WINTER – 2022 EXAMINATION
Model Answer

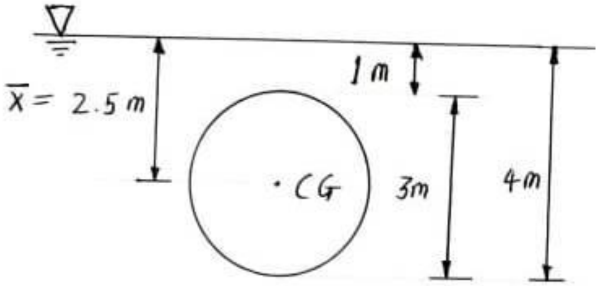
Subject Name: Fluid Mechanics and Machinery **Subject Code: 22445**

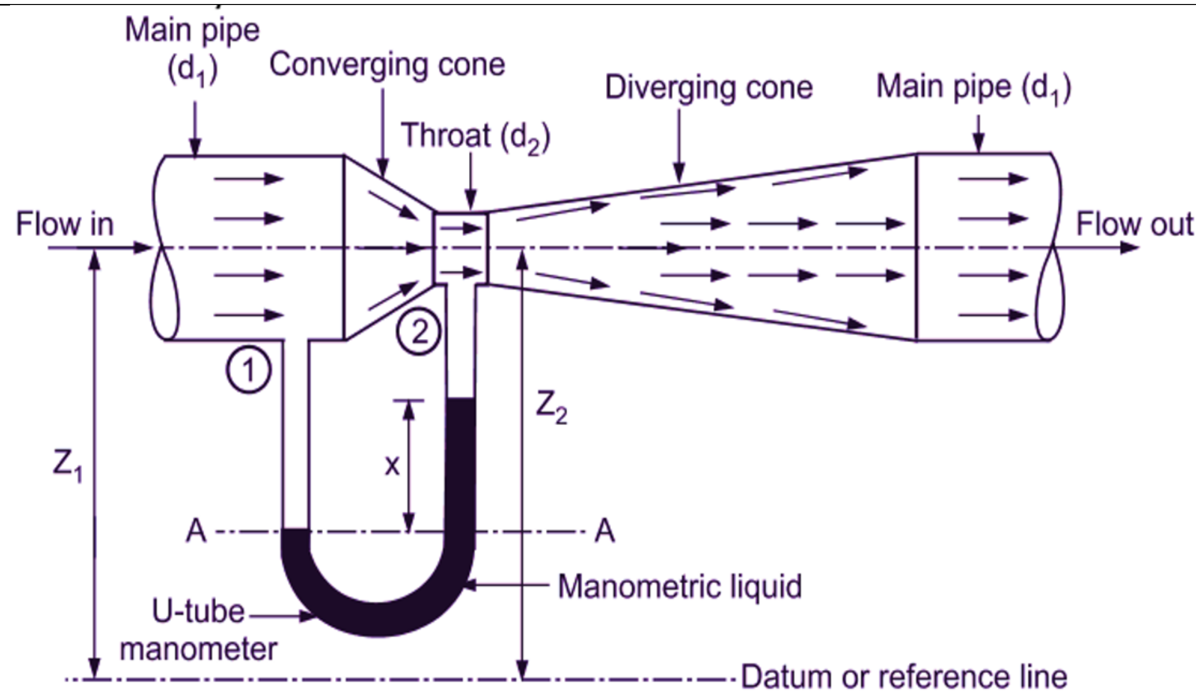
Important Instructions to examiners:

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.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

Q. No.	Sub Q. N.	Answer	Marking Scheme
Que.1		**Attempt any FIVE of the following**	**10 Marks**
	a)	**Define fluid pressure intensity and pressure head.**	
	Sol.	**Pressure intensity:** The force acting on the area in the normal direction is called as pressure Intensity. **Pressure head:** Pressure head is defined as the vertical height or the free surface above any point in a fluid at rest.	01 Mark for each definition
	b)	**Convert 10 N/cm² pressure in oil column of specific gravity 0.82**	
	Sol.	$P = 10\ N/cm^2 = 10 \times 10^4\ N/m^2$ Density of Oil = $\rho_o = 0.82 \times 1000 = 820\ kg/m^3$ **Pressure in oil column** = $H = P/W$ $= P/(\rho_o \times g) = (10 \times 10^4)/(820 \times 9.81) =$ **12.43 m of Oil**	01 Mark 01 Mark

