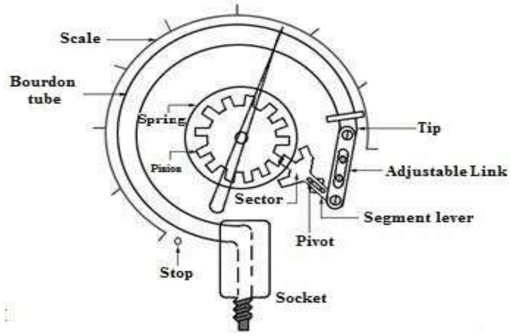
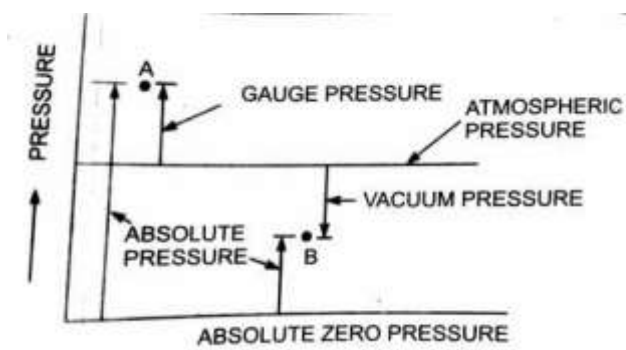
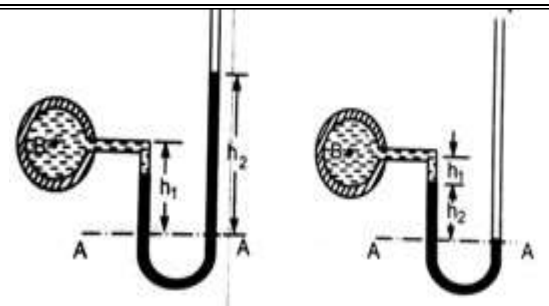
Important Instructions to examiners:

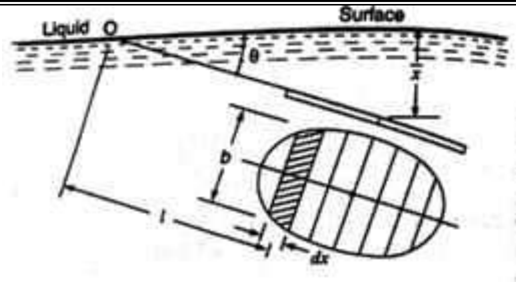
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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	Sub. **Q**	**Model Answer / Solution**	**Marks**
1	**A**	**Attempt any SIX of the following.**	**12**
	a	**Define specific gravity and specific volume.** **Specific gravity:** It is defined as the ratio of density of liquid to density of water or specific weight of liquid to specific weight of water. **Specific volume:** It is defined as the ratio of volume to unit mass.	01mark 01mark
	b	**Define fluid pressure intensity and pressure head.** **Fluid pressure intensity:** Whenever a liquid such as water, oil, etc is contained in the vessel, it exerts force at all points on the sides and bottom of container. This force per unit area is called intensity of pressure. **Pressure head:** The vertical height or free surface above any point in a liquid at rest or height of equivalent liquid column. $h = P / \rho g = P / w$	01mark 01mark
	c	**State the Bernoulli's theorem.** **Statement:** Total energy of an ideal and incompressible fluid at any point during fluid flow remains constant. Therefore, Total energy, $P/w + V^2/2g + z = \text{constant}$	02 marks
	d	**Sketch and label Bourden pressure gauge.**	02 marks

		 Bourdon Tube Pressure Gauge	
	e	**Define total pressure and centre of pressure.** **Total pressure:** Total pressure exerted by the liquid on immersed surface. **Centre of pressure:** The resultant pressure on an immersed surface will act some point below the centre of gravity of the immersed surface and towards the lower edge of the figure. The point through which this resultant pressure acts is known as Centre of pressure.	01 mark 01 mark
	f	**State any four functions of air vessels in reciprocating pump.** i. To obtain uniform discharge. ii. To maintain uniform rate of flow of liquid in suction and delivery pipes. iii. It reduces the work required to drive the pump due to reduction in accelerating heads and friction losses. iv. The pump can used at higher speeds without the fear of flow separation caused by reduced acceleration heads.	1/2mark each
	g	**Classify hydraulic turbines.** According to types of energy available at inlet of the turbine: i. Impulse turbine ii. Reaction turbine According to direction of flow through runner: i. Tangential flow turbine ii. Radial flow turbine iii. Axial flow turbine iv. Mixed flow turbine According to head available at inlet of the turbine:	02 marks

