Model Answer: Winter- 2018

Subject: Hydraulics | **Sub. Code: 17421**

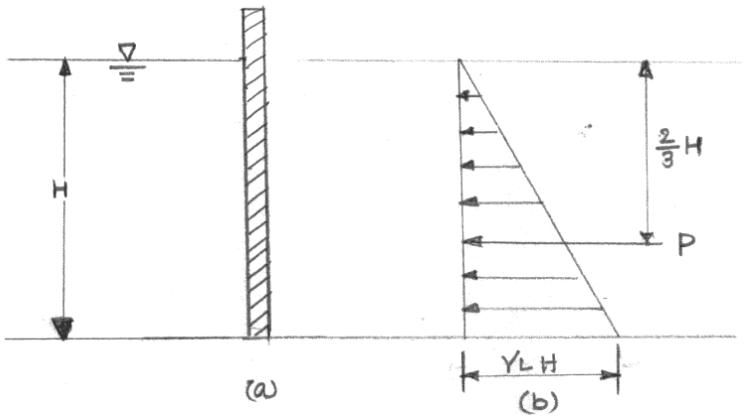
Important Instructions to examiners:

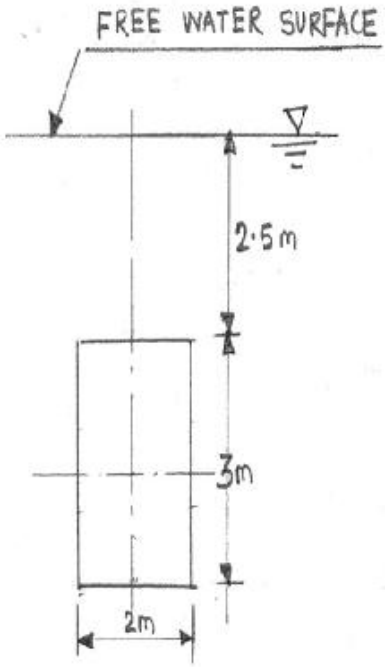
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 the candidate and those in the 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 the model answer.
6) In case of some questions credit may be given by judgment 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.

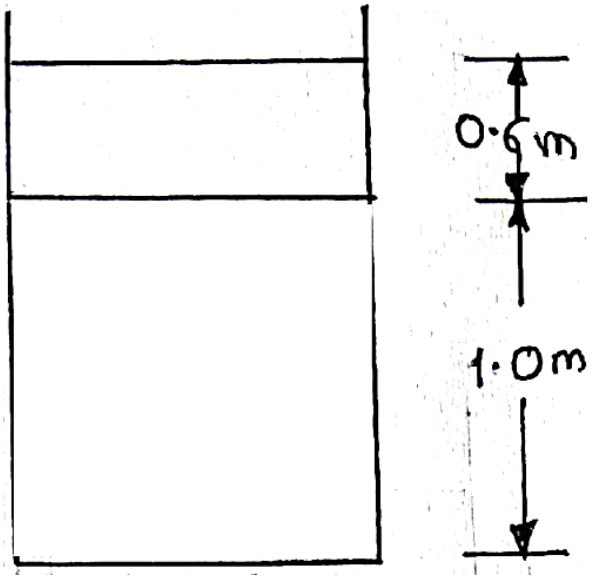
<table>
<tr><th>Que. No.</th><th>Sub. Que.</th><th>Model Answers</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>Q. 1</td><td>A)</td><td>Attempt any <u>SIX</u> of the following :</td><td></td><td>12</td></tr>
<tr><td></td><td>(a)</td><td>State the difference in behavior of liquid with solids (any two points).</td><td></td><td></td></tr>
<tr><td></td><td>Ans.</td><td>
<table>
<tr><th>Sr. No.</th><th>Liquids</th><th>Solids</th></tr>
<tr><td>1</td><td>The distance space between molecules is large as compared to solids.</td><td>Molecules are very closely spread spaced to each other.</td></tr>
<tr><td>2</td><td>Intermolecular cohesive force is less</td><td>Intermolecular cohesive force is lrge</td></tr>
<tr><td>3</td><td>Liquids cannot resist tensile force</td><td>Solids can resist tensile compressive force</td></tr>
<tr><td>4</td><td>Liquids take the shape of the container in which it stored.</td><td>Solids have definite shape</td></tr>
<tr><td>5</td><td>e.g. Water, Petrol, Kerosene</td><td>e.g. Metal, Timber, concrete</td></tr>
</table>
</td><td>1 Mark each (any two)</td><td>2</td></tr>
<tr><td></td><td>(b)
Ans.</td><td>State the Newton's law of viscosity.
It states that "The shear stress between adjacent fluid layers is proportional to velocity gradient between the two layers.on a layer of a fluid is directly proportional to the rate of shear strain".
OR
The shear stress on a layer of a fluid is directly proportional to the Velocity gradient.
$\varsigma \quad \alpha\ (v/y) = \mu \times (v/y)$</td><td>2</td><td>2</td></tr>
</table>