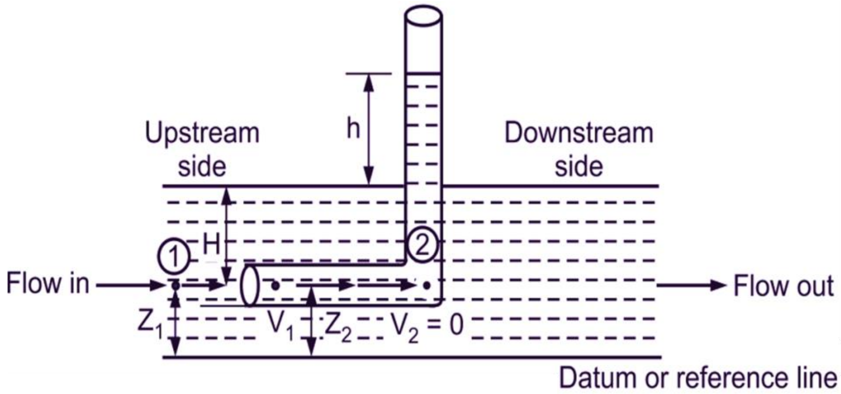
Q. No.	Sub Q. N.	Answer	Marking Scheme
	c)	**State the types of fluid flow.**	
	Sol.	(i) Steady and Unsteady flow. (ii) Uniform and Non-uniform flow. (iii) Laminar and turbulent flow. (iv) Rotational and Irrotational flow (v) Compressible and incompressible flow.	½ mark for each type
	d)	**State the various minor losses in the pipe.**	
	Sol.	(i) Loss of head at Entry. (ii) Loss of head at Exit. (iii) Loss of head due to sudden enlargement. (iv) Loss of head due to sudden contraction (v) Loss of head due to sudden obstruction. (vi) Loss of head due to bend or Elbow	½ mark for each loss
	e)	**Write Chezy's equation. State the meaning of each term.**	
	Sol.	Chezy's formula , $V= C\sqrt{mi}$ Where; V = velocity of water in pipe, C = Chezy's constant, m = hydraulic mean depth =A/P = d/4 i = loss of head per unit length	01 Mark 01 Mark
	f)	**State the necessity of draft tube for every reaction turbine.**	
	Sol.	(i) Draft tube permits a negative head to be established at the outlet of the runner and thereby increase the net head on the turbine. The turbine may be placed above the tail race without any loss of net head and hence turbine may be inspected properly. (ii) Draft tube converts a large portion of the kinetic energy rejected at the outlet of the turbine into useful pressure energy. Without draft tube, the kinetic energy rejected at the outlet of the turbine will go waste to the tail race. (iii) The net head on the turbine increases. (iv) The turbine develops more power and also the efficiency of the turbine increases.	**Any two** 01 Mark for each

Q. No.	Sub Q. N.	Answer	Marking Scheme
	g)	**Define the following terms-** **i) NPSH** **ii) Negative Slip**	
	Sol.	**NPSH:** The net positive suction head (NPSH) is defined as the absolute pressure head at the inlet of the pump to force the liquid into the pump at a given temperature. **Negative Slip:** When theoretical discharge is less than actual discharge then the difference is called as negative slip.	01 mark 01 mark
Q.2		**Attempt any THREE of the following:**	**12 Marks**
	a)	**Different pressure gauges shows following sets of reading** **i) 100 kgf/cm^2** **ii) 15 bar convert it into N/mm^2 and N/m^2**	
	Sol.	**i) 100 kgf/cm^2** We know, 1 Kg = 9.81 N 100 kgf/cm^2 = 100 x 9.81 = 981 N/cm^2 981 N/cm^2 = 981 / (10^2) = **9.81 N/mm^2** 9.81 N/mm^2 = 9.81 / (10^{-3})^2 = **9810 X 10^3 N/m^2** **ii) 15 bar** 15 bar = **15 X 10^5 N/m^2** 15 X 10^5 N/m^2 = 15 X 10^5 / (10^3)^2 =**1.5 N/mm^2**	 01 mark 01 mark 01 mark 01 mark
	b)	**A circular plate 3 m diameter is immersed in water is such a way that its greatest and least depth below the free surface of water are 4 m and 1 m respectively. Determine the total pressure and position of center of pressure.**	
	Sol.	d = 3 m greatest depth = 4 m least depth = 1 m 	01 mark