		i. Low head turbine (02 m -15 m) ii. Medium head turbine (16 m -70 m) iii. High head turbine (71m - above) According to specific speed of the turbine: i. Low specific speed ii. Medium specific speed iii. High specific speed	
	h	**Define cavitation in centrifugal pump.** The phenomenon of formation of vapour bubbles in the region of flowing liquid where its pressure falls below the vapour pressure of liquid, then the liquid will vapourises and flow will no longer will be continuous.	02 marks
	B	**Attempt any TWO of the following.**	08
	a	**Explain concept of Absolute vacuum, Gauge Pressure, Atmospheric pressure and absolute pressure with the help of diagram.**  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. Gauge pressure: - The pressure which is measured above the atmospheric pressure is called gauge pressure. Atmospheric pressure: - The pressure exerted by the atmosphere on any surface in contact is called atmospheric pressure. It decreases with increase in altitude. It can be measured by barometer. Absolute pressure: - pressure which is measured above the absolute vacuum pressure.	01 mark 03 marks
	b	**Describe the procedure of pressure measurement using simple U-tube manometer.** **Simple U-tube manometer Figure:**	02 marks

		 (a) For gauge pressure (b) For vacuum pressure It consists of a tube bent in U shape, one end of which is attached to the gauge point and the other is open to atmosphere. It connected to pipe containing a light liquid under a high pressure. The high pressure in the pipe will force heavy liquid, in the left limb of the U-tube To move downwards. This downwards movement of the heavy liquid in the left limb will cause a corresponding rise of the heavy liquid in the right limb. Negative pressure in the pipe will suck the right liquid which will pull up the heavy liquid in the left limb of the U- tube. This upward movements of the heavy liquid in the left limb will cause a corresponding fall of the liquid in the right limb.	02 marks
	c	**A pipe is used for energy transmission. Length and diameter of pipe are 80 m and 50 m respectively. Flow rate is 105 lit/s. Calculate frication loss. Neglect minor loss, Take f = 0.03.** **Solution:- Discharge = Area x Velocity** **0.105 |= $\pi/4$ xd^2x V** **0.105 = 0.7854 X 50^2X V** **V= 0.536** **Head loss hf= 4flv^2/2gd** **hf= 4x0.03x80x(0.535)/2x9.81x50** **hf= 0.28m**	01mark 01mark 01mark 01mark
	2	**Attempt any four of the following:**	
	a.	**Derive the equation for total pressure on an inclined immersed surface.** Consider a plane inclined surface, immersed in a liquid as shown in figure, let us divide the whole immersed surface into a number of small parallel strips as shown,	01 mark



03mark

Let W= Specific weight of the liquid ,

A = Area of the surface,

X = depth of c.g.

θ = angle at which the immersed surface is inclined with the liquid surface,

let us consider a strip of thickness dx, width b and at a distance l from o,

intensity of pressure on the strip = wlsin θ,

and area of the strip = bdx

so pressure on the strip p= intensity of pressure *area

= wlsin θ *bdx

Total pressure on the surface p = ∫wlsin θ*bdx = wsin θ∫lbdx,

But ∫l*bdx = moment of the surface area o = A$\bar{x}$/sin θ

∴ P = wlsin θ*A$\bar{x}$/sinθ = wA$\bar{x}$

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b. **Applying Bernoulli's equation derives the equation for discharge through a venturimeter.** **04marks**

Expression for rate of flow through venturimeter

Consider a venturimeter fitted in a horizontal pipe through which a fluid is flowing (say water), as shown

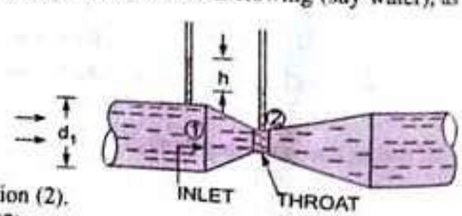
Let d_1 = diameter at inlet or at section (1),

p_1 = pressure at section (1)

v_1 = velocity of fluid at section (1),

a = area at section (1) = $\frac{\pi}{4} d_1^2$

and d_2, p_2, v_2, a_2 are corresponding values at section (2).



Venturimeter.

Applying Bernoulli's equation at sections (1) and (2), we get

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

As pipe is horizontal, hence $z_1 = z_2$

$$\therefore \quad \frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} \quad \text{or} \quad \frac{p_1 - p_2}{\rho g} = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

But $\frac{p_1 - p_2}{\rho g}$ is the difference of pressure heads at sections 1 and 2 and it is equal to h or $\frac{p_1 - p_2}{\rho g} = h$

Substituting this value of $\frac{p_1 - p_2}{\rho g}$ in the above equation, we get

$$h = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

Now applying continuity equation at sections 1 and 2

$$a_1 v_1 = a_2 v_2 \quad \text{or} \quad v_1 = \frac{a_2 v_2}{a_1}$$

Substituting this value of v_1 in equation (6.6)

$$h = \frac{v_2^2}{2g} - \frac{\left(\frac{a_2 v_2}{a_1}\right)^2}{2g} = \frac{v_2^2}{2g}\left[1 - \frac{a_2^2}{a_1^2}\right] = \frac{v_2^2}{2g}\left[\frac{a_1^2 - a_2^2}{a_1^2}\right]$$

or $$v_2^2 = 2gh \frac{a_1^2}{a_1^2 - a_2^2}$$

$\therefore$ $$v_2 = \sqrt{2gh \frac{a_1^2}{a_1^2 - a_2^2}} = \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

$\therefore$ Discharge, $$Q = a_2 v_2$$

$$= a_2 \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh} = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

Equation gives the discharge under ideal conditions and is called, theoretical discharge. Actual discharge will be less than theoretical discharge.