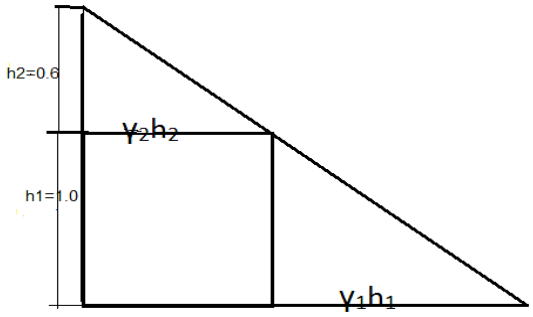
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	**(c)**	**Convert :** **i) 10 N/cm^2 in meters of water** **ii) 03 m of mercury in N/m^2**		
	Ans.	$P = 10 N/cm^2 = 10 \times 10^4 N/m^2$		
	i)	$S_{Water} = 1$ $P = \gamma_{Water} \times h_{Water}$ $P = S_{Water} \times \gamma_{Water} \times h_{Water}$ $1.0 \times 9810 \times h_{Water} = 10 \times 10^4 N/m^2$ $\boxed{h_{Water} = 10.19m}$	**1** 	**2**
	ii)	$h_{mercury} = 03m,\ S_{mercury} = 13.6$ $P = \gamma_{mercury} \times h_{mercury}$ $P = S_{mercury} \times \gamma_{Water} \times h_{mercury}$ $P = 13.6 \times 9810 \times 03$ $\boxed{P = 400248 N/m^2}$	**1**	
	(d)	**State any two advantages of simple U tube manometer over a piezometer.**		
	Ans.	1. It is suitable for measurement of high pressure 2. It is suitable for measurement of negative pressure 3. It requires a short U tube containing mercury in it.	**1 Mark each (any two)**	**2**
	(e)	**Write expression for minor losses in** **i) Sudden Enlargement ii) Exit**		
	Ans.	1. Minor Loss of head due to sudden enlargement $H_L = \frac{(V_1 - V_2)^2}{2g}$ 2. Minor Loss of head due to Exit $H_L = \frac{V^2}{2g}$	**1** **1**	**2**
	(f)	**Define i) Hydraulic Gradient Line ii) Energy Gradient Line**		
	Ans.	**Hydraulic Gradient Line (HGL)** is defined as the line which gives the sum of pressure head and datum head of a flowing fluid in a pipe with respect to some reference line. **Total Energy Gradient Line** is defined as the line which gives the sum of pressure head, datum head and velocity head of a flowing fluid in a pipe with respect to some reference line.	**1** **1**	**2**

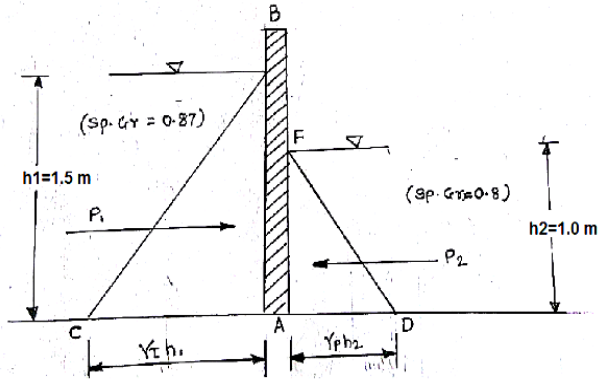
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	**g)**	**Define:** **i) Coefficient of contraction (C_c)** **ii) Coefficient of velocity (C_v)**		
	Ans.	1. **Coefficient of contraction (C_c)** The ratio of the cross-sectional area of the jet at vena contracta to the cross-sectional area of the orifice is called coefficient of contraction.	**1**	**2**
		2. **Coefficient of velocity (C_v)** The ratio of actual velocity of the jet at vena contracta to the theoretical velocity of the jet is called coefficient of velocity.	**1**	
	h) Ans.	**List any two velocity of flow measuring devices.** 1)Current meter 2)Single float or surface float 3)Double float or subsurface float 4)Rod float or velocity float 5) Pitot tube	**1 Mark each (any two)**	**2**
	B)	**Attempt any TWO of the following:**		**(8)**
	a)	**If the density of liquid is 800 kg/m^{3}and its kinematic viscosity as 1.73 cm^2/sec. find its** **i) Specific weight ii) Dynamic velocity** **iii) Specific volume iv) Specific gravity**		
	Ans.	Mass Density=ρ=800Kg/m^3 Kinematic Viscosity=J=1.73cm^2/sec=1.73×10^{-4}m^2/sec Specific Weight=γ=Mass Density×g γ=800×9.81 γ=7848N/m^3	**1**	
		Specific Volume=$\frac{1}{\rho}=\frac{1}{800}$ Specific Volume=1.25×10^{-3}m^3/kg	**1**	**4**
		Specific Gravity=$\frac{\rho_l}{\rho_w}$ ρ_w=1000Kg/m^3 ρ_l=800Kg/m^3 Specific Gravity=$\frac{800}{1000}$=0.8	**1**	
		Kinematic Viscosity=$\nu=\frac{\mu}{\rho_l}$ Dynamic Viscosity=$\mu=\nu\times\rho_l$=μ=1.73×10^{-4}×800 Dynamic Viscosity=μ=0.1384N-S/m^2	**1**	

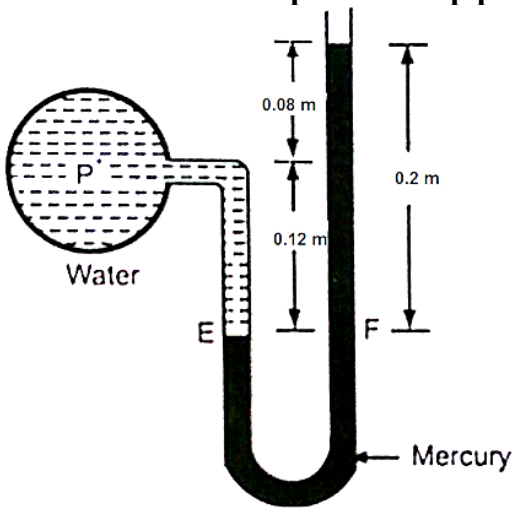
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	**b)**	**Define the following and state their SI units:** **i) Dynamic Viscosity ii) Weight Density**		
	Ans.	i) **Dynamic Viscosity:** It is defined as shear stress (τ) required to produce unit rate of shear strain (du/dy). It is denoted by (μ).	**1**	
		Unit = N.sec/m^2	**1**	
		ii) **Weight Density:** It is defined as the weight per unit volume at standard temperature and pressure	**1**	**4**
		OR It is defined as ratio of weight to volume.		
		S.I. Unit: N/m^3	**1**	
	c)	**Explain the concept of pressure diagram and state its use.**		
	Ans.	Pressure diagram is defined as "It is the graphical representation of variation of pressure on the surface with depth". The total pressure per unit length is the area of pressure diagram. The position of center of the pressure is the position of center of gravity of the pressure diagram.	**1**	
			**1**	**4**
		Uses: 1) To Calculate pressure exerted by liquid on the one side of surface. 2) To Calculate pressure due to liquid on both the side of surface 3) To Calculate pressure on vertical and inclined faces of dam. 4) To Calculate pressure on sluice gate, side and bottom of water tank. 5) To find position of centre of pressure.	**1 Mark each (any two)**	

