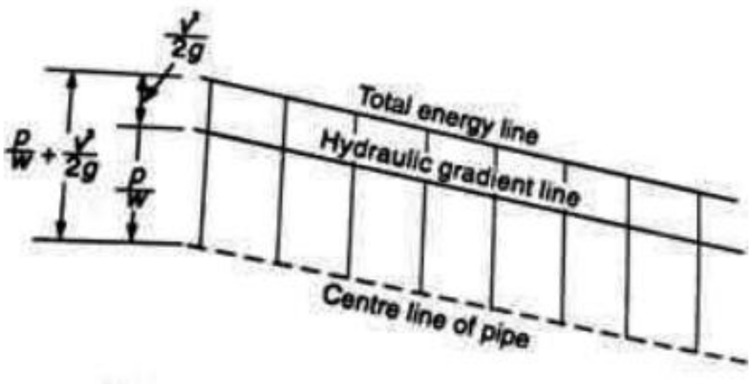
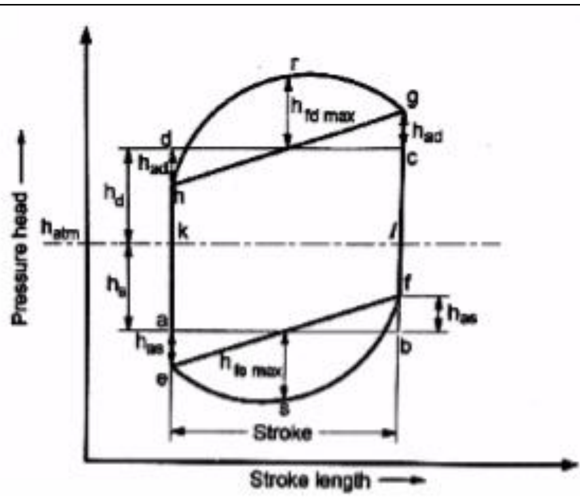
WINTER – 19 EXAMINATION

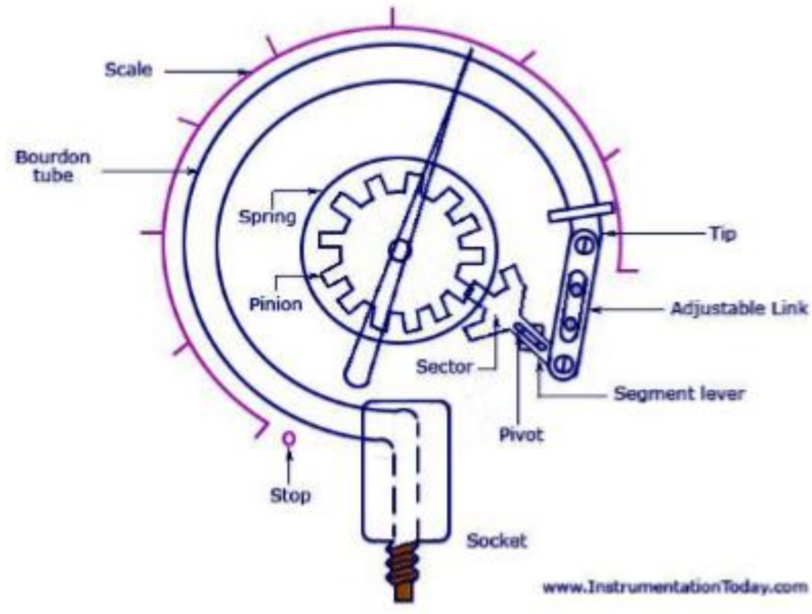
Subject Name: Fluid Mechanics & Machinery **Model Answer** **Subject Code: 22445**

Important Instructions to examiners:

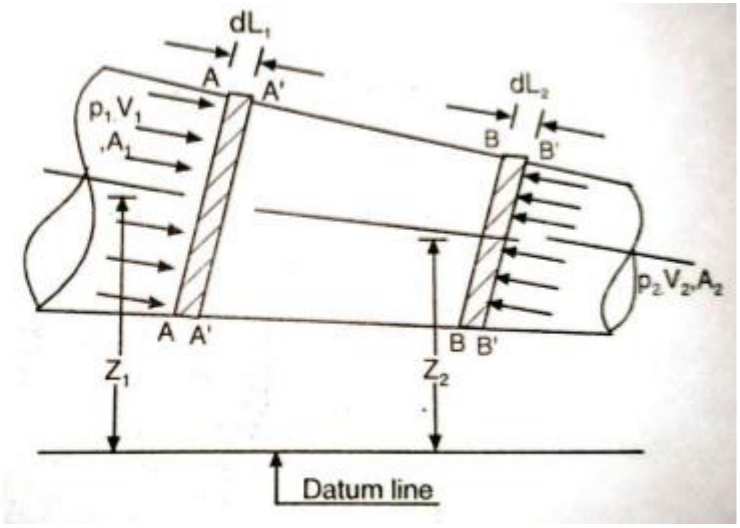
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 FIVE of the following:**	**10 Marks**
	a)	**Compare water and oil of specific gravity 0.8 on the basis of density & viscosity.**	
	Ans	Soil = $(\text{Density})_{oil}$ / $(\text{Density})_{water}$ $0.8 = (\text{Density})_{oil} / 1000$ $\mathbf{(Density)_{oil} = 800\ kg/\ m^3}$ **Here it is not possible to find out viscosity**	02 Marks
	b)	**The pressure in the tyres of the four wheeler was measured as 33. State the unit of pressure in this case. Name the device use to measure this pressure.**	
	Ans	The unit of pressure 33 in this case is PSI (Pound per square Inch). The name of device used to measure is Bourdon Tube Pressure Gauge	01 Mark 01 Mark
	c)	**Show the difference between hydraulic gradient line & total energy line with the help of suitable diagram.**	

	Ans		02 Marks
	d)	**Write Chezy's equation for frictional losses and list all the terms involved in it.**	
	Ans	$V=C\sqrt{mi}$ Where; V = velocity of water in pipe, m = hydraulic mean depth =A/P = d/4 I = loss of head per unit length, C = Chezy's constant	01 Mark 01 Mark
	e)	**State the need of surge tank in hydroelectric power plant.**	
	Ans	• It is the tank provided in the path of penstock to avoid pulsating discharge at inlet of turbines. • To reduce effect of water hammer surge tanks are provided. • During flow of water from reservoir to turbine through penstock pressure surges are created to compensate these surges surge tank is provided.	01 Mark for each point (any 2 point)
	f)	**State the difference between Static head & Manometric head in centrifugal pump.**	
	Ans	**Static head:** The sum of suction head & delivery head is known as static head. **Manometric head:** It is the total head that pump is required to develop. This include all losses. This is equal to difference between pressure head at inlet & outlet of pump.	01 Mark 01 Mark
	g)	**Draw indicator diagram for reciprocating pump showing the effect of accelerating head and frictional head.**	
	Ans		02 Mark

Q.2		**Attempt any <u>THREE</u> of the following:**	**12 Marks**
	a)	**Draw sketch of Bourdon tube pressure gauge and state its advantages.**	
	Ans	 Bourdon Tube Pressure Gauge **Advantages: (any four)** These give more accurate results. Bourdon tube cost low. Bourdon tube are simple in construction. They can be modified to give electrical outputs. They are safe even for high pressure measurement. Accuracy is high especially at high pressures.	**02 Marks for dia.** **1/2 Marks for any 4 adv.**
	b)	**A circular plate 3.5 m diameter is fully immersed in water at an angle of 45° with the vertical. Determine the total pressure and the centre of pressure on the plate when its centre is 3 m below the free surface of water.**	
	Ans	$d = 3.5\ m$ $\theta = 45^\circ$ $\bar{x} = 3m$ $I_G = \frac{\pi}{64} d^4 = \frac{\pi}{64} \times 3.5^4$ $\therefore I_G = 7.366\ m^4$ Area of circular plate $= \frac{\pi}{4} d^2$ $= \frac{\pi}{4} \times (3.5)^2$ $\therefore a = 9.62\ m^2$	01 Mark 01 Mark

		Total Pressure $= W \cdot A \cdot \bar{x}$ $= 9810 \times 9.62 \times 3$ $= 283149.78$ N $\therefore$ Total Pressure $= 283.149$ KN	01 Mark
		Centre of pressure $= \dfrac{I_G}{A\bar{x}} \cdot \sin^2\theta + \bar{x}$ $= \dfrac{7.366}{9.62 \times 3} \times \sin^2 45 + 3$ $\therefore$ Centre of pressure $= 3.1276$ m	01 Mark
	c)	**Explain Bernoulli's theorem with neat sketch. State its two important assumptions.**	
	Ans	This theorem states that whenever there is continuous flow of liquid the total energy at every section remains same provided that there is no any addition or loss of energy. $P/W + V^2/2g + Z$ = constant Where, P/W = Pressure energy $V^2/2g$ = Kinetic energy Z = Potential energy	01 Mark for statement
		Let us consider a conduit having 2-sections. Now, **By using Bernoulli's Theorem,** Total head at section 1 = Total head at section 2 $P_1/W + V_1^2/2g + Z_1 = P_2/W + V_2^2/2g + Z_2$	01 Mark