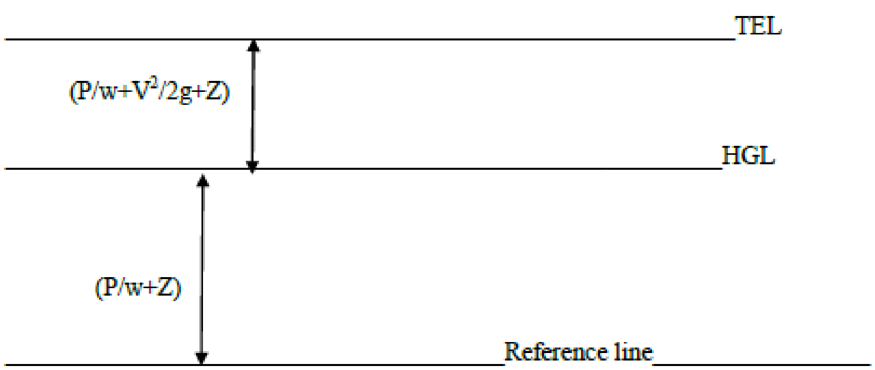
Q. No.	Sub Q. N.	Answer	Marking Scheme
		Here, Center of gravity, $\bar{X}$ = 1 + (3/2) = 2.5 m A =(π /4) X d^2 = (π /4) X ^{32} = 7.068 m^2 Now, **Total Pressure on circular Plate**, **P = W . A .** $\bar{X}$ = 9810 X 7.068 X 2.5 = **173357 N** Now, **Position of center of Pressure** = $I_G / (A\ \bar{X}) + \bar{X}$ I_G = (π /64) X d^4 = (π /64) X 3^4 = 3.976 m^4 Position of center of Pressure = $I_G / (A\ \bar{X}) + \bar{X}$ = 3.976 / (7.068 X 2.5) + 2.5 = **2.725 m**	01 mark 01 mark 01 mark
	c)	**Derive the equation for coefficient of discharge (C_d) for Venturimeter.**	
	Sol.		01 mark

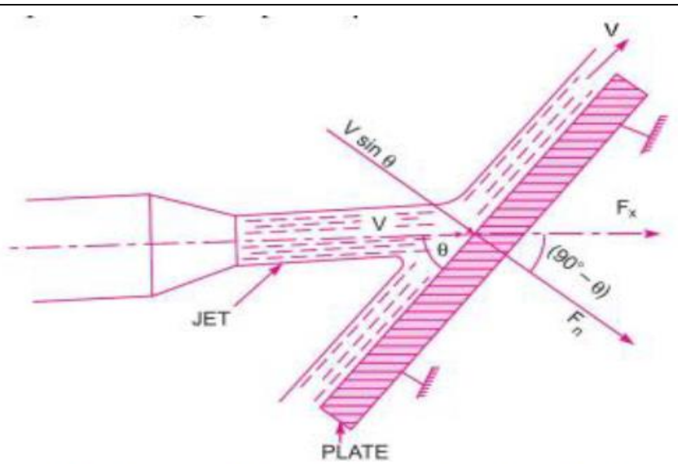
Q. No.	Sub Q. N.	Answer	Marking Scheme
		Consider a venturimeter fitted in a horizontal pipe through which a fluid is flowing Let P_1 = Pressure at section 1 V_1 = Velocity at section 1 a_1 = Area at section 1 Z_1 = Datum head at section 1 P_2, V_2, a_2, Z_2 are the corresponding value at section 2 Assuming that is no loss of energy and apply Bernoulli's equation to section (1) and (2) $$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2$$ Since the meter is horizontal $Z_1 = Z_2$ $$\therefore \frac{P_1}{w} + \frac{V_1^2}{2g} = \frac{P_2}{w} + \frac{V_2^2}{2g}$$ $$\frac{P_1 - P_2}{w} = \frac{V_2^2 - V_1^2}{2g}$$ $\frac{P_1 - P_2}{w}$ is the pressure head difference between section 1 and 2, and it is denoted by h. $$\therefore h = \frac{V_2^2 - V_1^2}{2g}$$ Now applying continuity equation, $$Q = a_1V_1 = a_2V_2$$ $$V_1 = \left(\frac{a_2}{a_1}\right) V_2$$	01 mark

Q. No.	Sub Q. N.	Answer	Marking Scheme
		$\therefore \quad h = \frac{V_2^2 - (a_2/a_1)^2 V_2^2}{2g}$ $= \frac{V_2^2}{2g}\left[1 - \left(\frac{a_2}{a_1}\right)^2\right]$ $h = \frac{V_2^2}{2g}\left(\frac{a_1^2 - a_2^2}{a_1^2}\right)$ $V^2 \quad \frac{a_1^2(2gh)}{(a_1^2 - a_2^2)}$ $V_2 = \frac{a_1\sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$	01 mark
		Discharge through venturimeter $Q = V_2 a_2$ $Q = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ This is the discharge under ideal condition, called as theoretical discharge. but Actual discharge = Coefficient of discharge × Theoretical discharge $Q = C_d \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ Where C_d = coefficient of discharge	01 mark