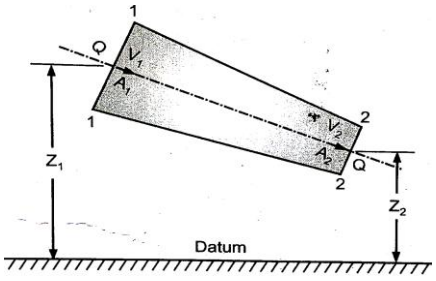
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2		**Attempt any FOUR of the following:**		**(16)**
	a)	**A rectangular plane surface is 2 m wide and 3 m deep. It lies in vertical plane in water. Determine the total pressure and position of centre of pressure on the plane surface when its upper edge is horizontal and 2.5 m below the free water surface.**		
	Ans.		**1**	**4**
		$P = \gamma \times A \times \bar{y}$		
		$A = b \times d = 2 \times 3 = 6m^2$		
		$\bar{y} = 2.5 + \frac{3}{2} = 4m$		
		$P = 9810 \times 6 \times 4 = 235440N = 235.44kN$	**1**	
		$\bar{h} = \frac{I_G \times \sin^2\theta}{A\bar{y}} + \bar{y}$		
		$I_G = \frac{bd^3}{12} = \frac{2 \times 3^3}{12} = 4.5m^4$	**1**	
		$\theta = 90^0$		
		$\bar{h} = \frac{4.5 \times 1}{6 \times 4} + 4 = 4.18m$	**1**	
		$\bar{h} = 4.18m$		