$\therefore$ $$Q_{act} = C_d \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

where C_d = Co-efficient of venturimeter and its value is less than 1.

c. **A jet of water 50 mm in diameter strives on a fixed plate normally with a velocity of 25 m/s. Find the force exerted on flat plate.**

Solution:- Given d= 50 mm,

V= 25 m/sec

Cross section area of the jet, **01mark**

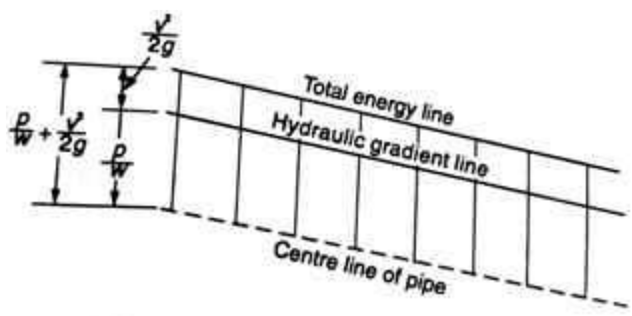
$A = \pi/4 * d^2 = \pi/4 * (0.05)^2 = 0.0019635\ m^2$ **01mark**

Force exerted on flat plate,

$F = \rho a v^2 = 1000 * 0.0019635 * (25)^2$ **01mark**

F= 1227.1875 N **01mark**

F= 1.227 KN

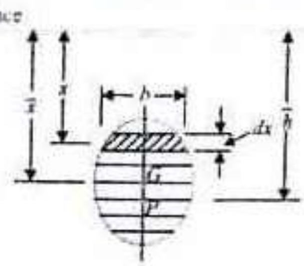
	d.	**Find the maximum power that can be transmitted by a power station through a hydraulic pipe of 3 kilometer long and 200 mm diameter. The pressure of water at the power station is 1500 kPa. Take f=0.01** **Solution:-** Given length l = 3km = 3000m, D= 200 mm pressure = 1500 kpa=1500KN/m^2 f= 0.01, Pressure head at the power station, H = P/W=1500/9.81=153M H=153M For maximum transmission of power, the loss of head due to friction hf=H/3=153/3=51m Loss of head due to friction hf=flQ^2/3d^5 51= 0.01*3000*Q^2/3*$(0.2)^5$=31250Q^2 Q= 0.04 m^3/sec Maximum power = WQ(H-hf) = 9.8*0.04*(153-51) = 40KW	01mark 01mark 01mark 01mark
	e.	**Explain with sketch hydraulic Gradiant Line and Total energy line.**  **Hydraulic Gradient Line:** If pressure head s(p/w) of a liquid flowing in a pipe be plotted as vertical ordinates on the centre line of the pipe, then the line joining the tops of such ordinates is known as hydraulic gradient line. **Total energy line:** If the sum of pressure heads & velocity heads (p/w + v^2/2g) of a liquid flowing in a pipe be plotted as vertical ordinates on the centre line of the pipe, then the joining the tops of such ordinates is known as Total energy line. The Total energy line lies over the hydraulic gradient by an amount equal to the velocity heads as shown in figure.	02marks 01mark 01mark

f. **Prove that the centre of a fully submerged uniformly thick plane lamina is always below the centre of gravity of the lamina.** **04** Marks

Solution:-

Centre of Pressure of a Vertically Immersed Surface

Consider a plane surface immersed vertically in a liquid as shown



Vertically immersed surface

First of all, let us divide the whole immersed surface into a number of small parallel strips shown in figure.

Let W=Specific weight of the liquid,

A= Area of the immersed surface, and

$\bar{x}$= Depth of centre of gravity of the immersed surfaccce from the liquid surface.

Let us consider a strip of thickness dx, widtg b and at a depth of x from the free surface of the liquid as shown in figure.

We know that, intensity of pressure on the strip, = wx

And Area of the strip, = bdx

$\therefore$ Pressure on the strip, p = Intensity of pressure * Area

= wx.bdx

Moments of this pessure about the liquid surface = (wx.bdx) = $wx^2.bdx$

Sum of moments of all such pressure $M = \int wx^2.bdx$

$= w\int x^2.bdx$

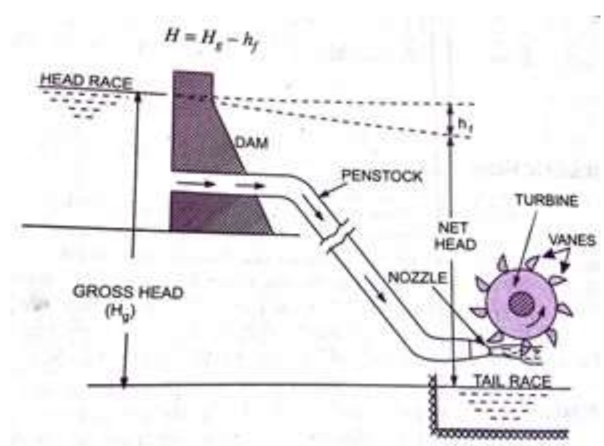
But $\int x^2.bdx = I_0$ (i.e. Moment of inertia of the surface about the liquid level or second moment of area)

$\therefore M = w.\ I_0$ ……..(i)

whererb I_0 = Moment of inertia of the surface about the liquid level.