<table>
<tr><td></td><td></td><td>

Assumptions: (any two)

1. The fluid is ideal.
2. The flow is steady & continuous.
3. The flow is incompressible.
4. Velocity is uniform over the cross section.
5. The flow is irrotational.</td><td>01 Mark for sketch

01 Mark</td></tr>
<tr><td></td><td>d)</td><td>**Compare i) Steady and uniform flow**
ii) Laminar and turbulent flow (Two important points)</td><td></td></tr>
<tr><td></td><td>Ans</td><td>**Steady flow:-** The flow is said to be steady when the flow characteristics, such as velocity, pressure, density and temperature do not change with time.

Water flowing through a tap at a constant rate is an example of steady flow.

Uniform flow:- The flow in which velocity at a given time does not change with respect to space (length of direction of flow) is called as uniform flow.

This term is generally applied to flow in channels.

Laminar flow:- The flow in which each liquid particle has definite path and path of individual particles do not cross each other is called as laminar flow.

e.g. Movement of blood in human body, the flow of thick oil through a small tube.

Turbulent flow:- Flow in which each liquid particle does not have a definite path and the path of individual particles also cross each other is called as turbulent flow.

e.g. The flow of river at the time of flood is turbulent flow.</td><td>01 Mark

01 Mark

01 Mark

01 Mark</td></tr>
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3		Attempt any THREE of the following	12
	a)	**An oil of specific gravity 0.7 is flowing through venturimeter having inlet diameter 35 cm and throat diameter 20cm. The oil-mercury differential manometer shows a reading of 30 cm. Calculate discharge of oil through the horizontal venturimeter. Take Co : 0.98.**	
	Ans:	Given data: i) Sd = 0.8 ii) Sh = 13.6 iii) Reading of differential manometer = 25 cm iv) dia at inlet d1=35 cm v) dia at throat d2=20 cm. Difference of pressure head = h = x{ Sh/ Sd – 1}• = 25{13.6/0.7 – 1} = 552.8 cm of oil. Area at inlet (a1) = $\pi/4 \times d1^2 = \pi/4 \times 35^2 = 962.11\ cm^2$ Area at throat (a2) = $\pi/4 \times d2^2 = \pi/4 \times 20^2 = 314.16\ cm^2$ Discharge Q = cd x a1 a2/($a1^2 - a2^2)^{1/2} \times (2gh)^{1/2}$ Q = $0.98 \times 962.11 \times 314.16 /(925655.6 - 98696.5)^{1/2} \times (2 \times 981 \times 552.8)^{1/2}$ = 339161.9 cm3 /sec = 339.17 lit/sec	01 01 01 01
	b)	Explain water hammer phenomenon and state the remedies measures to avoid it.	
	Ans:	Water hammer phenomenon: commonly occurs when a valve closes suddenly at an end of a pipeline system, and a pressure wave propagates in the pipe. Water hammer (or hydraulic shock) is the momentary increase in pressure inside a pipe caused by a sudden change of direction or velocity of the liquid in the pipe. Water hammer can be particularly dangerous because the increase in pressure can be severe enough to rupture a pipe or cause damage to equipment. **Effects of water hammer are as follows** 1) Due to rise in pressure the pipe may burst. 2) Erosion of inside surface of pipe. 3) Pressure drop in pipe **Remedies for water hammer:** 1) Controlling Velocity of flow. 2) Use of appropriate length of pipe. 3) Elastic properties of pipes. 4) Provide surge tank before the valve on main pipe line. 5) Provide bypass pipe near the valve. 6).Provide Air traps or stand pipes (open at the top) to absorb the potentially damaging forces. caused by the moving water. 7) Use high strength pipes. 8) Close the valve slowly.	2 Marks 2 Marks
	c)	List various minor losses in fluid flow. Explain any one type with sketch and formula.	
	Ans:	List various minor losses a) Sudden expansion of pipe	02 Marks

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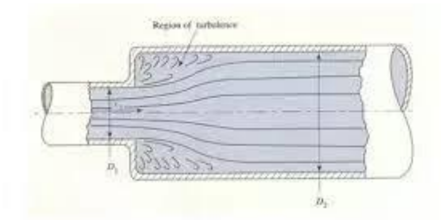
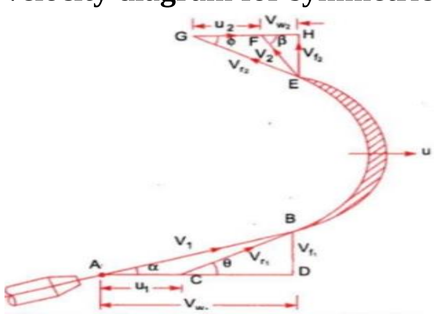
<tr><td></td><td></td><td>b) Sudden contraction of pipe
c) Pipe fittings
d) Bend in pipe
e) Loss of head at Entry.
f) Loss of head at Exit.