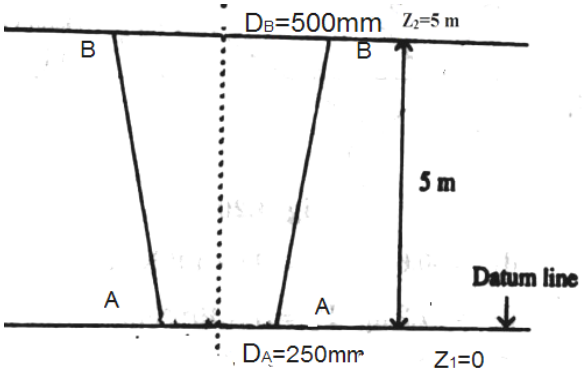
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	**b)**	**A square tank 2 m side and 2 m depth contain water to a depth of 1m and light liquid of specific gravity 0.80 on the water to a depth of 0.60 m. find the magnitude and location of pressure force on one of the vertical side and bottom of the tank.**		
	Ans.			
		for Water,		
		$P =$ Pressure intensity at bottom		
		$P = \gamma_w \times h$	½	
		$P_1 = 9.81 \times 1$		
		$\boxed{P_1 = 9.81 kN/m^2}$		
		$\boxed{P_1 = 9810\ N/m^2}$		
		for Oil,		
		$P_2 =$ Pressure intensity at bottom	½	
		$P_2 = \gamma_{oil} \times h$		
		$P_2 = S_{oil} \times \gamma_{water} \times 0.6$		
		$P_2 = 0.8 \times 9810 \times 0.6$		
		$\boxed{P_2 = 4708.8\ N/m^2}$		
		$P = P_1 + P_2$	½	
		$\boxed{P = 14518.8 N/m^2}$		
		Total pressure force $= p \times$ *Area*		
		Total pressure force $= 14518.8 \times 2 \times 2 = 58075.2N = 58.075kN$		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	**b)**		½	**4**
		P_{side} = Pressure per meter on one side of wall $y_1 = \frac{1}{3}\times h_1 = \frac{1}{3}\times 1 = 0.333m$ $a_1 = \frac{1}{2}\times \gamma_1 h_1 \times h_1 = \frac{1}{2}\times 9810\times 1\times 1 = 4905m^2$ $y_2 = \frac{1}{2}\times h_1 = \frac{1}{2}\times 1 = 0.5m$ $a_2 = \gamma_2 h_2 \times h_1 = 0.8\times 9810\times 0.6\times 1 = 4708.8m^2$ $y_3 = \frac{1}{3}\times h_2 + h_1 = \frac{1}{3}\times 0.6 + 1 = 1.2m$ $a_3 = \frac{1}{2}\times \gamma_2 h_2 \times h_2 = \frac{1}{2}\times 0.8\times 9810\times 0.6\times 0.6 = 1412.64m^2$	½	
		$\bar{y} = \frac{(a_1 y_1)+(a_2 y_2)+(a_3 y_3)}{a_1 + a_2 + a_3}$ $\bar{y} = \frac{(4905\times 0.33)+(4708.8\times 0.5)+(1412.64\times 1.2)}{4905+4708.8+1412.64}$ $\bar{y} = \frac{(1618.65)+(2354.4)+(1695.17)}{11026.44}$ $\bar{y} = 0.514m from base$	½	
		P_{side} = Pressure per meter on one side of wall $P_{side} = \left(\frac{1}{2}\times \gamma_1 \times h_1^2\right)+\left(\gamma_2 \times h_1 \times h_2\right)+\left(\frac{1}{2}\times \gamma_2 \times h_2^2\right)$ $P_{side} = \left(\frac{1}{2}\times 9810\times 1^2\right)+\left(0.8\times 9810\times 1\times 0.6\right)+\left(\frac{1}{2}\times 0.8\times 9810\times 0.6^2\right)$ $P_{side} = 4905+4708.8+2825.28$ $\boxed{P_2 = 12439.08\ N/m}$	½	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	**c)**	**A partition wall 2 m long divides a storage tank. On one side there is liquid with specific gravity 0.87 upto a depth of 1.5 m. on the other side there is another liquid with specific gravity 0.80 stored to a depth of 1 m . Determine the resultant pressure on the partition wall and the position of at which it acts.**		
	Ans.		½	
		Pressure due to liquid of sp.gr. 0.87		
		$P_1 = \frac{1}{2} \times \gamma_L \times h_1 \times h_1$		
		$P_1 = \frac{1}{2} \times S_L \times \gamma_w \times h_1^{\,2}$	½	**4**
		$P_1 = \frac{1}{2} \times 0.87 \times 9.81 \times 1.5^2$		
		$\boxed{P_1 = 9.6015 \text{kN/m}}$		
		Pressure due to liquid of sp. gr. 0.8		
		$P_2 = \frac{1}{2} \times \gamma_L \times h_2 \times h_2$		
		$P_2 = \frac{1}{2} \times S_L \times \gamma_w \times h_2^{\,2}$	½	
		$P_2 = \frac{1}{2} \times .80 \times 9.81 \times 1.0^2$		
		$\boxed{P_2 = 3.924 \text{kN/m}}$		
		Resultant Pressure	½	
		$P = P_1 - P_2$		
		$P = 9.6015 - 3.924$		
		$\boxed{P = 5.6775 \text{ kN/m}}$	½	
		And for 2 m lenght pressure will be		
		$P = 2 \times 5.6775 = 11.355 \text{kN}$		
		Position of center of pressure	**1**	
		$P\bar{h} = P_1\ \bar{h}_1 - P_2\ \bar{h}_2$		
		$5.6775 \times \bar{h} = 9.6015 \times \frac{1}{3} \times 1.5 - 3.924 \times \frac{1}{3} \times 1.0$		
		$\bar{h} = 0.615\ m$ from base	½	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	**d)**	**A simple U- tube manometer is used to measure water pressure in pipe. The left limb of manometer is connected to pipe and right limb is open to atmosphere. The mercury level in left limb is 120 mm below the centre of pipe and in right limb 80 mm above the centre of pipe . Calculate the water pressure in pipe.**		
	Ans.		**1**	
		$S_1 = 1$ $h_1 = 120mm = 0.12m$ $S_2 = 13.6$ $h_2 = 200mm = 0.20m$	**1**	**4**
		$h_p + (S_1 \times h_1) = (S_2 \times h_2)$ $h_p = (13.6 \times 0.20) - (1 \times 0.12)$	**1**	
		$\boxed{h_p = 2.6m}$ $P_p = \gamma_w \times h_p$ $P_p = 9.81 \times 2.6$		
		$\boxed{P_p = 25.506\, kN/m^2}$	**1**	
		OR	**Or**	
		$\frac{P_p}{\gamma_w} + (0.12 \times 1) - (0.20 \times 13.6) = 0$	**1**	
		$\frac{P_p}{\gamma_w} = 2.6m$ $P_A = 2.6 \times \gamma_w$		
		$\boxed{P_A = 25.506\, kN/m^2}$	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	**e)**	**Define the following types of flow:** **i) Gravity Flow ii) Steady Flow** **iii) Uniform Flow iv) Laminar Flow**		
	Ans.	**1) Gravity flow:** If the flow of water under gravitational force is called gravity flow	**1**	
		2) Steady flow: - If the depth of flow, the discharge and mean velocity of the flow at any section does not change with respect to time, the flow is called as steady flow	**1**	**4**
		3) Uniform flow: - If the depth of flow, the discharge and mean velocity flow at a given instant do not change along the length of channel, the flow is called as Uniform flow	**1**	
		4) Laminar flow: If fluid particles flows parallel to each other then flow is called laminar flow. **OR** If Reynold's number is less than 2000 then the flow is called as laminar flow.	**1**	
	f)	**State Bernoulli's theorem with its assumption and equation.**		
	Ans.	It states that in an ideal incompressible fluid when the flow is steady & continuous, the total energy of each particle of the fluid is the same. (Provided that no external energy enters or leaves the system at any point)	**2**	
		OR It states that in an incompressible fluid, when the flow is steady and continuous the sum of pressure energy, kinetic energy and potential energy (or datum energy) remains constant.		**4**
				
