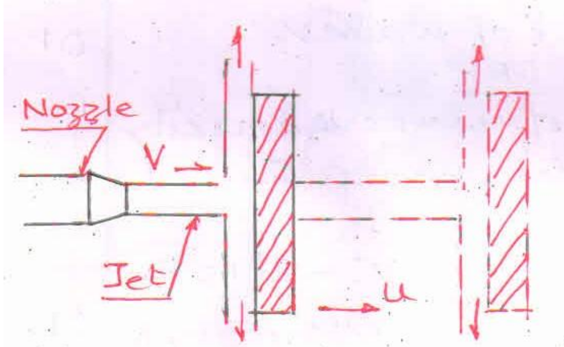
Important Instructions to examiners:

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.

Question No.		Model Answer / Solution	Marks
Q.	1	**(a) Attempt any Six**	12
	i)	1) **Specific Gravity** – It is the ratio of specific weight of fluid to the specific weight of water. OR It is the ratio of mass density of fluid to the mass density of water.	01
		2) **Kinematic Viscosity** – It is the ratio of dynamic viscosity to the mass density.	01
	ii)	**Positive gauge pressure** – when the pressure is measured above atmospheric pressure by an instrument is known as positive gauge pressure.	01
		Negative gauge pressure – when the pressure is measured below atmospheric pressure by an instrument is known as negative gauge pressure.	01
	iii)	**Steady flow** – The flow is said to be steady when flow parameters such as velocity pressure, density etc. remains constant with respect to time.	01
		Non Uniform flow – The flow is said to be non uniform when flow parameters such as velocity, pressure, density etc. varies from one section to another over a specified region at a particular instant.	01

iv)



Arrangement is as shown in the figure (02)

Force exerted by jet along the direction of jet –

$F = \rho A (v-u)[(v-u)-0]$

$F = \rho A(v-u)^2$ N

where v - Velocity of jet m/s u – Velocity of plate m/s

ρ – Mass density of water kg/m^3 A – area of jet m^2 d – Diameter of jet m

v) **Bernoulli's Theorem** – It states that for a frictionless incompressible fluid flow flowing steadily in a continuous stream, the sum of velocity, pressure and elevation heads remains constant at every section provided energy is neither added nor deleted from the system. 02

vi) **Seperation** – It is hydraulic phenomenon which occurs in a flow of water through suction pipe or delivery pipe of a reciprocating pump. It occurs when the absolute pressure, during flow falls below the vapour pressure of water.

a) For suction pipe – Hsep = Hatm – (Hs + Has) = 2.5 m of water absolute

b) For delivery pipe – Hsep = Hatm + (Hd – Had) < 2.5 m of water absolute. 02

vii) **Function of draft tube -**

i) To decrease the pressure at the runner exit to a value less than atmospheric pressure and thereby increase the effective working head.
ii) To recover a part of electric energy into pressure head at the exit of draft tube. This enables easy discharge to atmosphere. 02

viii) **Need of Priming:**
A centrifugal pump is primed when the water ways of the pump are filled with the liquid to be pumped in order to replace the air, gas or vapour in the water ways. If it is not done then the vacuum which would be produced at the centre of the impeller would not be sufficient to suck the water from the sump and set flow through suction pipe without Cavitation. 02

b. **(b) Attempt any Two**

i) Pressure given – 2.5 bar

$P = 2.5 \text{ bar} = 2.5 \times 100 \text{ kN/m}^2$

In terms of mercury column

$P = w_{Hg} \times h_{Hg}$ where W_{Hg} – specific weight of mercury

$w_{Hg} = 9.81 \times 13.6 = 133.416 \text{ kN/m}^2$

Therefore $2.5 \times 100 = 133.416 \times h_{Hg}$

$h_{Hg} = \frac{2.5\times100}{133.416}\, m$ of mercury 02

$h_{Hg} = 1.87$ m of mercury

In terms of water column

$p = W_w \times h_w$ where W_w - specific weight of water

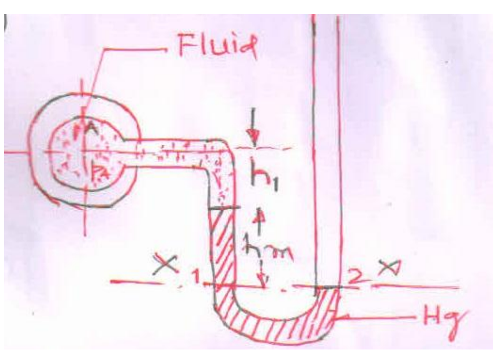
$W_w = 9.81 \times 1 = 9.81 \text{ kN/m}^3$

Therefore $2.5 \times 100 = 9.81 \times h_w$ 02

$h_w = 2.5 \times 100 / 9.81$

$h_w = 25.48$ m of water

ii) Measurement of pressure less than atmospheric pressure is done by means of an U tube manometer as shown in figure.



02

The negative pressure in the pipe sucks the manometric fluid (Hg) in the left limb causing the liquid in the right limb to go more down correspondingly.

In equilibrium, pressure in left limb above XX = pressure in right limb above XX

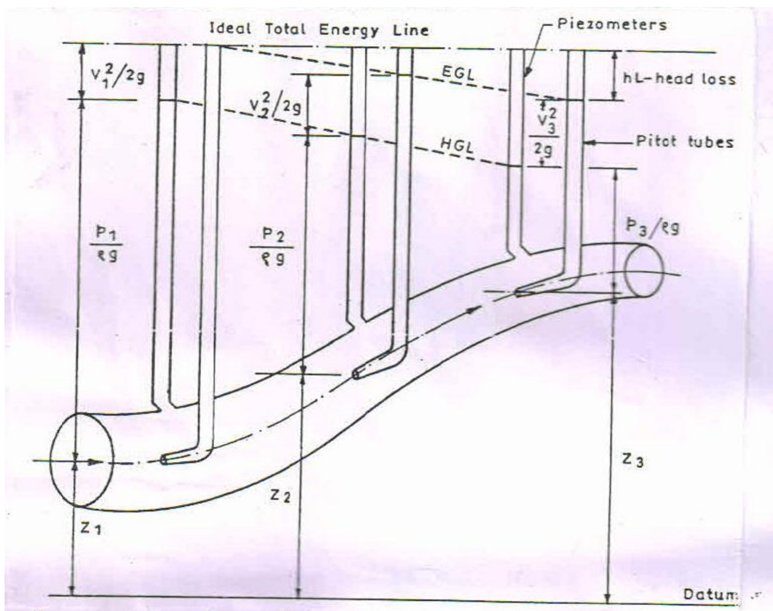
$P_1 = P_2$

$P_A + \rho_1.g.h_1 + \rho m.g.hm$ = Patm = O N/m^2 02

Pressure head $\frac{PA}{P_1 g} = -\left[\frac{Pm}{P_1} hm + h_1\right]$ m of fluid in pipe.