We know that sum of moment of pressure = $P*\bar{h}$

Where P = total pressure on the surface, and ……..(ii)

		$\bar{h}$ = Depth of center of pressure from the liquid surface. Now, equating equations (i) and (ii), we get $P*\bar{h} = w. I_0$ Or $wA\bar{x}*\bar{h} = w. I_0$ ……. ($\because P = w A\bar{x}$) Or $\bar{h} = I_0 / A\bar{x}$ ……. (iii) We know that from the **Theorem of parallel Axis that $I_0 = I_G + Ah^2$ Where I_G = moment of inertia of the figure, about horizontal axis through its centre of gravity, and h= Distance between the liquid surface and the centre of gravity of the figure ($\bar{x}$ in this case) now, rearranging the equation (iii), $\bar{h} = (I_G + A\bar{x}^2) / A\bar{x}^2$ $= I_G / A\bar{x}^2 + \bar{x}$ Thus, the centre of pressure is always below the centre of gravity of the area by a distance equal to $I_G / A\bar{x}^2$	
	3	**Attempt any FOUR of the following.**	**16**
	A	**Sketch layout of hydroelectric power plant and write any four features of it.** **Answer:** Layout of hydroelectric power plant:  Features of hydroelectric power plant: i. A dam constructed across a river to store water.	02 marks for figure 02 marks

ii. Pipes of large diameters called penstock, which carry water under pressure from the storage reservoir to the turbines. These pipes are made of steel or reinforced concrete.

iii. Turbines having different types of vanes fitted to the wheels.

iv. Tail race, which is a channel which carries water away from the turbines after the water has worked on the turbines.

(for features)

b **A Pelton wheel develops 2000kw under a head of 100meters and with an overall efficiency of 85%. Find the diameter of the nozzle if the co-efficient of velocity for the nozzle is 0.98.**

Solution:-

Given data :

$P = 2000\ kW;\ H = 100\ m;\ \eta_o = 85\% = 0.85$

$C_v = 0.98$

d = diameter of the nozzle

Q = discharge of the turbine

Velocity of jet,

$V = C_v\sqrt{2gH} = 0.98 \times \sqrt{2 \times 9.81 \times 100}$

$V = 43.4\ m/s$ — 01mark

Overall efficiency (η_o),

$\eta_o = \frac{P}{wQH} = \frac{2000}{9.81 \times Q \times 100} = \frac{2.04}{Q}$ — 01mark

$0.85 = \frac{2.04}{Q}$

$\therefore Q = \frac{2.04}{0.85} = 2.4$

$\therefore Q = 2.4\ m^3/s$ — 01mark

Total discharge of the wheel should be equal to the discharge through the jet i.e.,

$Q = AV = \frac{\pi}{4} d^2 \times 43.4$

$2.4 = \frac{\pi}{4} d^2 \times 43.4$

$d^2 = \frac{2.4 \times 4}{\pi \times 43.4}$

$d = \sqrt{0.0704}$

$d = 0.265\ m$ — 01mark

$\therefore d = 265\ mm$

$\therefore$ Diameter of the nozzle is 265 mm.

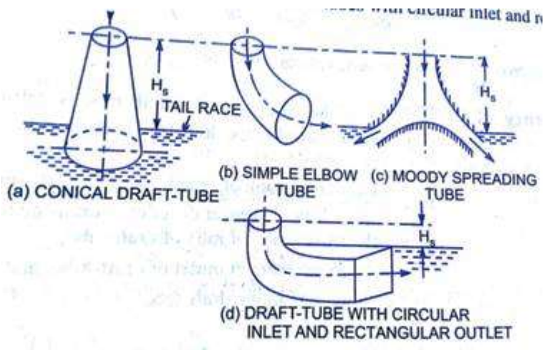
c **State any two functions of Draft tube. Explain the types of Draft tube. (Any two)**

Functions of Draft tube:

1. It enables the turbine to be placed above the tail race, so that the turbine may be inspected property.
2. to convert the kinetic energy (v12) of the water, exhausted by the runner into pressure energy tube.

