricants, paper pulp etc.

c. Open impeller: In this type the vanes are open from all the sides.
Uses: This is used for pumping liquid having debris or impurities of large size such as mixture of water, sand, clay etc.

IMPORTANT QUESTIONS FOR FMM FOR PASSING AND SCORING

Q1. Explain the construction and working of Pelton wheel turbine. (8 Marks)

Q2. Explain the construction and working of Francis turbine. (8 Marks)

Q3. Explain the construction and working of Kaplan turbine. (8 Marks)

Q4. Explain the function and different types of Draft tube. (8 Marks)

Q5. Differentiate between Impulse and Reaction Turbine. (8 Marks)

Q6. Explain the working of centrifugal pump with neat labeled sketch. (8 Marks)

Q7. Explain the different types of impellers and casing used in centrifugal pump. (8 Marks)

Q8. Define priming state its necessity. (2 Marks)

Q9. Define Slip and state the condition for negative slip? (4Marks)

Q10. Define the different head related to the Centrifugal pump. (4Marks)

Q11. Define Cavitation and state its effects. (4Marks)

Q12. Define the Specific Speed of Pump OR Specific speed of Turbine. (2 Marks)

Q13. Define NPSH. (2 Marks)

Q14. Differentiate between Centrifugal pump and Reciprocating Pump. (8Marks)

Q15. Explain Single acting or Double acting reciprocating pump. (4Marks)

Q. Explain the effect of Acceleration and Friction on Indicator diagram. (8 Marks)

Q16. Explain the effect of Acceleration on Indicator diagram. (4Marks)

Q17. Explain Jet pump.(4 Marks)

Q18. Explain Air Vessel and state its function.(4Marks)

Q19. Explain multi stage pump.(8 Marks)

Q20. Explain Hydraulic gradient and Total Energy Line. (HGL and TEL). (4Marks)

Q21. Define surface tension and capillarity. (4 marks)

Q22. Define Atmospheric pressure, Gauge pressure, Vacuum pressure, Absolute pressure and show there relation with diagram. (4 Marks)

Q23. Define Different types of flow with examples. (4 marks)

Q24. State Darcy's equation and Chezy's equation and state the meaning of each term. (4 marks)

Q25. State the law of fluid friction for laminar and turbulent flow. (4 marks)

Q26. Define Kinematic viscosity and Dynamic viscosity with unit. (2 marks)

Q27. Define Centre of pressure and Total Pressure. (2 marks)

Q28. Explain the different types of Minor losses in pipes. (8 Marks)

Q29. State the Bernoulli's theorem with meaning of each term. (4 marks)

Q30. State continuity equation. (2 marks)

Q31. Define impact of Jet. (2 marks)

ALONG WITH ABOVE QUESTIONS JUST SOLVE THE NUMERICAL ON TOTAL PRESSURE AND CENTRE OF PRESSURE FOR CIRCULAR PLATE AND ISOSCELES TRIANGLE. (8 marks)

TWO NUMERICALS ON CENTRIFUGAL PUMP TO FIND WORK DONE AND EFFICIENCY AND DISCHARGE. (4 marks)

ONE NUMERICAL ON POWER TRANSMISSION. (4 marks)

NUMERICAL ON FIRST FOUR CASES OF IMPACT OF JET. (8 Marks)