
WINTER-12 EXAMINATION

Subject Code-12093 **Model Answer**

Question No-1 a)

a. Kinematic viscosity – Ratio between the dynamic viscosity and density of fluid

V=Viscosity/ density Mark -1

Unit- Stoke or m^2 /sec Mark -1

b. Absolute pressure – sum of atmospheric pressure and gauge pressure

Pabs= P atm+ Pgauge

Pabs= Patm- Pvaccum Mark -1

Atmospheric pressure – Pressure exerted by the air on the earth surface.

Standard value- 101.3 KN/ m^2 and 760mm of Hg Mark -1

c. Continuity equation –

Statement- A Fluid flowing through the pipe at all cross-section, the quantity of fluid per second (Rate of flow) is constant. Mark -2

$A_1 V_1 = A_2 V_2$

d. 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. Mark -2

e. Impact of Jet- The force exerted by the jet on a plate which may be stationary or moving.

Stationary case-Plate is vertical /Inclined/ curved

Moving case-Plate is vertical /Inclined/ curved Mark -2

f. According to the action of water

-Impulse turbine e g Pelton wheel

-Reaction turbine e g Francis turbines, Kaplan turbines and propeller turbines. Mark -2

g. Cavitations – the phenomenon of formation of vapour bubbles and sudden collapsing of the vapour bubbles. Mark -2

h. i) Slip– difference between the theoretical discharge and actual discharge of the pump. Mark-1 ii) Negative slip- If actual discharge is more than the theoretical discharge, the slip of the pump will become negative. Mark -1

Question No-1 b)

a. If a centrifugal pump consists of two or more impellers, the pump is called a multistage pump. Mark -2

-To produce a high head and
-To discharge a large quantity of liquid.
Multistage pump with impeller in series-
For developing a high head , a number of impeller are mounted in series.
The water from suction pipe enters the 1 st impeller at inlet and is discharged at outlet with increased pressure. The water with increased pressure from the outlet of the I st impeller is taken to the inlet of 2nd impeller with the help of connecting pipe. The pressure of outlet of 2 nd impeller will be more.
Mark -2

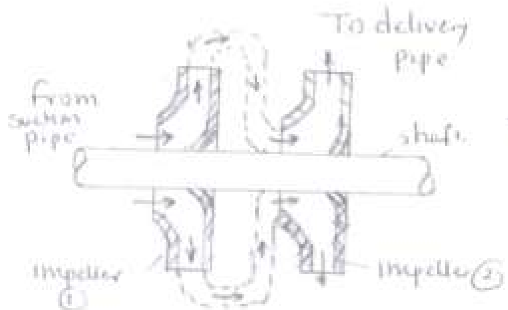
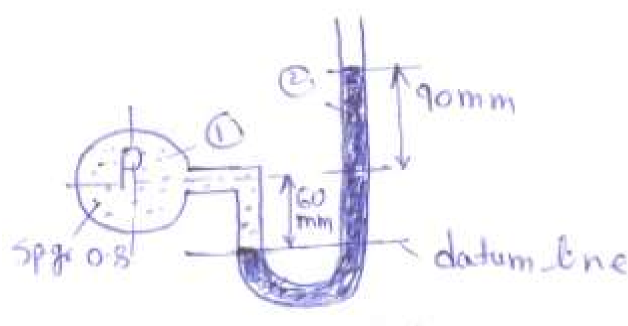


Figure - Multistage pump with impeller in series

b. Given data



w_1=0.8 X 9810 N/ m^3
w_2=13.6 X 9810 N/ m^3
P atm=101.3 KN/ m^2
Pressure in pipe = ω2(0.09 +0.06) –ω1(0.06)
=13.6 x 9810 x 0.15 – 0.8 x 9810 x 0.06
= 19541.51 N/m^2 = 19.54151 kN/m^2 Mark -2

Pabs= P atm+ Pgauge

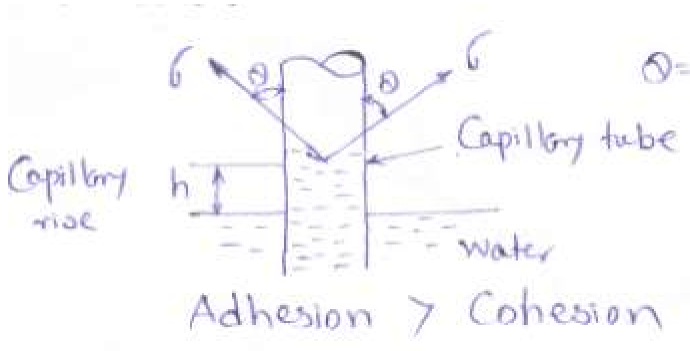
=101.3x 1000+19541.51= 120841.52 N/m^2 Mark -2

c. Capillary rise- Phenomenon of rise of liquid level in tube.

