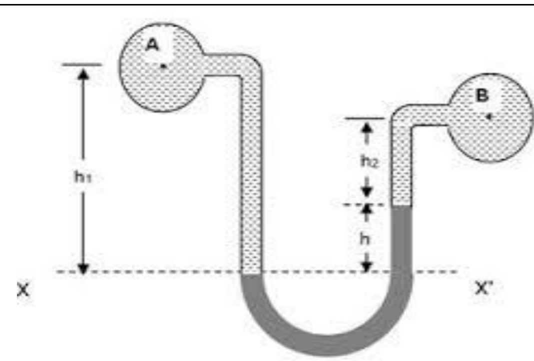
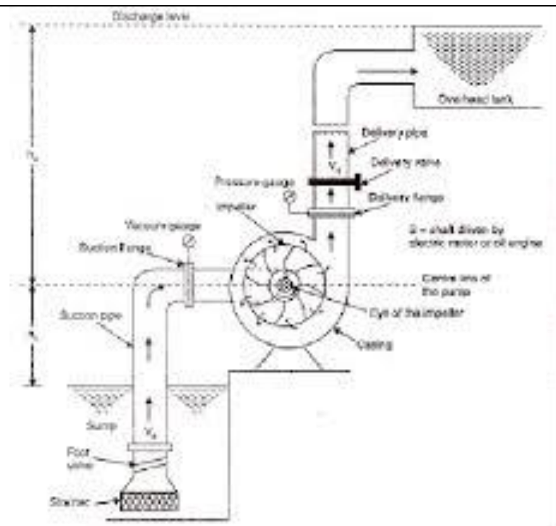
WINTER – 19 EXAMINATION

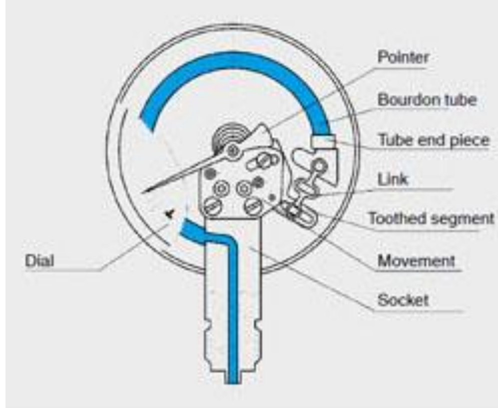
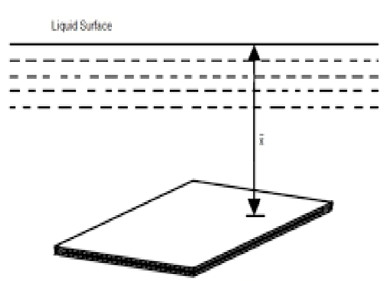
Subject Name: Fluid Mechanics & Machinery **Model Answer** **Subject Code: 17411**

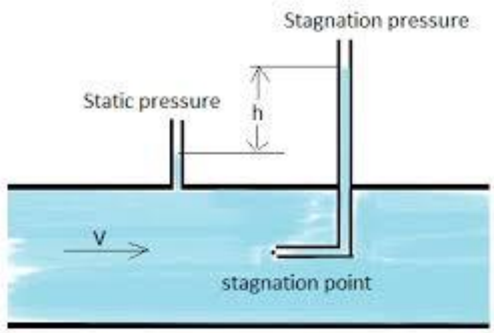
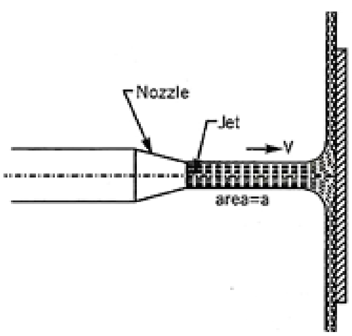
Important Instructions to examiners:

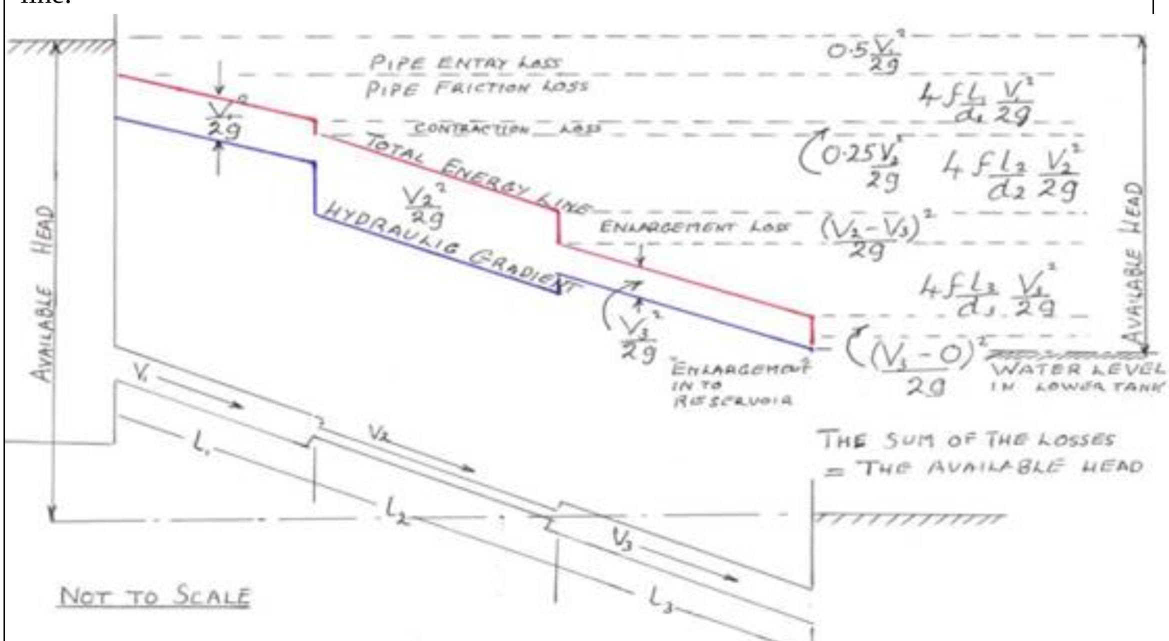
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