iii)

iii) Hydraulic gradient line and total energy line -



02

Hydraulic Gradient line (HGL)- It is the graphical representations of the longitudinal variation in piezometric head at salient points of a pipe line. 01

Total hydraulic gradient = $P/\rho.g + z$

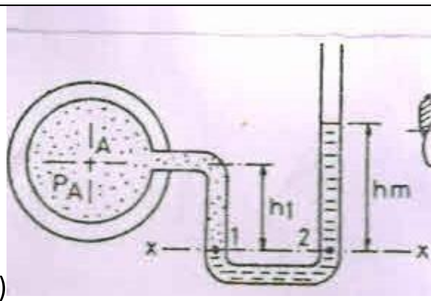
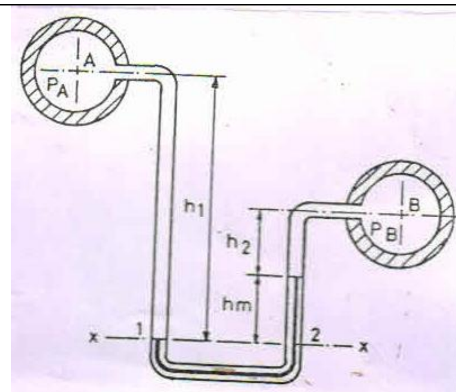
Total Energy Line (EGL) - It is the graphical representations of longitudinal variation in total head at salient points of pipe line. 01

Total Energy Head = $P/\rho.g + v^2/2g + z$

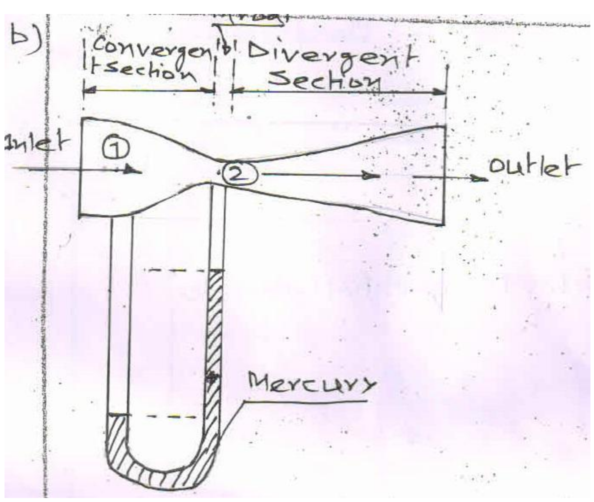
These lines are as shown in the figure above.

2 a **Attempt any Four**

Difference between simple manometer and differential manometer - 04

Simple manometer	Differential manometer
1) 	
2) It measures fluid pressure at a point in a pipe	It measures the difference of fluid pressure between two points in a pipe.
3) It hardly measures negative pressure with due care.	Negative pressure can be measured accurately.
4) It is accurate	It is more accurate.

b



04

Venturimeter: A constructional detail of Venturimeter is as shown in the fig. It is used for measuring discharge from pipe.

Discharge Through Venturimeter

Let P_1 – Pressure at section 1 …….N/m^2

V_1 – Velocity of liquid at section 1 ….m/s

Z_1 - Elevation head section 1 …..m

A_1 – Area of venturimeter at section 1 ….m^2

P_2, V_2, Z_2, A_2 = corresponding values at section 1

Applying Bernoulli,s Theoram at section 1 & 2 and neglecting losses.

$\frac{V1^2}{2g} + \frac{P_1}{pg} + Z_1 = \frac{V2^2}{2g} + \frac{P_2}{pg} + Z_2$….m of liquid

OR

$\frac{V2^2 - V1^2}{2g} = \left[\frac{P_1}{pg} + Z_1\right] - \left[\frac{P_2}{pg} + Z_2\right] = Hpiz$ ----- (1)

Where H_{piz} – Differential piezometeric head between 1 and 2.

From continuity equation

$Q = A_1V_1 = A_2V_2$

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

Substituting for V_1 in equation (1)

$\frac{V2^2}{2g}\left[\frac{A1^2 - A2^2}{A1^2}\right] = H_{piz}$ $V_2 = \frac{A_1}{\sqrt{A1^2 - A2^2}}\sqrt{2gH_{pig}}$

Discharge through pipe

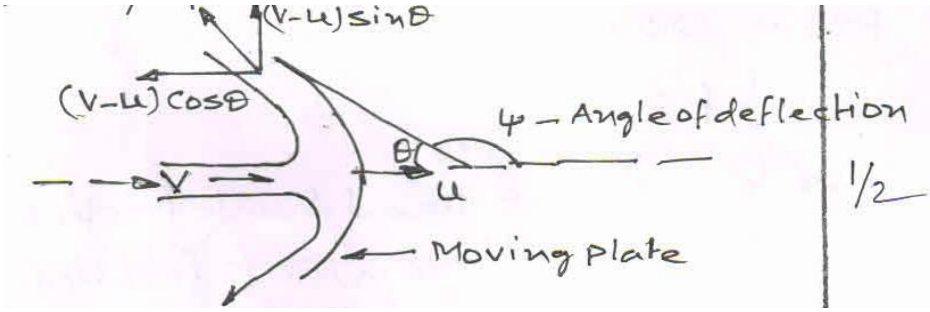
Q_{Th} – Theoretical discharge

$= A_2V_2$

$QTh = \frac{A_1A_2}{\sqrt{A1^2 - A2^2}}\sqrt{2gH_{piz}}\, m^3/s$

OR Actual discharge Qact = C_d x Q_{Th} where C_d – Coefficient of discharge.

c) Velocity of jet V = 20 m/s
Velocity of vane u = 8 m/s



In the problem value of angle of deflection y is not given. So assuming the value of y as 160^0 numerical has been solved.

