Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

1	**a)**	Attempt any **SIX**	
	(i)	**Surface tension**:- It is defined as the tensile force acting on the surface between two immiscible liquids such that the contact surface behaves like a membrane under tension. Its SI unit is N/m	01
		Dynamic viscosity:- It is defined as the shear stress required to produce unit rate of shear strain. Its SI unit is N-s/m^2	01
	(ii)	**Compressibility:-** It is defined as the ratio of compressive stress to volumetric strain. Also it is the reciprocal of bulk modulus of elasticity K. Compressibility= 1/K	01
		Vapour pressure:-It is defined as the pressure at which the liquid will transform into vapour at the given temperature. It is the function of temperature.	01
	(iii)	**Gauge pressure**:- It is defined as the pressure which is measured with the help of a pressure measuring instrument, in which the atmospheric pressure is taken as datum	01
		Atmospheric pressure:-It is defined as the pressure exerted by the air column on the surface of the earth. Its standard value is 101.3k Pa	01
	(iv)	**Types of fluid flow:-** a) Steady & Unsteady Flows b) Uniform & Non- uniform Flows c) Rotational &Irrotational Flows d) Laminar & Turbulent Flows	½ marks each
	(v)	**Uses of air vessels:-** a) To obtain a continuous supply of liquid at a uniform rate	02

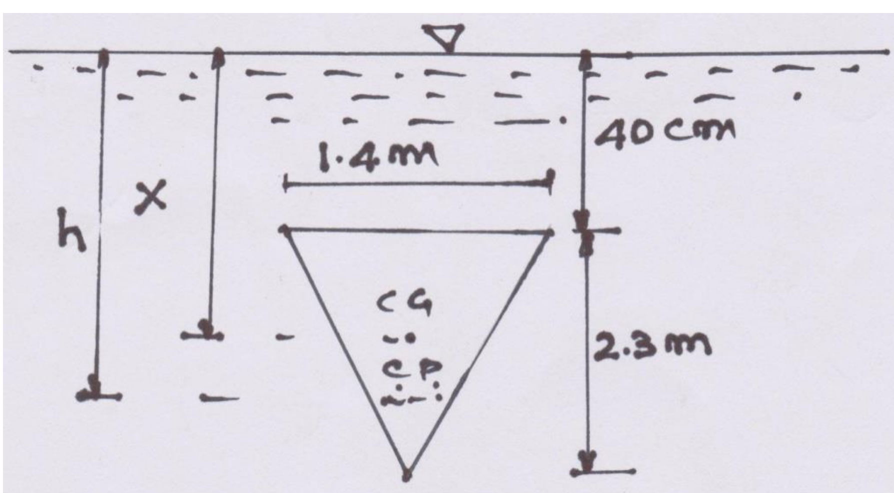
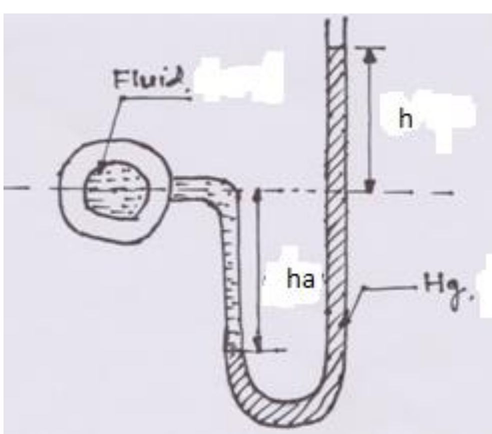
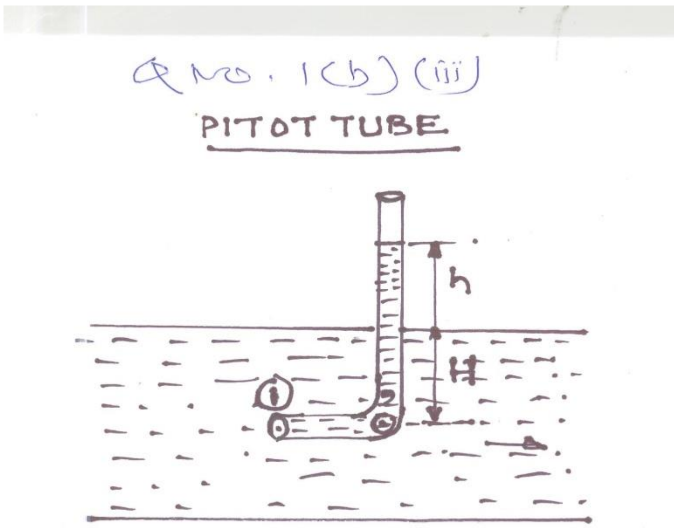
	.	b) To save a considerable amount of work in overcoming the frictional resistance in the suction and delivery pipes c) To run the pump at a high speed without separation.	
	(vi)	**Functions of draft tubes**:- a) To decrease the pressure at the runner exit to a value less than the atmospheric pressure & thereby increases the effective working head b) To recover a part of kinetic energy , into a pressure head at the exit of draft tube c) To prevent the cavitation at the exit of the runner d) It serves to fix the turbine above the tail race facilitating proper inspection of the turbine.	02
	(vii)	**Cavitation in Centrifugal pump**:-This is hydraulic phenomenon which is more likely to occur on the suction side of the pump at the centre line of the impeller since the pressure drops below atmosphere. When the absolute pressure falls below the vapour pressure of the liquid, liquid begins to vaporize & cavities (bubbles) are formed. These cavities move from zones of low pressure to the zones of high pressure & suddenly collapse at a terrific force causing damage to impellers called pitting & erosion of the material. Cavitation may also result in serious vibration with noise & drop in flow efficiency.	02
	(viii)	**Slip of the pump**:-It is defined as the difference between theoretical discharge and actual discharge. $$\text{Slip} = Q_{th} – Qa$$ Negative slip:- Sometimes, the actual discharge of a reciprocating pump is greater than the theoretical discharge. In such cases, the coefficient of discharge of a pump will be more than unity. Then, in this situation the slip (Q_{th} – Qa) is known as negative slip of a pump.	02
	b)	Attempt any **TWO**	
	(i)		