		$\frac{P_1}{\gamma_L}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\gamma_L}+\frac{V_2^2}{2g}+Z_2$	**2**	
		Where, $\frac{P_1}{\gamma_L}$ and $\frac{P_2}{\gamma_L}$ = Pressure head or Pressure Energy per unit weight at section 1-1 and 2-2 $\frac{V_1^2}{2g}$ and $\frac{V_2^2}{2g}$ = Velocity head or kinetic energy per unit weight at section 1-1 and 2-2 Z_1 and Z_2 = Datum head or Potential Energy per unit weight at section 1-1 and 2-2		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3		**Attempt any FOUR of the following:**		**16**
	a)	**A pipe line carrying an oil of specific gravity 0.9 has a diameter 250 mm at A which is gradually increase to a diameter of 500 mm at B, which is 5 m above A. if the pressure at A and B are 125 KPa and 75 Kpa respectively and discharge is 225 Litres per second , Find the loss of head and the direction of flow.**		
	Ans.			
		Given, Specific Gravity of oil-= 0.9 D_A= 250 mm= 0.25 m D_B = 500 mm= 0.5 m Z_A= 0 Z_B = 5 m P_A= 125KPa = 125 x 10^3 Pa P_B=75KPa= 75 x 10^3 Pa Q = 225 lit/sec Loss of head = ? Direction of flow = ? Q = 225 Lit/sec= 225/1000 m^3/sec = 0.225 m^3/sec		
		$Q = a_A v_A = 0.225 = \frac{\Pi}{4} \times 0.25^2 \times v_A$	½	
		$V_A = 4.586 m/s$		
		$Q = a_B v_B = \frac{\Pi}{4} \times 0.5^2 \times v_B$	½	
		$v_B = 1.146 m/s$		**4**
		Total Energy at A		
		$TE_A = \frac{P_A}{\gamma} + \frac{v_A^2}{2g} + z_A$	**1**	
		$TE_A = \frac{125 \times 10^3}{(0.9 \times 9810)} + \frac{4.586^2}{2 \times 9.81} + 0 = 15.2299 m$		
		Total Energy at B		
		$TE_B = \frac{P_B}{\gamma} + \frac{v_B^2}{2g} + z_B$	**1**	
		$TE_B = \frac{75 \times 10^3}{(0.9 \times 9810)} + \frac{1.146^2}{2 \times 9.81} + 5 = 13.562 m$		
		$Loss\ of\ Head = TE_A - TE_B = 15.2299 - 13.562$	**1**	
		$Loss\ of\ Head = 1.6679 m$		
		As TE_A is greater than TE_B direction of flow is from A to B		

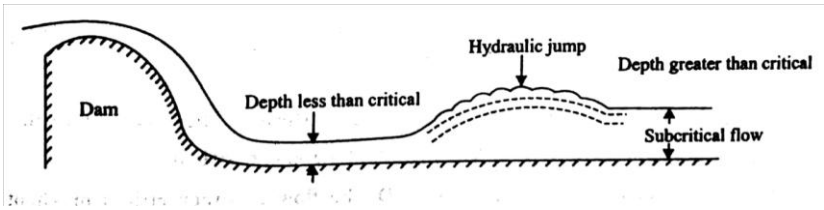
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.3	**b)**	**Define following terms :** **i) Reynolds Number ii) discharge** **iii) Flow net iv) Stream line**		
	Ans.	**i) Reynolds Number-** It is defined as the ratio of Inertia force to Viscous Force.	**1**	
		ii) Discharge – It is defined as the quantity of liquid flowing per second through a section of pipe or a channel.	**1**	
		iii) Flow net- a grid obtained by drawing a series of streamlines and equipotential lines is known as known as Flow net.	**1**	**4**
		iv) Stream line- It is defined as imaginary line within the flow so that the tangent at any point on it indicates the velocity at that point.	**1**	
	c)	**Three pipes having same length , same friction factor , but different diameters as 250 mm , 100 mm and 50 mm are connected in parallel . if the total discharge through these pipe is 500 Litres per second. Calculate the discharge through each Pipe.**		
	Ans.	d_1 = 250 mm= 0.25 m d_2 = 100 mm= 0.10 m d_3 = 50 mm= 0.05 m Q = 500 lit/sec = 0.5 m^3/sec $f_1 = f_2 = f_3$ $l_1 = l_2 = l_3$ $h_f = \frac{f_1 l_1 v_1^2}{2gD_1} = \frac{f_2 l_2 v_2^2}{2gD_2} = \frac{f_3 l_3 v_3^2}{2gD_3}$ $\frac{v_1^2}{D_1} = \frac{v_2^2}{D_2} = \frac{v_3^2}{D_3}$ $v_1^2 = \frac{D_1}{D_2} v_2^2$ $v_1^2 = \frac{0.25}{0.10} v_2^2$ $v_1^2 = 2.5 v_2^2$ $v_1 = 1.58\, v_2$ $v_3^2 = \frac{D_3}{D_2} v_2^2$ $v_3^2 = \frac{0.05}{0.10} v_2^2$		