The value of θ i.e. angle made by tip of vane at outlet as

$\theta = 180 - \gamma = 180 - 160 = 20^0$ 01

Assuming the diameter of nozzle as 30 mm

Force exerted by the jet on vane

$Fx = Pa\,(v-u)^2\,(1+cos\theta)$

$= 1000 \times \frac{\pi}{4}(30/1000)^2(20-8)^2[1+cos20^0]$ 02

$Fx = 197.266\,N$

Work done $W = Fx \times u = 197.266 \times 8$

$W = 1578.128\,Watt$ 01

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d. <u>Data -</u> Length of pipe = L = 5Km = 5000 M
Discharge = Q = 1000 lit/min = 0.016 m^3/s

Coefficient of friction = f = 0.008

Loss of head due to friction = hf = 20m

From Darcy's formula we have

$$hf = \frac{4fLV^2}{2gD}$$

where hf – loss of head due to friction

f - coefficient of friction

L – Length of pipe

V- Velocity of pipe

D – Diameter of pipe

By putting respective values

$$20=\frac{4\times 0.008\times 5000\times V^2}{2\times 9.81\times D}$$

OR

01

Velocity $V=\frac{Q}{A}=\frac{Q}{\pi}/4D^2$

$$=\frac{4Q}{\pi D^2}$$

$$20=\frac{4\times 0.008\times 5000\times (4Q)^2}{2\times 9.81\times D\times \pi^2\times D^2}$$

$$=\frac{4\times 0.008\times 5000\times 16\times (0.016)^2}{2\times 9.81\times D\times (3.14)^2\times D^4}$$

$$=\frac{0.655}{193.44D^5}$$

$$20=\frac{0.0033}{D^5}$$

$$D^5=0.000165$$

03

$D=0.175\,Meter$ $D=175\,mm$

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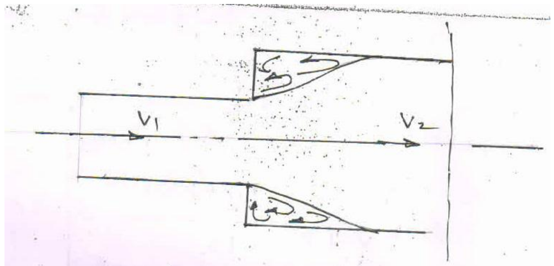
e.

Minor Losses –

1) Loss due to sudden expansion

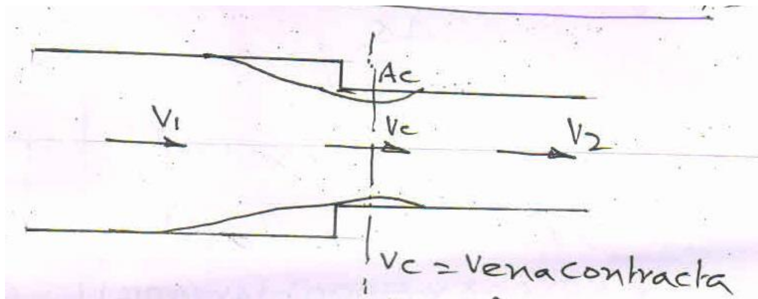
$$h_{exp}=\frac{(V_1-V_2)^2}{2g}$$



Any four

04

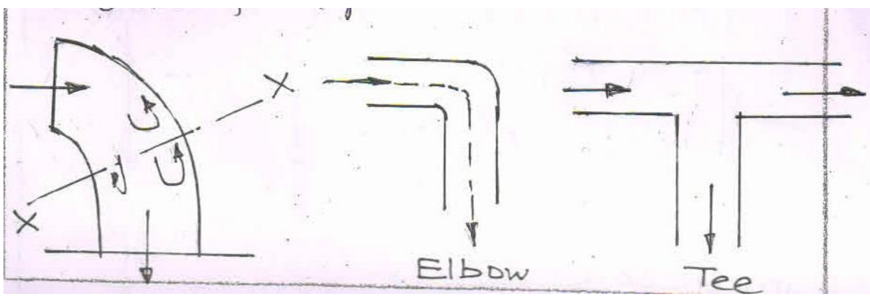
2) Loss due to sudden contraction –

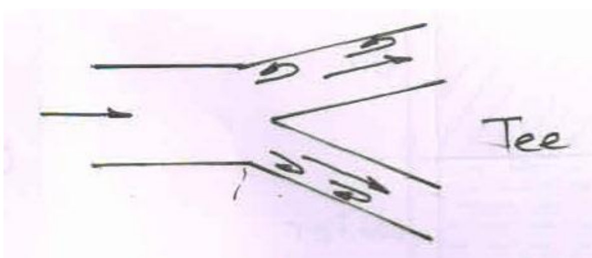


$$h_{con} = \left[\frac{1}{C_c} - 1\right]^2 \frac{V_2^2}{2g}$$

Where Cc – Coefficient of contraction

3) Losses due to bends, elbows, tees and other fittings





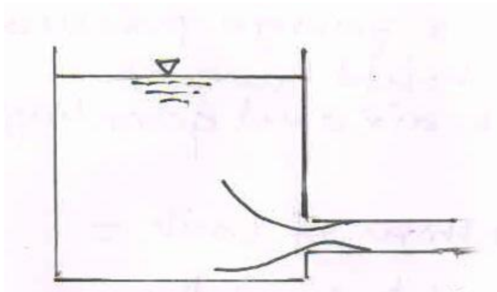
$h_{fitting} = K\frac{V^2}{2g}$ m of fluid.

Where K – constant and its value depends pon type of pipe fitting e.g.

K = 0.35 to 0.45 for 45^0 bend

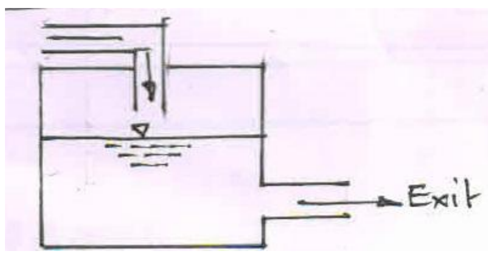
= 0.5 to 0.75 for 90^0 bend etc.

4) Entrance loss – tank to pipe.



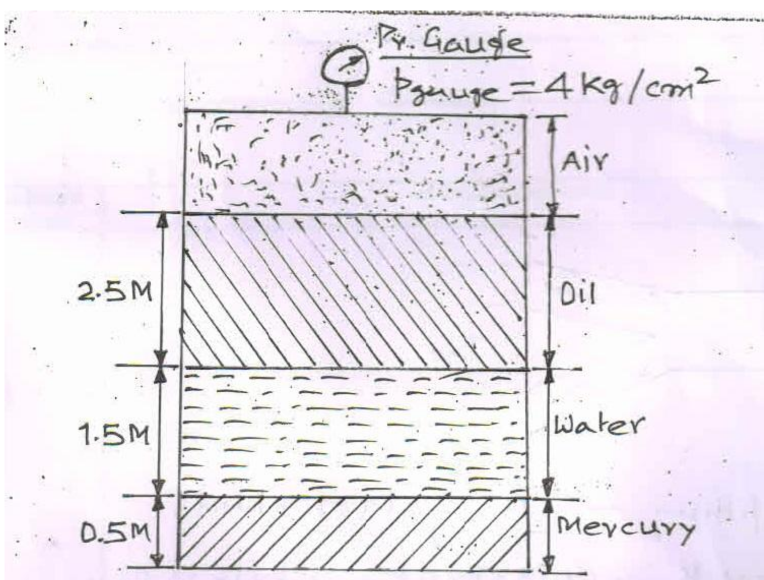
$h_{ent} - 0.5\frac{V^2}{2g}$ m of fluid

5) Exit – Pipe to tank



$h_{exit} = V^2/2g$ m of fluid.

f.