		Figure shows vertical immersion of triangular plate according data given Data:- Base:- 1.4 m, Height:- 2.3 m, Area of the plate= A =½ x 1.4 x 2.3 = 1.61 m^2 From the above fig. we have, CG of the plate from free surface= X = 0.4 + 1/3 2.3 = **1.166 m** Thus Total Pressure = P = W x A x X = 9.81 x 1.61 x 1.166 **= 18.41 KN Ans.** Now M. I. of the plate about its cg= I_{gg} = bh^3/ 36 **=** **$1.4 \times 2.3^3 / 36 = 0.473\ m^4$** Centre of the pressure = h = I_{gg}/ A X + X = 0.473/ 1.61 X **1.166 + 1.166** **h = 1.417 m Ans.**	 01 01 01 01
	ii	**Types of manometers**:- Following are the types of manometers a) Simple Manometer b) Differential Manometer Types of simple manometer:- i) Piezometer ii) U-tube manometer iii) Single Column manometer Types of Differential manometer:- i) U-tube differential manometer ii) Inverted U-tube differential manometer Working of any one of them with sketch  U-tube manometer	02 02

iii **Bernoulli's theorem as applied to Pitot tube**:- 02

Pitot tube is an instrument to determine the velocity of flow at required point in a pipe or a stream. In its simplest form , a Pitot tube consists of a glass tube bent at 90^0 as shown in the figure.

The lower end of the tube faces the direction of flow as shown in the figure. The liquid rises up in the tube due to the pressure exerted by the flowing liquid. By measuring the rise of liquid in the tube we can find out the velocity of the liquid flow.



02

Let h = Height of the liquid in the pitot tube above the surface.

H = Depth of tube in the liquid, and

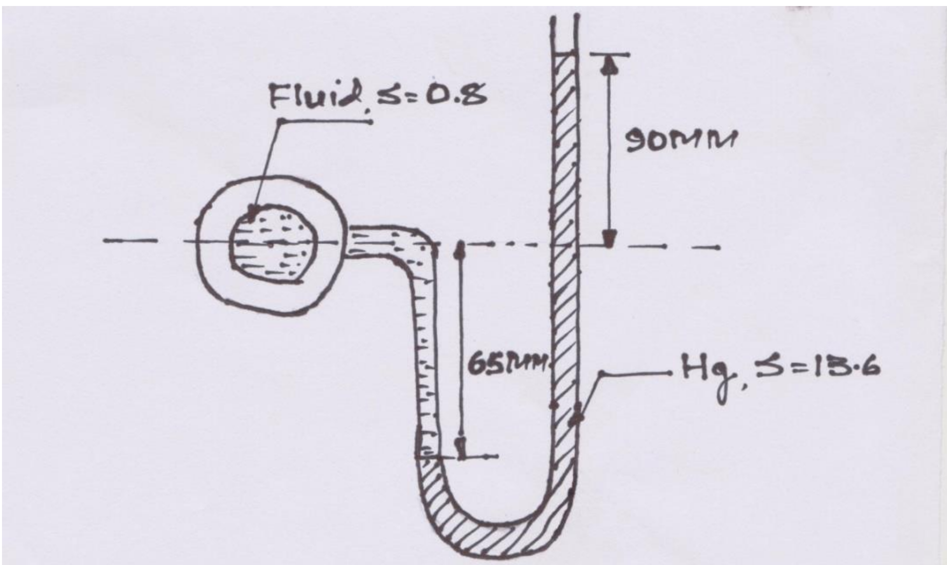
V = Velocity of the liquid.

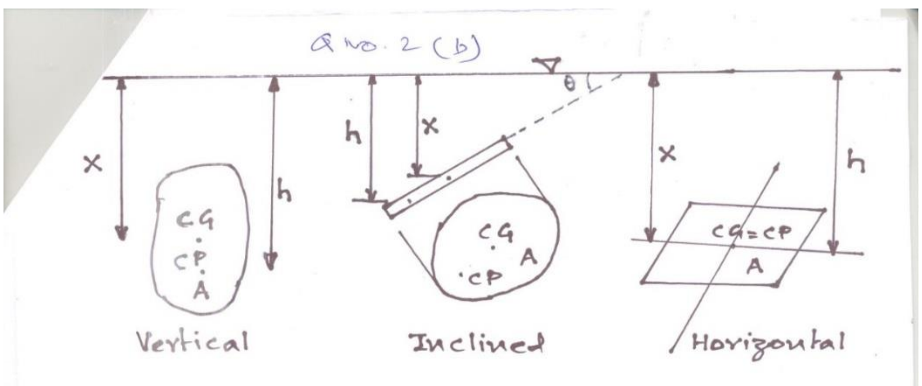
Applying Bernoullis theorem for the section 1 and 2,

$H + v^2/2g = H + h$

Or $h = v^2/2g$

Therefore $v = \sqrt{2gh}$

2	A	Attempt any FOUR	
		Arrangement of manometer is as shown in the figure Let h_a be the pressure head in the pipe in M of water. From mano-metric principle , we have,	
			01
		Total pressure head on X = Total pressure head on Y $h_a + 0.065 \times 0.8 = .155 \times 13.6$ $h_a = 2.108 - 0.052 = 2.056$ M of water Therefore pressure in the pipe $p = w \times h_a$ $= 9810 \times 2.056$ $= 20169.36\ N/m^2$	01
		Let atmospheric pressure be $101300\ N/M^2$ Now Absolute pressure in the pipe $P_{abs} = P_{atm} + p$ $= 20169.36 + 101300$ $=$ **121469.36** N/m^2 Ans.	02
		--	

	b	Whenever any plane surface (Body) is immersed in the static fluid the body experiences the force exerted by the fluid particles in all directions The immersed surfaces may be • Verticle plane surface • Inclined plane surface • Horizontal surface The magnitude of all the forces taken together is termed as total pressureand its application point is known as centre of pressure **Total Pressure (P)** is efined as the resultant of the all the forces exerted by the static fluid on the surface when fluid comes in the contact with the surface **Centre of Pressure (h)** is the pont of application of total pressure on the surface	04
	b	 These two terms are calculated as follows P= WxAxX kN Where W = Specific wt of fluid in KN/M^3 A= Area of the surface in M^2 X= Vertical distance of CG of the surface from the free surface of the fluid in M These relations are same for all the three cases mentioned in the figure **Centre of pressure** h = Igg / AX + X for vertical immersion h = Igg Sin^{2}θ / AX + X for inclined immersion h= X for horizontal immersion	

	c	The phenomenon of rising water in a tube of smaller diameter is called **capillary rise**.	

This is due to the reason that the adhesion is more than the cohesion between water molecules.