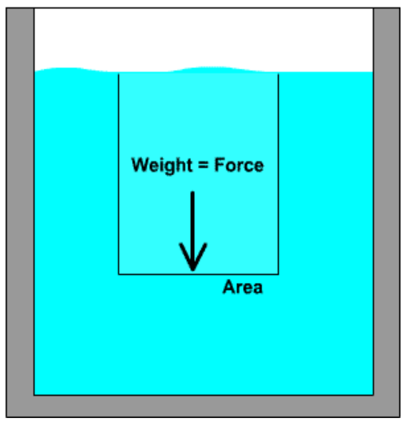
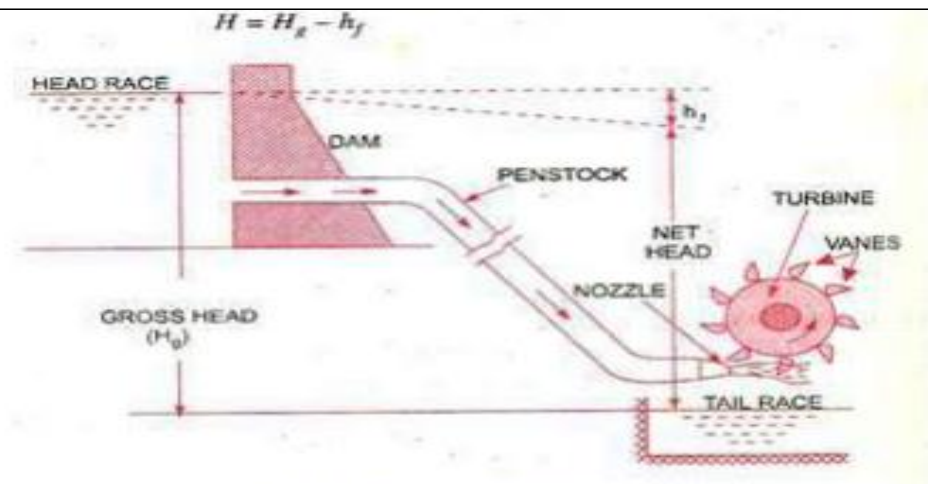
Q. No.	Sub. Q. No.	Answer	Marking Scheme
1.		**Attempt any SIX of the following:**	**12 Marks**
	i)	**Define kinematic viscosity.**	
	Ans	A quantity representing the dynamic viscosity of a fluid per unit density. The ratio of dynamic viscosity to its density	**02 Mark**
	ii)	**Draw a neat sketch of differential manometer.**	
	Ans		**02 Mark**
	iii)	**State Bernoulli's theorem.**	
	Ans	The theorem states, in effect, that the total mechanical energy of the flowing fluid, comprising the energy associated with fluid pressure, the gravitational potential energy of elevation, and the kinetic energy of fluid motion, remains constant. Bernoulli's theorem is the principle of energy conservation for ideal fluids in steady, or streamline, flow and is the basis for many engineering applications. $p/w+v^2/2g+z$ = constant where p/w = Pressure energy, $v^2/2g$ = kinetic energy, Z = datum energy	**02 Mark**
	iv)	**List out different types of draft tube.**	

	Ans	Types of draft tube- 1.conical draft tube 2.Simple elbow draft tube 3.Elbow draft tube with circular inlet and rectangular outlet 4.Moody's spreading draft tube	**02 Mark**
	v)	**Define turbulent flow.**	
	Ans	Flow of fluid in which fluid particles have a zig-zag path during flow is called turbulent flow.	**02 Mark**
	vi)	**Draw a neat sketch of centrifugal pump.**	
	Ans		**02 Mark**
	vii)	**State the concept of cavitation in turbine.**	
	Ans	The cavitation may occur at inlet of draft tube where the pressure is considerably reduced which may be below the vapour pressure of the liquid flowing through the turbine. It is formation of vapour filled bubbles of flowing fluids in a region where the pressure of liquid falls below its vapour pressure. The vapour pressure of a liquid is the function of temperature and its height from mean sea level	**02 Mark**
	viii)	**State the use of air vessel.**	
	Ans	It is used to get continuous supply of liquid at uniform rate and to maintain uniform rate of flow of liquid in suction and delivery pipes. It reduces the work required to drive the pump due to reduction in accelerating heads and friction losses	**01 Mark** **01 Mark**
	b)	**Attempt any <u>TWO</u> of the following:**	**08 Marks**
	i)	**Explain construction & working of bourdon tube pressure gauge with neat sketch.**	
	Ans	Bourdon tubes are radially formed tubes with an oval cross-section. The pressure of the measuring medium acts on the inside of the tube and produces a motion in the non-clamped end of the tube. This motion is the measure of the pressure and is indicated via the movement. The C-shaped Bourdon tubes, formed into an angle of approx. 250°, can be used for pressures up to 60 bar. For higher pressures, Bourdon tubes with several superimposed windings of the same angular diameter (helical tubes) or with a spiral coil in the one plane (spiral tubes) are used.	**02 Mark**