01

Figure shows arrangement of different fluid according to the data given in the problem.

Pressure due to air – 4 kg/cm^2

- 4 bar
- 4 x 100 kN/m^2

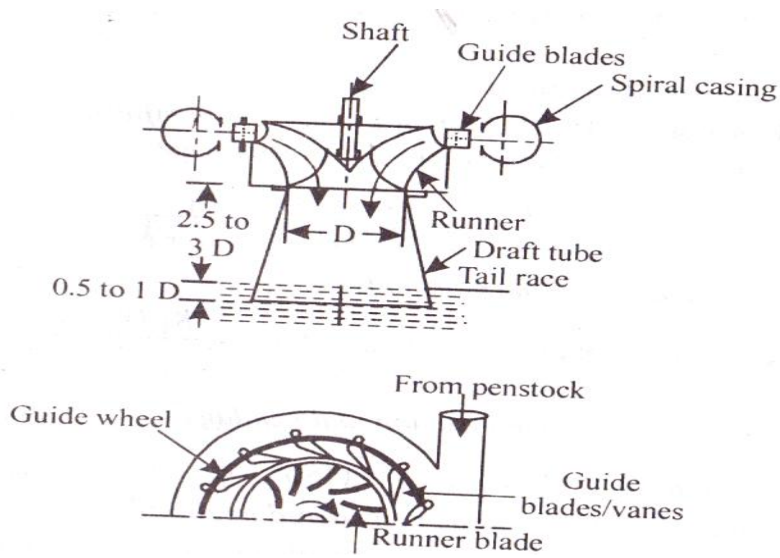
		In the problem the gauge pressure given as $4 kg/cm^2$. should have been the pressure due to air and accordingly problem is solved. Pressure at the bottom of tank = P_{bottom} = Pair + Poil + Pwater + Pmercury = 4 x 100 + 2.5 x 0.8 x 9.81 + 1.5 x 9.81 + 0.5 x 9.81 x 13.6 = 501.043 kN/m^2 Pressure at the bootom of the Tank P_{bottom} = 501.043 kN/m^2 gauge.	03

3.	**(a)**	**Explain the concept of cavitation in turbines.** • Cavitation is defined as the phenomenon of formation of vapour bubbles of a flowing liquid. • Cavitation occurs when the pressure in any condition falls below the vapour pressure. • While passing through hydraulic turbine water comes in a region where its pressure falls below vapour pressure. At this point vapour bubbles are formed. • This can happen at the outlet of the turbine, inlet of pump, bend of pipe or convex surface of curved vanes. • The vapour bubbles travel along with the liquid and on reaching in region of high pressure, suddenly collapse creating a vacuum in the place. • Collapsing of bubbles produce very high pressure which causes damage in the blades of runner and draft tube, etc. • It causes small pits cavities to be formed on inside surface. This action is known as pitting. • Cavitation reduces efficiency of turbine and hence it is not desirable.	4 Marks
3	**(b)**	**Given: D=Diameter of Bucket=**1m **Pressure at Nozzle=**15Bar **Q=Discharge=**$3.5 m^3/60=0.058 m^3/s$ N=600 RPM, $u=(\pi DN/60)=(3.14\times1\times600)/60=31.41 m/s$ $C_v=0.98$, $\eta_o=85\%$ **To find:** Power developed and Hydraulic Efficiency.	

		Solution: As the bucket is semi circular= $\Phi=0^0$ **Head of Nozzle=(H)=(Pressure at the Nozzle)/(Specific weight of water)** $=(15\times10^5) / (9810)$ **Head of Nozzle =152.905 m** **Velocity of Jet (V_1)** = $C_V\times\sqrt{2gH}$ **Velocity of Jet (V_1)** = $0.98\times\sqrt{2\times9.81\times152.905}$ **Velocity of Jet (V_1)** = 53.67m/s 1) **Power Developed P** = $\eta_o\times W\times Q\times H$ $=0.85\times9810\times0.058\times152.91$ =73.95Kw. 2) **Hydraulic efficiency** $\eta_h=\{[2(V_1-u)(1+\cos\Theta)\times u]/[V^2]\}$ $=\{[2(53.67-31.41)(1+\cos 0^0)\times31.41]/[53.67^2]\}$ $\eta_h = 0.9709=97.09\%$	 2M 2M
3	(c)	**Explain with neat sketch construction and working of Francis Turbine** **Construction:** 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	 2 M

and reaction effect. The number if a runner blade usually varies between 16 and 24.

5) **Draft tube:** It is gradually expanding tube which discharges the water passing through the runner to the tail race.



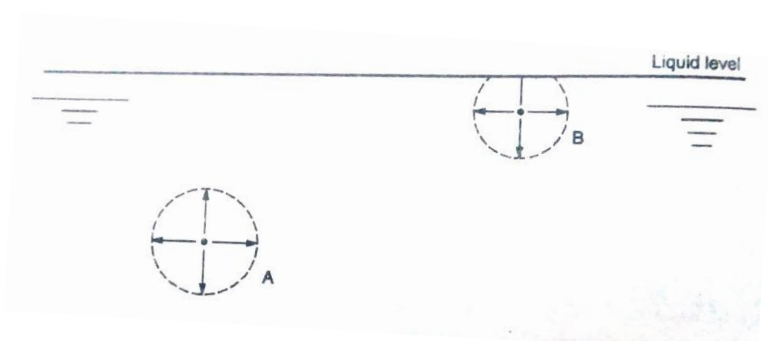
1 M

Fig. Francis Turbine

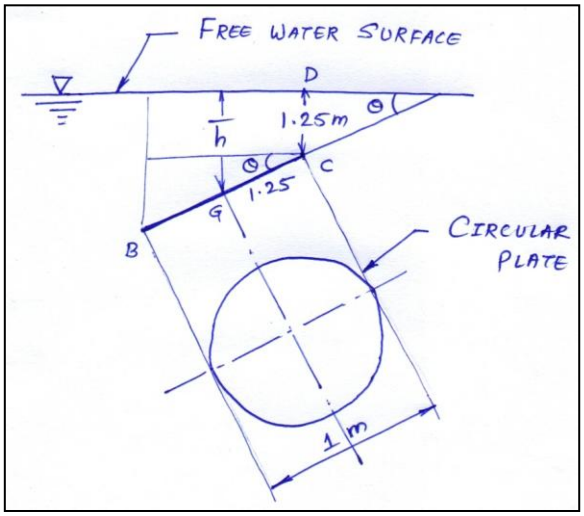
Working:

1 M

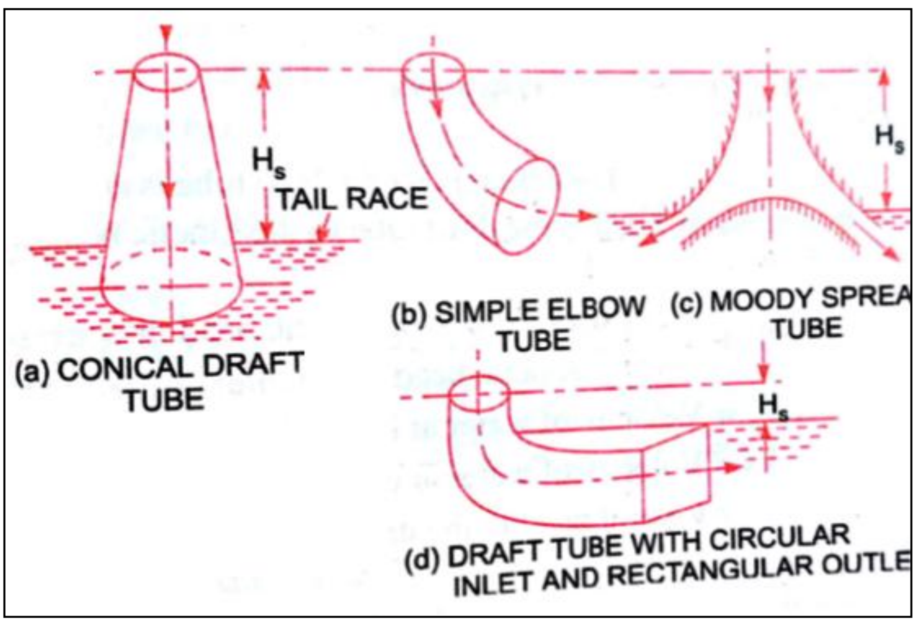
1) It is inward mixed flow reaction turbine i.e. Water under the pressure enters the runner from the guide vanes towards the centre in the radial direction and discharge out axially.
2) It operates under the medium head and medium discharge.
3) Water is brought down to the turbine through the penstock 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.

3	d)	**Given**: d=diameter of jet=7.5cm=0.075m V=Velocity of Jet=20m/s U=Velocity of plate=8m/s Angle of Deflection=165^0 Θ=180- Angle of Deflection=180-165=15^0 **To find:** 1) Force on the plate 2) Efficiency of the jet **Solution:**1)Force exerted by jet on the plate $\mathbf{F_x = \rho a(V - u)^2(1+\cos \Theta)}$ $a=(\pi/4)\times(0.075)^2=4.417\times10^{-3}\ m^2$ $F_x=1000\times4.417\times10^{-3}\times(20-8)^2(1+\cos15)$ $F_x=4.417\times(12)^2(1+\cos15)$ $\mathbf{F_x=1250.67\ N}$ **2 M** 2) Efficiency of jet Efficiency of jet **= (Work done by jet /sec)/(Kinetic energy of jet/sec)** $= F_x\times u$ **Kinetic energy of jet/sec** = $1/2\times(\rho aV^3)$ Efficiency of jet **=(Work done by jet /sec)/(Kinetic energy of jet/sec)** $=(1250.67\times8)/[\ 1/2\times(1000\times4.41\times10^{-3}\times20^3)]$ $\eta=0.567=56.7\%$ **2 M**	
3.	**(e)**	**Explain the concept of surface tension.** Following figure shows the two molecules of liquid at point A and B.  **Fig. Intermolecular forces near a liquid surface**	1 Marks

		• Molecule at point 'A' is in equilibrium condition. So molecule at 'A' is equally attracted from all sides. But at point 'B' there is no liquid molecule at above side and consequently there is a net downward force on the molecule due to attraction of the molecule below it. This force on the molecules at the surface of liquid is normal to the liquid surface, due to this a special layer seems to form on liquid at the surface, which is in tension and small load can be supported over it. • This property of liquid surface film to exert the tension is called 'Surface tension'. OR Surface tension is defined as the force required to maintain unit length of the film in equilibrium condition. It is denoted by 'σ' (sigma).	03 M
3	**(f)**		



		Given :- Diameter of Circular plate, $d = 1\ m$ Angle made by plate with horizontal, $\theta = 30°$ $\therefore$ Area, $A = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times (1)^2 = 0.7854\ m^2$ Distance, $DC = 1.25\ m$, $BC = 1\ m$, $GC = 1.25\ m$ Distance of C.G. from free surface, $\bar{h} = CD + GC \sin\theta = 1.25 + 1.25 \sin 30°$ $\therefore \boxed{\bar{h} = 1.875\ m}$	**1 Mark**
		(i) Total pressure (F), $F = \rho g A \bar{h}$ $= 1000 \times 9.81 \times \frac{\pi}{4} \times (1)^2 \times 1.875$ $\therefore \boxed{F = 14.4464 \times 10^3\ N \text{ or } 14.4464\ KN}$	**1 Mark**
		(ii) Centre of pressure (h^*), Using equation, we have $h^* = \frac{I_G \sin^2\theta}{A\bar{h}} + \bar{h}$ where, $I_G = \frac{\pi}{64} d^4 = \frac{\pi}{64} \times (1)^4 = 0.04909\ m^4$ $\therefore h^* = \frac{0.04909 \times (\sin 30)^2}{0.7854 \times 1.875} + 1.875$ $\therefore \boxed{h^* = 1.8833\ m}$	**2 Marks**

4.	**(a)**	**State the necessity of the draft tube in reaction turbine. State and draw the sketches of different types of draft tubes.**	
		A draft tube is necessary in reaction turbine for the following reasons, 1. By providing draft tube, it is possible to install the turbine above the tail race without loss of head. This makes the inspection and maintenance of turbine easy. 2. By providing draft tube, the velocity is largely reduced at the exit of draft tube. Thus the kinetic head is gained.	**4 Marks**
		Types of draft tube: i. Conical draft tube ii. Simple elbow draft tube iii. Moody spreading draft tube iv. Elbow draft tube with circular cross section at inlet and rectangular at outlet	**2 Marks**
		 **Fig. Types of draft tubes**	**2 Marks**