Expansion Minor Loss, $h_L = \frac{(V_1 - V_2)^2}{2g}$
When V1, V2 are velocities on the two sides or the section at which sudden enlargement occurs. The head loss resulting from pipe expansion may be greatly reduced by introducing gradual pipe transition known as diffuser.</td><td>02 Marks</td></tr>
<tr><td></td><td>d)</td><td>Draw velocity diagram for symmetrical and moving curved vane when jet strikes at one end with certain velocity at certain angle and meaning the vane from other end. State the meaning of terminologies used in the diagram.</td><td></td></tr>
<tr><td></td><td>Ans:</td><td>velocity diagram for symmetrical and moving curved vane:


• V1 = Velocity of the jet (AB), while entering the vane,
• V2 = Velocity of the jet (EF), while leaving the vane,
• u1, u2 = Velocity of the curved vane at inlet & outlet (AC, FG)
• 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,
• Vr1 = Relative velocity of the jet and the vane (BC) at entrance (it is the vertical difference between V1 and u1)
• Vr2 = Relative velocity of the jet and the vane (EG) at exit (it is the vertical difference between V2 and u2)
• ϴ = Angle, which Vr1 makes with the direction of motion of the vane at inlet (known as vane angle at inlet),
• β = Angle, which Vr2 makes with the direction of motion of the vane at outlet (known as vane angle at outlet),
• Vw1 = Horizontal component of V1 (AD, equal to). It is a component parallel to the direction of motion of the vane (known as velocity of whirl at inlet),
• Vw2 = Horizontal component of V2 (FH, equal to). It is a component parallel to the direction of motion of the vane (known as velocity of whirl at outlet),
• Vf1 = Vertical component of V1 (BD, equal to). It is a component at right angles to the direction of motion of the vane (known as velocity of flow at inlet),</td><td>02 Marks

