

220

VERSION-A

April-24  
Page No - 8

## SCORING INDICATORS

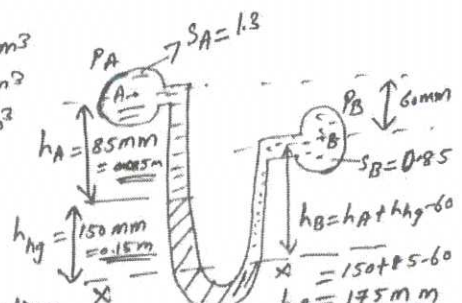
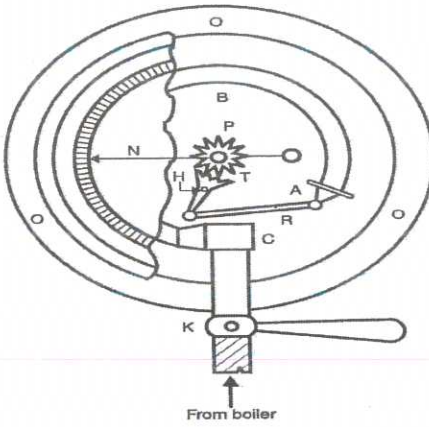
Course Name: Fluid Mechanics & Hydraulic Machines  
Course Code: 4022

QID: 2103230215

| Q.No | Scoring Indicators  | Split score | Sub Total | Total Score |
|------|---|-------------|-----------|-------------|
|      | Part A  |             |           | 9           |
| I.1  | Viscosity   | 1           | 1         |             |
| I.2  | Atmospheric Pressure  | 1           | 1         |             |
| I.3  | Simple manometer, Differential Manometer  | 0.5X2       | 1         |             |
| I.4  | Rate of flow or Discharge   | 1           | 1         |             |
| I.5  | Venturimeter, Orifice meter, Pitot Tube<br>Any 2 , each carries a half mark   | 0.5X2       | 1         |             |
| I.6  | Draft tube  | 1           | 1         |             |
| I.7  | Impulse turbine   | 1           | 1         |             |
| I.8  | Cavitation  | 1           | 1         |             |
| I.9  | Centrifugal pump  | 1           | 1         |             |
|      | Part B  |             |           | 24          |
| II.1 | 1. Density / Mass density / Specific Mass<br>2. Specific Weight / Weight Density<br>3. Specific Gravity / Relative Density<br>4. Specific Volume<br>5. Dynamic Viscosity<br>6. Kinematic Viscosity<br>7. Surface tension<br>8. Capillarity<br>9. Vapour Pressure<br>10. Compressibility<br>Any 3 points , each carries one mark   | 1X3         | 3         |             |
| II.2 | 1. Mass density = Specific gravity of liquid * Density of Standard fluid<br>(water) = $0.85 \times 1000 = 850 \text{ Kg/m}^3$<br>2. Weight Density = Specific gravity of liquid * Density of Standard fluid<br>(water) * acceleration due to gravity = $0.85 \times 1000 \times 9.81 = 8338.5 \text{ N/m}^3$<br>Each carries 1.5 mark   | 1.5X2       | 3         |             |
| II.3 | 1. Steady flow and unsteady flow<br>2. Uniform and non-uniform flow<br>3. Compressible flow and incompressible flow<br>4. Rotational and irrotational flow<br>5. One, two, three-dimensional flow<br>6. Laminar and turbulent flow<br>Answer any 3, each carries 1 mark   | 1X3         | 3         |             |
| II.4 | (1) Loss of energy due to sudden enlargement.<br>(2) Loss of energy due to sudden contraction.<br>(3) Loss of energy at the entrance to a pipe from the large vessel.<br>(4) Loss of energy at the exit from a pipe.<br>(5) Loss of energy due to an obstruction in the flow passage.<br>(6) Loss of energy due to gradual contraction or enlargement.<br>(7) Loss of energy in bends.<br>(8) Loss of energy in various pipe fittings<br>Answer any 3 , each carries one mark | 1X3         | 3         |             |