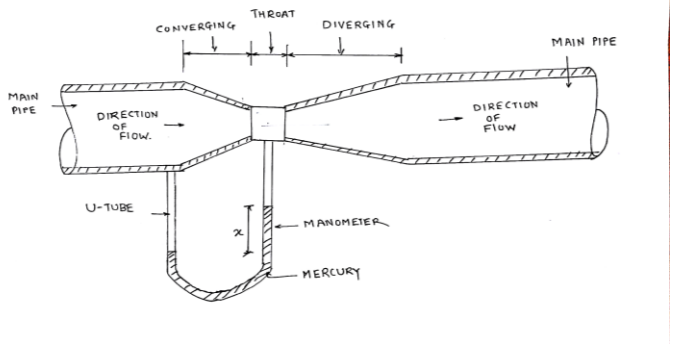
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3	**c)**	$v_3 = 0.707\, v_2$	**1**	**4**
		$Q = Q_1 + Q_2 + Q_3$		
		$Q = A_1 V_1 + A_2 V_2 + A_3 V_3$		
		$0.5 = \left[\frac{\pi}{4}(0.25)^2 \times 1.58 v_2\right] + \left[\frac{\pi}{4}(0.1)^2 \times v_2\right] + \left[\frac{\pi}{4}(0.05)^2 \times 0.707 v_2\right]$		
		$0.5 = \frac{\pi}{4}\{[0.098758 v_2] + [0.01 v_2] + [0.00176 v_2]\}$		
		$0.5 = \frac{\pi}{4}(0.1105 v_2)$		
		$0.5 = 0.08675\ V_2$		
		$V_2 = 5.763$m/s		
		$V_1 = 1.58\ V_2$		
		$V_1 = 9.112$ m / sec		
		$Q_1 = A_1 V_1$		
		$Q_1 = A_1 V_1$		
		$Q = \frac{\pi}{4} \times 0.25^2 \times 9.112$	**1**	
		$Q_1 = 0.4469\ m^3$ / sec	**1**	
		$Q_2 = A_2 V_2 = \frac{\pi}{4} \times 0.1^2 \times 5.763 = 0.0450\ m^3/sec$		
		$V_3 = 0.707\ V_2$		
		$V_3 = 0.707 \times 5.763$	**1**	
		$V_3 = 4.0744$ m/sec		
		$Q_3 = A_3 V_3 = \frac{\pi}{4} \times 0.05^2 \times 4.0744 = 0.00799\ m^3/sec$		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.3	**d)**	**Explain Water hammer in a pipe with its effects and remedial measure.**		
	Ans.	**Water hammer**- In a long pipe, when flowing water is suddenly brought to rest by closing the value or by any similar cause, there will be sudden rise in pressure as the momentum of water is being destroyed. A pressure wave is a transmitted along the pipe. A sudden rise in pressure has the effect of hammering action on the walls of the pipe . this phenomenon of sudden rise in pressure is known as water hammer or hammer blow.	**2**	**4**
		The magnitude of pressure rise depend on – speed at which valve is closed, velocity of flow, length of pipe, elastic properties of pipe material.		
		Effect: 1. Noise (Roaring Noise) is created. 2. Pipe may burst.	**2**	
		Remedial Measures: 1. Close the valve gradually. 2. Rise in pressure should be gradual.		
	e)	**A horizontal pipe of 150 mm diameter is suddenly enlarged to 200 mm diameter. Calculate the loss of head if 12 litres per second of water flows from smaller to larger section . also calculate the loss of head if the direction of flow is reversed. Take Cc= 0.62 .**		
	Ans.	Q = 12 Lit/sec Loss of head in sudden expansion= ? Loss of head in sudden contraction = ? Cc= 0.62		
		$Q = A_1V_1=A_2V_2$ = 12 lit / sec = 0.012 m^3/sec	**1**	
		$0.012 = \frac{\pi}{4}0.15^2 v_1$ V_1= 0.6794 m/sec		
		$Q = A_2V_2$	**1**	
		$0.012 = \frac{\pi}{4}0.20^2 v_2$ V_2 = 0.3822 m/sec		
		Loss of head due to sudden expansion = $\frac{(v_1 - v_2)^2}{2g} = \frac{(0.6794-0.3822)^2}{2\times 9.81} = 0.0045\ m$	**1**	**4**
		Loss of head when direction of flow is reversed that is due to sudden contraction = h_{conc} $h_{conc} = \frac{v_1^2}{2g}[\frac{1}{c_c} - 1]^2$ $h_{conc} = \frac{0.6794^2}{2 \times 9.81}[\frac{1}{0.62} - 1]^2$	**1**	
		H_{conc} = 0.0088277 m		

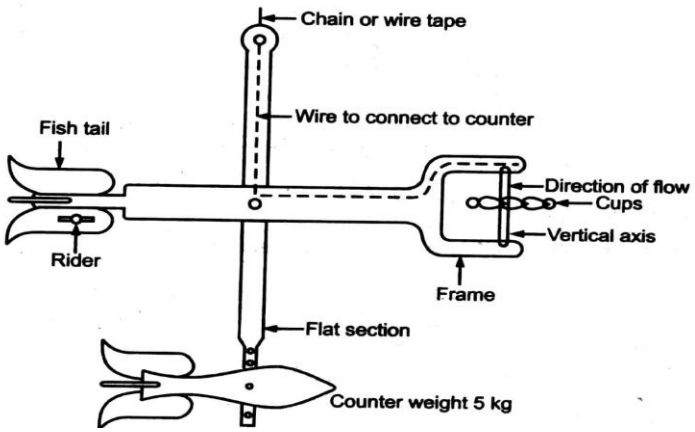
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3	**f)**	**Define the following terms:** **i) Wetted area ii) Wetted perimeter iii) Hydraulic mean depth iv) Open channel flow.**		
	Ans.	**Wetted area-** It is wetted cross sectional area of flow section of the channel	**1**	
		Wetted perimeter – It is length of channel boundary in contact with the flowing water / liquid at any section.	**1**	**4**
		OR It is perimeter of the section getting wet during the flow		
		hydraulic mean depth – it is the ratio of wetted area to wetted perimeter.	**1**	
		Open channel flow- It is defined as a passage in which liquid flows with its upper surface exposed to atmosphere.	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4		**Attempt any FOUR of the following:**		**(16)**
	a)	**Define most economical channel section and state the conditions for a trapezoidal section to be most economical.**		
	Ans.	Most economical channel section –		
		A channel section is considered to be the most economical when it can pass a maximum discharge for a given cross sectional area, resistance coefficient and bottom slope.		
		Or	**2**	
		The most economical channel section is the one which gives maximum discharge for a given amount of excavation.		**4**
		Conditions for a trapezoidal section –		
		1. Half of the top = Length of the sloping side		
		$\frac{b+2ny}{2} = y\sqrt{n^2+1}$	**1 Mark each**	
		b = bottom width, side slope 1 vertical to n horizontal, y= depth of flow		
		2. Hydraulic Radius = R = y / 2		
	b)	**A rectangular channel 6 m wide carries water at a rate of 10 m^3/sec. calculate the slope required to maintain a depth of 1.5 m.**		
	Ans.	A rectangular channel section		
		b= 6m		
		Q = 10 m^3/sec		
		y =1.5 m		
		slope = ?		
		P = b+ y+ y = 9 m	**1**	
		A = b x y = 6 x 1.5 = 9 m^2		**4**
		R = A/ P = 9 / 9 = 1		
		Q = A. V	**1**	
		$V = C\sqrt{R\,S}$		
		Assume C = 60	**1**	
		$10 = 9 \times 60\sqrt{1 \times S}$		
		$0.0185 = \sqrt{S}$		
		S = 0.0003422 or 1 in 2916	**1**	
		(Note : If students assume suitable value of C , appropriate marks should be given)		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	**c)** **Ans.**	**Explain the phenomenon of hydraulic jump and its occurance in field.** **Hydraulic Jump and its occurrence in the field:** Hydraulic jump is defined as sudden and turbulent passage of water from super critical state to subcritical state. It is rapidly varied flow. It occurs where there is change in depth of flow from rapid to tranquil state is in abrupt manner over a relatively short distance. The flow in hydraulic jump is accompanied by the formation of turbulent rollers and there is dissipation o f energy. **Occurrence-** 1. In a canal below a regulating sluice 2. At the foot of spillway 3. Where steep channel bottom slope suddenly changes to flat slope  	**1** **1** **Mark each (Any two)** **1**	**4**
	d) **Ans.**	**i) Define Froud's number and state its significance.** **ii) Write chezy's equation and Manning's equation used for determination of velocity of flow through open channel.** **i) Froud's number-** It is defined as the square root of the ratio of Inertia force and gravity force. $F_r = \frac{v}{\sqrt{gD}}$ Where, v = mean velocity of flow g = Gravitational acceleration D = Hydraulic depth Significance- If Fr > 1 It is supercritical force If Fr = 1 It is critical flow If Fr < 1 It is subcritical force Frouds number is used to identify the type of flow **ii) Chezy's equation** $V = C\sqrt{RS}$ C = Chezy's constant R = hydraulic mean depth S = bed slope **Manning's equation** $V = \frac{1}{N} \times R^{2/3} \times S^{1/2}$ N = Manning's constant R= hydraulic radius S= bed slope	**1** **1** **1** **1**	**4**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	**e) Ans.**	**Explain the working of venturimeter with neat sketch.** Venturimeter is practical application of Bernoulli's theorem. It is an instrument used to measure discharge in a pipeline, generally permanently fixed in pipe line. It consists of three parts a) Convergent Cone b) Throat c) Divergent Cone $Q_{actual} = \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$ h = shows pressure difference between inlet and throat **Working :** 1) The Venturimeter consist of a short converging tube leading to a cylindrical portion called throat. 2) The angle of convergent cone is 21° and the angle of divergent cone is from 7° to 15°. 3) The angle of divergent cone is smaller because when water is passing through throat, its velocity is more, since area of throat is less. 4) As this water passing through diversion cone there is chance of separation of fluid flow from boundary of diversion cone causing cavitation. 5) The pressure difference from section 1 and section 2 is measured by U-tube manometer. 6) The axis of Venturimeter may be horizontal or vertical or incline.  Fig: Venturimeter	**2** **2**	**4**