01 mark

Types of Draft tube:



03 marks for explanation (any two)

a) Conical draft tubes

b) Simple Elbow draft tubes

c) Moody spreading tube

d) Draft tube with circular inlet and rectangular outlet

Explanation:-

a) In a Conical type, the diameter of the tube gradually increases from the outlet of the runner to the channel. These are commonly used in Francis turbine.

b) In elbow type, the bend of the draft tube is generally increases from the outlet of the runner to the channel.

c) Moody spreading tube is best suited for inward and outward flow turbines, having helical flow which is due to velocity of whirl at outlet of the runner.

d) Draft tube with circular inlet and rectangular outlet is used in Kaplan turbine. Efficiency of elbow draft tube is as large as 60%-70%.

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d **A jet of water of diameter 7.5 cm moving with a velocity of 25 m/s strikes a fixed plate in such a way that the angle between the jet and plane is 600. Find the force exerted by the jet on the plate,**

i. In the direction normal to the plane. (ii) In the direction of the jet.

i) The force exerted by the jet of water in the direction normal to plate is given by :-

$$F_n = \rho a v^2 \sin\theta$$

$$= 1000 \times 0.004417 \times 25^2 \times \sin 60^\circ$$

$$\boxed{F_n = 2390.7\ N}$$

02 Marks

ii) The force exerted in the direction of the jet is given by :-

$$F_x = \rho a v^2 \sin^2\theta$$

$$= 1000 \times 0.004417 \times 25^2 \times \sin^2 60^\circ$$

$$\boxed{F_x = 2070.4}\ N$$

02 Marks

e **Define:**

I. **Viscosity:** **Viscosity** is defined as the property of a fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid. — 02 Marks

SI unit of viscosity: Ns/m^2

II. **Kinematic Viscosity: Kinematic Viscosity** is defined as the ratio between the dynamic viscosity and density of fluid. Mathematically, — 02 Marks

ν = viscosity/ density

$\nu = \mu \div \rho$

f. **The discharge through an horizontal trapping is 0.06 m^3/s. the diameter at the inlet and outlet are 250 mm and 200 mm respectively. If the water enters the pipe at a pressure of 9.81bar, calculate the outlet pressure.**

Solution :-

Givendata:-

Discharge $= Q = 0.06\ m^3/s$

Diameter at inlet $d_1 = 250\ mm = 0.25\ m$

Diameter at outlet $d_2 = 200\ mm = 0.20\ m$

Pressure at entry (inlet) $P_1 = 9.81$ bar

Pressure at outlet $P_2 = ?$

Area at inlet $= a_1 = \frac{\pi}{4}(0.25)^2 = 0.049\ m^2$

Area at outlet $= a_2 = \frac{\pi}{4}(0.2)^2 = 0.031\ m^2$

Let the datum line passes through the centre of the lower end. Then

$$\boxed{Z_1 = Z_2}$$

By using Continuity equation, — 01mark

$Q = a_1 v_1 = a_2 v_2$

$\therefore v_1 = \frac{Q}{a_1} = \frac{0.06}{0.049} = 1.22\ m/s$

$v_2 = \frac{Q}{a_2} = \frac{0.06}{0.031} = 1.93\ m/s$ — 01mark

Applying Bernoulli's eq^n at section ① & ②.

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2$$ — 01mark

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

$$P_2 = P_1 + \frac{v_1^2}{2g} - \frac{v_2^2}{2g}$$

$$= 9.81 + \frac{(1.22)^2}{2\times 9.81} - \frac{(1.93)^2}{2\times 9.81}$$

$$\boxed{P_2 = 9.696\ bar}$$ — Pressure at outlet. — 01mark

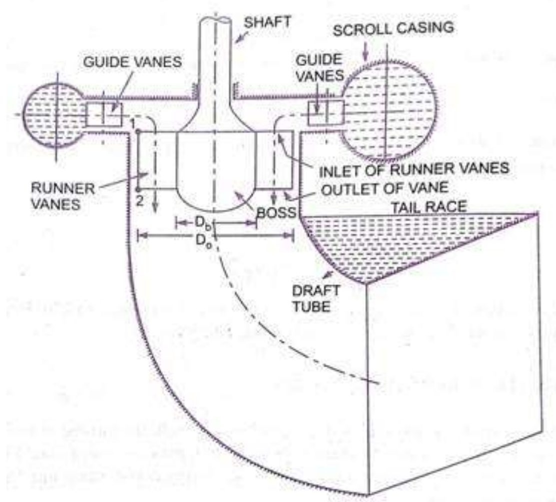
4 **Attempt any TWO of the following.**

a. **With labeled sketch explain the working of Kaplan turbine.**

Answer:

Diagram of Kaplan turbine:

04 marks for figure



Working of Kaplan turbine:

i. It consists of hub fixed to the shaft. On the hub the adjustable vanes are fixed.

ii. The water from penstock enters the scroll casing and then moves to the guide vanes.

iii. From the guide vanes, the water turns through 90^0 and flows axially through the runner as shown in figure.

iv. This turbine is suitable where a large quantity of water at low head available.