①

|       |   |       |   |  |
|-------|---|-------|---|--|
| II.5  | <p>1. Rectangular Notch</p> $Q = \frac{2}{3} \times C_d \times L \times \sqrt{2g} \times H^{3/2}$ <p>2. Triangular Notch</p> $Q = \frac{8}{15} C_d \tan \frac{\theta}{2} \sqrt{2g} \times H^{5/2}$ <p><i>Each carries 1.5 mark</i></p>  | 1.5X2 | 3 |  |
| II.6  | $F = \frac{wa(V-u)^2}{g}$ $= \frac{9810 \times (0.00442) \times (20-5)^2}{9.81} = 994.5 \text{ N}$ <p>Work done per second by the jet on the plate</p> $= (F \times u)$ $= (994.5 \times 5) = 4972.5 \text{ N.m}$ <p><i>Each carries 1.5 mark</i></p>   | 1.5X2 | 3 |  |
| II.7  | <p>Unit power (Pu) is the power developed by a turbine when the head on the turbine is unity</p> $P_u = \frac{P}{H^{3/2}}$ <p><i>Each carries 1.5 mark</i></p>  | 1.5X2 | 3 |  |
| II.8  | <p>Priming is the operation in which the suction pipe, casing of the pump and the portion of the delivery pipe upto the delivery valve are completely filled with the liquid which is to be pumped, so that all the air (or gas or vapour) from this portion of the pump is driven out and no air pocket is left.</p> <p><i>Explanation: 3 marks</i></p>  | 3     | 3 |  |
| II.9  | <p>The manometric efficiency <math>\eta_{\text{mano}}</math> is defined as the ratio of the manometric head developed by the pump to the head imparted by the impeller to the liquid</p> $\eta_{\text{mano}} = \frac{H_m}{(V_{w1} u_1 / g)} = \frac{g H_m}{V_{w1} u_1}$ <p><i>Each carries 1.5 mark</i></p>   | 1.5X2 | 3 |  |
| II.10 | <p>For most of the reciprocating pumps the actual discharge <math>Q_a</math> is less than the theoretical discharge <math>Q_{\text{th}}</math>, in which case <math>C_d</math> of the pump is less than one and the slip of the pump is positive. However, in some cases the actual discharge of the pump may be more than the theoretical discharge, in which case <math>C_d</math> will be more than one and the slip will be negative, which is then known as negative slip</p> <p><i>Explanation: 3 marks</i></p> | 3     | 3 |  |

|       | Part C  |       |   | 42 |
|-------|---|-------|---|----|
| III.1 | <p> <math>S_A = 1.3</math> <math>\rho_A = 1300 \text{ kg/m}^3</math><br/> <math>S_B = 0.85</math> <math>\rho_B = 850 \text{ kg/m}^3</math><br/> <math>S_{hg} = 13.6</math> <math>\rho_{hg} = 13600 \text{ kg/m}^3</math> </p>  <p>             Taking X-X as datum line<br/>             Left limb pressure = Right limb pressure<br/> <math>P_A + \rho_A h_A g + \rho_{hg} h_{hg} g = P_B + \rho_B h_B g</math><br/> <math>P_A - P_B = \rho_B h_B g - \rho_A h_A g - \rho_{hg} h_{hg} g</math><br/> <math>= 850 \times 0.175 \times 9.81 - 1300 \times 0.085 \times 9.81 - 13600 \times 0.15 \times 9.81</math><br/> <math>= -19637.1675 \text{ N/m}^2</math><br/> <math>= -19.637 \text{ kN/m}^2</math> </p>  | 2+3+2 | 7 |    |
| III.2 |  <p> <b>Figure: 3 marks</b><br/> <b>Explanation: 4 marks</b><br/>             A Bourdon gauge is a mechanical device used to measure and display pressure. The gauge can be used for measuring pressure in both gas and liquid state systems.<br/>             The heart of the Bourdon gauge is the Bourdon tube. The tube is manufactured in a semi-circular C-shape, or, coiled shape. The tube is open to atmosphere at one end and sealed closed at the other. Any increase in system pressure within the tube causes the tube to expand and straighten, the change is small but magnified due to the shape of the tube. The change in C-shape or coil radius is transferred to the indicator needle and this movement allows personnel to visually view the pressure within the system         </p> | 3+4   | 7 |    |