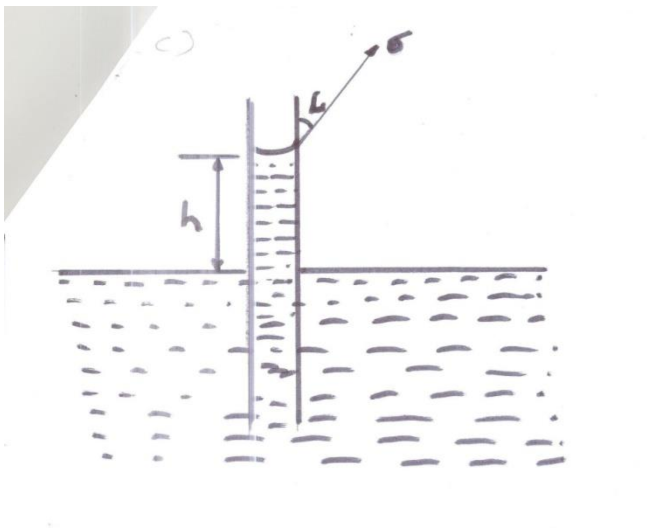
This phenomenon with the above diagram as follows----

Let h = Height of the capillary rise,

d = Diameter of the capillary tube,

α = Angle of contact of the water surface and

σ = Force of surface tension per unit length of the periphery of the capillary tube in N/ mm 02



Weight of the water column in the tube above the water surface acting downwards-

= $wh \times \Pi /4\ d^2$ w- specific weight of water in N / M^3

Vertical component force of surface tension— 02

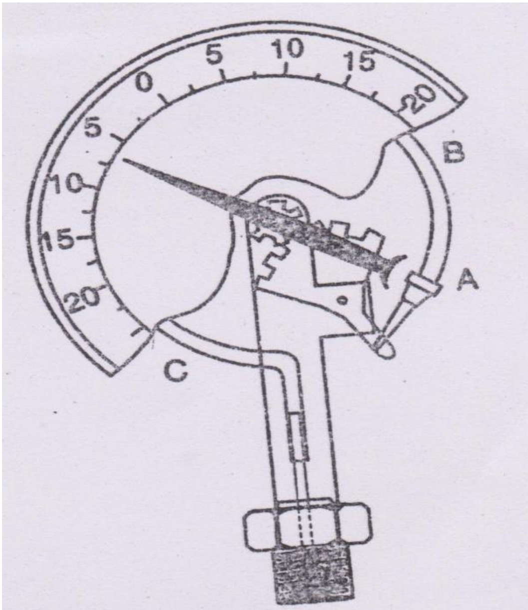
= $\sigma \Pi d \cos\alpha$

From above two equation we have;

$wh \times \Pi /4\ d^2 = \sigma \Pi d \cos\alpha$

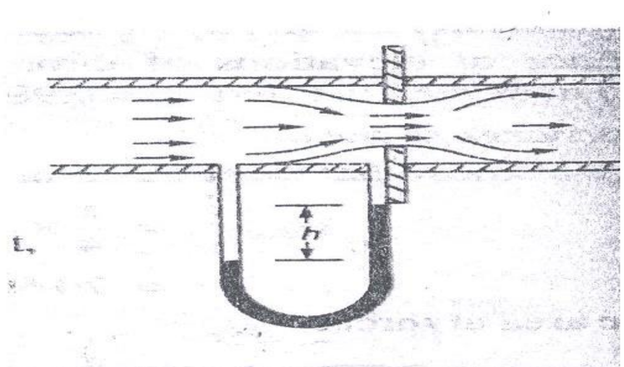
or **$h = 4 \sigma \cos\alpha / wd$**

This is capillary rise

	d	Following figure shows the constructional details of Bourdon pressure gauge  It consists of an elliptical tube ABC; bent into an arc of a circle. This bent-up tube is called Bourdons tube. When the gauge tube is contacted to the fluid at C, the fluid under pressure flows into the tube. The Bourdons tube , as a result of the increased pressure, tends to straighten itself. Since the tube is encased in a circular cover, therefore it tends to become circular instead of straight. With the help of a simple pinion and sector arrangement , the elastic deformation of the Bourdons tube rotates the pointer. This pointer moves over a calibrated scale, which directly gives the pressure.	02 02
	e	1) **Density**:-It is defined as the ratio of mass to the volume. It is also known as **Mass Density** $\rho = M / V$ Kg / M^3 2) **Specific Gravity**:- It is the ratio of specific weight of fluid to the specific weight of Water. $S = W_f / W_w$ 3) **Specific Volume**:- It is the ratio of Volume to the Mass of fluid. Also it is the reciprocal of Mass Density. V= Volume / Mass m^3 / Kg 4) **Specific Weight**:- It is the ratio of Weight to the volume of the fluid. It is also known as Weight Density. W = W / V kN / m^3	01 each

f

An orifice meter is used to measure the discharge in a pipe. The constructional detail is as shown in the figure above. It consists of a plate having a sharp edged circular hole is known as an orifice. This plate is fixed inside a pipe as shown in the figure. 01



01

A mercury manometer is inserted to know the difference of pressures between the pipe and the throat (i.e. orifice)

Let h = Reading of mercury manometer,

p_1 = pressure at inlet,

v_1 = Velocity of liquid at inlet,

a_1 = Area of pipe at inlet, and

p_2 , v_2 , a_2 ,= Corresponding values at the throat

01

Applying Bernoul theorem for inlet and throat we have,

$$Z_1 + \frac{v_1{}^2}{2g} + \frac{P_1}{w} = Z_2 + \frac{v_2{}^2}{2g} + \frac{P_2}{w}$$

Or $h = v^2_1/ 2g - v^2_2/ 2g$

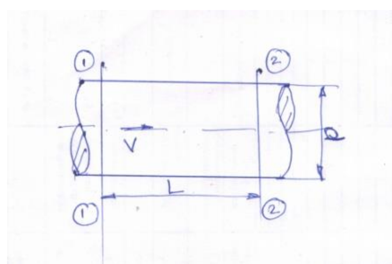
From equation of continuity we have, $a_1 \times v_1 = a_2 \times v_2$

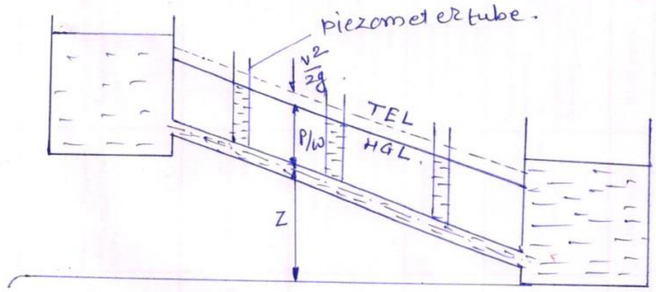
By simplifying above equation and substituting the value of v^2_1 in terms of v_2 we get equation for discharge from orifice meter as