4 **(b)**

Solution :-

Given :-

Dia. at outlet, $D_2 = 1.75\,m$

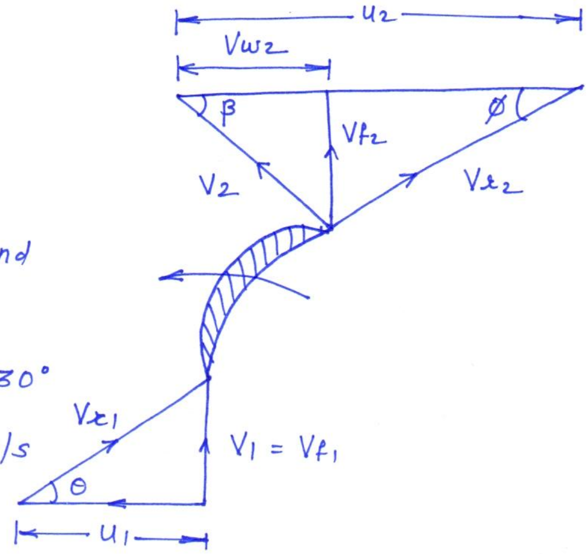
Speed, $N = 210$ rpm

Discharge, $Q = 2000$ lit / second $= 2\ m^3/s$

Angle of vane at outlet, $\phi = 30°$

velocity of flow, $V_{f2} = 2.75\ m/s$

Manometric Efficiency, $\eta_m = 75\%$



We know,

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 1.75 \times 210}{60} = 19.2422\ m/s$$

1 Mark

and $\tan\phi = \frac{V_{f2}}{u_2 - V_{w2}}$ or $u_2 - V_{w2} = \frac{V_{f2}}{\tan\phi} = \frac{2.75}{\tan 30°}$

$\therefore\ u_2 - V_{w2} = 4.7631$

$\therefore\ V_{w2} = 19.2422 - 4.7631 = 14.4791\ m/s$

1 Mark

Now, $\eta_m = \frac{g H_m}{V_{w2}\, u_2}$

$\therefore\ 0.75 = \frac{9.81 \times H_m}{14.4791 \times 19.2422}$

$\therefore\ \boxed{H_m = 21.3004\ m}$

3 Marks

Power required to drive the pump,

$= W Q H_m$

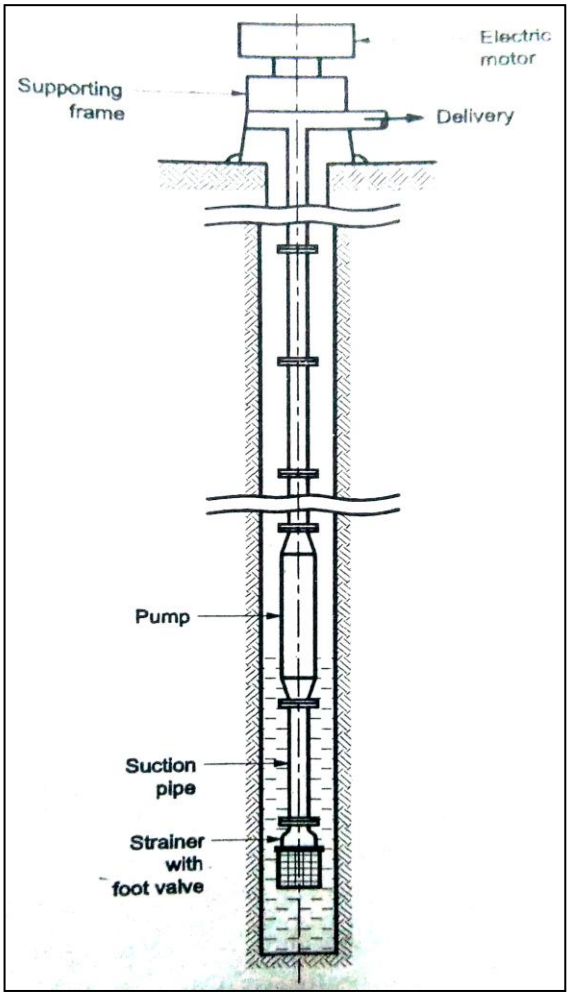
$= \rho g Q H_m$

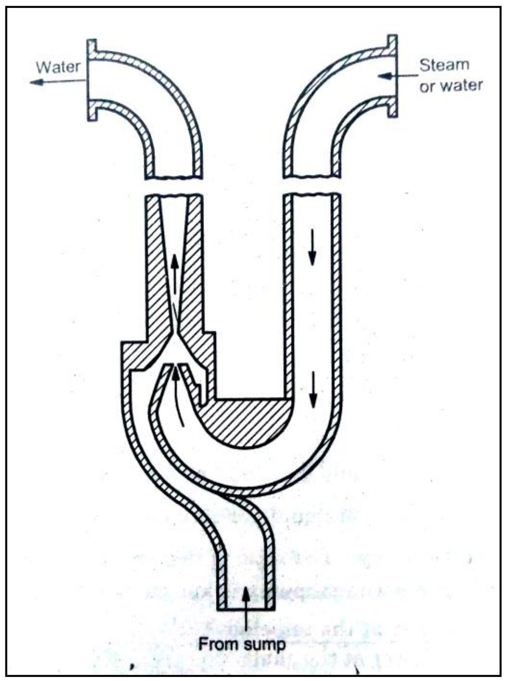
$= 9.81 \times 1000 \times 2 \times 21.3004$

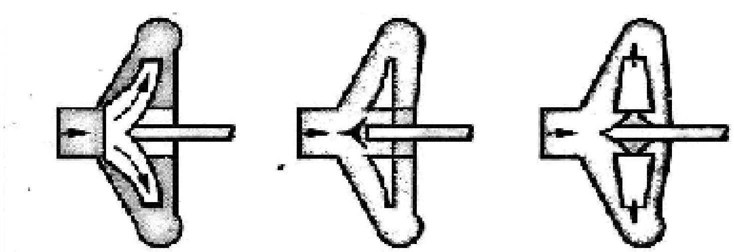
$\therefore\ \boxed{P = 417.9138 \times 10^3\ W = 417.9138\ kW}$

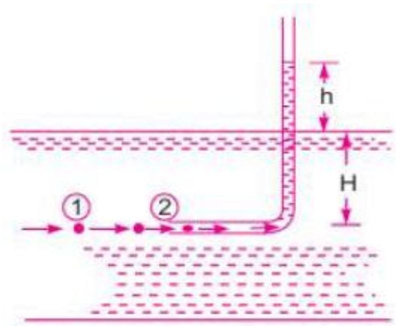
3 Marks

4.	(c)	**Submersible Pumps**	
	(i)	• A submersible pump as the name indicates consists of electric motor and pump both submerged in the water. • By submerging electric motors, pumps, large economy can be made by avoiding long shaft, large number of bearings, and large sized rising main, etc. • The complications due to thrusts are also avoided. • As it is a submersible pump, the only problem is to prevent the motor windings and the other electrical connections to be spoiled by water coming in contact. • For this purpose a special protection by suitable type of insulation is provided to prevent the water flow inside. • These pumps are vertical centrifugal pumps with radial or mixed flow impellers. All the metallic bearings are water lubricated and protected against the sand. • A non-return valve is fitted to a flange at the top of the pump. • The suction housing of pump is situated between the pump and motor and provided with a performed strainer. • Motor of the submersible pumps are wet squirrel cage type and are completely filled with water. Thrust bearings are provided for absorbing the axial thrust. • The pump shaft is connected to motor shaft by muff coupling. Gate valve is provided at the top of the pump as a non-return valve to discharge the water. • The total efficiency of these pumps is superior to conventional deep well pumps at much cheaper costs.	**3 Marks**