Q. No.	Sub Q. N.	Answer	Marking Scheme
	d)	**Explain with sketch the procedure for measuring velocity in pipe using Pitot tube.**	
	Sol.		01 Mark
		• Pitot tube is used for measuring the local velocity of flow at any point in a pipe or channel.	01 Mark
		• Its working principle is if velocity of flow at a point becomes zero, there is increase in pressure energy. • In its simplest form, it is a glass tube bent at right angle as shown in fig. • The lower end is bend through 90^0 is facing the upstream direction. The liquid rises up in the tube due to the conversion of kinetic energy into pressure energy.	01 Mark
		• Piezometer tube gives pressure head and pitot tube gives pressure and velocity head. • The velocity is determined by measuring the rise (h) of liquid in the tube as shown in fig. Actual velocity = V = $C_v \sqrt{2gh}$	01 Mark
		• The bent end of pitot tube should be facing the direction of flow of liquid otherwise there will error in calculation.	
Que.3		**Attempt any <u>THREE</u> of the following**	**12 Marks**
	a)	**A Venturimeter is installed in a pipeline of 30 cm diameter, the difference of pressure at entrance and throat read by mercury manometer is 5 cm. When the water flows at a rate of 0.05 m^3/sec. If the discharge coefficient of meter is 0.96 determine the diameter of throat**	

Q. No.	Sub Q. N.	Answer	Marking Scheme
	Sol.	Soln - Given data - Diameter at inlet $d_1 = 30cm. = 0.3m$ - Difference of mercury level $x = 5cm. = 0.05m$ - Flow Rate $Q = 0.05 m^3/sec$ - Coeff. of discharge $Cd = 0.96$ - Diameter of throat $d_2 = ?$ - Spec. gravity of mercury $Sm = 13.6$ - Spe. gravity of water $Sw = 1$ 1) Area at inlet $\therefore a_1 = \frac{\pi}{4}(d_1)^2 = \frac{\pi}{4}(0.3)^2$ $a_1 = 0.0706\ m^2$	01 Mark
		2) Pressure head $\therefore$ Pressure difference $h = x\left(\frac{Sm}{Sw} - 1\right)$ $= 0.05\left(\frac{13.6}{1} - 1\right)$ $h = 0.63m$	01 Mark
		3) For venturimeter $\therefore Q = \frac{Cd \cdot a_1 \cdot a_2 \cdot \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ $\therefore 0.05 = \frac{0.96 \times 0.0706 \times a_2 \times \sqrt{2 \times 9.81 \times 0.63}}{\sqrt{(0.0706)^2 - (a_2)^2}}$ $\sqrt{(0.0706)^2 - (a_2)^2} = 4.76 a_2$ Squaring on both side $(0.0706)^2 - (a_2)^2 = (4.76 \times a_2)^2$ $\therefore 4.98 \times 10^{-3} = 22.65 a_2^2 + a_2^2$ $\therefore 4.98 \times 10^{-3} = 23.65 a_2^2$ $\therefore a_2^2 = 2.10 \times 10^{-4}$ $a_2 = 0.01449$ We know that $a_2 = \frac{\pi}{4} d_2^2$ $\therefore 0.01449 = \frac{\pi}{4} d_2^2$ $d_2^2 = 0.01844$ $\therefore d_2 = 0.1358\ m$ $\therefore$ Diameter of throat $d_2 = 13.58\ cm$	02 Mark

Q. No.	Sub Q. N.	Answer	Marking Scheme
	b)	**Explain H.G.L. and T.E.L. with neat sketch.**	
	Sol.	**Hydraulic gradient line (HGL) :-** Hydraulic gradient line is basically defined as the line which will give the sum of pressure head and datum head or potential head of a fluid flowing through a pipe with respect to some reference line. **Hydraulic gradient line=** $P/w + z$ **Total Energy Line (TEL):-** Total energy line is basically defined as the line which will give the sum of pressure head, potential head and kinetic head of a fluid flowing through a pipe with respect to some reference line. **Total Energy Line=** $v^2/2g + P/w + z$ 	01 Mark 01 Mark 02 Mark
	c)	**State the equation for hydraulic power transmission through pipe and obtain the condition for maximum power transmission.**	
	Sol.	Power transmitted through pipe P= (weight of liquid flowing per second) x (Outlet Head) $P = w \times Q \times (H - h_f)$ Condition for maximum power transmission through the pipe:- Differentiate the above equation w.r.t. velocity 'v' and equate with zero	01 Mark

Q. No.	Sub Q. N.	Answer	Marking Scheme
		$\frac{d(Power)}{dV} = 0$ $\frac{d}{dV}[WQ(H - h_F)] = 0$ $\therefore \frac{d}{dV}\left[W \cdot Q\left(H - \frac{4 F l V^2}{2 g d}\right)\right] = 0$ $\therefore \frac{d}{dV}\left[\left(W \cdot \frac{\pi}{4} d^2 V\right) \cdot \left(H - \frac{4 F l V^2}{2 g d}\right)\right] = 0$ $\therefore \frac{d}{dV}\left[\left(W \cdot \frac{\pi}{4} d^2\right) \cdot \left(H \cdot V - \frac{4 F l V^3}{2 g d}\right)\right] = 0$ $\therefore W \cdot \frac{\pi}{4} d^2 \frac{d}{dV}\left[H \cdot V - \frac{4 F l V^3}{2 g d}\right] = 0$ $\therefore W \cdot \frac{\pi}{4} d^2 \left[H - \frac{4 \times 3 \; F l V^2}{2 g d}\right] = 0$ $\therefore H - 3 \times \frac{4 F l V^2}{2 g d} = 0$ $\therefore H - 3h_F = 0$ $H = 3h_F$ $\therefore \boxed{h_F = \frac{H}{3}}$	01 Mark 01 Mark 01 Mark
	d)	**Derive an expression for force exerted by jet on stationary inclined flat plate in direction of jet.**	
	Sol.	 **Fig.** Impact of jet on an inclined fixed plate	01 Mark