Q = meter costant x a_2 x v_2

$$\mathbf{Q = \frac{C\, a1\, a2}{\sqrt{a1^2 - a2^2}} \sqrt{2gh} \quad m^3 / sec}$$

01

3.	a)	Laws of Fluid Friction for Turbulent Flows 1. The frictional resistance is proportional to the square of velocity of flow. 2. The Frictional resistance is independent of pressure. 3. The frictional resistance is proportional to the density of fluid. 4. The frictional resistance is slightly varies with temperature. 5. The frictional resistance is proportional to the surface area of contact.	4 pt. 4mark
	b)	Darcy's Formula for Head Loss due to friction, $hf = \frac{4 fLV^2}{2 g d}$ ……………….. 2m Where f - Darcy's friction factor Meaning of each term 2m L – Length of Pipe V- Velocity of flow d- diameter of pipe hf- Head loss due to friction 	4
	c)	**Hydraulic Gradient Line and Total energy line** **Hydraulic Gradient Line (Define with diagram 2m)** 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. OR It is the line which is obtained by joining the top of all vertical ordinates, showing the pressure head of a flowing fluid in a pipe from center of the pipe. **Total Energy Line (TEL) (Define with diagram 2m)** 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. OR It is defined as the line which is obtained by joining the tops of all the tops of all vertical ordinates showing the sum of pressure head and kinetic head from center of the pipe.	4m



$HGL = Z + P/w$

$TE = Z + P/w + \frac{V^2}{2g}$

d

Given,

$L = 800\ m$.

$d = 0.5\ m$

$f = 0.01$

Applying Bernoulli's eqn to free surface of water in two tank, we have

$H_1 = H_2 + \text{losses}$

$H_1 - H_2 = \text{Losses}$

$= h_i + h_f + h_o$

h_f = head loss due to friction

h_i = Loss of head at inlet

h_o = Loss of head at outlet

$H_1 - H_2 = 0.5\frac{V^2}{2g} + \frac{4fLV^2}{2gd} + \frac{V^2}{2g}$ ——— 1m 01

$60 = \frac{0.5(V^2)}{2\times9.81} + \frac{4\times0.01\times800\times V^2}{2\times9.81\times0.5} + \frac{V^2}{2\times9.81}$ ——— 1 m

$\therefore V = 4.24\ m/s$ 01

& Discharge $= Q = aV$

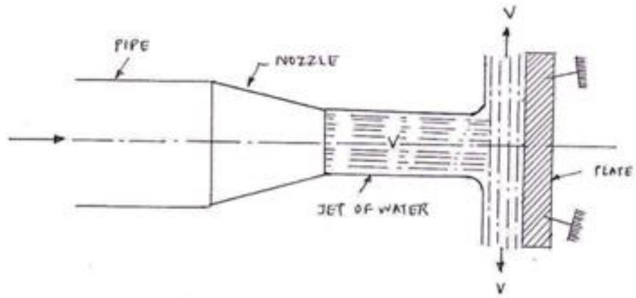
$= \pi/4 \times (0.5)^2 \times 4.24$

$Q = 0.832\ m^3/s$

$Q = 0.832\times10^3$ lps ——— 2 m.

$Q = 832$ lps (lit/sec) 02

e) **Derivation to find the force of impact of jet which strikes on flat plate at right angle which is fixed:-**



FORCE EXERTED BY JET ON VERTICAL PLATE.

Consider a jet of water coming out from the nozzle, strikes a flat vertical plane as shown in fig.

Let V= velocity of jet, d= diameter of the jet,

a= are of cross-section of the jet = $\frac{\pi}{4}$ d^2

The jet after striking the plate will move along the plate. But the plate is t right angle to the jet. Hence the jet after striking will get deflected through 90˚. Hence the component of the velocity of jet, in the direction of jet, after striking will be zero. 02

The force exerted by the jet on the plate in the direction of jet,

F_x= Rate of change of momentum in the direction of force. = $\frac{\text{Initial momentum} - \text{Final momentum}}{\text{Time}}$

$= \frac{(\text{Mass} \times \text{Initial velocity} - \text{Mass} \times \text{Final velocity})}{\text{Time}}$

$= \frac{\text{Mass}}{\text{Time}}$ [Initial velocity − Final velocity] 02

= (Mass /sec)× (velocity of jet before striking- velocity of jet after striking)

= ρa V[V-0] Fx = ρa V^2

f)

Given,

$d = 95 mm = 95 \times 10^{-3}$

$d = 0.095 m$, $a = \pi/4 \, d^2$

$V = 25 m/s$, $a = \pi/4 \times (0.095)^2$

$F_n = ?$ $a = 7.08 \times 10^{-3} \, m^2$

i). plate is normal to the jet

$F = \rho a V^2$ $\rho = 1000 \, kg/m^3$

$F = 1000 \times 7.08 \times 10^{-3} \times (25)^2$

$F = 4425 N$ — (2m) — 02

ii). The angle between jet and plate is 30°,

$\therefore \theta = 30°$

$F_n = \rho a V^2 \sin\theta$ — 02

$= 1000 \times 7.08 \times 10^{-3} \times 25^2 \times \sin 30$

$F_n = 2212.5 N$ — 2m.

4. a) **Multistage centrifugal pump**

If a centrifugal pump consists of two or more impellers, the pump is called Multistage centrifugal pump. The impellers may be mounted on the same shaft or different shaft.

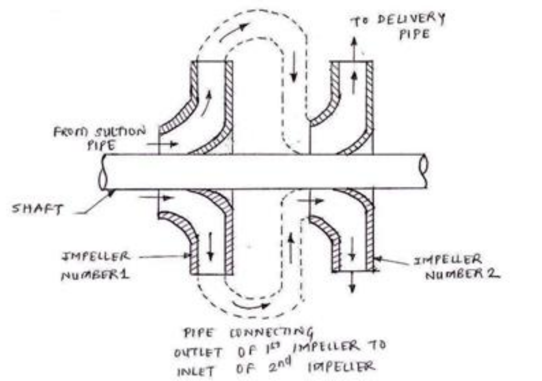
If a high head is to be developed the impellers are connected in series or on the same shaft, while for discharging large quantity of liquid , the impellers are connected in parallel. 02

Multistage centrifugal pump for High Head For developing a high head, a number of impellers are mounted in series or on the same shaft.