02 Marks</td></tr>
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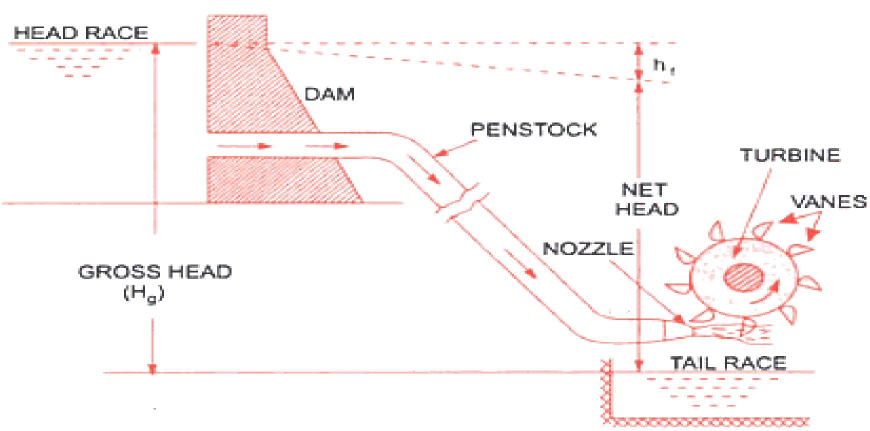
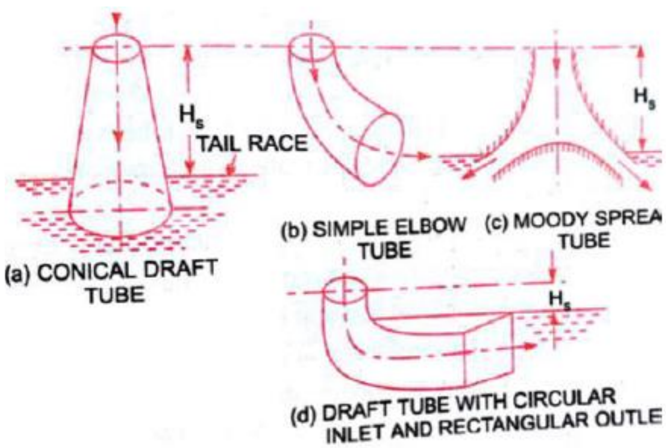
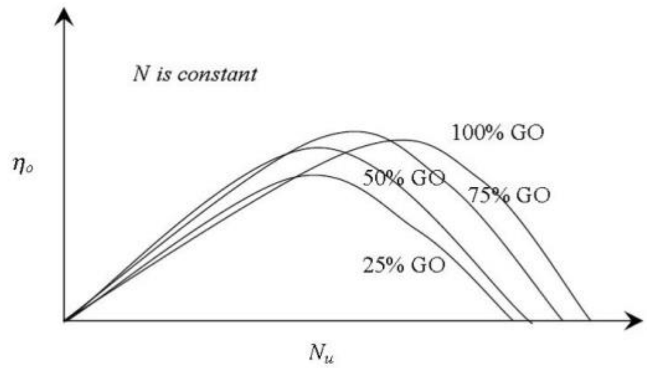
		• Vf2 = Vertical component of V2 (EH, equal to). It is a component at right angles to the direction of motion of the vane (known as velocity of flow at outlet)	
	e)	A jet of water of diameter 30 mm moving with velocity of 35 m/s ,strikes a curved symmetrical plate at the center Find the force exerted by jet of water in direction of jet. If jet is deflected through an angles of 150^o at outlet of curved plate. If the vane is moving with the velocity of 20 m/s in the direction of jet .Find out the force exerted .	
	Ans:	Velocity of jet V = 35 m/s Velocity of vane u = 20 m/s The value of θ i.e. angle made by tip of vane at outlet as Θ= 180 – angle of deflection = 180-150 = 30^o Calculate : Force exerted ny jet diameter of nozzle as 30 mm a $=\pi/4 \times d^2 = \pi/4 \times 0.03^2 = 7.07 \times 10^{-4}$ Force exerted by the jet on vane $Fx = Pa\,(v-u)^2\,(1+cos\theta)$ Fx = 1000x 7.07 x 10^{-4} $(35\text{-}20)^2$ (1+ cos 30)= 296.83 N Force exerted by the jet on vane = 296.83 N	2 Marks 2 Marks
4		Attempt any THREE of the following	
	a)	Draw the layout of hydroelectric power plant and classify the turbines used in it.	
		Layout of hydroelectric power plant:  *Layout of a hydro-eletric power plant.*	2 Marks
		Classification of the hydraulic turbines: According to the type of energy available at inlet to the turbine 1)impulse turbine and 2) Reaction turbine According to direction of flow through runner 1)tangential flow turbine 2) radial flow turbine 3) axial flow turbine 4) mixed flow turbine According to the head available at inlet to the turbine	2 Marks

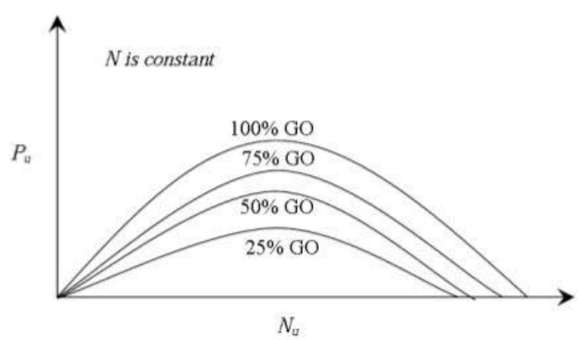
		1) Low head turbine (2 m to 15 m) 2)Medium head turbine (16 m to 70 m) 3)High head turbine (71 m and above) According to the specific speed of the turbine 1)low specific speed 2)medium specific speed 3)High specific speed	
	b)	**Explain the Need of draft tube in reaction turbine .state the types of draft tube used in it**	
	Ans:	Draft tube is a pipe of gradually increasing diameter which connects the exit of runner of turbine to tail race. In case of reaction turbine , one part of available head is converted into K.E before entry to runner and rest of energy is in the form of pressure energy. This pressure energy is gradually converted into runner, thus the velocity leaving the runner is at high velocity. Draft converts K.E to pressure head . also 1) 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. **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 2 Marks
	c)	Draw and explain performance and operating characteristics curves of a Pelton turbine	
	Ans:	The followings are the important **characteristic curves** of a **turbine** : Main **Characteristic Curves** or Constant Head **Curve**. ... The speed of the **turbine** is varied by changing load on the **turbine**. For each value of the speed, the corresponding values of the power (P) and discharge (Q) are obtained.	2 Marks



2 Marks

OPERATING CHARACTERISTIC CURVES / Const. Speed curves • Tests are performed at constant speed. • Const. speed is attained by regulating the gate opening thereby varying the discharge flowing through the turbine as the load varies. • Head may or may not kept constant.

