Apr .25

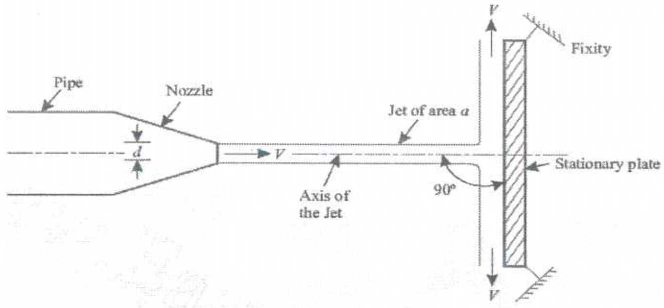
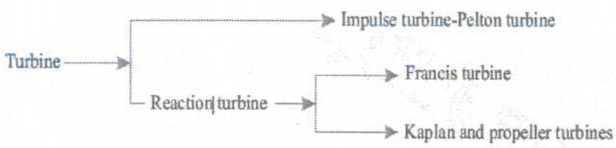
P6

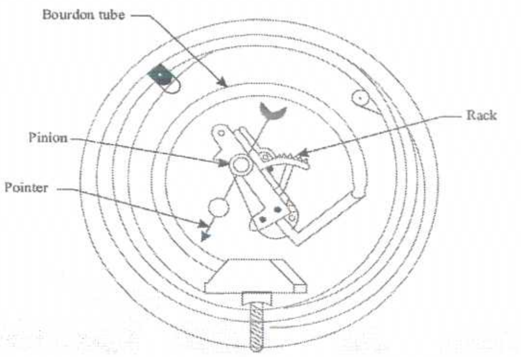
VERSION-A

SCORING INDICATORS

Course Name: **FLUID MECHANICS & HYDRAULIC MACHINES**
Course Code: **4022**
QID: 2103230214

Q.No	Scoring Indicators	Split score	Sub Total	Total Score
	Part A			9
I.1	N. s/m^2	1	1	
I.2	Newtonian Fluids	1	1	
I.3	Laminar flow	1	1	
I.4	Rate of Flow	1	1	
I.5	Hydraulic Turbines	1	1	
I.6	Pelton wheel turbine	1	1	
I.7	Hydraulic Efficiency	1	1	
I.8	Slip	1	1	
I.9	Suction head	1	1	
	Part B			24
II.1	**Dynamic Viscosity** is defined as the property of a fluid which offers resistance to the movement of one layer of fluid over another adjuscent layer of the same fluid Unit of Dynamic Viscosity is **N. s/m2 (SI Unit)** **Kinematic viscosity** is defined as the ratio between the dynamic viscosity and density of fluid. Unit of Dynamic Viscosity is **m^2/sec (SI Unit)**	1 1/2 1 1/2	3	
II.2	**Gauge pressure:** It is the pressure measured with the help of pressure measuring instrument, in which the atmospheric pressure is taken as datum. The atmospheric pressure on the scale is marked as zero. **Vacuum pressure:** Vacuum pressure is defined as the pressure below the atmospheric pressure **Absolute pressure:** Any pressure measured above the absolute zero of pressure is termed as an 'absolute pressure'	3 X 1	3	
II.3	The intensity of pressure at any point in a liquid at rest, is the same in all directions OR At any point in a fluid at rest the intensity of pressure is exerted equally in all directions,	3	3	
II.4	1. The fluid is ideal (Viscosity is zero) 2. The flow is steady 3. The flow is incompressible (Any three)	3 X 1	3	