-Depends upon the surface tension of the liquid ,specific weight of the liquid and diameter of the tube .

Formula- $h=4\sigma \cos\theta / \rho g d$, σ- surface tension, h- capillary rise. Mark -2

If surface tension increases, the capillary rise level also increases. Mark -1



Mark -1

Question No-2

a) Pump fails to start pumping (any four points Mark -4)

1. Pump may not be properly primed (Reprime the pump)
2. Impeller may be clogged (clean the impeller)
3. The rotation of the impeller may be in the wrong direction (change the direction of the Rotation)
4. Too high suction lift (reduce the suction lift)
5. Low speed (increase the speed)
6. Total head against which pump is working may be much higher than that for which the pump is designed (check the head with accurate gauge, reduce the head or change the pump)

b) Given data d = 50 mm = 0.05 m

Area $a = \pi/4\ (0.05)^2 = 1.96 \times 10^{-3}\ m^2$

$V = 15$ m/s, $u = 6$ m/s,

$\rho = 1000\ kg/m^3$

Force exerted by the jet = $\rho a V (V-u)$

$= 1000 \times 1.96 \times 10^{-3} \times 15 \times 9 = 265$ N Mark -2

Work done by the jet = F x u = 265 x 6 = 1590 Nm/s Mark -1

Efficiency, $\eta = 2u\,(V-u)/\,V^2$

$= 2 \times 6\,(15-6)/\,15^2$

$= 0.48$ or 48% Mark -1

c) H = 50 m, L =850 m, d = 0.5 m, F= 0.01

Total losses = loss of head at inlet + loss of head due to friction + loss of head at outlet

$50 = 0.5V^2/\,2g + FLV^2/2gd + V^2/\,2g$

$50 = V^2/\,2g\,(0.5 + 0.01 \times 850/0.5 + 1)$

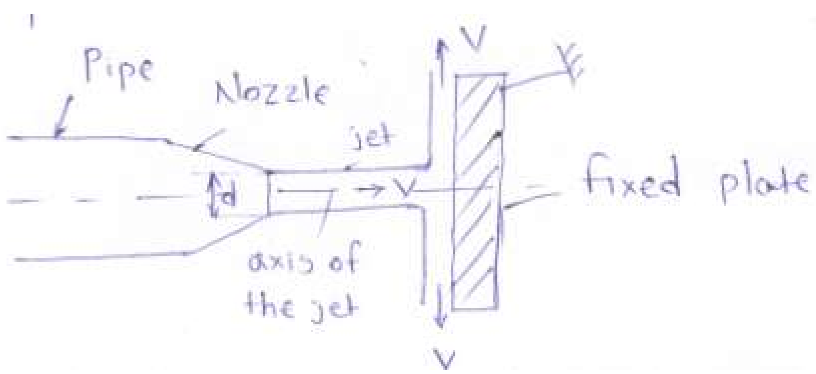
$50 = V^2/\,2g\,(18.5)$

V = 7.28 m/s Mark -2

Discharge in pipe = aV = $\pi/4\,(0.5)^2 \times 7.28 = 1.43\ m^3/s$

Q = 1430 lit/s Mark -2

d) Impact of jet on a fixed vertical flat plate,



Mark -2

Force exerted by the jet = $\rho a V^2$ Mark -1

ρ =density of flowing liquid

a = cross sectional area of jet = $\pi/4\,(d)^2$

d =diameter of jet of liquid

V= velocity of jet. Mark -1

e) Concept of vapour pressure: - a change from the liquid stage to gaseous stage is known as vaporization. The vaporization occurs because of continues escaping of the molecule through the liquid surface. When the vaporization take place the molecule escape from the free surface of liquid. These accumulated vapours exert a pressure on the liquid surface. This pressure is known as vapour pressure of the liquid.