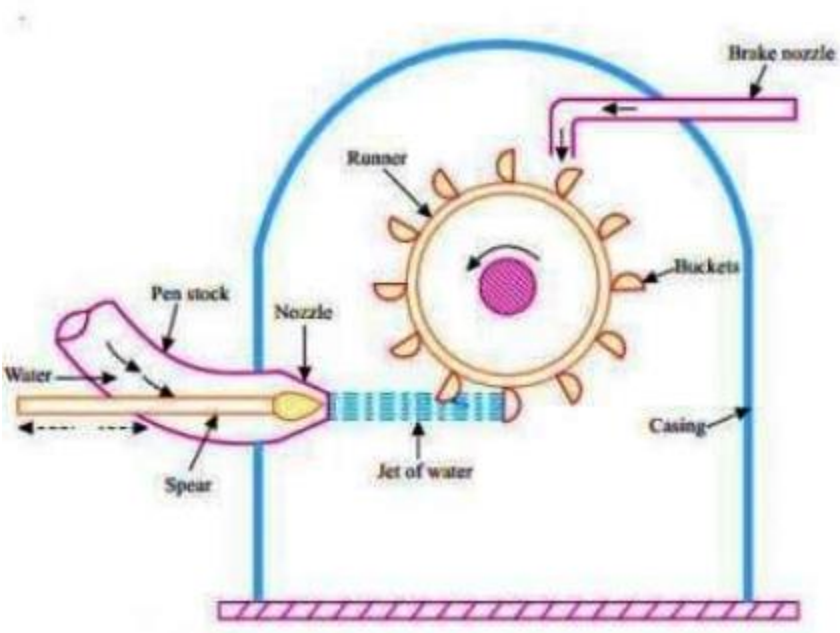
			**02 Mark dia.**
	ii)	**Describe the concept of absolute vacuum, gauge pressure, atmosphere pressure, absolute pressure**	
	Ans	**1) Absolute vacuum-** If a tube / container is completely evacuated then the pressure exerted on the surface is zero. Such a zero pressure is called absolute vacuum pressure. **2) Gauge pressure-** It is the pressure measured above the atmospheric pressure. It is zero-referenced against ambient air pressure, so it is equal to absolute pressure minus atmospheric pressure. **3) Atmospheric pressure-** It is also called barometric pressure which is the pressure within the atmosphere of Earth (or that of another planet). The standard atmosphere is a unit of pressure defined as 1013.25 mbar (101325 Pa), equivalent to 760 mm Hg. Atm unit is roughly equivalent to the mean sea-level atmospheric pressure on Earth, that is, the Earth's atmospheric pressure at sea level is approximately 1 atm. **4) Absolute pressure-** The pressure which is measured above the absolute vacuum pressure. It is zero-referenced against a perfect vacuum, using an absolute scale, so it is equal to gauge pressure plus atmospheric pressure.	**01 Mark** **01 Mark** **01 Mark** **01 Mark**
	iii)	**Write Darcy's formula for head loss due to friction. State the meaning of each term.**	
	Ans	Darcy's formula - $H_f = flv^2/2Dg$ Where: h_f = Friction head loss f = Darcy resistance factor L = Length of the pipe D = Pipe diameter V = Mean velocity g = acceleration due to gravity	**02 Mark** **02 Mark**
2.		**Attempt any FOUR of the following:**	**16 Marks**
	a)	**Explain total pressure & centre of pressure acting on immersed body.**	
	Ans	Fig 1: Horizontally Immersed Surface Figure shows a body immersed in the fluid. The **total pressure** is defined as the force exerted by a static fluid on a surface (either plane or	**02 Mark** **01 Mark**

		curved) when the fluid comes in contact with the surface. This force is always normal to the surface which is given by - P= w.A.X **The centre of pressure** is defined as the point of application of the resultant pressure on the surface which is given by - h= Ig/AX+X	**01 Mark**
	b)	**Explain with neat sketch, principle of working of pitot tube.**	
	Ans	Principle: The pitot tube is a differential pressure measuring device. The pitot tube installed in the flow stream measures the direct pressure at the contact pitot tube hole and a second measurement is required, being of static pressure. The difference between the two measurements gives a value for dynamic pressure  A pitot tube is a flow measurement device used to measure fluid flow velocity.	**02 Mark** **02 Mark**
	c)	**Derive an equation to find force of impact of jet which strikes on a flat plate at right angle which is fixed.**	
	Ans	 Consider a jet of water impinging normally on a flat plate at rest as shown in figure. Let, a = Cross-sectional area of the jet in metre^2. V = Velocity of the jet in metres per second. M = Mass of water striking the plate per second. $\therefore$ M = ρaV kg/sec where ρ = density of water in kg/cum Force exerted by the jet on the plate- P = Change of momentum per second = (Mass striking the plate per second) x (Change in velocity) = M (V – 0) = MV = ρaV.V. $\therefore P = \rho a V^2$ Newton	**02 Mark** **01 Mark** **01 Mark**

	d)	**Explain with neat diagram hydraulic gradient line & total energy line with its application.**	
	Ans	**Hydraulic Gradient Line (H.G.L)** It is defined as the line which gives the sum of pressure head (p/w) and datum head (z) of flowing fluid in a pipe w.r.t some reference line. OR It is the line which is obtained by connecting the top of all vertical ordinates, showing the pressure head (p/w) of a flowing fluid in a pipe from the center of the pipe. **Total Energy Line (T.E.L)** 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 w.r.t some reference line. OR It is the line which is obtained by connecting the tops of all vertical ordinates showing the sum of the pressure head and kinetic head from the center of the pipe. **Diagram showing TEL and HGL** A turbine in the flow reduces the energy line and a pump or fan in the line increases the energy line.  **Application-**A turbine in the flow reduces the energy line and a pump or fan in the line increases the energy line.	**01 Mark** **01 Mark** **01 Mark** **01 Mark**
	e)	**State laws of fluid friction for laminar flow. (any four)**	
	Ans	i) The frictional resistance is proportional to velocity of flow. ii) The frictional resistance is independent of pressure. iii) The frictional resistance is proportional to the surface area in contact iv) The frictional resistance is varies with changes in temperature	**01 Mark for 01 point**

		v) The frictional resistance is independent of the nature of surface of contact	
	f)	**Define i) fluid pressure ii) pressure head, iii) pressure intensity**	
	Ans	**i) Fluid pressure-**fluid pressure is a measurement of the force per unit area on a object in the fluid or on the surface of a closed container. This pressure can be caused by the gravity, acceleration, or by forces outside a closed container. **ii) Pressure head-**it is the height of a liquid column that corresponds to a column on the base of its container. It may also called static pressure head or simply static head. **iii) Pressure intensity-**it is a qualitative measurement in a particular flow of air, the pressure intensity might be high while the total pressure that would exist when that flow is brought to complete stop.  	**01 Mark** **01 Mark** **01 Mark** **01 Mark**
3.		**Attempt any <u>FOUR</u> of the following:**	**16 Marks**
	a)	**Draw a layout of hydroelectric power plant & explain in brief.**	
	Ans	 **Layout of Hydraulic 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	2 Marks for fig. 2 Marks for explanation