II.5	The continuity equation based on the principle of conservation of mass is stated as follows: "If no fluid is added or removed from the pipe in any length then the mass passing across different sections shall be same". ρ1A1V1 = ρ2A2V2 ...in case of compressible fluids A1V1 = A2V2 ...in case of incompressible fluids.	2 1	3	
II.6	The force exerted by the jet on the plate (assuming it smooth) in the direction of jet (X-direction), Fx = Rate of change of momentum (in the direction of force) = (Initial momentum – final momentum) = (Mass/sec) × [velocity of jet before striking the plate – velocity of jet after striking the plate] = $\rho aV(V-0) = \rho aV^2$ 	2 1	3	
II.7		3	3	
II.8	The draft tube serves the following two purposes : 1. It allows the turbine to be set above tail-water level, without loss of head, to facilitate inspection and maintenance. 2. It regains, by diffuse action, the major portion of the kinetic energy delivered to it from the runner.	1.5 x 2	3	
II.9	1. The cost of a centrifugal pump is less as it has fewer parts. 2. Installation and maintenance are easier and cheaper. 3. Its discharging capacity is much greater than that of a reciprocating pump. 4. It is compact and has smaller size and weight for the same capacity and energy transfer. 5. Its performance characteristics are superior. 6. It can be employed for lifting highly viscous liquid such as paper pulp, muddy and sewage water, oil, sugar molasses etc 7. It can be operated at very high speeds without any danger of separation and cavitation. 8. It can be directly coupled to an electric motor or an oil engine. 9. The torque on the power source is uniform, the output fron the pump is also uniform.	Any three	3	
II.10	Hydraulic ram is device with which small quantities of water can be pumped to higher levels from the available large quantity of water of low head. It works on the principle of water hammer. Working. It works on the principle of 'water hammer'. When a flowing liquid is suddenly brought to rest, the change in momentum of liquid mass causes a sudden rise in pressure. This rise in pressure is utilised to raise a portion of the liquid to higher levels.	3	3	

	Part C			42
III.1	Bourdon tube pressure gauge is used for measuring high as well as low pressures. The pressure element consists of a metal tube of approximately elliptical cross-section. This tube is bent in the form of a segment of a circle and responds to pressure changes. When one end of the tube which is attached to the gauge case, is connected to the source of pressure, the internal pressure causes the tube to expand, whereby circumferential stress is set up. The free end of the tube moves and is in turn connected by suitable levers to a rack, which engages with a small pinion mounted on the same spindle as the pointer. Thus the pressure applied to the tube causes the rack and pinion to move. The pressure is indicated by the pointer over a dial which can be graduated in a suitable scale. 	7 Marks	7	
III.2	(a) Simple manometers: (i) Piezometer (ii) U-tube manometer (iii) Single column manometer. (b) Differential manometers. (i) U-tube differential manometer. (ii) Inverted U-tube differential manometer. Explanation -5 Marks	2 + 5	7	
III.3	Statement - 2 Marks Proof - 5 Marks	2 + 5	7	
III.4	**Co-efficient of Contraction (Cc)** The ratio of the area of the jet at vena-contracta to the area of the orifice is known as Co-efficient of contraction. It is denoted by Cc. Let, a_c = Area of jet at vena contracta, and a = Area of orifice. Then, Cc = a_c/a **Co-efficient of Velocity (Cv)** The ratio of actual velocity (V) of the jet at vena-contracta to the theoretical velocity (Vth) is known as Co-efficient of velocity. It is denoted by Cv and mathematically, Cv is given as: Cv = Actual velocity of jet at vena contracta/ Theoretical velocity **Co-efficient of Discharge (Cd)** The ratio of actual discharge (Q) through an arifice to the theorerical discharge,(Qth) is known as Co-efficient of discharge. It is dinoted by Cd. Mathematically, Cd = Actual discharge / Theoretical discharge Cd = Cc × Cv	2 2 2 1	7	

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<tr>
<td>III.5</td>
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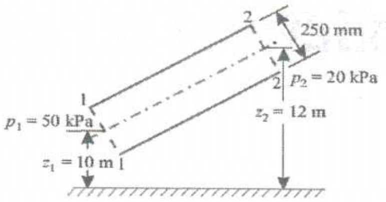