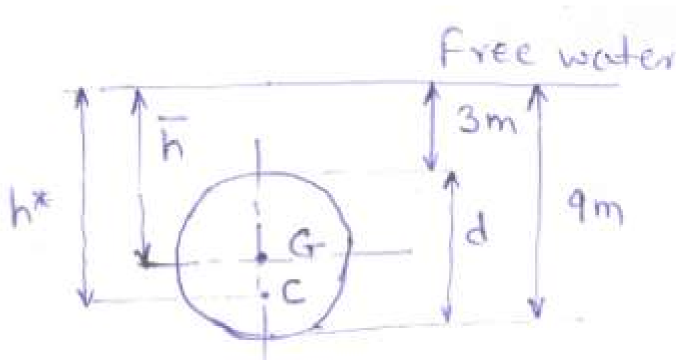
This is the pressure at which liquid converted into vapours. Vapour pressure increase with rise in temperature. Mercury has very low vapour pressure so it is used in a barometer.

Mark -4

f) Given data d = 6 m

Area a = $\pi/4\ (6)^2 = 28.27\ m^2$

$\rho = 1000\ kg/m^3$, $\omega = 9810\ N/m^3$



h = distance between free surface of water level and centre of gravity

$h = 3 + d/2 = 3 + 6/2 = 6\ m$

Total pressure on the plate, $F = \omega A\bar{h} = 9810 \times 28.27 \times 6 = 1663972.2\ N$ Mark -2

Position of centre of pressure h*

$I_G = \pi/64\ d^4 = \pi/64\ (6)^4 = 63.62$

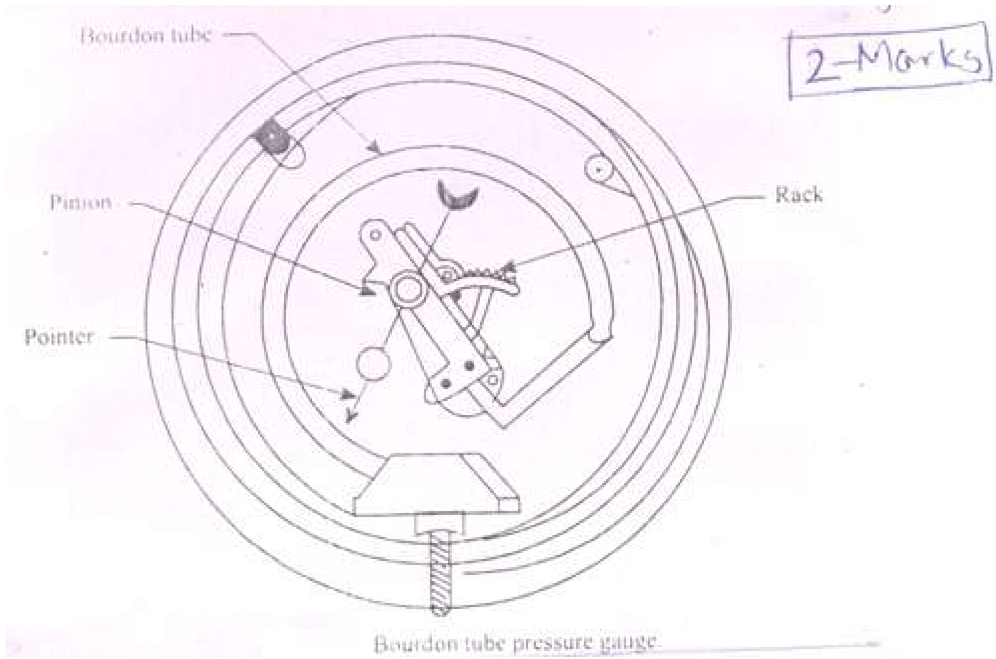
$\bar{\bar{h}} = I_G/A\bar{h} + \bar{h} = 63.62 / 28.27 \times 6 + 6 = 6.375\ m$ Mark -2

Question 3:

a) Bourdon pressure gauge :

Working – when the one end of elliptical cross sectional tube which is attached to the gauge case is connected to the sources of the pressure. The internal pressure causes the tube to expand. Free end of the tube moves and is in turn connected by suitable lever to a rack. This engages with small pinion mounted on the same spindle as the pointer. Thus pressure applied to the tube cause the rack and pinion to move. The pressure is indicated by the pointer over a dial which can graduate in a suitable scale.