		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.	
	b)	**Give classification of hydraulic turbine & their application.**	
	Ans	**I. According to the type of energy available at inlet to the turbine** 1) Impulse turbine (only K.E. available at inlet) eg. Pelton wheel turbine 2) Reaction turbine (only KE. & Pressure energy available at inlet) eg. Francis, Kaplan turbine **II. According to the head available at inlet to the turbine** 1) Low head turbine (less than 60 m) eg. Kaplan turbine 2) Medium head turbine (60 m to 250 m) eg. Francis turbine 3) High head turbine (above 250 m) eg. Pelton wheel turbine **III. According to the specific speed of the turbine** 1) Low specific speed (less than 60) eg. Pelton wheel turbine 2) Medium specific speed (60 to 400) eg. Francis turbine 3) High specific speed (greater than 400) eg. Kaplan turbine **IV. According to direction of flow through runner** 1) Tangential flow turbine 2) Radial flow turbine 3) Axial flow turbine 4) Mixed flow turbine	01 Mark 01 Mark 01 Mark 01 Mark
	c)	**Explain construction and working of Pelton wheel turbine with neat sketch**	
	Ans	**Construction:** The main parts of Pelton Wheel turbine are: 1. Penstock & Nozzle with flow regulating arrangement 2. Runner and buckets 3. Casing 4. Breaking jet	1 Mark for construction



2 Marks for sketch

Fig. Pelton Wheel Turbine

1 Mark for working

Working: Impulse turbine changes the velocity of a water jet. The jet impinges on the turbine's curved blades which change the direction of the flow. The resulting changes in momentum (impulse) causes a force on the turbine blades. Since the turbine is spinning, the force acts through a distance (work) and the diverted water flow is left with diminished energy prior to hitting the turbine blades, the water's pressure (potential energy) is converted to kinetic energy by a nozzle and focused on the turbine. No pressure change occurs at the turbine blades, and the turbine doesn't require hosing for operation.

d) **A jet of water diameter 8 cm strikes on a curved plate at its centre with velocity of 25 m/sec. The curved plate is moving with a velocity of 9 m/sec in the direction of jet. The jet is deflected through an angle of 165°. Assuming plate smooth. Find**

i) Force exerted on plate **ii) Power of jet in KW**

Ans Given:

Diameter of jet = d = 8 cm = 0.08 m

Velocity of jet = v = 25 m/sec

Velocity of plate = u = 9 m/sec

Angle of deflection = θ = 180° - 165° = 15°

i) **Force** exerted by jet on plate $F_x = \rho a (v - u)^2 (1 + \cos\theta)$ — 01 Marks

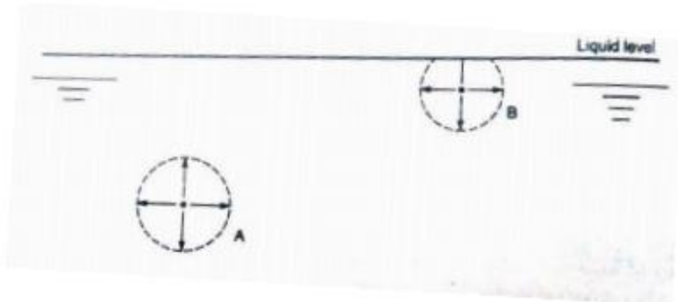
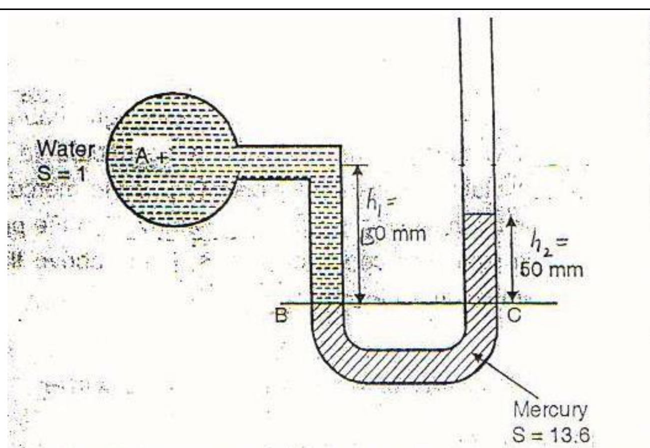
$= 1000 \times (\pi/4 \times 0.08^2)(25 - 9)^2 (1 + \cos 15°)$ — 01 Marks

$\mathbf{F_x = 2529.74\ N}$

ii) **Powe**r of jet = $F_x \times u$ — 01 Marks

$= 2529.74 \times 9$ — 01 Marks

= 22,767.71 Watt = 22.767 KW

	e)	**Define i) Surface tension ii) Compressibility**	
	Ans	**i) Surface tension** Following figure shows the two molecules of liquid at point A and B.  **Fig. Intermolecular forces near a liquid surface** As shown in fig, 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 in maintaining unit length of the film in equilibrium condition. It is denoted by 'σ' (sigma). **ii) Compressibility** It is the measure of elasticity in fluid. Fluids are compressed under pressure due to change in their mass density. More mass can be accommodated in the unit volume & when the pressure is removed the fluid regain to its original volume.	2 Marks 2 Marks
	f)	**A simple manometer containing mercury is used to measure pressure of water flowing in a pipeline. The mercury level in the open tube is 60 mm higher than that as the lift limb tube. If height of water in the tube is 150 mm, determine the pressure in the pipe in terms of head of water.**	
	Ans	 	01 Mark