Given:
$D = 250 \text{ mm} = 0.25 \text{ m}.$
$p_1 = 50 \text{ kPa} = 50 \times 10^3 \text{ N/m}^2;$
$z_1 = 10 \text{ m}; z_2 = 12 \text{ m};$
$p_2 = 20 \text{ kPa} = 20 \times 10^3 \text{ N/m}^2,$
$V_1 = V_2 = 1.25 \text{ m/s}, \rho = 998 \text{ kg/m}^3.$
Refer to Fig. 6.15.
Loss of head h_L:
Total energy at section 1–1,
$$E_1 = \frac{p_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{50 \times 10^3}{998 \times 9.81} + \frac{1.25^2}{2 \times 9.81} + 10 = 15.187 \text{ m}$$
Total energy of section 2–2,
$$E_2 = \frac{p_2}{w} + \frac{V_2^2}{2g} + z_2 = \frac{20 \times 10^3}{998 \times 9.81} + \frac{1.25^2}{2 \times 9.81} + 12 = 14.122 \text{ m}$$
∴ Loss of head, $h_L = E_1 - E_2 = 15.187 - 14.122 = \mathbf{1.065 \text{ m}}$
Direction of flow:
Since $E_1 > E_2$ direction of flow is from section 1-1 to section 2-2.
</td>
<td>Given Data - 1

Calculaton of loss of head - 4

Calculation of direction of flow - 2</td>
<td>7</td>
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<td>III.6</td>
<td>
Inlet diameter of venturimeter, $D_1 = 200 \text{ mm} = 0.2 \text{ m}$
∴ Area at inlet, $A_1 = \frac{\pi}{4} \times 0.2^2 = 0.0314 \text{ m}^2$
Throat diameter, $D_2 = 100 \text{ mm} = 0.1 \text{ m}$
∴ Area of throat, $A_2 = \frac{\pi}{4} \times 0.1^2 = 0.00785 \text{ m}^2$
Reading of differential manometer, $y = 180 \text{ mm } (= 0.18 \text{ m})$ of mercury
Co-efficient of discharge, $C_d = 0.98$
Rate of flow, Q:
To find difference of pressure head (h) using the relation,
$$h = \left[\frac{S_{hl}}{S_p} - 1\right], \text{ we have:}$$
where, S_{hl} = Sp.gr. of mercury (heavy liquid) = 13.6, and
S_p = Sp. gr. of liquid through the pipe i.e., water = 1
$$h = 0.18\left[\frac{13.6}{1} - 1\right] = 2.268 \text{ m}$$
To find Q, using the relation,
$$Q = Cd \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}, \text{ we get:}$$
$$Q = 0.98 \times \frac{0.0314 \times 0.00785}{\sqrt{(0.0314)^2 - (0.00785)^2}} \times \sqrt{2 \times 9.81 \times 2.268}$$
or $Q = \frac{0.000241}{0.0304} \times 6.67 = \mathbf{0.0528 \text{ m}^3\text{/s (Ans.)}}$
</td>
<td>Area at inlet - 1 Marks

Area at throat - 1 Marks

Difference of Pressure head - 2 Marks

Rate of flow - 3 Marks</td>
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<td>III.7</td>
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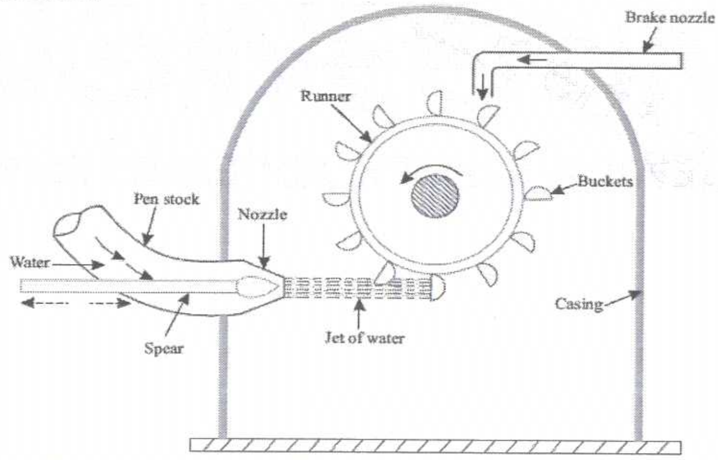
A Pelton wheel/turbine consists of a rotor, at the periphery of which are mounted equally spaced double hemispherical or double ellipsoidal buckets. Water is transferred from a high head source through penstock which is fitted with a nozzle, through which the water flows out at a high speed jet. A needle spear moving inside the nozzle controls the water flow through the nozzle and the same time, provides a smooth flow with negligible energy loss. All the available potential energy is thus converted into kinetic energy before the jet strikes the buckets of the runner. The pressure all over the wheel is constant and equal to atmosphere, so that energy transfer occurs due to purely impulse action.