04 marks for working

b. **A centrifugal pump is to discharge 0.13 m^3/s at a speed of 1200 rpm against a total head of 20 meter. The impeller diameter is 250 mm, its with at outlet is 40mm and manometric efficiency is 75%. Determine the vane angle at the outer periphery of the impeller.**

Solution:-

Tangential velocity of impeller at outlet u_2.

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.25 \times 1200}{60} = 15.71 \text{ m/s}$$

Discharge. $\therefore Q = \pi D_2 B_2 \times V_{f2}$

$$V_{f2} = \frac{Q}{\pi D_2 B_2} = \frac{0.13}{\pi \times 0.25 \times 0.04} = 4.14 \text{ m/s}$$

Manometric efficiency

$$\eta_{mano} = \frac{g H_{mano}}{V_{w2} \cdot u_2}$$

$$V_{w2} = \frac{g H_{mano}}{\eta_{mano} \times u_2} = \frac{9.81 \times 20}{0.75 \times 15.71}$$

$$\boxed{V_{w2} = 16.65 \text{ m/s}}$$

From velocity triangle at outlet;

$$\tan\phi = \frac{V_{f2}}{u_2 - V_{w2}} = \frac{4.14}{15.71 - 16.65}$$

$$\phi = \tan^{-1}\left(\frac{4.14}{15.71 - 16.65}\right)$$

$$\boxed{\phi = -77.21^\circ}$$

Vane angle at outlet $\phi = -77.21^\circ$.

c. **Define in connection with centrifugal pump:**

- **i. Manometric Efficiency**
- **ii. Mechanical Efficiency**
- **iii. Overall efficiency**
- **iv. Net positive suction head.**

Answer:

i. Manometric Efficiency:

The ratio of the manometric head to the head imparted by the impeller to the water is known as manometric efficiency. Mathematically it is written as, — 02 marks

η_{man} = manometric head / head imparted by impeller to water.

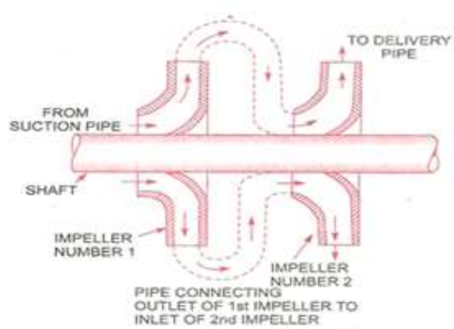
ii. Mechanical Efficiency:

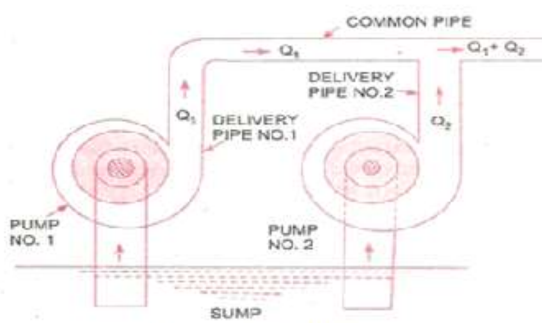
The ratio of the power available at the impeller to the power at the shaft of the centrifugal pump is known as mechanical efficiency. Mathematically it is written as,

η_m = power at the impeller / power at the shaft — 02 marks

iii. Overall efficiency: — 02 marks

It is defined as ratio of power output of the pump to the power input to the pump. The power output of the pump in KW. Mathematically it is written as,

<table>
<tr><td></td><td></td><td>$\eta_O = \eta_{man} * \eta_m$
iv. Net positive suction head:
The net positive suction head (NPSH) is defined as the absolute pressure head at the inlet to the pump minus the vapor pressure head(in absolute head) plus the velocity head.</td><td>02 marks</td></tr>
<tr><td>Q.5</td><td></td><td>Attempt any FOUR of the following</td><td>16</td></tr>
<tr><td></td><td>a)</td><td>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, the numbers of impellers are mounted in series or on the same shaft.
ii) Multistage centrifugal pump for High Discharge (Pumps are in Parallel) :-To obtain high discharge pumps should be connected in parallel .


Two-stage Pumps with Impellers in Series


Pumps in Parallel</td><td>1M
1M
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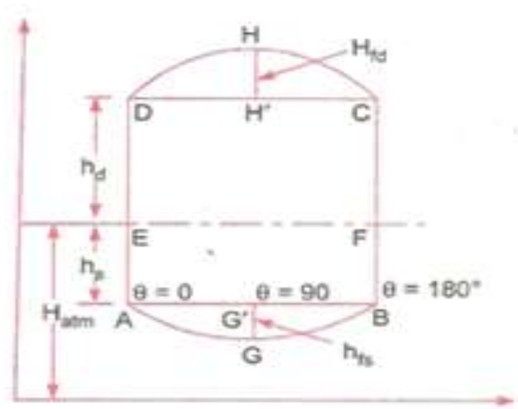
<tr><td></td><td>b)</td><td>