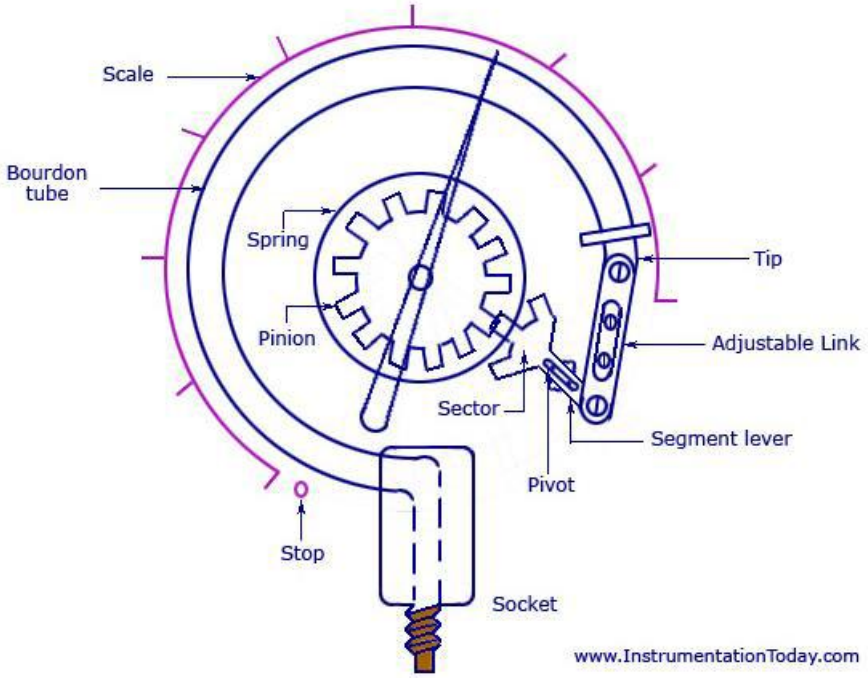
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	**f)**	**A sharp edged orifice has a diameter of 25 mm and coefficient of velocity and coefficient of contraction are 0.98 and 0.62 respectively. The jet drops 1 m in horizontal distance of 2.5 m .Determine the flow in m^3/sec and head over the orifice.**		
	Ans.	C_c =0.62 C_v = 0.98 d_1 = 25 mm y = 1 m x = 2.5 m		
		$C_v = \frac{x}{\sqrt{4yH}}$		
		0.98		
		$C_v = \frac{x}{\sqrt{4yH}}$		
		$0.98 = \frac{2.5}{\sqrt{4 \times 1 \times H}}$	**1**	
		$\sqrt{4H} = \frac{2.5}{0.98}$		**4**
		$\sqrt{4H} = 2.55$		
		Squaring on both sides		
		4H = 6.5077		
		H = 1.626 m= Head over the orifice	**1**	
		$C_d = C_c \times C_v$		
		C_d = 0.98 x 0.62 = 0.6076	**1**	
		Actual discharge = C_d x Theorotical discharge		
		$= C_d \times Area\ of\ orifice \times \sqrt{2gH}$		
		$= 0.60 \times \frac{\pi}{4} \times (0.025)^2 \times \sqrt{2 \times 9.81 \times 1.626}$		
			1	
		Q = 0.0016837 m^3/sec		