</td>
<td>Figure - 3 Marks

Explanation - 4 Marks</td>
<td>7</td>
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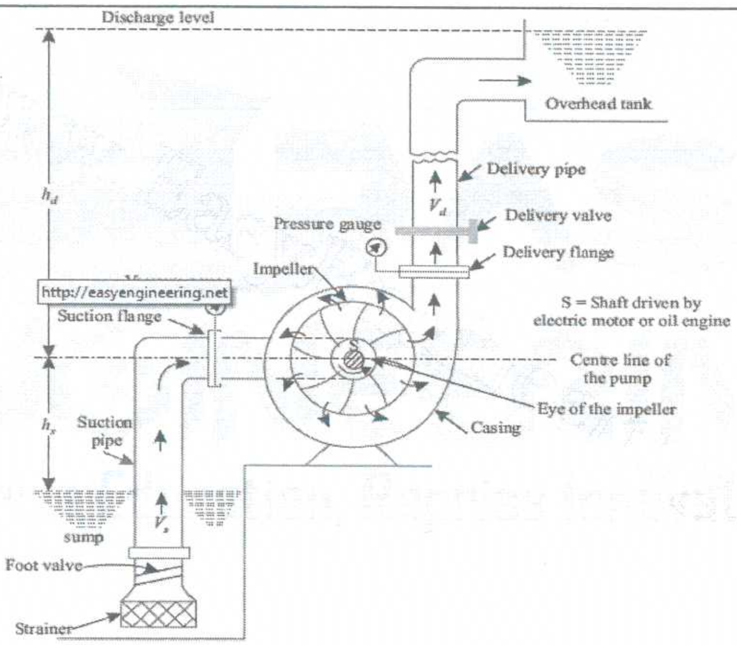
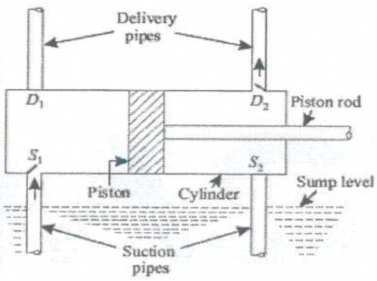
III.8	The formation, growth, and collapse of vapour filled cavities or bubbles in a flowing liquid due to local fall in fluid pressure is called cavitation. When the pressure at any point in a flow field equals the vapour pressure of the liquid at that temperature vapour cavities (bubbles of vapour) begin to appear. It is presumed that a vapour cavity is formed around a dust nuclei which is in the liquid . The cavities thus formed, due to motion of liquid, are carried to high pressure regions where the vapour condenses and they suddenly collapse. The adjoining liquid rushes with a very great velocity to occupy the empty spaces thus created, causes series of violent, irregular, spherical shock waves. When these irregular implosions occur on the metallic surface, they produce noise and vibration. In reaction turbines the cavitation may occur at the runner exit or the draft tube inlet where the pressure is negative. The hydraulic machinery is affected by the cavitation in the following three ways : 1. Roughening of the surface takes place due to loss of material caused by pitting. 2. Vibration of parts is caused due to irregular collapse of cavities. 3. The actual volume of liquid flowing through the machine is reduced causing sudden drop in output and efficiency.	4+3	7	
III.9	Velocity of the jet, $V = 35$ m/s Inclination of the plate with the jet axis, $\theta = 30°$ Area of the jet, $a = 25\ cm^2 = 25 \times 10^{-4} m^2$ (*i*) **The force exerted by the jet, F :** $F = \rho a V^2 \sin\theta$ $= 1000 \times (25 \times 10^{-4}) \times 35^2 \times \sin 30° =$ **1531.25 N (Ans.)** (*ii*) **The components of the force, F :** $F_x = F \sin\theta = 1531.25 \times \sin 30° =$ **765.625 N (Ans.)** $F_y = F \cos\theta = 1531.25 \times \cos 30° =$ **1326.1 N (Ans.)** (*iii*) **The ratio in which the discharge gets divided :** $\frac{Q_1}{Q_2} = \frac{1+\cos\theta}{1-\cos\theta}$ or $\frac{Q_1}{Q_2} = \frac{1+\cos 30°}{1-\cos 30°} = \frac{1+0.866}{1-0.866} =$ **13.925 (Ans.)**	1 + 4 + 2	7	
III.10	Speed of the wheel, $N = 300$ r.p.m. Diameter of jet, $d = 200$ mm $= 0.2$ m Net head, $H = 510$ m Angle of deflection of jet = 165° Reduction of relative velocity due to friction = 15% Mechanical losses = 3% Co-efficient of velocity, $C_v = 0.98$ Speed ratio, $K_u = 0.46$. (*i*) **Water power :** Velocity of jet, $V_1 = C_v\sqrt{2gH} = 0.98\sqrt{2 \times 9.81 \times 510} = 98$ m/s ∴ Discharge through the Pelton wheel. Q = Area of jet (a) × velocity (V_1) $= \frac{\pi}{4} \times (0.2)^2 \times 98 = 3.078\ m^3/s$ Water power $= wQH = 9.81 \times 3.078 \times 510$ kW = **15399.5 kW (Ans.)**	2 + 2 + 3	7	