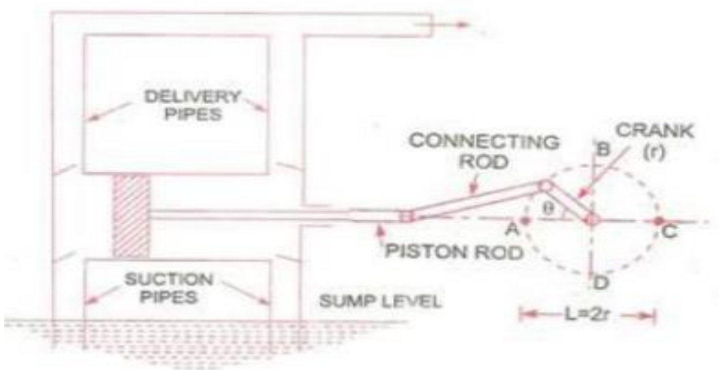
Q. No.	Sub Q. N.	Answer	Marking Scheme
		Let, d = diameter of jet a = Area of jet = $(\pi/4)\ d^2$ V = Velocity of jet before striking the plate Vsinθ= component of velocity normal to plate m = mass of water striking the plate per sec in Kg. m= ρ a V Fn = Normal force on the plate. Fn = mass of water X (velocity before impact in the direction normal to plate – Velocity after impact in the direction normal to plate) Fn = ρ a V (Vsinθ -0) = $\rho\ a\ V^2 \sin\theta$ Fx = Force in the direction of jet, Fx= = Fn sinθ = $\rho\ a\ V^2 \sin^2\theta$	01 Mark 01 Mark 01 Mark
	e)	**A horizontal jet of water is delivered under an effective head of 25 m. Calculate the diameter of jet if the force exerted by the jet on a vertical fixed plate is 2.22 KN. Take coefficient of velocity as 0.99**	
	Sol.	- Given data. effective head h = 25m. Force F = 2.22KN = 2.22×10^3 N. coefficient of velocity Cv = 0.99 Mass density of water ρ = 1000 kg/m³ Diameter of jet d = ? ∴ velocity of jet $V = C_v \sqrt{2gh}$ $= 0.99 \sqrt{2\times9.81\times25}$ $V = 21.93$ m/sec	01 Mark

Q. No.	Sub Q. N.	Answer	Marking Scheme
		∴ Force exerted by jet normal to fixed plate is $F = \rho \cdot a \cdot V^2$ $\therefore 2.22 \times 10^3 = 1000 \times \frac{\pi}{4} d^2 \times (21.93)^2$ $\therefore 2.22 \times 10^3 = 377.71 \times 10^3 \times d^2$ $\therefore d^2 = 0.005877$ $d = 0.0766$ m. $d = 76.66$ mm	01 Mark 01 Mark 01 Mark
Que.4		**Attempt any THREE of the following**	**12 Marks**
	a)	**Differentiate between Francis turbine and Kaplan turbine. (any four points)**	
	Sol.	(see table below)	1 Mark each Any 4

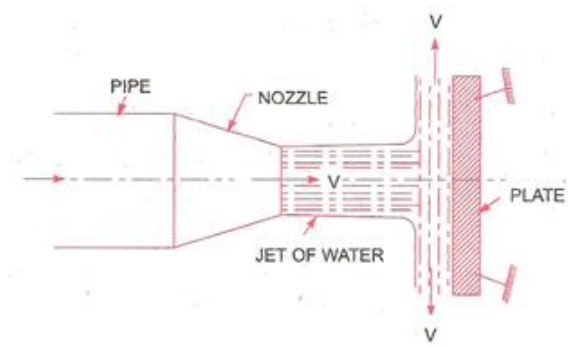
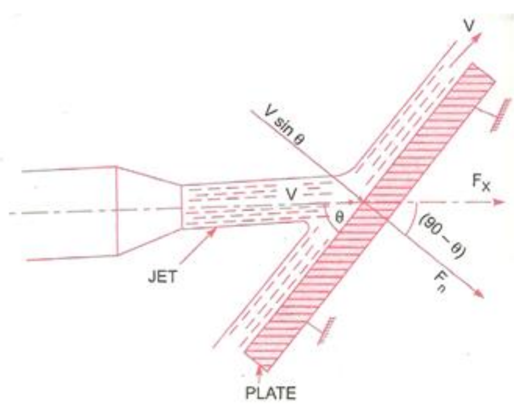
Criteria	**Francis Turbine**	**Kaplan Turbine**
Type of flow	Radial flow turbine.	Axial flow.
Efficiency	Less as compare to Kaplan turbine.	Higher than Francis turbine.
Losses	Friction losses are higher.	Less friction losses as compare to Francis turbine.
Size	Quite large as compare to Kaplan turbine.	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.