h_A = Pressure of water in a pipe in mm of water

h_1 = 150 mm

h_2 = 60 mm

S_1 = Specific gravity of water = 1

S_2 = Specific gravity of mercury = 13.6

Now, Pressure in left tube = Pressure in right tube

$h_A + h_1 S_1 = h_2 S_2$ — 01 Mark

$h_A + (150 X 1) = (60 X 13.6)$ — 01 Mark

h_A = 666 mm = **0.666 m** — 01 Mark

Pressure at the centre of pipe $P_A = W. h_A$ = 9810 X 0.666 = **6533.46 N/m²**

Q. 4 **Attempt any TWO of the following:** **16 Marks**

a) **Differentiate between Francis & Kaplan turbine (any eight point).**

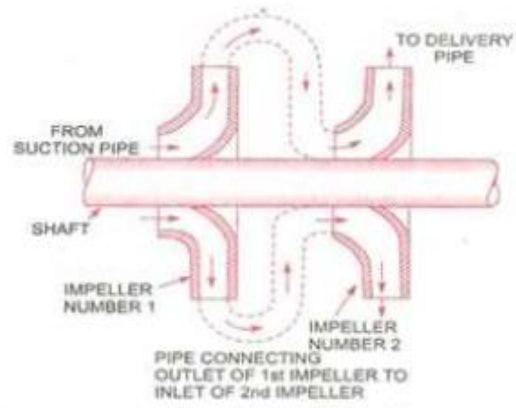
Ans

Criteria	Francis Turbine	Kaplan Turbine
Type of flow	Radial flow turbine	Axial flow
Efficiency	Less as compare to Kaplan turbine	Higher than Francis turbine
Losses	Friction losses are higher	Less friction losses as compare to Francis turbine
Size	Quite large as compare to Kaplan turbine	Compact in cross sectional area
Vanes	Number of vanes are 16 to 24	Number of vanes are 4 to 8.
Type of shaft	Shaft is may be vertical or horizontal as per requirement.	The direction of shaft is always in vertical
Head available	Requires medium range of water head	works on very low head
Flow rate	Requires medium flow rate.	Requires high flow rate of water
Specific speed	Medium range of specific speed	High value of specific speed
Runner vanes	Fixed runner vanes on the shaft	Vanes are adjustable.

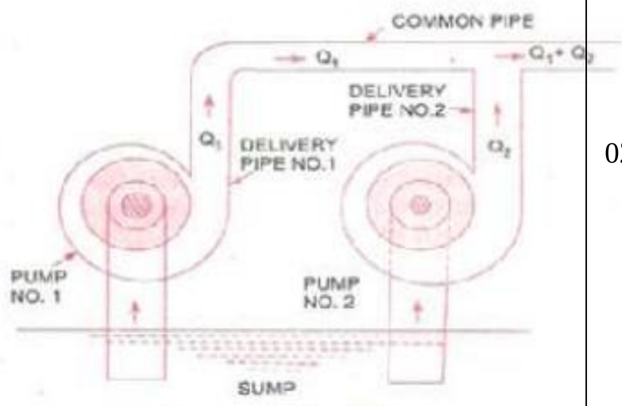
01 Mark for each point

b) **Explain construction & working principle of multistage pump with neat sketch & its application.**

Ans



Two-stage Pumps with Impellers in Series



Pumps in Parallel

02 Marks of each fig.

Multistage of centrifugal pumps:- If the centrifugal pump consists of two or more impellers then pump is called multistage of centrifugal pump. The impellers are mounted on the same shaft or on the different shafts.

i) Multistage centrifugal pump for High Head (**Pumps are in Series**):- To develop a high head but same discharge, the numbers of impellers are mounted in series or on the same shaft. The discharge from impeller passes through a guide passage & enters the second impeller. At the outlet of second impeller the pressure of water will be more than the pressure of water at outlet of first impeller. The pump in series arrangement is employed for delivering a relatively small quantity of liquid against high head. — 02 Marks

ii) Multistage centrifugal pump for High Discharge (**Pumps are in Parallel**) :-To obtain high discharge but same head pumps should be connected in parallel. Each of these pumps working separately lifts the liquid from a common sump and delivers it to a common collection pipe through which it carries to required height. If Q is the discharge capacity of one pump and there are n number of identical pumps (arranged in parallel) the total discharge is = n.Q — 02 Marks

c) **Two jet strike the buckets of pelton turbine which is having shaft power as 15500 KW. The diameter of each jet is 200 mm. If net available head on turbine is 400 m. Find overall efficiency of turbine assuming C_v = 1.00**

Ans Shaft power = 15500 KW

n = 2

H = 400 m

d = 0.2 m

C_v = 1.00

Area of jet = $\pi/4 \times d^2 = (\pi/4 \times 0.08^2) = 0.0314\ m^2$ — 01 Mark

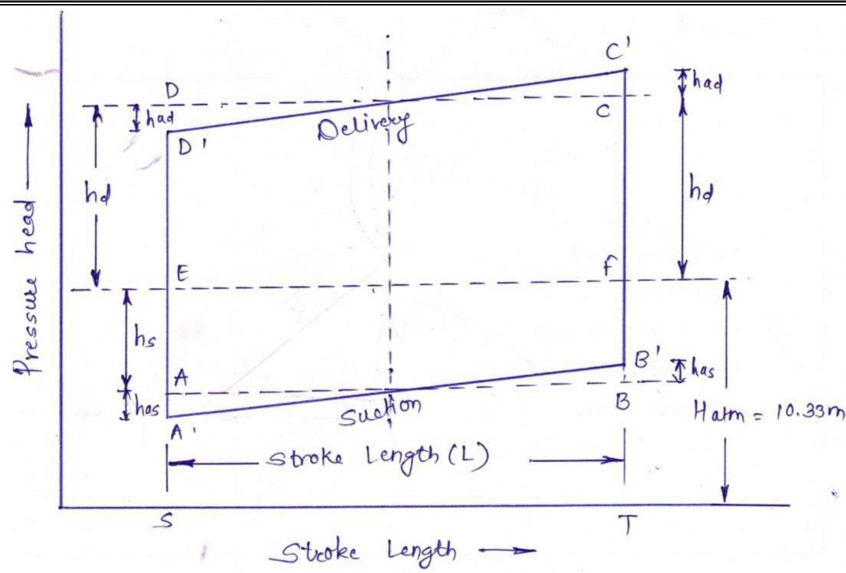
Velocity of each jet = V

$$V = C_v\sqrt{2gh}$$

V = 88.59 m/sec

		Discharge of jet = a X v = 0.0314 X 88.59 = 2.78 m^3/sec Total Discharge Q = 2 X 2.78 = 5.56 m^3/sec Power at inlet of turbine = W Q H = 9810 X 5.56 X 400 = 21817.44 KW Overall efficiency = Shaft Power / Water Power = 15500 / 21817.44 = 0.7104 **Overall efficiency = 71.04 %**	01 Mark 01 Mark 01 Mark 02 Mark 02 Mark
Q. 5		**Attempt any <u>FOUR</u> of the following:**	**16 Marks**
	a)	**State any one cause of trouble given below**	
	Ans	i)Pump starts and suddenly stops: • improper priming • leakage in suction pipe • air pockets in suction line • Suction lift too high ii)Pump consumes so much power: • Speed may be high • Head may be low and pump discharge is more • Impeller may be rotating in wrong direction • Shaft may be bend • Liquid handled may be very high viscosity iii) Pump does not start: • Pump not properly primed • Speed of prime mover too low • Discharge heat too high • Suction lift too high • Vapour lock in suction line iv) Discharge of pump is too low: • Pump not properly primed • Speed of prime mover too low • Discharge heat too high • leakage in suction pipe	01 Marks 01 Marks 01 Marks 01 Marks
	b)	**With the help of neat indicator diagram, explain separation and cavitation in the reciprocating pump. What are its effects?**	

Ans



Indicator diagram for reciprocating pump

02 Marks

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 = Hatm - ($h_s+ h_{as}$) is too small then separation will occur.