Mark -2



Bourdon tube pressure gauge

b) pitot tube : Given data density of water = ρ= 1000 kg/ m^3

Water level h = 87.5 mm

Density of air = 1 kg/m^3

H= air height

$\rho_{water} \times h = \rho_{air} \times H$

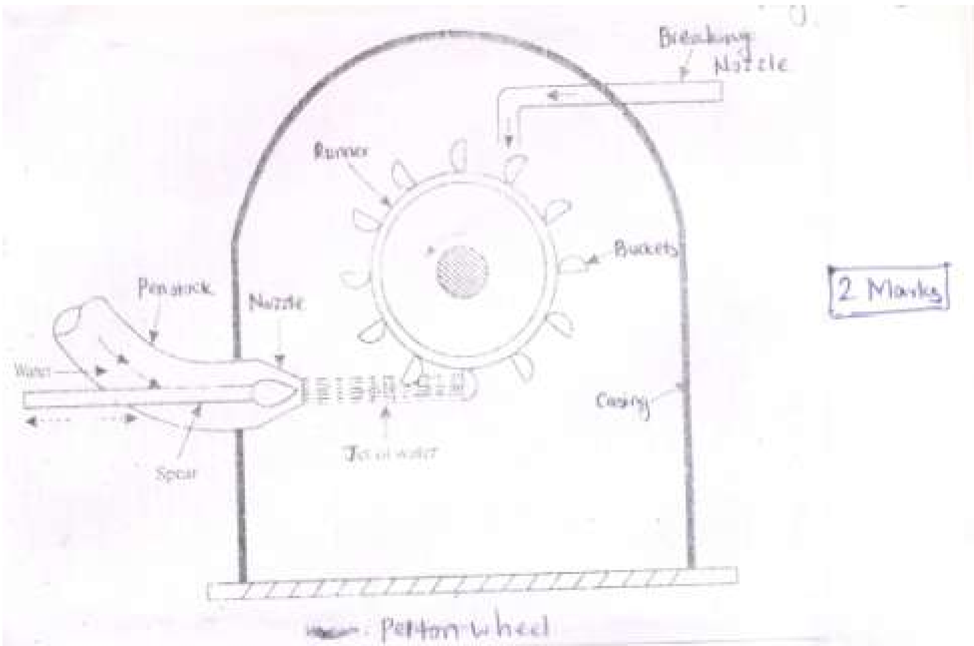
1000 x 87.5/1000 = 1 x H

H = 87.5 m Mark -2

Velocity of flow of air in the pipe= Cv $\sqrt{2gH}$ = $0.99\sqrt{2 \times 9.81 \times 87.5}$ = 41.02 m/s Mark 2

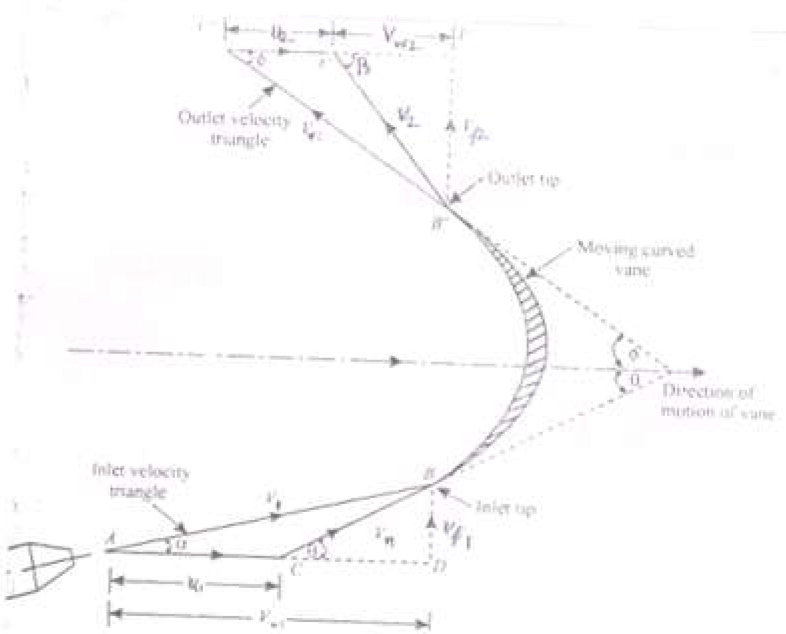
Note- ρ = Density of air = 1.2 kg/ m^3. Answer- H = 73 m, V = 37.5 m/s

c) Working of pelton wheel: water is transfer from high head source through penstock which is fitted with a nozzle through which water flows out at a high speed jet. All available potential energy is converted into kinetic energy before the jet strike the bucket of the runner. The energy transfer occurs due to purely impulse action. The runner is rotated and mechanical energy is developed. Mark -2



Mark -2

d) Inlet and outlet velocity diagram



Mark -2 for inlet & Mark -2 for outlet

Jet striking a moving curved vane tangentially at one tip and leaving at the other

V_1, V_2 = Absolute velocities of the jet at the inlet and outlet respectively.

u_1, u_2 = Peripheral velocities of the vane at the inlet and outlet respectively.