Main Characteristic curves of a Pelton turbine



Main Characteristic curves of a Pelton turbine

d) State any four faults in centrifugal pump and their remedies

Ans:

Sr.No	Fault	remedies
1	Pump fails to start pumping	Reprime the pump , Clean the impeller Reduce suction lift , Increase the speed
2	Pump stops working	Remove air by priming Reduces suction lift
3	Pump is not lifting water up to capacity	Plug leakage Replace the damaged or worn out parts
4	Pump has very low efficiency	Reduce the speed Correct the direction of rotation of impeller Reduce the discharge , Repair affected parts

4 Marks

f) Discuss the factors considered for selection of pump

Ans:

1) Pressure: Pump is ued to pressurize the fluid in system according to need of pressure we can select pump as below

Types of pump	Pressure range (In bar)
External gear pump	300
Internal gear pump	350
Fixed vane pump	175
Variable vane pump	125
Screw pump	175
Axial piston type	700 More than 500 bar)

4 Marks

Any four points

2) Speed of pump: if the speed of pump is increased beyond its rated speed then problems like cavitations takes place. This problem directly affect on efficiency & working of hydraulic system.
3) Flow of pressurized oil: Vol. of oil at output is measured in litre per min have flow of oil deciding speed of actuators
4) Efficiency of pump:
Selection of pump depends on required efficiency like volumetric efficiency , mechanical efficiency, overall efficiency
5) Oil compatibility:
The meaning of compatibility is nothing but acceptance .each pump is compatible to hy.oil but if used different oil, then pump will not give a good performance.
6) cost of pump:
There are different varieties o pumps available in market according to application we can choose it by economical aspect cost of pump & its spares should be less.

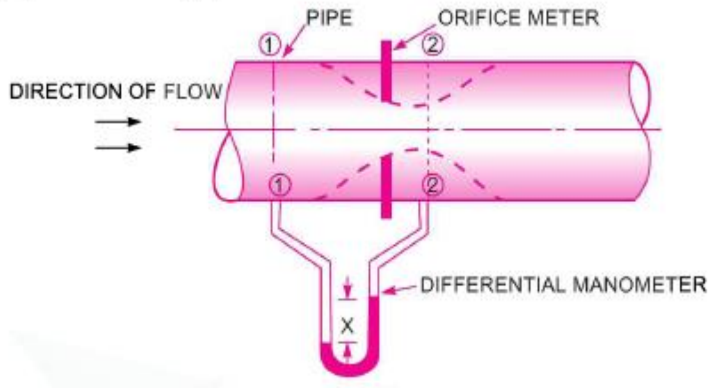
5		**Attempt any TWO of the following:**	12
	a)	Derive equation for discharge through orifice meter with the help of neat sketch.	

Ans:

Orifice Meter or orifice Plate: It is a device used for measuring the rate of flow of a fluid through a pipe. It is Cheaper device as compared to venturimeter. It also works on the same principle as that of venturimeter. It consist of flat circular plate which has a cirxular sharp edged hole called orifice, which is concentric with the pipe. The orifice diameter is kept generally 0.5 times the diameter of the pipe, though it may vry from 0.4 to 0.8 times the pipe diameter.

A differential manometer is connected at section (1) , which is at a distance of about 1.5 to 2.0 times the pipe diameter upstream from the orifice plate, and at section (2), which is at a distance of about half the diameter of the orifice on the downstream side from the orifice plate.

Let p_1 = pressure at section (1),
v_1 = velocity at section (1),
a_1 = area of pipe at section (1), and



2 Marks

p_2, v_2, a_2 are corresponding values at section (2). Applying Bernoulli's equation at sections (1) and (2), we get

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

or $$\left(\frac{p_1}{\rho g} + z_1\right) - \left(\frac{p_2}{\rho g} + z_2\right) = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

But $$\left(\frac{p_1}{\rho g} + z_1\right) - \left(\frac{p_2}{\rho g} + z_2\right) = h = \text{Differential head}$$

$\therefore$ $$h = \frac{v_2^2}{2g} - \frac{v_1^2}{2g} \quad \text{or} \quad 2gh = v_2^2 - v_1^2$$

or $$v_2 = \sqrt{2gh + v_1^2} \qquad ...(i)$$

2 Marks

Now section (2) is at the vena-contracta and a_2 represents the area at the vena-contracta. If a_0 is the area of orifice then, we have

$$C_c = \frac{a_2}{a_0}$$

where C_c = Co-efficient of contraction

$\therefore$ $$a_2 = a_0 \times C_c \qquad ...(ii)$$

By continuity equation, we have

$$a_1 v_1 = a_2 v_2 \quad \text{or} \quad v_1 = \frac{a_2}{a_1} v_2 = \frac{a_0 C_c}{a_1} v_2 \qquad ...(iii)$$