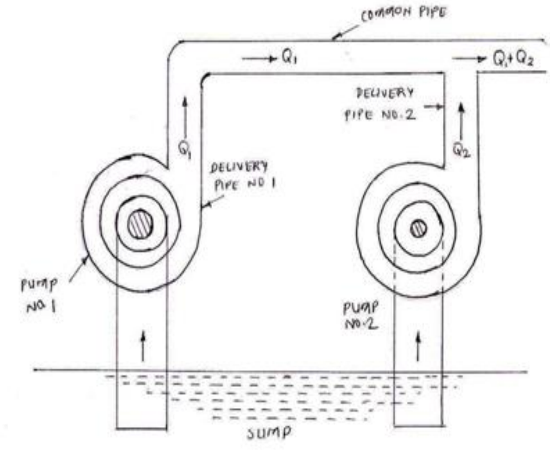
The water from the suction pipe enters the 1st impeller at inlet and is discharged at outlet with increased pressure. The water with increased pressure from the outlet of the 1st impeller is taken to the inlet of 2nd impeller with the help of a connecting pipe as shown in fig. At the outlet of the 2nd impeller, the pressure of water will be more than the pressure of water at the outlet of 1st impeller. Thus if more impellers are mounted on the same shaft, the pressure at the outlet will be increased further. 03

Multi stage centrifugal pumps for high discharge For obtaining high discharge the pumps should be connected in parallel. Each of the pump and discharges water to a common pipe to which the delivery pipes of each pump are connected. Each of the pump is working against the same head.

Application: - Submersible Pump is a Multistage centrifugal pump used for delivering water at high head.



TWO STAGE PUMPS WITH IMPELLER IN SERIES.



PUMPS IN PARALLEL

03

b

$N = 400$ rpm.
$H = 125$ m.
$D = 1.2$ m.
$A = 0.4\ m^2$.
$\alpha = 20°,\ \theta = 60°$

Assuming discharge at outlet is radial,
$\therefore$ we have, $\beta = 90°$ & $V_{w_2} = 0$.

From inlet velocity triangle.

$\tan\alpha = \frac{V_{f1}}{V_{w1}} \Rightarrow V_{f1} = V_{w1}\tan 20°$

$V_{f1} = 0.363 V_{w1}$, $u = \frac{\pi D N}{60} = \frac{\pi \times 1.2 \times 400}{60}$

$u = 25.13$ m/s

and $\tan\theta = \frac{V_{f1}}{V_{w1} - u_1} = \frac{0.363 V_{w1}}{V_{w1} - 25.13}$ 01

$\tan 60 \times (V_{w1} - 25.13) = 0.363 V_{w1}$

$1.732 V_{w1} - 43.52 = 0.363 V_{w1}$ 01

$1.363 V_{w1} = 43.52$

$V_{w1} = 31.92$ m/s ——— 1 m

$\therefore V_{f1} = 0.363 \times 31.92$

$V_{f1} = 11.59$ m/s ——— 1 m 01

i] Flow rate, is

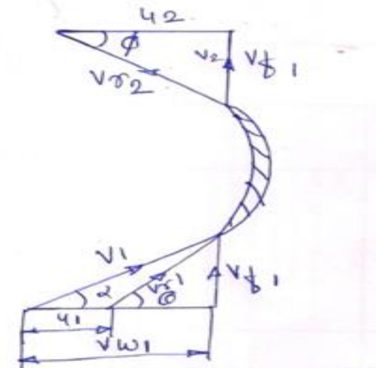
$Q = (\pi D B) \times V_{f1} = 0.4 \times 11.59$

$Q = 4.636$ m/s ——— 1 m 02

ii] Power developed, ——— 2 m

$= \rho Q [V_{w1} u_1]$

$= 1000 \times 4.636 \times 25.13 \times 31.92 = 116.50 \times 31.92 = 3718765.5$ Nm/s

		iii) Hydraulic efficiency $\eta_h = \frac{V_{w_1} u_1}{g \cdot H}$ $= \frac{31.92 \times 25.13}{9.81 \times 125}$ $= 0.654$ $\eta_h = 65.4\%$ ——— 2m. diagram 1m.  Figure Q.NO.4b	01 02
	c	$d_1 = 300\ mm = 0.3\ m$. $d_2 = 150\ mm = 0.15\ m$. $C_d = 0.98$ Reading of differential manometer. $x = 200\ mm = 0.2\ m$. ∴ Differential head, $h = x\left[\frac{S_{Hg}}{S_w} - 1\right]$ $= 0.2\left[\frac{13.6}{1} - 1\right]$ $h = 2.52\ m$ ——— 2m. $a_1 = \pi/4 \times (0.3)^2 = 0.0706\ m^2$ ——— 1m. $a_2 = \pi/4 \times (0.15)^2 = 0.0176\ m^2$ ——— 1m. ∴ Discharge, $Q = C_d \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$ ——— 2m. $Q = 0.98\left[\frac{0.0706 \times 0.0176}{\sqrt{0.0706^2 - 0.0176^2}}\right] \times \sqrt{2 \times 9.81 \times (2.52)}$ ——— 2m. $Q = 0.12518\ m^3/sec$. $Q = 125.18\ lit/sec$	02 01 01 02 02
5	a	Minor Losses in the pipe fittings and valves (1 Marks Each=1x4=4marks) 1) Loss of head due to sudden enlargement	4