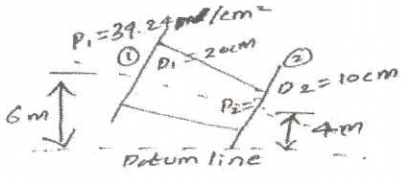
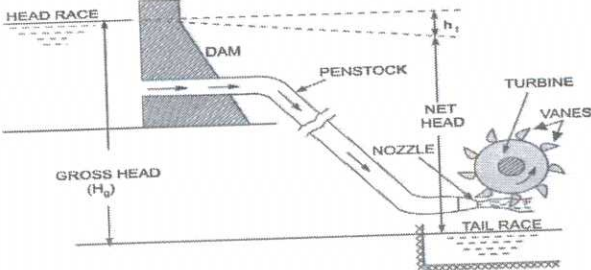
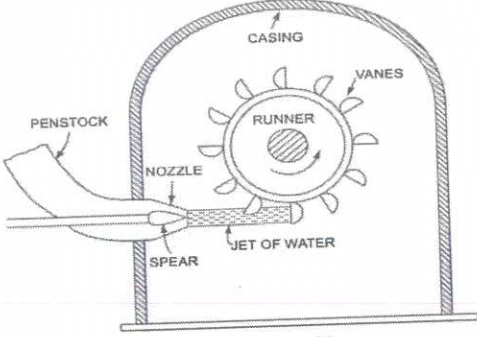
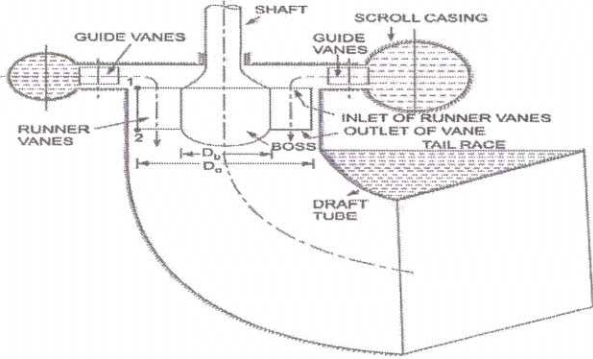
|              |  |              |          |  |
|--------------|--|--------------|----------|--|
| <p>III.3</p> | <p><b>Coefficient of velocity (<math>C_v</math>):</b> The ratio of actual velocity of a jet of water at vena-contracta to the theoretical velocity is known as coefficient of velocity</p> <p><b>Coefficient of discharge (<math>C_d</math>):</b> The ratio of actual discharge of a jet of water to its theoretical discharge is known as coefficient of discharge</p> <p><b>Coefficient of contraction (<math>C_c</math>):</b> The ratio of the area of the jet of water at vena-contracta to the area of orifice is known as coefficient of contraction</p> <p><b>Relation between hydraulic coefficient</b></p> <p>Coefficient of discharge = Coefficient of contraction * Coefficient of Velocity</p> <p><math>C_d = C_c * C_v</math></p> <p><i>Explanation: 2 marks for each definition and 1 mark for relation</i></p>  | <p>3X2+1</p> | <p>7</p> |  |
| <p>III.4</p> |  <p> <math>D_1 = 20 \text{ cm} = 0.2 \text{ m}</math>    <math>A_1 = \frac{\pi}{4} \times 0.2^2 = 0.0314 \text{ m}^2</math><br/> <math>D_2 = 10 \text{ cm} = 0.1 \text{ m}</math>    <math>A_2 = \frac{\pi}{4} \times 0.1^2 = 0.00785 \text{ m}^2</math><br/> <math>p_1 = 39.24 \text{ N/cm}^2 = 39.24 \times 10^4 \text{ N/m}^2</math><br/> <math>z_1 = 6 \text{ m}</math><br/> <math>z_2 = 4 \text{ m}</math><br/> <math>Q = 35 \text{ l/sec} = 0.035 \text{ m}^3/\text{sec}</math><br/> <math>v_1 = \frac{Q}{A_1} = \frac{0.035}{0.0314} = 1.114 \text{ m/sec}</math><br/> <math>v_2 = \frac{Q}{A_2} = \frac{0.035}{0.00785} = 4.456 \text{ m/sec}</math> </p> <p>Apply Bernoulli's equation b/w ① and ②</p> $\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$ $\frac{39.24 \times 10^4}{1000 \times 9.81} + \frac{(1.114)^2}{2 \times 9.81} + 6 = \frac{p_2}{1000 \times 9.81} + \frac{(4.456)^2}{2 \times 9.81} + 4$ $p_2 = 41.051 \times 9810 = 40.27 \times 10^4 \text{ N/m}^2$ $p_2 = 40.27 \text{ N/cm}^2$ | <p>2+3+2</p> | <p>7</p> |  |