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 cavitation which takes place at the start of the suction stroke.

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

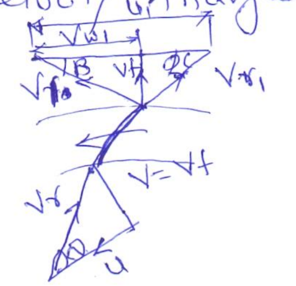
02 Marks

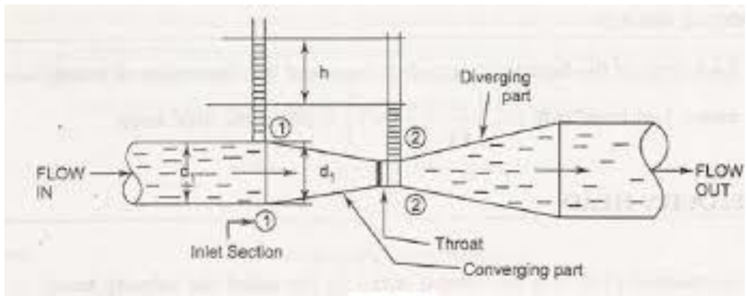
To avoid Separation-

1) The absolute pressure head at the end of the delivery stroke should not be less than the vapour pressure.

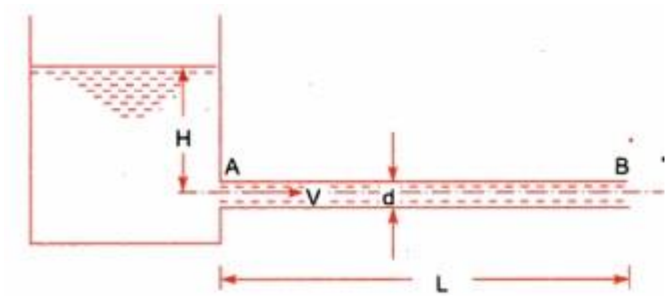
2) Use of air vessel helps to run the pump at high speed without separation

c) **A centrifugal pump is to discharge 110 lit/sec at speed of 1440 rpm, against ahead of 25 m. The impeller diameter is 250 mm and its width 50 mm at outlet. Find the vane angle at outlet assuming a manometric efficiency of 80% .**

	Ans	Given data: Centrifugal Pump. Rate of flow $Q = 110$ lit/sec $= 0.11\ m^3/sec$ $N = 1440$ rpm $H = 25$ m. $D_1 = 250$ mm $= 0.25$ m. $B_1 = 50$ mm $= 0.05$ m $\eta_{man} = 80\%$. $\phi = ?$ Rate of flow $Q = \pi D_1 B_1 V_{f1}$ $0.11 = \pi \times 0.25 \times 0.05 \times V_{f1}$ $\therefore V_{f1} = 2.8$ m/sec	01 Marks
		$u_1 = \frac{\pi D_1 N}{60} = \frac{\pi \times 0.25 \times 1440}{60}$ $\therefore u_1 = 18.84$ m/sec	01 Marks
		$\eta_{man} = \frac{gH}{V_{w1} u_1}$ $\therefore 0.8 = \frac{9.81 \times 25}{V_{w1} \times 18.85}$ $\therefore V_{w1} = 16.27$ m/sec	01 Marks
		Velocity triangle  outlet velocity triangle $\tan\phi = \frac{V_{f1}}{u_1 - V_{w1}} = \frac{2.8}{18.84 - 16.27} = 1.08$ $\phi = 47^\circ 26''$ Vane angle at outlet.	01 Marks
	d)	**What are minor losses in pipes? List of them.**	
	Ans:	**Minor Losses:-** **Losses** due to the local disturbances of the flow in the conduits such as changes in cross section, projecting gaskets, elbows, valves and similar items are called **minor losses**. List: (Any THREE) (i) Loss of head at Entry. HL = 0.5 (V2/2g) (ii) Loss of head at Exit. HL = (V2/2g) (iii) Loss of head due to sudden enlargement. HL = (V1-V2)2 / 2g	01 Marks 03 Marks

		(iv) Loss of head due to sudden contraction HL = (1/Cc-1)2 (V2/2g) (v) Loss of head due to sudden obstruction. (vi) Loss of head due to bend or Elbow, HL = K (V2/2g)	
	e)	Derive an expression for discharge through venturimeter.	
	Ans:	**Venturimeter** is a device used for measuring the rate of flow of a fluid flowing through a pipe. It consists of three parts: • A short converging part • Throat • Diverging part  Let d_1 = diameter at the inlet (section 1) P_1 = pressure at section 1 V_1 = velocity at section 1 A_1= area at section1 d_2, P_2, V_2, A_2 are the corresponding values at the throat (section 2) Applying Bernoulli,s Theorem at section 1 & 2 and neglecting losses.	01 Mark