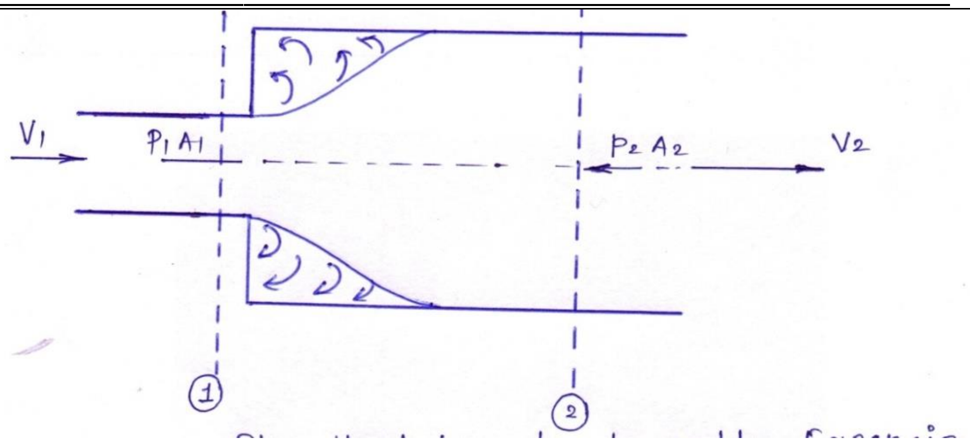


Fig-Head Loss due to sudden Expansion

$h_e=(V_1-V_2)^2/(2g)$

2) Loss of head due to sudden contraction

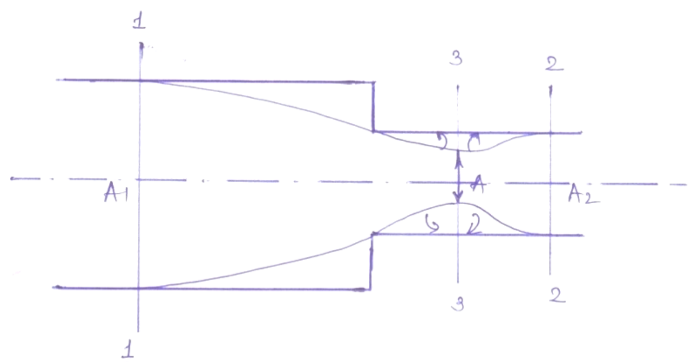


Fig-Loss of head due to sudden contraction.

$h_c=[(1/C_c-1)]^2\times(V_2/(2g)$

3) Loss of head at entrance

$h_i= 0.5V^2/(2g)$

4) Loss of head at exit

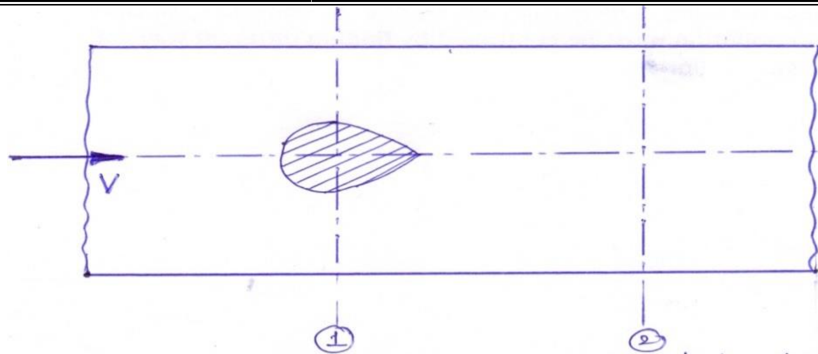
$h_o= V_2^2/(2g)$

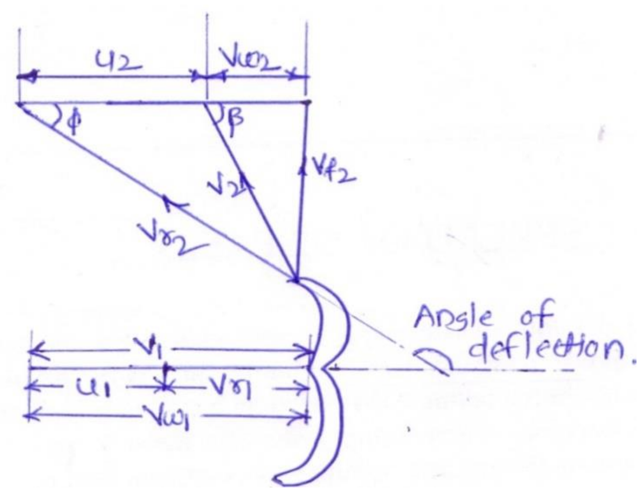
5) Loss of head due to bend & pipe fitting