A-G-B=Suction stroke ,C-H-D=Delivery Stroke,
H_{atm}=Atmospheric pressure head,h_s=Suction Head,h_d=Delivery Head
<table><tr><th>Stroke</th><th>Crank</th><th></th><th>Friction Head</th><th>Total Head</th></tr></table></td><td>3M</td></tr>
</table>

	Angle				
Suction Stroke	θ= 0^0	sin θ= 0	$h_{fs} = 0.$	h_s	1M
	θ= 90^0	sin θ= 1	$h_{fs} = +ve$	$h_s + h_{fs}$	
	θ= 180^0	sin θ= 0	$h_{fs} = 0.$	h_s	
Delivery Stroke	θ= 0^0	sin θ= 0	$h_{fd} = 0.$	h_d	
	θ= 90^0	sin θ= 1	$h_{fd} = +ve$	$h_d + h_{fd}$	
	θ= 180^0	sin θ= 0	$h_{fd} = 0.$	h_d	

c) **Cavitation:-**The phenomenon in which the vapour bubbles are formed when vapour pressure of liquid (Water) falls below atmospheric pressure. The subsequent collapsing of vapour bubbles in high pressure region of centrifugal pump creates high stresses on metallic body of impeller, casing this produces cavities on such surfaces. Cavitation reduces efficiency of pumps. 2M

Prevention Methods:-

i) The design of pump should be such that the pressure of flowing liquid in any part of turbine should not be allowed to fall below vapour pressure of liquid. 2M

ii) The special materials or coatings such as aluminum, bronze and stainless steel should be used as a cavitation resistant.

d) **Chezy's formula**

$$V = C\sqrt{mi}$$ 2M

Where; V = velocity of water in pipe, m = hydraulic mean depth =A/P = d/4

i = $\frac{h_f}{L}$ = loss of head per unit length, C =Chezy's constant 2M

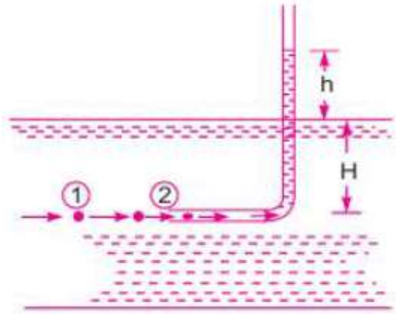
e) **Use:-**It is a device used for measuring velocity of flow at any point in a pipe or channel. 1M (Use)

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. 1M (Prin)

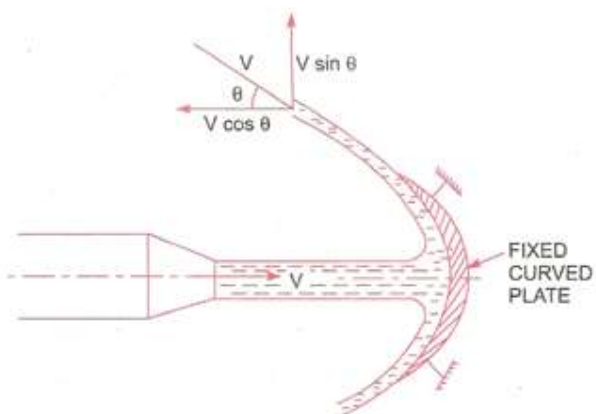
It is the glass tube with lower end of tube bent at 90^0 is directed in upstream direction. The liquid rises up in the tube due to conversion of kinetic energy into pressure energy.

$$V = C_v\sqrt{2gh}$$ 1M (Eqn)

V= velocity of flow, C_v= Coefficient of velocity, h= Dynamic Pressure head

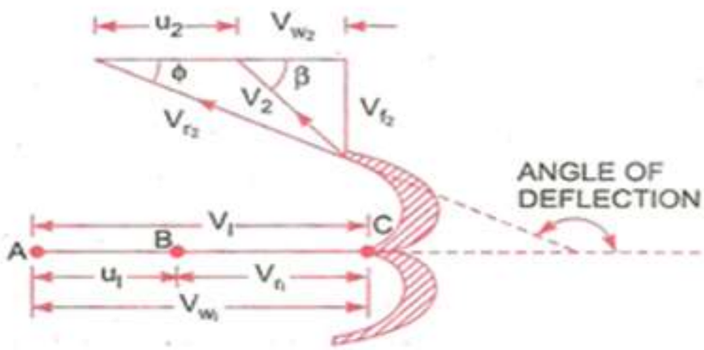
<table>
<tr><td></td><td></td><td>
</td><td>1M
(Dig)</td></tr>
<tr><td></td><td>f)</td><td>**Loss of Energy of fluid in pipes**: When fluid is flowing through a pipe, the fluid experiences some resistance to flow due to which some of energy of fluid is lost called Loss of Energy of fluid in pipes