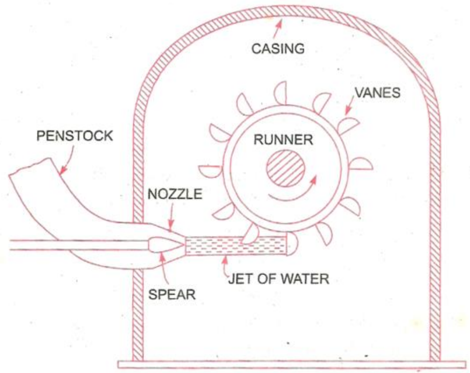
Q. No.	Sub Q. N.	Answer	Marking Scheme
	b)	**Classify turbines according to following:** **i) Head at the inlet of turbine** **ii) The direction of flow of water through runner**	
	Sol.	**According to the head available at inlet to the turbine** 1) Low head turbine (2 m to 15 m) eg. Kaplan turbine 2) Medium head turbine (16 m to 70 m) eg. Francis turbine 3) High head turbine (71 m and above) eg. Pelton wheel turbine **According to the direction of flow of water through runner: -** 1) Tangential flow turbine eg. Pelton wheel turbine 2) Radial flow turbine eg. Inward flow and outward flow turbine. 3) Axial flow turbine eg. Kaplan turbine 4) Mixed flow turbine eg Modern Francis turbine	02 Mark 02 Mark
	c)	**A pelton wheel bucket is 1m in diameter. Pressure head at nozzle when it is closed is 15 bar. The discharge when nozzle is open is 3.5 m^3/min. If speed is 600 RPM, Calculate power developed and hydraulic efficiency.**	
	Sol.	Sol^n - Given data. Diameter of bucket $D = 1\,m$ Pressure at nozzle $P = 15$ bar $= 15\times10^5\,N/m^2$ Discharge $Q = 3.5\,m^3/min = 0.058\,m^3/sec$ Turbine speed $N = 600$ rpm Power $P = ?$ $\eta_{hyd} = ?$ Let $C_v = 0.98$, $\eta_{overall} = 85\%$ (student may assume $C_v = 1$, $\eta_{overall} = 100\%$.) 1) Pressure head $H = \frac{P}{w} = \frac{15\times10^5}{9810}$ $H = 152.9\,m$ 2) velocity of jet $v = C_v \times \sqrt{2gH}$ $\therefore = 0.98 \times \sqrt{2\times9.81\times152.9}$ $v = 53.67\,m/s$	Find H,v,u 02 Mark

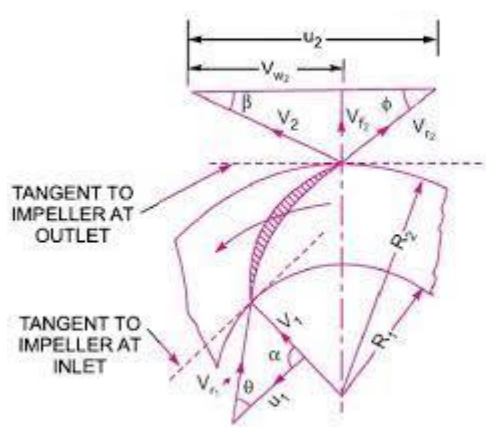
Q. No.	Sub Q. N.	Answer	Marking Scheme
		3) Tangential velocity $u = \frac{\pi D N}{60} = \frac{\pi \times 1 \times 600}{60}$ $u = 31.41\ m/s$ 4) Power developed $\eta_{overall} = \frac{P}{\omega \cdot Q H}$ $\therefore P = \eta_{overall} \times \omega \cdot Q H$ $= 0.85 \times 9810 \times 0.058 \times 152.9$ $= 73.94 \times 10^3$ Watt $P = 73.94\ KW$ 5) Hydraulic efficiency $\eta_{hyd} = \frac{2u(V-u)(1+\cos\phi)}{V^2}$ (But $\phi = 0°$) $\cos\phi = 1$, $\cos 0 = 1$ $= \frac{2 \times 31.41\ (53.67 - 31.41)(1+1)}{(53.67)^2}$ $= \frac{2796.74}{2880.46}$ $\eta_{hyd} = 0.9709$ $\%\ \eta_{hyd} = 97.09\%$	01 Mark 01 Mark
	d)	**Define the following w.r.t. centrifugal pump.** **i) Manometric head ii) Manometric efficiency**	
	Sol.	**Manometric Head :-** It is the total head that pump is required to develop. This includes all losses. This is equal to difference between pressure head at inlet & outlet of pump. $Hm = h_s + h_d + h_{fs} + h_{fd} + v^2_d/2g$ **Manometric Efficiency :-** It is define as a ratio of the manometric head to the work done by impeller per newton of flowing water. $\eta_{mano} = \frac{\text{Manometric Head}}{\text{Work done by Impeller}}$ $\eta_{mano} = \frac{H_m}{\frac{V_{w1} u_1}{g}}$	02 Mark 02 Mark