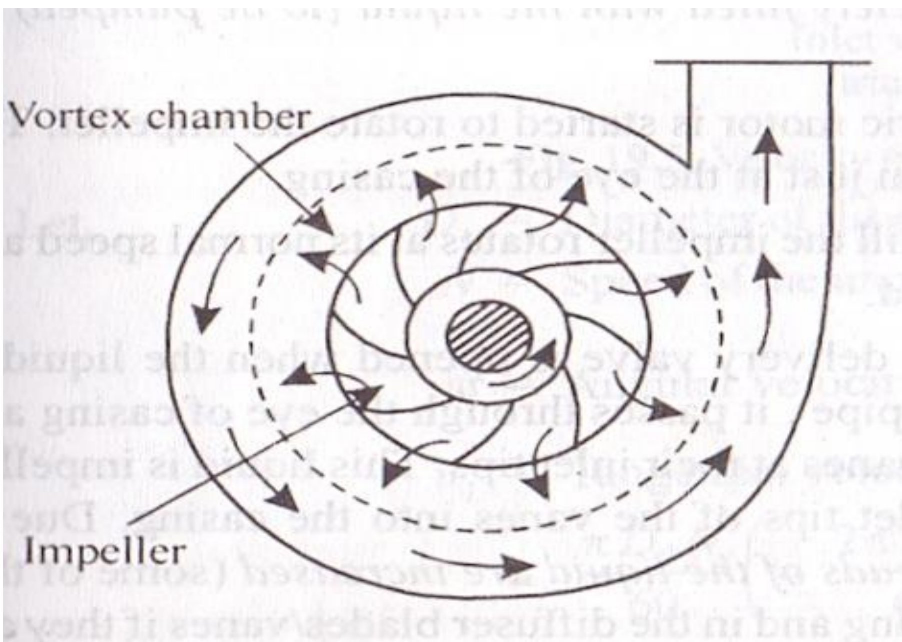
$h_b= KV^2/(2g)$

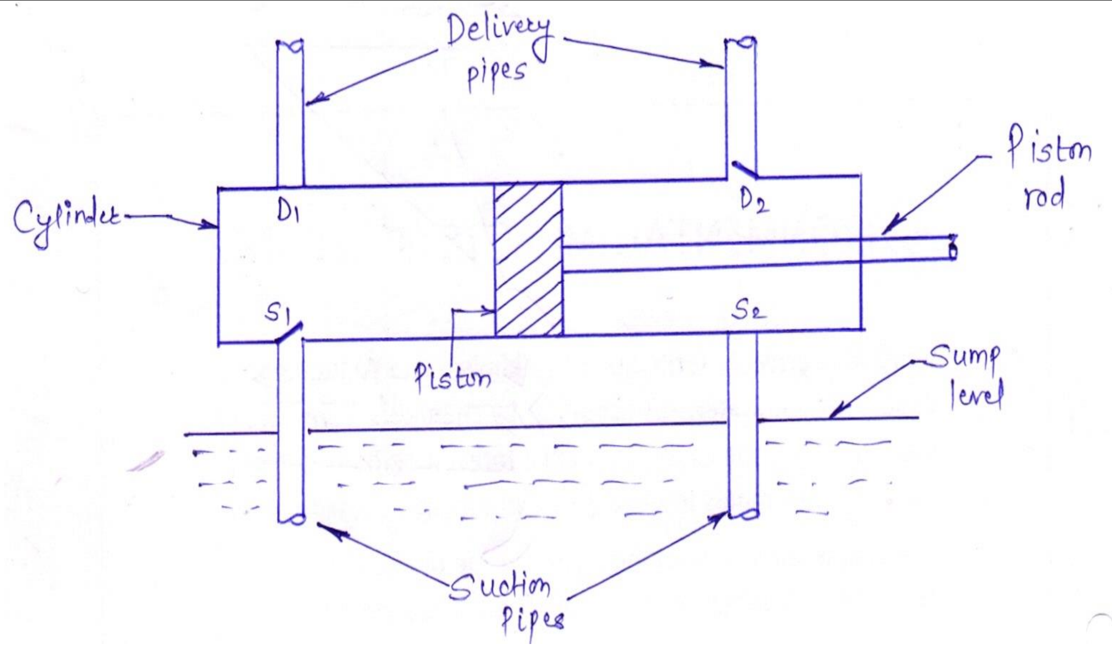
Where K=Coefficient of bend and pipe fittings.

6) Loss of head due to obstruction in pipe

5		 Fig – Head Loss due to obstruction $h_b = V^2/(2g)\times\{[A/ C_c (A-a)]-1\}^2$	
	b	**Given**:d=diameter of jet=8cm=0.08m V=Velocity of Jet=25m/s U=Velocity of Vane=9m/s Angle of Deflection=165^0 Θ=180- Angle of Deflection=180-165=15^0 **To find:** 1) Force on the plate 2) Power of jet in kW. **Solution:**1)Force exerted by jet on the plate $\mathbf{F_x= \rho a(V-u)^2(1+\cos \Theta)}$ $a=(\pi/4)\times(0.08)^2=5.03\times10^{-3}\ m^2$ $F_x=1000\times5.03\times10^{-3}\times(25-9)^2(1+\cos15)$ $F_x=5.03\times(16)^2(1+\cos15)$ $\mathbf{F_x=2531.48N}$ 2)Power of Jet **P=Work done per second/1000** Work done/ second= $F_x\times u$ W=2531.48×9 =22783.35 Nm/s =22.78kNm/s P=22.78/1000 **P=22.78Kw.**	02 02

	c	Classification of hydraulic Turbines 1. According to type of energy at inlet a)Impulse turbine b) reaction Turbine 2. According to the direction of the flow through the runner a)Tangential flow turbine b) Radial Flow Turbine c)Axial flow turbine d) Mixed flow turbine 3. According to the head at the inlet of the turbine a) High head turbine b) Medium head Turbine c) Low head Turbine 4. According to the specific speed of the turbine a) Low specific speed turbine b) Medium specific speed turbine c) High specific speed turbine	01 mark each
	d	Velocity Triangle for pelton wheel turbine  [2 Marks for Velocity Triangles]	02
		Different terms used in the velocity triangle are as follows V_1=Absolute Velocity of entering water U_1= Relative Velocity of bucket and water at inlet Vr_1= Relative Velocity at inlet V_{f1}=Velocity of flow at inlet V_{w1}=Whirl Velocity at inlet	02

		V_2= Absolute Velocity of the leaving water U_2=Velocity of the bucket at outlet Vr_2= Relative Velocity of bucket and water at outlet V_{f2}=Velocity of flow at outlet V_{w2}=Whirl Velocity at outlet Φ=Tip angle at outlet β=Angle of jet at outlet with flow velocity	
	e	sketch of Vortex Casing  	4 Marks
	f	Construction and working of double acting reciprocating pump	

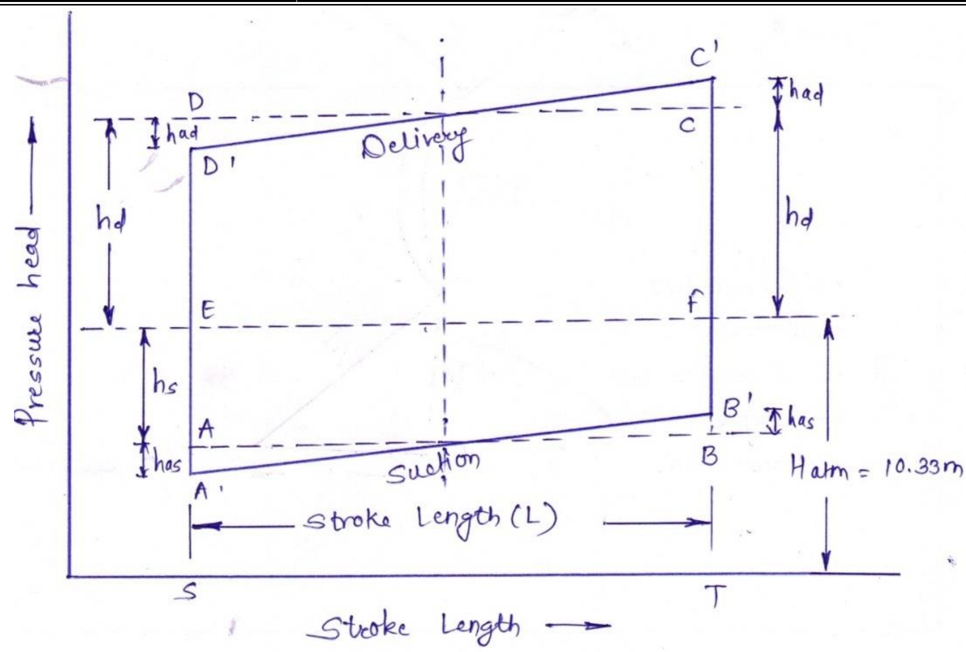


02

1) In this pump the suction and delivery strokes occur simultaneously so it is called as double acting.
2) It consists of two deliver valve and two suction valves. The pump is usually placed above the liquid level in the sump. 02
3) When the crank rotates from IDC in the clockwise direction a vacuum is created on the left hand side of the piston and the liquid is sucked in from the sump through valve S_1.
4) At the same time the liquid on the right side of the piston is pressed and a high pressure causes the deliver valve D_2 to open and the liquid is passed on the discharge tank, this operation continues till the tank reaches the ODC.
5) With the further rotation of the crank the liquid is sucked in from the sump through the suction valve S_2 and is delivered to the discharge tank through the delivery valve D_1.
6) When the crank reaches the IDC the piston is in the extreme left position, thus one cycle is completed and as the crank further rotates cycles is repeated.