V_{r1}, V_{r2} = Relative velocities at the inlet and outlet respectively.

V_{f1}, V_{f2} = Velocities of the flow at the inlet and outlet respectively.

V_{w1}, V_{w2} = Velocities of the whirl at the inlet and outlet respectively.

θ, ϕ = Tip angles at the inlet and outlet respectively.

α, β = Angles which the absolute velocities make at the inlet and outlet respectively.

d) Given data d = 30 cm = 0.3 m, L = 50 m, V = 3m/s,Type equation here.

Kinematic viscosity $\nu = 0.01$ stoke $= 0.01 \times 10^{-4}\ m^2/s$

Darcy's formula $h_f = 4\ f\ L\ V^2/2gd$

Reynolds number $= Vd/\nu = 3 \times 0.3/\ 0.01 \times 10^{-4} = 9 \times 10^5$ Mark 1

Coefficient of Friction $f = 0.0791/(Re)^{1/4}$ $Re > 4000$

$= 0.0791/(9 \times 10^5)^{1/4}$

$= 0.00263$ Mark -1

$h_f = 4 \times 0.00263 \times 50 \times 3^2\ /2 \times 9.81 \times 0.3 = 0.804$ m =804 mm Mark -2

e) Pressure head

The height of free surface of liquid above any point. Unit – meter

$h = P/\ \omega$ Mark -2

h = pressure head

P = intensity of pressure.

ω = specific weight of liquid

$P = \omega \times h$

P = pressure in Pascal, 1 Pascal= 1 N/m^2 Mark -2

Liquid column $h = P/\ \omega$ or

For water, P = 100 Pascal= 100 N/m^2

h= 100/9810 = 0.0102 m (liquid column of water)

Q:4:a)Given: P=3160 kW

h=144 m

η_0=86 %

N=1000 rpm

η_h=90% =0.9

Speed ratio=0.9

Flow ratio= 0.3

speed ratio=$U/\sqrt{2gh}$=0.9

$u = 0.9\times\sqrt{2gh}$
$= 0.9\times\sqrt{2\times9.81\times144}$
$u = 47.83$ m/s

flow ratio $= Vf/\sqrt{2\times g\times h}$

$Vf = 0.3\times\sqrt{2\times9.81\times14}$

$Vf = 15.94$ m/s

$\eta_h = Vw1\times u1/g\times H$
$0.9 = Vw1\times47.83/9.81\times144$
$Vw1 = 26.58$ m/s

i) Guide blade angle i.e. α from inlet velocity triangle
$\tan\alpha = Vf1/Vw1 = 15.94/26.58 = 0.599$
$\alpha = \tan^{-1} 0.599$
[α =30.94°]-Ans (2 marks)

ii) When angle at inlet i.e.θ
$\tan\theta = Vf1/(u1-Vw1) = 15.94/(47.83-25.39) = 0.710$
$\theta = \tan^{-1} 0.710$
[θ = 35.38°]-Ans (2 marks)

iii) Diameter of runner at inlet (D1)
$U1 = \pi D1N/60$
$D1 = 60\times u1/\pi\times N = 60\times47.83/\pi\times1000$
[D1=0.913 m]-Ans (2 marks)

iv) Width of runner at inlet (B1)
η_0 =S.P/W.P =3160/w.p
but w.p=wh/1000 =$p\times g\times Q\times H/1000$
$=1000\times9.81\times Q\times144/1000$
$\eta_0 = 3160/(1000\times9.81\times Q\times144/1000)$
$=3160\times1000/1000\times9.81\times Q\times144$
$Q=3160\times1000/1000\times9.81\times144\times0.86=2.601$ m3/sec
$Q=\pi D1\times B1\times Vf1$
$2.601=\pi\times0.913\times B1\times15.94$
[B1=0.0568 m]-Ans (2 marks)

b) (any eight points 01 mark each)