III.11	 A centrifugal pump works on the principle that when a certain mass of fluid is rotated by an external source, it is thrown away from the central axis of rotation and a centrifugal head is impressed which enables it to rise to a higher level. The working /operation of a centrifugal pump is explained step-wise below: 1. The delivery valve is closed and the pump is primed that is, suction pipe, casing and portion of the delivery pipe upto the delivery valve are completely filled with the liquid (to be pumped) so that no air pocket is left. 2. Keeping the delivery valve still closed the electric motor is started to rotate the impeller. The rotation of the impeller causes strong suction or vaccum just at the eye of the casing. 3. The speed of the impeller is gradually increased till the impeller rotates at its normal speed and develops normal energy required for pumping the liquid. 4. After the impeller attains the normal speed the delivery valve is opened when the liquid is continuously sucked (from sump well) up the suction pipe, it passes through the eye of casing and enters the impeller at its centre or it enters the impeller vanes at their inlet tips. This liquid is impelled out by the rotating vanes and it comes out at the outlet tips of the vanes into the casing. Due to impeller action the pressure head as well as velocity heads of the liquid are increased. 5. From casing, the liquid passes into pipe and is lifted to the required height (and discharged from the outlet or upper end of the delivery pipe). 6. So long as motion is given to the impeller and there is supply of liquid to be lifted the process of lifting the liquid to the required height remains continuous. 7. When pump is to be stopped the delivery valve should be first closed, otherwise there may be some backflow from the reservoir	Figure - 3 Explanation - 4 Marks	7	
III.12	In a double-acting reciprocating pump, suction and delivery *strokes occur simultaneously*. When the crank rotates from *I.D.C.* in the clockwise direction, a vacuum is created on the left side of piston and the liquid is sucked in from the sump through value S_1. At the same time, the liquid on the right side of the piston is pressed and a high pressure causes the delivery valve D_2 to open and the liquid is passed on to the discharge tank. This operation continues till the crank reaches *O.D.C.*  With further rotation of the crank, the liquid is sucked in from the sump through the suction valve S_2 and is delivered to the discharge tank through the delivery valve D_1. When the crank reaches *I.D.C.*, the piston is in the extreme left position. Thus one cycle is completed and as the crank further rotates, cycles are repeated.	Figure - 3 Marks Explanation - 4 Marks	7	