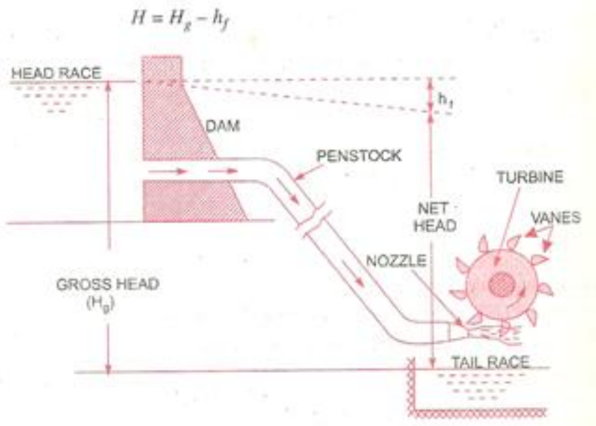
		 **Fig. Submersible Pump**	**1 Mark**
	(ii)	**Jet Pumps** • A jet pump, in its simplest form, consists of a pipe having a convergent end at its bottom. • The upper end of the pipe leads to required height. Now steam or sometimes water under a high pressure is introduced through a nozzle as shown in the fig. • The pressure energy of the steam is converted into kinetic energy, as it passes through the nozzle. • As a result of this, the pressure in convergent portion of the pipe is considerably reduced and water is sucked into the pipe.	**3 Marks**

		• The sucked water after coming in contact with the jet is carried into the delivery pipe. • Here the kinetic head of the water is converted into pressure head, which forces the water into the delivery pipe. • It is used for lifting water for boilers.  **Fig. Jet Pump**	**1 Mark**
Q.5		**Attempt any FOUR of the following**	16
a)		i) **Manometric Efficiency (η_{man}):-**It is the ratio of the Manometric head to the head imparted by the impeller to the water is known as Manometric efficiency. $(\eta_{man}) = \frac{\text{Manometric head}}{\text{Head imparted by the impeller to water}}$ ii) **Static Head (H)**:-The sum of Suction Head and Delivery Head is called Static Head. $H = Hs + Hd$ iii) **Mechanical Efficiency (η_m)**:-It is the ratio of power available at the impeller to the power at the shaft of the centrifugal pump is known as mechanical efficiency.	1M 1M 1M

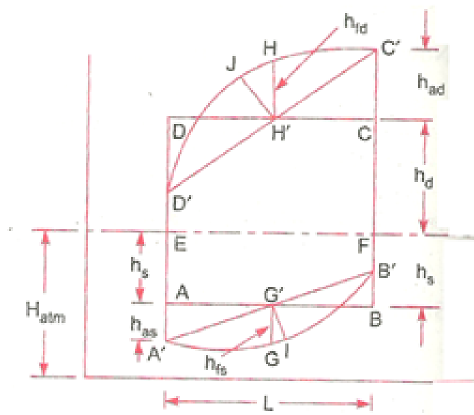
		$(\eta_m) = \frac{\text{Power at the impeller}}{\text{Power at the shaft}}$ iv)**Neat Positive Suction Head(NPSH)**:-NPSH is the absolute pressure head at inlet to pump minus vapour pressure head (In absolute units) plus velocity head. NPSH= (Absolute pressure head at inlet)-(Vapour Pressure head)+(Velocity Head).	1M
b)		**Air Vessels:-**An air vessel is a closed chamber containing compressed air in the top portion and liquid (Or water) at the bottom of chamber. An air vessel is fitted to suction pipe and to the delivery point at a point close to cylinder of a single acting reciprocating pump. **Functions of Air vessel:** i) To obtain a continuous supply of liquid at uniform rate. ii) To save a considerable amount of work in overcoming the frictional resistance in suction and delivery pipe. iii) To run the pump at high speed without separation.	2M 2M
	c)	**Types of impellers** i)Closed or Shrouded ii)Open iii)Semi Open  i)Closed or Shrouded ii)Semi open iii)Open **Applications:** i)Closed or Shrouded :-Liquid to be pumped is pure and relating free from debris ii)Open :- Liquid to be pumped is impure and Containing small amount ofdebris iii)Semi open:- Liquid to be pumped containing suspended solid matter like paper pulp, sewage , water containing sand etc	1M 2M 1M
	d)	i) **Laws of fluid friction for Turbulent Flow** • Frictional resistance is proportional to square of velocity of flow. • Frictional resistance is independent of pressure. • Frictional resistance slightly varies with change in temperature of fluid.	2M

		• Frictional resistance is proportional to density of fluid flow. ii) **Darcy's equation for frictional losses** is given by, $h_f = \frac{4fLV^2}{2gD}$ h_f= Head loss due to friction, 4f=F=Friction factor, f =coefficient of friction, V=velocity of flow, L=length of pipe, D= Diameter of pipe	2M
	e)	**Pitot Tube:** It is a device used for measuring velocity of flow at any point in a pipe or channel. Principle:- If the velocity of flow at any point becomes zero, the pressure there is increased due to conversion of Kinetic energy into pressure energy. It is the glass tube with lower end of tube bent at 90^0 and is directed in upstream direction. The liquid rises up in the tube due to conversion of kinetic energy into pressure energy. $V = C_v\sqrt{2gh}$ V= velocity of flow,C_v= Coefficient of velocity, h= Dynamic Pressure head  **Fig. Pitot tube**	2M 1M 1M
	f)	Diameter of smaller pipe,D_1=30cm=0.3m Area = $A_1 = \frac{\pi}{4}D_1^2 = \frac{\pi}{4}0.3^2$= 0.070685 m^2 Diameter of larger pipe,D_2=40cm=0.4m Area=$A_2 = \frac{\pi}{4}D_2^2 = \frac{\pi}{4}0.4^2$=0.12564$m^2$ Discharge, Q=300 Lit/Sec = 0.3m^3/Sec Velocity,$V_1 = \frac{Q}{A_1} = \frac{0.3}{0.070685}$ = 4.244 m/sec	1M 1M