Sr.No.	Centrifugal Pump	Reciprocating Pump
1	Simple in construction because of less number of parts.	Complication in construction because of more number of parts.
2	Total weight of pump is less for given discharge.	Total weight of pump is more for given discharge.
3	Suitable for large discharge and small heads.	Suitable for less discharge and higher heads.
4	Requires less floor area and simple foundation .	Requires more floor area and comparatively heavy foundation .
5	Since it has rotating element there is less wear and tear.	Since it has reciprocating element there is more wear and tear.
6	Balancing is proper.	Balancing is not proper.
7	Maintenance cost is less.	Maintenance cost is more.
8	Suction and delivery values are not necessary.	Suction and delivery values are necessary.
9	It can handle dirty water.	It cant handle dirty water.
10	Starting torque is more.	Starting torque is less.
11	It can run at high speed.	It cant run at high speed.
12	It has less efficiency.	It has more efficiency.
13	Its delivery is continuous.	Its delivery is pulsating.
14	Air vessels are not required.	Air vessels are required.
15	Thrust on the crank shaft is uniform.	Thrust on the crank shaft is not uniform.
16	Operation is quite simple.	Much care is required on Operation.

c) Laws of fluid friction for laminar flow: (2 marks)

1)The frictional resistance is proportional to the velocity of flow .

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 various considerably with temperature.

5) The frictional resistance is independent of the nature of surface of contact.

Law of fluid friction for Turbulent flow: (2 marks)

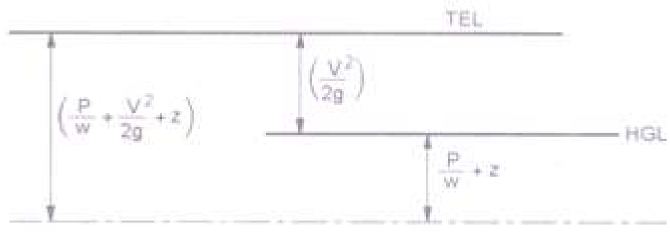
1)The frictional resistance is proportional to the square of velocity of flow.

2) The frictional resistance is independent of the pressure.

3) The frictional resistance is proportional to the density of fluid.

4) The frictional resistance slightly varies with temperature.

5) The frictional resistance is proportional to the surface area of contact.



Total energy and hydraulic gradient line

Hydraulic Gradient Line(H.G.L) (2 marks)

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

Hydraulic gradient line may rise or fall depending upon the pressure changes.

Hydraulic gradient line lies below total energy line by $V^2/2g$

H.G.L=P/W+Z

Total Energy Line(T.E.L) (2 marks)

Total energy line is which gives sum of pressure head datum head and kinetic head of a flowing fluid of a flowing pipe with respect to some reference line.

When the fluid flows along the pipe there is loss of head and total energy decreases in the direction of flow.

When total energy at various points along the axis of pipe is plotted and joined by a line the line obtained is called as energy gradient line.

Total energy line is above hydraulic gradient line by $V^2/2g$

T.E.L=P/w+ $V^2/2g$+Z

Q:5:

a)Given : height= 6m

Calculate i) Intensity of pressure (2 marks)

P=wXh

=9810X6

=58860 N/m^2

P=58.86 KPa

ii) mm of mercury (2 marks)

p= Wxh
58.86=13.6X9.81Xh
h=0.441m =441.17 mm of mercury

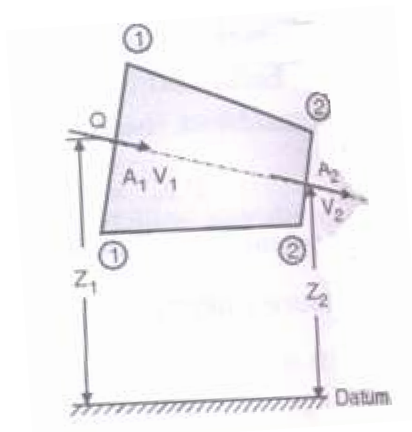
iii)meter of water (2 marks)

p=wXh
58.86=9.81Xh
h=6m of water

iv) N/m^2 absolute (2 marks)

$P_{abs}= P_{atm}$ + Pgague
=101300+ 58860
= 160160 N/m^2

b)