Figure 2 mark + Equation and steps 3 mark + Final answer 2 mark

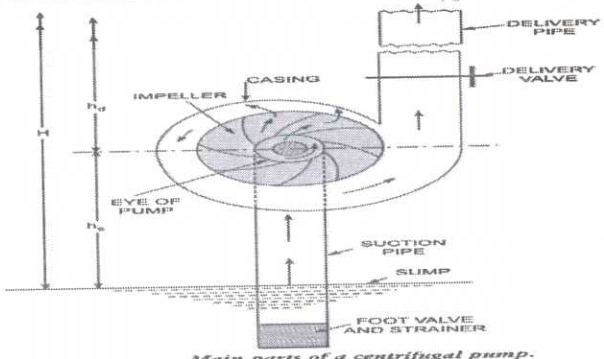
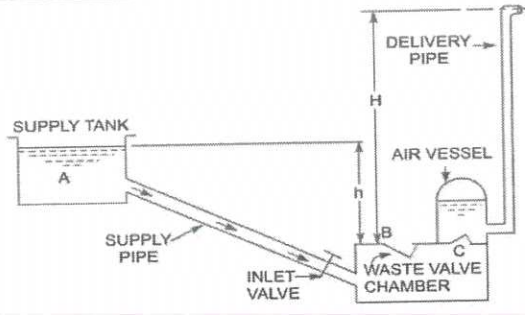
④

|              |  |              |          |  |
|--------------|--|--------------|----------|--|
| <p>III.5</p> | <p>Bernoulli's equation states that in a steady, irrotational flow of an incompressible fluid the total energy at any point is constant. In other words, if the Bernoulli's equation is applied between any two points in a steady irrotational flow of an incompressible fluid then. we get</p> $\frac{p_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{w} + \frac{V_2^2}{2g} + z_2$ <p><b>LIMITATIONS OF BERNOULLI'S PRINCIPLE</b></p> <p>1.The Bernoulli equation has been derived by assuming that the velocity of every element of the liquid across any cross-section of the pipe is uniform. Practically, It is not true. The elements of the liquid in the innermost layer have the maximum velocity. The velocity of the liquid decreases towards the walls of the pipe. Therefore, we should take into account the mean velocity of the liquid.</p> <p>2.While deriving Bernoulli's equation, the viscous drag of the liquid has not been taken into consideration. The viscous drag comes into play when a liquid is in motion.</p> <p>3.Bernoulli's equation has been derived from the assumption that there is no loss of energy when a liquid is in motion. In fact, some kinetic energy is converted into heat energy and a part of it is lost due to shear force.</p> <p>4.If the liquid is flowing along a curved path, the energy due to centrifugal force should also be taken into consideration.</p> <p><i>Statement and equation 3 mark and Limitations 1 mark for each point</i></p> | <p>3+1X4</p> | <p>7</p> |  |
| <p>III.6</p> | $d_1 = 30\text{cm} \quad a_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} (30)^2 = 706.85\text{cm}^2$ $d_2 = 15^2 \quad a_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} (15)^2 = 176.7\text{cm}^2$ $h = x \left[ \frac{S_1}{S_2} - 1 \right] = 20 \left[ \frac{13.4}{1} - 1 \right] = 252\text{ cm of water}$ $Q = C_d \frac{a_1 a_2}{\sqrt{a_1^2 + a_2^2}} \times \sqrt{2gh}$ $= 0.98 \times \frac{706.85 \times 176.7}{\sqrt{(706.85)^2 + (176.7)^2}} \times \sqrt{2 \times 9.81 \times 252}$ $= \underline{\underline{125756\text{cm}^3/\text{sec}}} = \underline{\underline{125.756\text{ l/sec}}}$ <p><i>Equations 2 marks steps 3 marks final answer 2 marks</i></p>  | <p>2+3+2</p> | <p>7</p> |  |

|              |  |              |          |  |
|--------------|--|--------------|----------|--|
| <p>III.7</p> |  <p style="text-align: center;"><i>Layout of a hydroelectric power plant.</i></p> <p>A general layout of a hydroelectric power plant which consist of :</p> <ol style="list-style-type: none"> <li>1. A dam constructed across a river to store water.</li> <li>2. Pipes of large diameters called penstocks, which carry water under pressure from the storage reservoir to the turbines. These pipes are made of steel or reinforced concrete.</li> <li>3. Turbines having different types of vanes fitted to the wheels</li> <li>4. Tail race, which is a channel which carries water away from the turbines after the water has worked on the turbines. The surface of water in the tail race channel is known as tail race.</li> </ol> <p style="text-align: center;"><b>Figure: 3 marks</b><br/><b>Marking: 2 marks</b><br/><b>Explanation: 2 marks</b></p> | <p>3+2+2</p> | <p>7</p> |  |
| <p>III.8</p> |  <p style="text-align: center;"><i>Pelton turbine.</i></p> <p>The pelton wheel or pelton turbine is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmospheric. This turbine is used for high heads. The main parts of the pelton turbine are :</p> <ol style="list-style-type: none"> <li>(1) Nozzle and flow regulating arrangement (spear)</li> <li>(2) Runner and Buckets</li> <li>(3) Casing</li> <li>(4) Breaking Jet</li> </ol> <p style="text-align: center;"><b>Figure: 3 marks</b><br/><b>Marking: 2 marks</b><br/><b>Explanation: 2 marks</b></p>  | <p>3+2+2</p> | <p>7</p> |  |