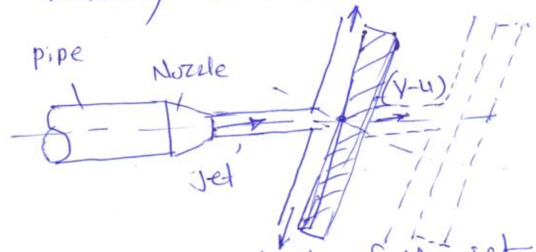
		$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2$ — (1) $Z_1 = Z_2 =$ pipe is horizontal $\frac{P_1}{w} + \frac{V_1^2}{2g} = \frac{P_2}{w} + \frac{V_2^2}{2g}$ $\frac{P_1 - P_2}{w} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$ — (2) $\therefore \frac{P_1 - P_2}{w} =$ difference of pressure head. $\frac{P_1 - P_2}{w} = h$ $\therefore$ put in equ^n (2) $h = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$ —— (3) Applying continuity equation $A_1 V_1 = A_2 V_2$ $\therefore V_1 = \frac{A_2 V_2}{A_1}$ Substituting the value of V_1 in equ^n (3) $h = \frac{V_2^2}{2g} - \frac{\left(\frac{A_2 V_2}{A_1}\right)^2}{2g}$ $h = \frac{V_2^2}{2g}\left(\frac{A_1^2 - A_2^2}{A_1^2}\right)$ $\therefore V_2^2 = 2gh\left(\frac{A_1^2}{A_1^2 - A_2^2}\right)$ $V_2 = \sqrt{2gh\left[\frac{A_1^2}{A_1^2 - A_2^2}\right]} = \frac{A_1}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$ Discharge $Q = A_2 V_2$ $Q = \frac{A_2 A_1}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$. $Q_{act} = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$.	01 Mark 01 Mark 01 Mark
	f)	Explain hydraulic power transmission through pipe.	
	Ans:	**Power transmission through pipes** Power is transmitted through pipes by flowing water or other liquids flowing through them. Power transmitted through pipes will be dependent over the following factors as mentioned here. • Weight of the liquid flowing through the pipe	02 Marks

		• Total head available at the end of the pipe Now we will consider a tank with which a pipe AB is connected. Let us consider the following terms from figure.  L = Length of the pipe D = Diameter of the pipe H = Total head available at the inlet of the pipe V= Velocity of flow in pipe h_f = Loss of head due to friction f = Co-efficient of friction Power transmitted at the outlet of the pipe will be determined with the help of following formula as mentioned here. $$P = \frac{\rho g}{1000} \times \frac{\pi}{4} d^2 \times V \left(H - \frac{4fLV^2}{d \times 2g} \right) \text{kW}$$ **Efficiency of power transmission** Efficiency of power transmission will be determined with the help of following formula as mentioned here. $$\eta = \frac{\text{Power available at outlet of the pipe}}{\text{Power supplie at the inlet of the pipe}}$$ $$= \frac{\text{Weight of water per sec} \times \text{Head available at outlet}}{\text{Weight of water per sec} \times \text{Head at inlet}}$$ $$= \frac{W \times (H - h_f)}{W \times H} = \frac{H - h_f}{H}.$$ Power transmitted through a pipe will be maximum, when the head loss due to friction will be one-third of the total head at inlet. Loss of head h_f= H/3	01 Mark 01 Mark
Q. 6		**Attempt any <u>TWO</u> of the following:**	**16 Marks**
	a)	i) Derive an expression for the force exerted by a jet of water on moving inclined plate	

Force exerted by a jet of water on moving inclined plate:

As shown in fig. shows a fluid jet striking on inclined plate, which is moving with uniform velocity in the direction of the jet.

04 marks



F= Absolute velocity of the jet
u= velocity of plate in the direction of jet.
a = Cross-sectional area of jet.
θ = Angle between jet and the plate.

Relative velocity with which the jet strikes the plate = (V-u)

Mass of fluid striking/sec on the plate= ρa(V-u)

∴ Force exerted by jet on the moving plate

F_n= Mass of fluid strike/sec [Initial velocity - final velocity]

$F_n = \rho a(V-u)[(V-u)\sin\theta - 0]$

$F_n = \rho a(V-u)^2 \sin\theta$

Component of this force in the direction of jet

$F_x = F_n \sin\theta = \rho a(V-u)^2 \sin\theta \cdot \sin\theta$

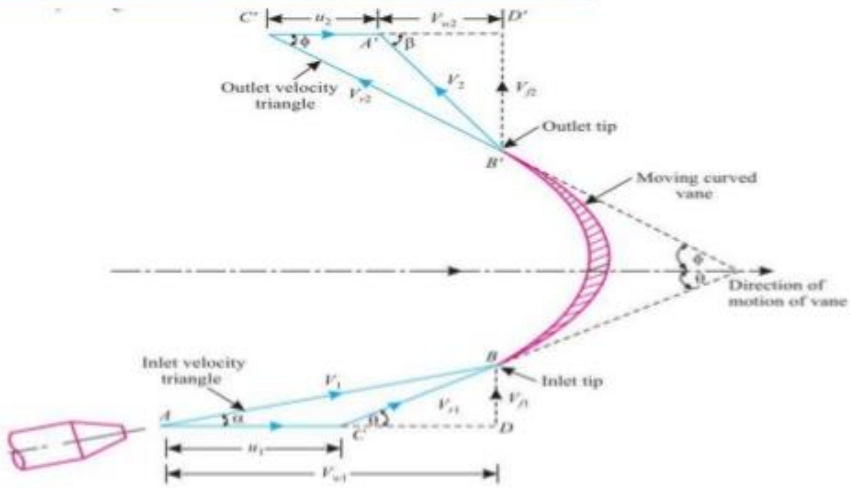
$F_x = \rho a(V-u)^2 \sin^2\theta$

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

ii)Draw and explain velocity triangle for jet striking tangentially on an unsymmetrical curved plate.