This theorem states that whenever there is a continuous flow of liquid the total energy at every section remains the same provided that there is no loss or addition of the energy. (2 marks)

i.e. Z+ V^2/2g + P/W=Constant (2 marks)

Where Z=Potential energy

V^2/2g=Kinetic energy

And P/w= Pressure energy

Let us consider a conduit having section

Now by using Bernoulli's theorem

Total head at section=Total head at section

$P1/w + V^2_1/2g+Z_1 = P2/w + V^2_2/2g+Z_2$

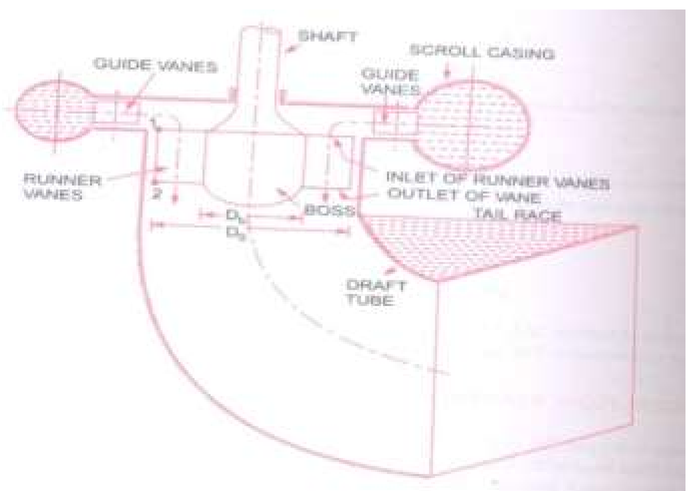
Limitation of Bernoulli's Equation (2 marks)

1. It is applicable to ideal incompressible flow.
2. The heat transfer into and out of fluid should be zero.
3. The temperature remains constant so that internal energy does not change.
4. The effects of presence of any mechanical device between two sections is ignored

Following application (2 marks)

Venturimeter,
Orifice meter,
Pitot tube

C) Construction of Kaplan Turbine

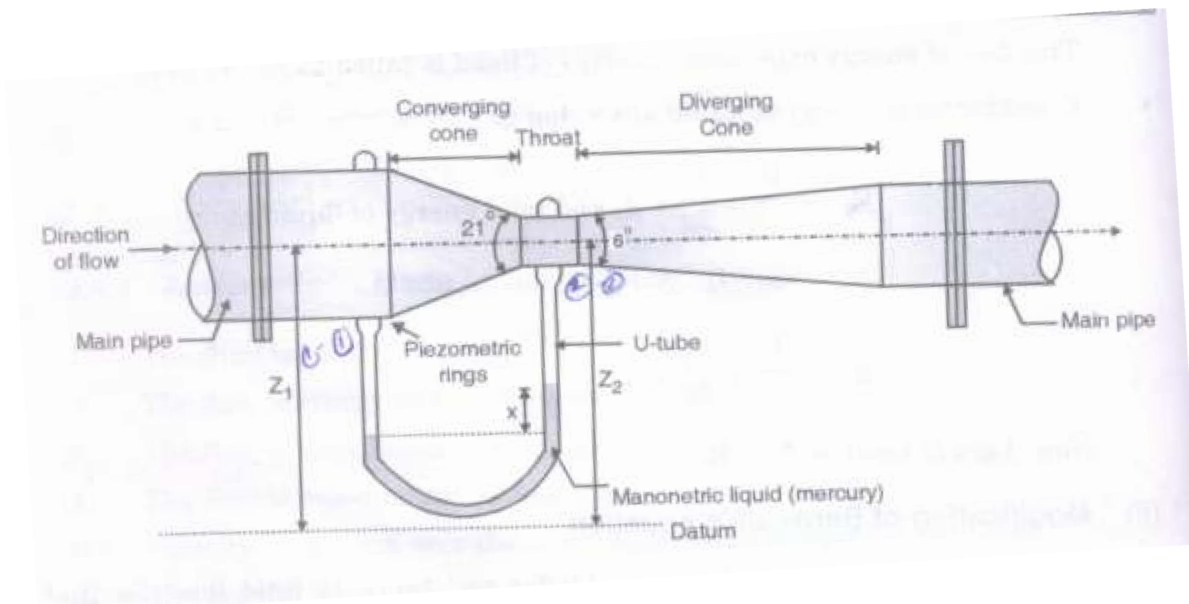


(3 marks)