Substituting the value of v_1 in equation (i), we get

$$v_2 = \sqrt{2gh + \frac{a_0^2 C_c^2 v_2^2}{a_1^2}}$$

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or $$v_2^2 = 2gh + \left(\frac{a_0}{a_1}\right)^2 C_c^2 v_2^2 \text{ or } v_2^2\left[1-\left(\frac{a_0}{a_1}\right)^2 C_c^2\right] = 2gh$$

$\therefore$ $$v_2 = \frac{\sqrt{2gh}}{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2 C_c^2}}$$

$\therefore$ The discharge $Q = v_2 \times a_2 = v_2 \times a_0\, C_c$ $\{\because\ a_2 = a_0 C_c \text{ from } (ii)\}$

$$= \frac{a_0 C_c \sqrt{2gh}}{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2 C_c^2}} \quad ...(iv)$$

The above expression is simplified by using

$$C_d = C_c \frac{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2}}{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2 C_c^2}}$$

$\therefore$ $$C_c = C_d \frac{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2 C_c^2}}{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2}}$$

Substituting this value of C_c in equation (iv), we get

$$Q = a_0 \times C_d \frac{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2 C_c^2}}{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2}} \times \frac{\sqrt{2gh}}{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2 C_c^2}}$$

$$= \frac{C_d a_0 \sqrt{2gh}}{\sqrt{1-\left(\frac{a_0}{a_1}\right)^2}} = \frac{C_d a_0 a_1 \sqrt{2gh}}{\sqrt{a_1^2 - a_0^2}}.$$

</td><td>2 Marks</td></tr>
<tr><td></td><td>b)</td><td>A pipe line 2000m long carries water having pressure of 50 bar at inlet. The pressure drop over the length of pipe is 1000 kN/m^2 . If the power transmitted through pipr is 110kw and coefficent of friction is 0.0055 Find 1) Diameter of pipe 2) Efficiency of transmission</td><td></td></tr>
<tr><td></td><td>Ans:</td><td>

Given:

L= 2000 m, P=50 bar=50 x 10^5 N/m^2,

dP=1000 kN/m^2 P=110 kW,

f=0.0055

1) Diameter of pipe

Presure head at inlet H = P/ρg =50 x 10^5/ (1000 x 9.81) = 509.7 m

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		Loss of head h_f=d P/ρg = 1000 x10^3/ (1000 x9.81) = 101.94 m $h_f=fLV^2/2gd$ 101.94 =0.0055 x 1000x v^2 / (2 x 9.81 d) v= 19.06 $d^{1/2}$ Head availavle at the end of pipe = H-h_f Power trasnmitted through pipe P= ρgQ(H-h_f)/1000 kW 110 x 10^3=1000 x 9.81x (Π/4) x d^2 x v x (509.7 - 101.94) 110 x 10^3=1000 x 9.81x (Π/4) x d^2 x $d^{1/2}$ x (509.7 - 101.94) $d^{3/2}$=0.035 d=0.1069 m 2) Efficiency of power Transmission η=(H-h_f)/H = (509.7-101.94)/509.7= 0.8 = 80%	2 Marks 2 Marks 2 Marks
	c)	A jet moving with a velocity of V m/s is made to strike a stationary i) flat plate normally ii) flat inclined at an angle θ iii)symmertical curved vane at centre with tip angle θ In which case the force exerted by the jet is maximum? Justify with suitable sketch and formula.	
	Ans:	i) Force excerted by jet on flate plate normally =ρAV^2 ii) Force excerted by jet on flate plate inclined at an angle θ= ρAV^2sinθ iii) Force Excerted by jet on symmetrical curved vane at centre with tip angle θ F= ρAV^2(1+cosθ) Force excerted by jet on symmetrical curved vane at centre with tip angle θ is maximum. **Justification:** • Force excerted by jet on symmetrical curved vane at centre with tip angle θ is maximum. • Because it contains (1+cosθ) term and as θ varies between to (1+cosθ)90 ^{0} cosθ is positive and (1+cosθ) is always greater than 1. • Hence Force excerted by jet on symmetrical curved vane at centre with tip angle θ is maximum.	1 Marks 1 Marks 2 Marks 2 Marks
6		**Attempt any TWO of the following:**	12
	a)	**Explain Construction and working of Francis Turbine with neat sketch.**	