Q. No.	Sub Q. N.	Answer	Marking Scheme
		$\eta_{mano=} \dfrac{g H_m}{V_{w1} u_1}$	
	e)	**Explain the working of double acting Reciprocating pump with neat sketch.**	
	Sol.	 **Fig. Double Acting Reciprocating Pump** **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 $\theta=0^0$to $\theta=180^0$) 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. 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 $\theta=180^0$to $\theta=360^0$) 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.	02 Mark 02 Mark
Que.5		**Attempt any <u>TWO</u> of the following**	**12 Marks**
	a)	**A pitot tube was used to measure the quantity of water flowing in a pipe of 0.3 m diameter. The water was raised to a height of 0.25 m above the centerline of pipe in a vertical limb of the tube. If the mean velocity is 0.78 times the velocity at center and coefficient of pitot tube is 0.98, find the quantity of water in lit/sec. Static pressure head at centre of the pipe is 0.2m.**	

Q. No.	Sub Q. N.	Answer	Marking Scheme
	Sol.	Diameter of pipe, d = 0.3m Total head = 0.25m Static head = 0.2 Dynamic Head=0.25-0.2=0.05m/sec Mean velocity = 0.78 Central Velocity Coefficient of velocity, $C_v = 0.98$ Central Velocity = $C_v\sqrt{2gh}$=0.98$\sqrt{2X9.81X0.05}$ = **0.97 m/sec** Mean velocity = 0.78 X **0.97= 0.7566** m/sec Discharge, Q= Area of pipe X Mean velocity $Q = \frac{\pi}{4}d^2X\ Mean\ Velocity = \frac{\pi}{4}(0.3)^2\text{X}\ 0.7566 = 0.05348m^3/sec.$ Quantity of water in lit/sec=$0.05348\text{X}\ 1000 = 53.48\ lps$	01 Mark 01 Mark 01 Mark 01 Mark 01 Mark 01 Mark
	b)	**Find the maximum power that can be transmitted by a power station through a hydraulic pipe 3 Km long and 0.2m diameter. The pressure at the power station is 60 bars. Take f = 0.0075**	
	Sol.	Length of pipe, L =3km=3000m Diameter of pipe, D =0.2m Coefficient of friction, f= 0.0075 Pressure at power station, P =60bar= 60 X 10^5 N/m^2 H = $\frac{P}{w} = \frac{60\text{ X }10^5}{9810}$ = 611m h_f=$\frac{H}{3} = \frac{611}{3}$= 203.66m $h_f = \frac{4flV^2}{2gd}$=$\frac{4\ x\ 0.075\ x\ 3000V^2}{2\ x\ 9.81\ x\ 0.2}$ =229.35 V^2 203.66=229.35 V^2 , v^2 = 0.8879 V **= 0.9422m**/sec Discharge, Q=V x Area=**0.9422** x $\frac{\pi}{4}d^2$ =0.9422 x$\frac{\pi}{4}(0.2)^2 = 0.0296\text{m}^3$/sec Head available at outlet of pipe = $H - h_f$= 611-203.66 = **407.34m** Maximum power available = $\frac{\rho gQ\text{ X Head at outlet of pipe}}{1000}\ Kw$ Maximum power available = $\frac{1000\text{X }9.81\text{ X }0.0296\text{ X }407.34}{1000}$= 118.28 kw	01 Mark 01 Mark 01 Mark 01 Mark 01 Mark 01 Mark