6 **Attempt any Two of the following** **(8×2=16 Marks)**

a **Indicator diagram with the separation and cavitations.**



Indicator diagram for reciprocating pump 03

1. At the start of suction stroke suction head due to friction is zero and hence pressure head used to lift the water from sump into the cylinder is h_s+h_{as}.

2) If the value of this quantity is too much or if the absolute pressure head H_{am}-(h_s+h_{as}) is too small then separation will occur. 03

3)The meaning of the separation is that piston runs faster to the right ,the water is not able to keep with it and there is air gap between water and the piston face.

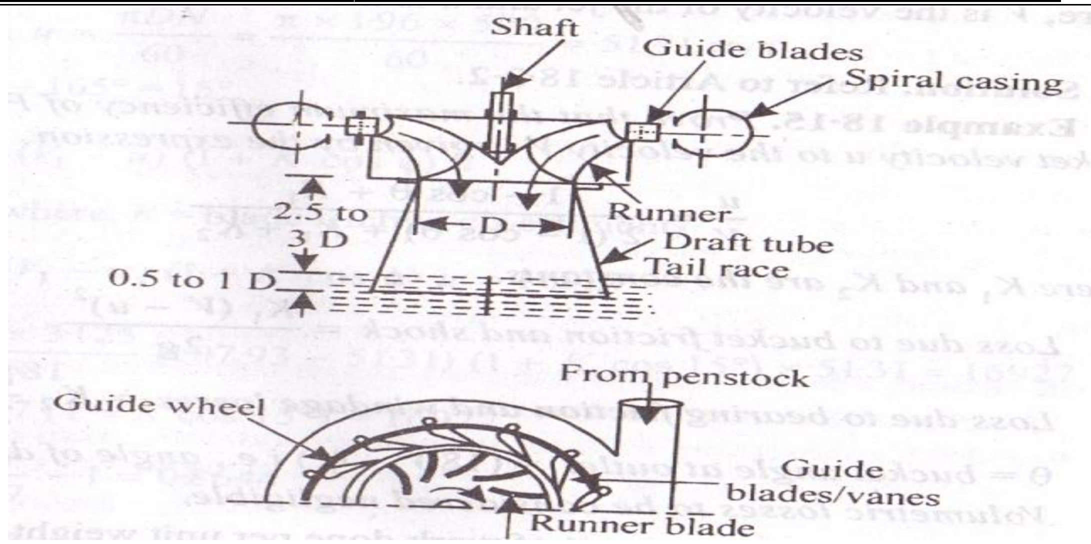
4) This separation of water with the piston face will remain for the very short time immediately after which the water come speedily and hit the piston face which makes loud noise, this is known as cavitations which takes place at the start of the suction stroke.

5) For the reciprocating pump the separation and cavitations takes place simultaneously.

To avoid Separation-1)The absolute pressure head at the end of the delivery stroke should not be less than the vapour pressure. 02

2)Use of air vessel helps to run the pump at high speed without separation

b **Construction and working of Francis Turbine**



04

The main parts of the Francis turbine are:

1) Penstock: It is the large pipe which conveys water from the upstream of the reservoir to the turbine runner.
2) Spiral casing: It is a closed passage whose cross sectional area gradually decreases along the flow direction. Area is maximum at the inlet and nearly zero at the outlet.
3) Guide vanes: These vanes direct the water onto the runner at an angle appropriate to the design.
4) Runner and runner blades: The driving force on the runner is both due to impulse and reaction effect. The number if a runner blade usually varies between 16 to 24.
5) Draft tube: It is gradually expanding tube which discharges the water passing through the runner to the tail race.

02

Working

1) It is inward mixed flow reaction turbine i.e. Water under the pressure enters the runner from the guide vanes towards the centre in the radial direction and discharge out axially.
2) It operates under the medium head and medium discharge.
3) water is brought down to the turbine through the penstock and directed to the guide vanes which direct the water onto the runner at an angle appropriate to the design.
4) In the Francis turbine runner is always full of water.
5) After doing the work the water is discharge to the trail race through the draft tubes.

02

c

Given:H_m=Manometric head=12m

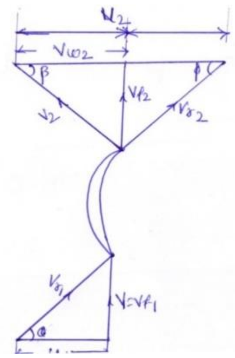
N=900rpm,Φ=Vane angle at outlet=30^0

D_2=Diameter at outlet=30cm=0.3m

B_2=Width at the outlet=5cm=0.05m & ηmano $= 0.95$ &$\eta\ overall = 0.65$

To find: 1) Discharge. 2) Power required to the drive the pump.

Solution: 1) Discharge (Q)



Velocity Triangle

2 Marks

Discharge (Q) = $\pi D_2 B_2 V_{f2}$

Tan 30= ($V_{f2}/u_2 - V_{w2}$)

Now, $\eta mano = (gHm/\ u_2 V_{w2})$

Also $u_2 = (\pi D_2 N)/(60) = (\pi \times 0.3 \times 900)/(60) = 14.14$m/s

$0.95 = (9.81 \times 12/\ 14.14 \times V_{w2})$

V_{w2}=8.76m/s

Tan 30= (V_{f2}/14.14- 8.76)

Tan 30= (V_{f2}/5.38)

V_{f2}= 5.38×Tan 30= 3.11m/s

Q = $\pi D_2 B_2 V_{f2}$

Q= $\pi \times 0.3 \times 0.05 \times 3.11 = 0.1465 m^3/s$

3 Marks

2) Power required to the drive the pump

$\eta\ overall = wQHm/Input\ Power$

Input Power=$\rho g QHm/\ \eta\ overall = \mathbf{1000} \times \mathbf{9.81} \times 0.1465 \times 0.65$

3 Marks

Input Power=$26.53 kW$