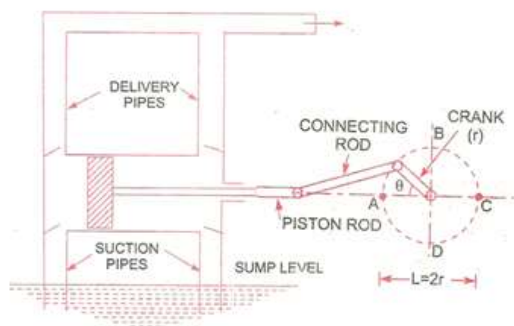
<table>
<tr><th colspan="2">Energy Losses</th></tr>
<tr><th>Major Energy Losses
(Frictional Losses)</th><th>Minor Energy Losses</th></tr>
<tr><td>Are calculated by
i) Darcy's Weisbach equation
ii) Chezy's equation</td><td>i)Loss due to sudden expansion in pipe
ii)Loss due to sudden contraction in pipe
iii)Loss due to bend in pipe
iv)Loss due to fittings in pipe
v)Loss due to obstruction in pipe</td></tr>
</table></td><td>1M
3M</td></tr>
<tr><td>Q6</td><td></td><td>Attempt any TWO of the following</td><td>16</td></tr>
<tr><td></td><td>a)</td><td>**i) Force exerted by the jet of water on stationary Curved plate**



Let,V=Velocity of jet,d= Diameter of jet, a = C/S Area of jet = $\frac{\pi}{4}r^2$</td><td>4M</td></tr>
</table>

		Component of velocity in the direction of jet = - $V \cos\theta$ Component of velocity perpendicular to the jet = $V \sin\theta$ Force exerted by the jet on stationary curved plate in the direction of jet, F_x= Rate of change of momentum in the direction of force $$F_x = \frac{\text{Initial Momentum} - \text{Final Momentum}}{\text{Time}}$$ $$F_x = \frac{(\text{Mass x Initial Velocity} - \text{Mass x Final Velocity})}{\text{Time}}$$ $$F_x = \frac{\text{Mass}}{\text{Time}}(\text{Initial Velocity} - \text{Final Velocity})$$ F_x= (Mass/Sec) x (Velocity just before striking- Velocity just after striking) $$F_x = \rho\ a\ V\ [V - (-V\cos\theta)]$$ $$F_x = \rho\ a\ V\ [V + V\cos\theta]$$ $$F_x = \rho\ a\ V^2\ [1 + \cos\theta]$$ Force exerted by the jet on stationary curved plate in perpendicular direction of jet, F_y= (Mass/Sec) x (Velocity just before striking- Velocity just after striking) $$F_y = \rho\ a\ V\ [0 - V\sin\theta]$$ $$F_y = -\rho\ a\ V^2 \sin\theta$$ **ii)Velocity Triangles of Pelton Wheel** u_1= Plate Velocity at inlet, u_2= Plate Velocity at outlet V_1= Absolute Velocity of jet at inlet, V_2= Absolute Velocity of jet at outlet V_{r1}= Relative Velocity of jet and plate at inlet V_{r2}= Relative Velocity of jet and plate at outlet V_{w1}= Whirl Velocity of jet at inlet, V_{w2}= Whirl Velocity of jet at outlet θ= Vane angle at inlet, ϕ= Vane angle at outlet α=Guide blade angle at inlet, β =Guide blade angle at inlet	2M (Terms)

			2M (Tri..)
	b)	Given Data d_1=160mm= 0.16m,d_2= 0.08m= 8cm,Q=50lps= 0.05m^3/sec,C_d=1,S_{oil}=0.8 a_1 =Area of pipe = $\frac{\pi}{4}d_1^2$ = $\frac{\pi}{4}(0.16)^2$ = 0.0201m^2 a_2 =Area of throat = $\frac{\pi}{4}d_2^2$ = $\frac{\pi}{4}(0.08)^2$ = 0.005026m^2 We know that, $Q = \frac{C_d a_1 a_2\sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ $0.05 = \frac{1x\ 0.0201x0.005026\sqrt{2\ x\ 9.81\ h}}{\sqrt{0.0201^2 - 0.005026^2}}$ $\sqrt{h}$ = 2.17 h = 1.4730 m of Oil h=$x[\frac{S_h}{S_o} - 1]$ $S_h = Specific\ gravity\ of\ water = 13.6$ $S_o = Specific\ gravity\ of\ oil = 0.8$ X = Reading of manometer 1.4730 =$x[\frac{13.6}{0.8} - 1]$ x = 0.0920625 m = 92.0625mm	 1M 1M 1M 2M 1M 2M
	c)	**Slip of Reciprocating Pump:-**Slip of a pump is defined as the difference between theoretical discharge and actual discharge of a pump. Slip = Q_{th}-Q_{act} Negative Slip of Reciprocating Pump: - If actual discharge of a pump is greater than theoretical	1M

		discharge then the slip become negative.	1M
		Double Acting Reciprocating Pump -Following are the Main Parts	
		i) A cylinder with piston, piston rod, connecting rod and a crank	
		ii) Two Suction Pipes iii) Two Delivery Pipes	
		iv) Two Suction Valves v) Two Delivery Valves	
			3M (Dig + labeled)
		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.	3M (Work..)
		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.	