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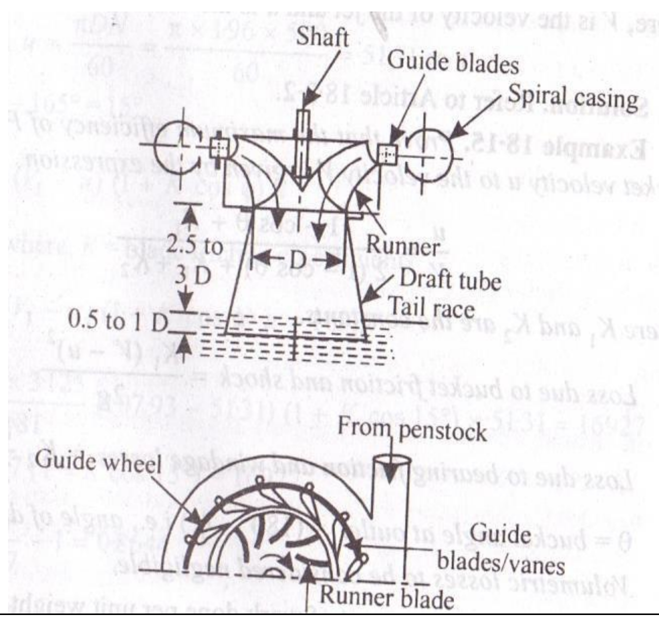
<td>Ans:</td>
<td>The main parts of the Francis turbine are:
1) Penstock: It is the large pipe which conveys water from the upstream of the reservoir to the turbine runner.
2) Spiral casing: It is a closed passage whose cross sectional area gradually decreases along the flow direction. Area is maximum 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.
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.
After doing the work the water is discharge to the trail race through the draft tubes.

</td>
<td>2 Marks

2 Marks

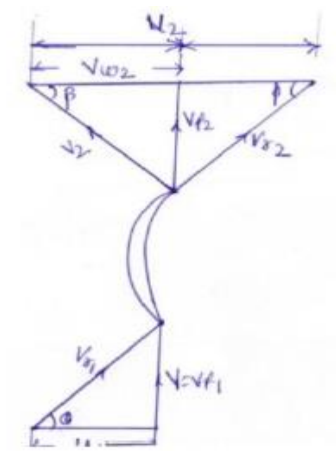
2 Marks</td>
</tr>
<tr>
<td>b)</td>
<td>Ans:</td>
<td>Given:
Hm=Manometric head=14.5m
N=1000rpm , Φ=Vane angle at outlet=30^0
D2=Diameter at outlet=300mm=0.3m
B2=Width at the outlet=50mm=0.05m & $\eta_{mano} = 0.95$ &$\eta_{over} = 0.90$</td>
<td></td>
</tr>
</table>

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

Solution:

1) Discharge (Q)

Velocity Triangle



2 Marks

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

$\eta_{mano} = (gH_m/ u_2\, V_{w2})$

Also $u_2 = (\pi\, D_2 N)/(60) = (\pi \times 0.3 \times 1000)/(60) = 15.71$ m/s

$0.95 = (9.81 \times 14.5/ 15.71 \times V_{w2})$

$V_{w2} = 9.53$ m/s

2 Marks

$\tan 30 = (V_{f2}/15.71 - 9.53)$

$\tan 30 = (V_{f2}/6.18)$

$V_{f2} = 6.18 \times \tan 30 = 3.57$ m/s

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

$Q = \pi \times 0.3 \times 0.05 \times 3.57 = 0.1682\ m^3/s$

2 Marks

2) Power required to the drive the pump

η overall = wQH_m/Input Power

Input Power = $\rho QH_m/ \eta_{overall} = 1000 \times 9.81 \times 0.1682 \times 14.5/0.9$

Input Power = 26.58 kW

c) **Ans:** Given: N = 50 rpm, $Q = 0.00736\ m^3/s$ D=300mm,

L=300 mm Hs= 3.5 m Hd =11.5 m,

Determine : 1) Therotical Discharge 2) Slip 3) Power required to run the pump

		Solution: 1) Theoretical Discharge Q_{th}= ALN/60 = (Π/4) x D^2 x LN/60 = (Π/4) x 0.3^2 x 0.3 x 50/60 = 0.0176 m^3/s	2 Marks
		2) Slip = Q_{th}-Q_{act} =0.021-0.0176 = 0.0034 m^3/s	2 Marks
		3) Power required to run the pump P= ρg A LN (Hs+Hd) / 60000 kW P=1000 x 9.81 x (Π/4) x 0.3^2 x0.3 x 50 x (3.5+11.5) /60000 P= 2.6 kW	2 Marks