Q. No.	Sub Q. N.	Answer	Marking Scheme
	c)	**A jet of water 80 mm diameter moving with a velocity 20 m/sec, strikes a stationary plate. Find the normal force on the palate, when i) The plate is normal to the jet ii) The angle between jet and plate is 30^0**	
	Sol.	**Case 1) Force exerted by the jet of water on stationary vertical flat plate**  V=Velocity of jet = 20m/sec d= Diameter of jet = 80mm = 0.80m a = C/S Area of jet = $\frac{\pi}{4}d^2 = \frac{\pi}{4}(0.8)^2$ = 0.5024m^2 Force exerted by the jet on stationary vertical flat plate in the direction of jet, F_x= ρ a V^2 =1000 X 0.5024 X (20^2) = 200960 N **Force exerted by the jet of water on stationary inclined flat plate**  V=Velocity of jet = 20m/sec, d= Diameter of jet = 80mm = 0.80m a = C/S Area of jet = $\frac{\pi}{4}d^2 = \frac{\pi}{4}(0.8)^2$ = 0.5024 m^2, θ = Angle between jet and plate = 30^0 Force exerted by the jet on stationary vertical flat plate in normal direction to plate, F_n=ρ a V^2 sin θ = 1000 X 0.5024 X (20^2) Sin (30) = 100480N	01 Mark 02 Mark 01 Mark 02 Mark

Que.6		**Attempt any TWO of the following**	**12 Marks**
	a)	**Explain the construction and working principle of Pelton wheel turbine with neat sketch.**	
	Sol.	 *Pelton turbine.*	02 Mark
		Construction: - i) Nozzle and flow regulating arrangement ii) Runner with Blades iii) Casing iv) Breaking Jet	
		i) Nozzle and flow regulating arrangement: -The amount of water striking the buckets (Vanes) of the runner is controlled by providing a spear in the nozzle shown in fig. The spear is conical needle which is operated either by hand wheel or automatically. When spear is pushed forward into the nozzle the amount of water striking the runner is reduced. On the other hand, if the spear is pushed back, the amount of water striking the runner increases.	01 Mark
		ii) Runner with Blades: -It consists of a circular disc on the periphery of which a number of buckets evenly spaced are fixed. The shapes of buckets are double hemispherical cup or bowl. Each bucket is divided into two symmetrical parts by dividing wall called Splitter. The buckets are so shaped that jet gets deflected through 160^0 to 170^0.	01 Mark
		iii) Casing: - The function of casing is to prevent the splashing of water and to discharge water at tail race. It also acts as safeguard against accidents. It made of cast iron or fabricated steel plates. It does not perform any hydraulic function.	01 Mark
		iv) Breaking Jet: -When the nozzle is completely closed by moving the spear in the forward direction the amount of water striking the runner reduces to zero. But the runner due to inertia goes on rotating for a long time. To stop the runner in short time, a small nozzle is provided which directs the jet of water on the back of vanes. This jet of water is called Breaking Jet.	01 Mark
		Working: -The water at inlet of Pelton wheel possesses only kinetic energy. When jet of water strikes the runner at splitter is deflects and rotates the runner. Runner is provided on the shaft which gives mechanical energy at outlet of turbine.	

Q. No.	Sub Q. N.	Answer	Marking Scheme
	b)	**A centrifugal pump is to discharge water at the rate of 110 lit/sec at the speed of 1450 rpm against head of 13m. Impeller diameter is 250 mm and its width is 50mm. If manometric efficiency is 75 %, determine=ne Vane angle at outer periphery.**	
	Sol.	Discharge Q=110 lit/sec = 0.110m^3/sec Speed N = 1450rpm Manometric head H_{mano}=13m Impeller Diameter at outlet D_2=250mm=0.250m Width at outlet B_2=50mm=0.050m Manometric Efficiency η_{Mano}= 0.75 Vane angle at outlet of periphery, ϕ Tangential velocity of impeller at outlet = $u_2 = \frac{\pi D_2 N}{60} = \frac{\pi\ x\ 0.25x\ 1450}{60} = 18.98 m/sec$ Discharge, Q = $\pi D_2 B_2$X V_{f2} $V_{f2} = \frac{Q}{\pi D_2 B_2} = \frac{0.110}{\pi x\ 0.25x\ 0.05}$3.0m/sec Manometric Efficiency $\eta_{Mano} = \frac{g\ H_{mano}}{V_{w2}\ u_2}$ $0.75 = \frac{9.81\ x\ 13}{V_{w2}\ X\ 18.98}$ $V_{w2} = 8.9589 m/sec$ From velocity triangle at outlet,  $\tan ϕ = \frac{V_{f2}}{u_2 - V_{w2}} = \frac{3.0}{18.98-8.9589} = 0.299$ ϕ =16.64^0	01 Mark 02 Mark 01 Mark 01 Mark 01 Mark

Q. No.	Sub Q. N.	Answer	Marking Scheme
	c)	**Centrifugal pump not delivering water, give at least three reasons and remedies.**	
	Sol.	1)Pump may not be properly primed: -Re prime the pump properly 2) Impeller may be clogged: - Clean the impeller 3) Total head against which pump is working may be much higher than that for which the pump is designed: - Check the head or reduce or adjust accordingly. 4) Rotation of impeller may be in wrong direction: -Change the direction of rotation. 5) Too high suction lift: - Reduce the suction lift.	Any 03 02 Mark each