The components of Kaplan turbine are runner, guide vanes, scroll casing, draft tube The runner vanes of Kaplan turbine are also adjustable just like the guide vanes of Francis turbine. (2 marks)

The turbine gives good efficiency even at different load condition and water flows over the blades without shock. in Kaplan turbine water enters the runner in an axial direction and during process of energy transfer it travels across the blade passage in axial direction and leaves axially. The pressure at inlet of blades is larger than the pressure at the exit of the blades. The energy transfer is due to the change in magnitude of relative velocity across the blades in Kaplan turbine the runner blades are adjustable and can be rotated about pivots fixed to the boss of runner. The blades are adjusted automatically by servo mechanism so that at all loads, the flow enter without shock. High efficiency is maintained even at part load. (3 marks)

Q:6:a)



(2 marks)

Venturimeter is the device used for measuring the rate of flow of fluid flowing through the pipelines.

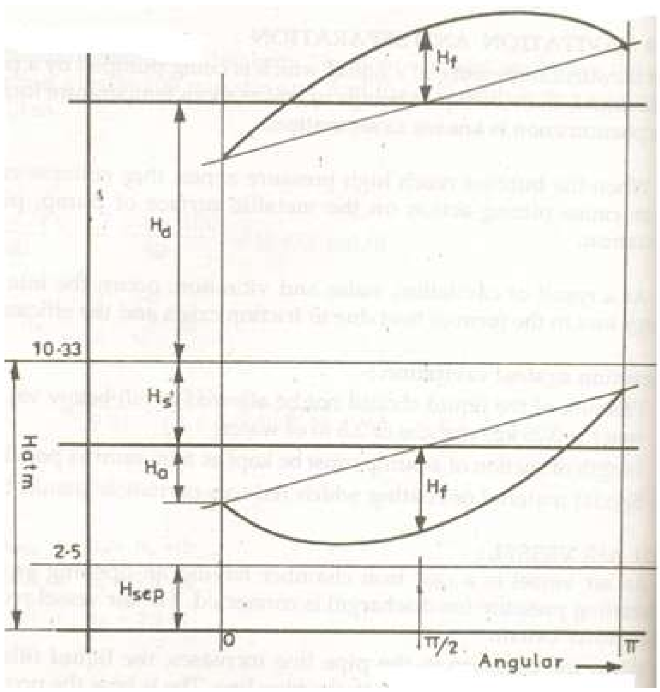
Construction: It consists of a short converging conical tube which has a total included angle of 21±1˚ leading to a cylindrical portion of short length known as throat diameter of throat varies between 1/3 to ¾ of main pipe diameter (preferable 1/2)which is followed by a diverging section known as diffuser having total included angle 5˚ to7˚(preferably 6˚)which is again connected to the main pipe line.

Angle of diversion cone is smaller because when water is passing through throat its velocity is more since area of throat is less.

The pressure difference from which the volume rate of flow can be determined is measured between the entry section 1 and the throat section 2.often by means of U-tube manometer.

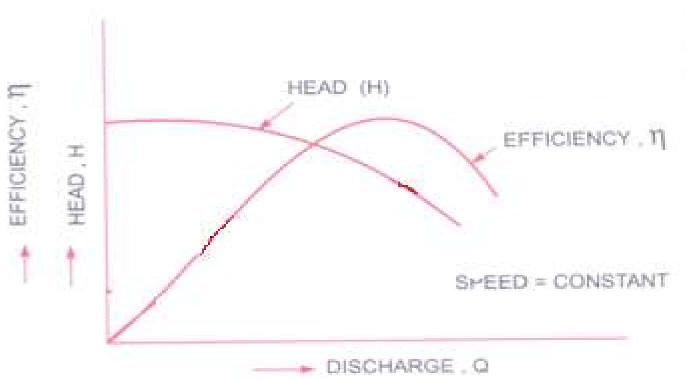
The axis of venturimeter may be horizontal or inclined vertical. (2 marks)

b) (08 marks)



Indicator diagram considering effects of acceleration head (04 marks) and frictional head(04 marks).

c)



(4 marks)

If the speed is kept constant the variation of manometric head and efficiency with respect to discharge gives the operating characteristics curve of the pump.

The head curve will have maximum value of head when discharge is zero.

The efficiency curve will start from origin as at Q=0,η=0 (4 marks)