		Velocity, $V_2 = \frac{Q}{A_2} = \frac{0.3}{0.12564} = 2.3877$ m/sec Velocity of head due to enlargement is given by $= \frac{(V_1 - V_2)^2}{2g}$ $= \frac{(4.244 - 2.3877)^2}{2g} = 0.1756$ m of water	2M
Q6		**Attempt any TWO of the following**	16
a)	i)	**Impact of Jet:** - The stream of water leaving from a nozzle fitted at the end of water carrying pipe with high velocity and strikes on the blades of runner called as impact of jet. **Conversion of Hydraulic energy into Mechanical Energy:-** The water is stored in a reservoir containing tremendous potential energy. This water then carried by penstock (Pipe) to the inlet of turbines. At the end of penstock a nozzle is fitted that creates higher velocity jet water. As per the Newton's Second Law of motion, the rate of change in momentum exerts a force on blades of runner. Then due to this force runner will rotates where we get the mechanical energy as an output.	2M 2M
	ii)	**Hydroelectric Power Plant:** i) Dam (Reservoir):- It is water reservoir generally constructed over the river it contains lot of potential energy. ii) Penstock: - Pipes of large diameters called penstock, which carries water under high pressure from storage reservoir to the turbines. These pipes are made of steel or reinforced concrete. iii) Turbines:- These are the wheels on which number of vanes are fitted and converts hydraulic energy to mechanical energy. iv) Tail race:- It is the channel which carries water away from turbines after the water has worked on turbines. The surface of water in the tail race is also known as tail race. v) Surge tank:-It is the tank provided in the path of penstock to avoid pulsating discharge at inlet of turbines. During flow of water from reservoir to turbine through penstock pressure surges are created to compensate these surges surge tank is provided.	2M

		 Layout of Hydraulic Power plant	2M
b)	i)	i) Diameter of orifice= d_0 =12 cm = 0.12 m Area = $a_0 = \frac{\pi}{4} {d_0}^2 = \frac{\pi}{4} 0.12^2 = 0.0113 m^2$ Diameter of pipe =d_1= 20 cm = 0.20 m Area = $a_1 = \frac{\pi}{4} {d_1}^2 = \frac{\pi}{4} 0.2^2 = 0.0314 m^2$ $P_1 - P_2$=9.81N/cm^2= 9.81 x10^4N/m^2 h =$\frac{P_1}{\rho g}$ - $\frac{P_2}{\rho g}$ = $\frac{9.81 \times 10^4}{1000 \times 9.81}$ = 10 m of water C_d= 0.6 Actual Discharge Q = $C_d \frac{a_0 a_1}{\sqrt{{a_1}^2 - {a_0}^2}} \sqrt{2gh}$ =0.6 $\frac{0.0113 x\ 0.0314}{\sqrt{0.0314^2 - 0.0113^2}} \sqrt{2x\ 9.81x10}$ = 0.1017 m^3/sec = 101.7 lps	1M 1M 2M
	ii)	ii) Water stream Velocity , V=2.3 m/sec, Reading of manometer = 30cm = 0.30m h =$x\left(\frac{S_m}{S_w} - 1\right)$ = 0.30$\left(\frac{13.6}{1} - 1\right)$ = 0.30x 12.6 = 3.78m of water V=$C_v\sqrt{2gh}$	2M

		$2.3 = C_v\sqrt{2x\ 9.81x3.78}$ $Coefficient\ of\ Velocity, C_v$=0.267	2M
c)		**Explanation of effect of friction and acceleration head on indicator diagram** The pressure head in cylinder during suction and delivery strokes changes as follows: i) At beginning of suction stroke, $\theta=0^0$ hence h_{as} from equation is equal to $\frac{l_s}{g}$ x $\frac{A}{a_s}\omega^2 r$ But $h_{fs}=0$. Thus the pressure head in cylinder will be ($h_s + h_{as}$) below atmospheric pressure head. ii) At middle of suction stroke, h_{as}= 0, but $h_{fs}=\frac{4fl_s}{d_s 2g}(\frac{A}{a_s}\omega r)^2$ thus the pressure head in cylinder will be ($h_s + h_{fs}$) below atmospheric pressure head. iii) At the end of suction stroke, h_{as} = - $\frac{l_s}{g}$ x $\frac{A}{a_s}\omega^2 r$ but h_{fs}=0. Thus the pressure head in cylinder will be ($h_s - h_{as}$) below atmospheric pressure head. iv) At beginning of delivery stroke, $h_{ad} = \frac{l_d}{g}$ x $\frac{A}{a_d}\omega^2 r$ .But $h_{fd}=0$. Thus the pressure head in cylinder will be($h_d + h_{ad}$) above atmospheric pressure head. v) At middle of delivery stroke, h_{ad}=0, but $h_{fd}=\frac{4fl_d}{d_d 2g}(\frac{A}{a_d}\omega r)^2$ thus the pressure head in cylinder will be ($h_d + h_{fd}$) above atmospheric pressure head. vi) At the end of delivery stroke, $h_{ad} = -\frac{l_d}{g}$ x $\frac{A}{a_d}\omega^2 r$. But $h_{fd}=0$. Thus the pressure head in cylinder will be ($h_d - h_{ad}$) above atmospheric pressure head. The indicator diagram with acceleration and friction in suction and delivery pipes is Area of indicator diagram A'GB'C'HD'= Area of A'G'B'C'H'D'+ Area of Parabola A'GB'+ Area of Parabola C'HD' But Area of A'G'B'C'H'D'=Area ABCD=$(h_s + h_d)$ x L Area of Parabola A'GB'=A'B' x $\frac{2}{3}$ x G'I =$\frac{2}{3}$ x (A'B' x G'I)=$\frac{2}{3}$ x (AB x GG') =$\frac{2}{3}$ x L x h_{fs} Similarly, Area of Parabola C'HD' = $\frac{2}{3}$xL x h_{fd}	3M

		Area of indicator diagram= $(h_s + h_d)$ x L+$\frac{2}{3}$ x L x h_{fs}+$\frac{2}{3}$x L x h_{fd} = $(h_s + h_d + \frac{2}{3} h_{fs} + \frac{2}{3} h_{fd})$x L We know that work done by pump is proportional to area of indicator diagram. Work done by pump per second α $(h_s + h_d + \frac{2}{3} h_{fs} + \frac{2}{3} h_{fd})$x L $= KL(h_s + h_d + \frac{2}{3} h_{fs} + \frac{2}{3} h_{fd})$ K = Constant of Proportionality = $\frac{\rho g L A N}{60}$ … For single acting Reciprocating compressor Work done by pump per second for single acting = $\frac{\rho g L A N}{60}$ $(h_s + h_d + \frac{2}{3} h_{fs} + \frac{2}{3} h_{fd})$  Effect of Acceleartion and Friction on Indicator Diagram	3M 2M