|               |  |                  |          |  |
|---------------|--|------------------|----------|--|
| <p>III.9</p>  |  <p style="text-align: center;"><i>Main components of Kaplan turbine.</i></p> <p>Kaplan turbine is a axial flow reaction turbine. The head at the inlet of turbine is the sum of pressure and kinetic energy and during the flow of water through runner a part of pressure energy is converted to kinetic energy. The shaft of the turbine is vertical. The lower end of the shaft is made larger which is known as 'hub' or boss. The adjustable vanes are fixed on the hub. The main parts of the kaplan turbine are :</p> <ol style="list-style-type: none"> <li>(1) Scroll casing,</li> <li>(2) Guide vanes mechanism</li> <li>(3) Hub with vanes or runner of the turbine</li> <li>(4) Draft tube.</li> </ol> <p style="text-align: center;"><i>Figure: 3 marks</i><br/><i>Marking: 2 marks</i><br/><i>Explanation: 2 marks</i></p> | <p>3+2+2</p>     | <p>7</p> |  |
| <p>III.10</p> | <ol style="list-style-type: none"> <li>1. According to the type of energy at inlet :<br/>(a) Impulse turbine (b) Reaction turbine</li> <li>2. According to the direction of flow through runner :<br/>(a) Tangential flow turbine (b) Radial flow turbine (c) Axial flow turbine (d) Mixed flow turbine</li> <li>3. According to the head at the inlet of turbine :<br/>(a) High head turbine (b) Medium head turbine (c) Low head turbine</li> <li>4. According to the specific speed of turbine :<br/>(a) Low specific speed turbine (b) Medium specific speed turbine (c) High specific speed turbine</li> </ol> <p><i>For (1) and (2) 2 mark each and (3) and (4) 1.5 mark each</i></p>  | <p>2X2+2X1.5</p> | <p>7</p> |  |

7

|               |   |              |          |  |
|---------------|---|--------------|----------|--|
| <p>III.11</p> |  <p style="text-align: center;"><i>Main parts of a centrifugal pump.</i></p> <p>The centrifugal pump acts as a reverse of an inward radial flow reaction turbine. The centrifugal pump works on the principle of forced vortex flow which means that when a certain mass of liquid is rotated by an external torque, the rise in pressure head of the rotation liquid takes place. This rise in pressure head at point of rotating liquid is proportional to the square of tangential velocity of the liquid at that point. Thus at the outlet of the impeller, where radius is more, the rise in pressure head will be more and the liquid will be discharged at the outlet with a high pressure head. Due to this high pressure head, the liquid can be lifted to a high level. The main parts of centrifugal pump :</p> <p>(1) Impeller (2) Casing (3) Suction pipe with foot valve and a strainer<br/>(4) Delivery Pipe</p> <p style="text-align: center;"><i>Figure: 2 marks</i><br/><i>Marking: 2 marks</i><br/><i>Explanation: 3 marks</i></p>  | <p>2+2+3</p> | <p>7</p> |  |
| <p>III.12</p> |  <p style="text-align: center;"><i>The hydraulic ram.</i></p> <p>The hydraulic ram is a pump which raises water without any external power for its operation. When large quantity of water is available at a small height, a small quantity of water can be raised to a greater height with the help of hydraulic ram. It works on the principle of water hammer.</p> <p>When the inlet valve fitted to the supply pipe is opened, water starts flowing from supply tank to the chamber, which has two valves at B and C. The Valve B is called waste valve and valve C is called the delivery valve. The valve C is fitted to an air vessel. As the water is coming into the chamber and waste valve B starts moving upward. A stage comes, when the waste valve B suddenly closes. This sudden closure of waste valve creates high pressure inside the chamber. The high pressure forces opens the delivery valve C. The water from chamber enters the air vessel and compresses the air inside the air vessel. This compressed air exerts force on the water in the air vessel and small quantity of water is raised to a greater height.</p> <p style="text-align: center;"><i>Figure: 2 marks</i><br/><i>Marking: 2 marks</i><br/><i>Explanation: 3 marks</i></p> | <p>2+2+3</p> | <p>7</p> |  |