Ans

When jet strikes tangentially at one of the tips



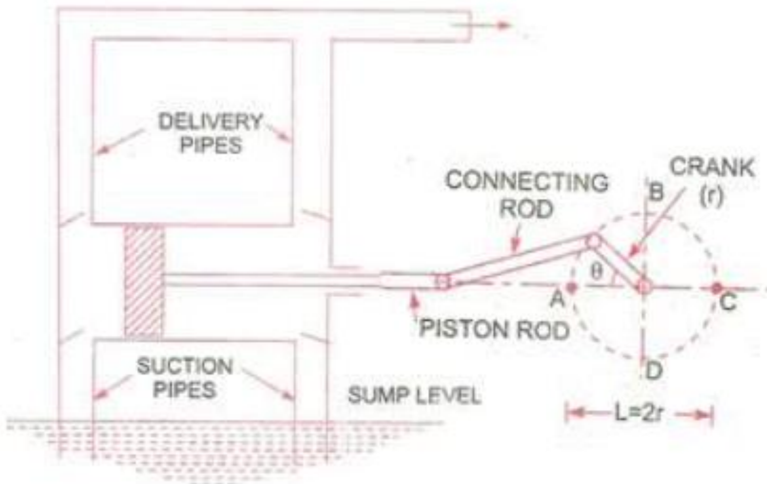
02 Marks

- V_1 = Velocity of the jet , while entering the vane,
- V_2 = Velocity of the jet , while leaving the vane,
- u_1, u_2 = Velocity of the curved vane at inlet & outlet
- α = Angle with the direction of motion of the vane, at which the jet enters the vane,
- β = Angle with the direction of motion of the vane, at which the jet leaves the vane,
- Vr_1 = Relative velocity of the jet and the vane at entrance (it is the vertical difference between V_1 and u_1)
- Vr_2 = Relative velocity of the jet and the vane at exit .(difference between V_2 and u_2)
- Θ = Angle, which Vr_1 makes with the direction of motion of the vane at inlet (known as vane angle at inlet),
- β = Angle, which Vr_2 makes with the direction of motion of the vane at outlet (known as vane angle at outlet),
- Vw_1 = Horizontal component of V_1 . It is a component parallel to the direction of motion of the vane (known as velocity of whirl at inlet),
- Vw_2 = Horizontal component of V_2. It is a component parallel to the direction of motion of the vane (known as velocity of whirl at outlet),
- Vf_1 = Vertical component of V_1 .It is a component at right angles to the direction of motion of the vane (known as velocity of flow at inlet),
- Vf_2 = Vertical component of V_2. It is a component at right angles to the direction of motion of the vane (known as velocity of flow at outlet)

02 Marks

b) Explain construction and working of double acting reciprocating pump and its application.

Ans: Double acting reciprocating pump:



02 Marks

Fig. Double Acting Reciprocating Pump

Construction

(i) Cylinder – It is the heart of reciprocating pump. It is made from cast iron, Cast steel or other metal which suitable to handle liquid flowing through it.

02 Marks

(ii) Piston – It is fits inside the cylinder and piston rod is connected to crank by connecting rod.

(iii) Connecting rod and crank – Connecting rod connects piston to crank. Crank is rotated by engine or electric motor.

(iv) Valves – One way valves are provided at inlet and outlet. Inlet valve admits water into cylinder while outlet valve permits exit of water from cylinder.

(v) Air Vessels – In order to make uniform discharge I dome shaped metal vessels are fitted on delivery pipe.

Working: -i) When crank is at A, The piston is at the extreme left position in cylinder. As the crank rotates from A to C (From θ=00to θ=1800) the piston is moving towards right in cylinder. The movement of piston towards right creates a partial vacuum in cylinder. Due to this suction valve opens and water is sucked in the cylinder in piston end side while delivery takes place on other side.

03 Marks

ii) When crank is at C, The piston is at the extreme Right position in cylinder. As the crank rotates from C to A (from θ=1800to θ=3600) the piston is moving towards left in cylinder. Due to this delivery takes place from piston side while suction takes place on other side of piston. During each stroke when suction takes place on one side of the piston, the other side delivers the liquid.

Thus for one complete revolution of the crank there are two delivery strokes and water is delivered to the pipes by the pump during these two delivery strokes.

Applications: 1) Oil Drilling operations 2) Pneumatic pressure systems 3) Light oil pumping 4) Feeding small boilers condensers returns.

01 Marks

c) **A Francis turbine operating under a head of 60m runs at 420 rpm, If the outer diameter is 0.90m and inner diameter are 0.45m. If the discharge is radial, determine the vane angles at inlet and outlet, if the velocity of flow is constant and 12 m/sec and hydraulic efficiency is 80%**

Ans

Given data:

Francis Turbine

Head $H = 60\,m$ $N = 420\,rpm$

$D_o = 0.9\,m$ $D_i = 0.45\,m$

Discharge is Radial $\beta = 90^\circ$ $V_{w_2} = 0$

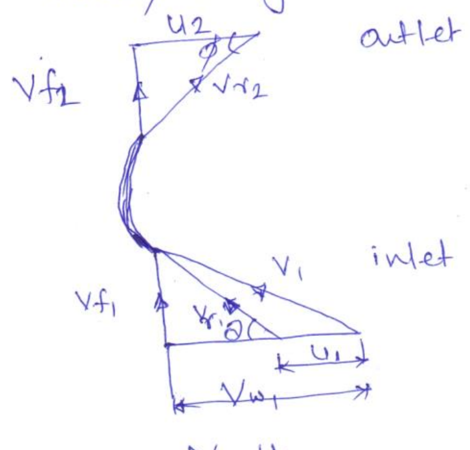
$V_{f_1} = V_{f_2} = 12\,m/sec$. $\eta_{Hyd} = 80\%$

$u_1 = \frac{\pi D_o N}{60} = \frac{\pi \times 0.9 \times 420}{60} = 19.8\,m/sec$

$u_2 = \frac{\pi D_i N}{60} = \frac{\pi \times 0.45 \times 420}{60} = 9.9\,m/sec$

02 Marks

Velocity triangle.



$\eta_{Hyd} = \frac{V_{w_1} u_1 \pm V_{w_2} u_2}{gH}$

$V_{w_2} = 0$.

02 Marks

$\eta_{Hyd} = \frac{V_{w_1} u_1}{gH}$

$0.8 = \frac{V_{w_1} \times 19.8}{9.81 \times 60}$ $\boxed{V_{w_1} = 23.78\,m/sec}$

02 Marks

Inlet

$\tan\theta = \frac{V_{f_1}}{V_{w_1} - u_1} = \frac{12}{23.78 - 19.8} = 3.01$

$\boxed{\theta = 71^\circ 65''}$ → Vane angle at inlet.

Outlet

$\tan\phi = \frac{V_{f_2}}{u_2} = \frac{12}{9.9} = 1.212$

02 Marks

$\boxed{\phi = 50^\circ 48''}$ → Vane angle at Outlet.