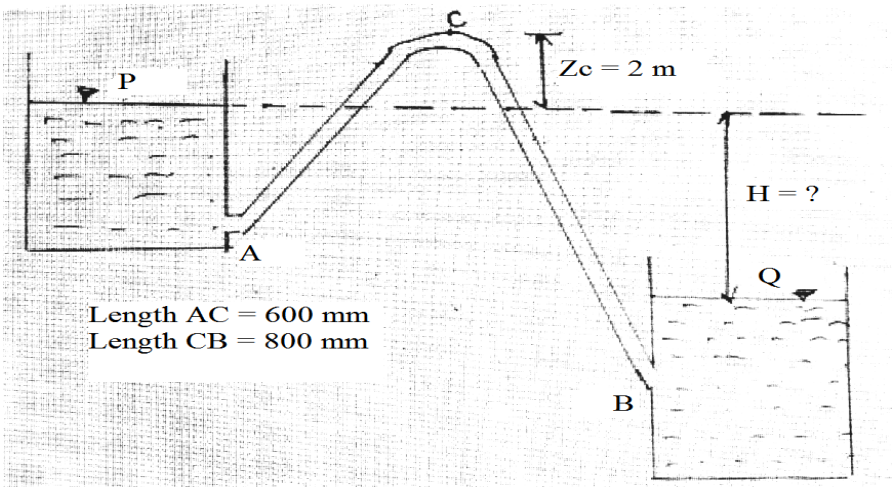
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5		**Attempt any FOUR of the following:**		**(16)**
	a)	**A reservoir has catchment area of 20 km^2 .The intensity of maximum rainfall over the catchment area is 2.5 cm/hr, 40% of which flows to the reservoir over the weir .Using Francis formula, Find length of weir. The head over the weir does not exceed 80 cm.**		
	Ans.	Area = 20 km^2=20 x10^6 m^2 Discharge =(20 x 10^6 x 2.5) / (100x60x60) =138.89 m^3/s	**1**	
		Discharge over weir 40%= 40/100 x 138.89 = 55.55 m^3/s		
		We know $Q = 1.84 \times (L - 0.1\,n\,H)H^{\frac{3}{2}}$	**1**	**4**
		$55.55 = 1.84 \times (L - 0.1 \times 2 \times 0.8) \times 0.8^{\frac{3}{2}}$ $55.55 = 1.84 \times (L - 0.16) \times 0.715$ $42.22 = (L - 0.16)$ L = 42.38 m	**2**	
	b)	**Sketch and describe cup type current meter.**		
	Ans.	 *(Note: 1 mark for sketch and 1 mark for labeling.)*	**2**	
		Working: 1. **I**n a cup type current meter the wheel or revolving element has the form of a series of conical cups, mounted on a spindle. Spindle is held vertical at right angle to the direction of flow. 2. Current meter is used to find out velocity of water. Current meter consist of a wheel containing blades on cups. 3. These cups are vertically immersed in stream of water. The thrust exerted by water on the cups. 4. The number of revolutions of the wheel per unit time is proportional to the velocity of flow. 5. The revolution counter operated by dry cell. The counter is calibrated or a calibration curve is provided to read velocity.	**2**	**4**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	**c)**	**Determine the discharge through 60^0 triangular notch in m^3/sec under the head of 0.16 m. If cd = 0.6.**		
	Ans.	$\Theta = 60^0$ H = 0.16 $C_d = 0.6$		
		$Q = \frac{8}{15} c_d \sqrt{2g} \tan\frac{\Theta}{2} H^{5/2}$	**2**	
		$Q = \frac{8}{15} \times 0.6 \times \sqrt{2 \times 9.81} \times \tan\frac{60}{2} \times 0.16^{5/2}$	**2**	**4**
		$Q = 8.380 \times 10^{-3}$ m^3/sec		
	d)	**A centrifugal pump has 70% efficiency. It is used to deliver 25 lit/sec of water a static head of 17 m. The delivery and Suction pipe together are 90 m long and are 100 mm diameter and f= 0.04 for both pipes. Calculate the power of pump.**		
	Ans.	Q = 25 lit/sec = 25 x 10^{-3} m^3/sec η = 70% f= 0.04 D = 0.1 m H = 17		
		$velocity = \frac{Q}{A}$		
		$velocity = \frac{25 \times 10^{-3}}{\frac{\pi}{4} \times (0.1)^2}$		
		V = 3.183 m/sec Head loss due to friction		
		$h_f = \frac{flv^2}{2gD}$	**1**	
		$h_f = \frac{0.04 \times 90 \times 3.183^2}{2 \times 9.81 \times 0.1}$		
		h_f = 18.59 m		
		Total manometric head = Hm = 17 +18.59 = 35.59 m	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	**d)**	$P = \frac{\gamma_w Q H_m}{\eta}$ $P = \frac{9810 \times 25 \times 10^{-3} \times 35.59}{0.70}$ P = 12469.21 watt = 12.469 kW	**2**	**4**
		OR		
		If sunction head is considered $h = \frac{v^2}{2g} = \frac{3.183^2}{2 \times 9.81} = 0.516\, m$	**1**	
		Total manometric head = Hm = 17 +18.59 + 0.516 = 36.106 m $P = \frac{9810 \times 25 \times 10^{-3} \times 36.106}{0.70}$ P = 12649.99 Watt = 12.649 kW **(Note- if students consider minor losses = 10% of major loss, then appropriate marks should be given.)**	**1**	
	e) **Ans.**	**Enlist any four component parts of centrifugal pump with their function.** The following are the main component parts of centrifugal pump. 1. Impeller 2. Casing 3. Suction pipe with a foot valve and strainer 4. Deliver pipe	**2**	
		1. Impeller: the rotating part of the centrifugal pump is called impeller. It consists of series of backward curved vanes. The impeller is mounted on a shaft which is connected to the shaft of an electric motor. **2. Casing:** It is as air tight passage surrounding the impeller and is designed in such a way that the kinetic energy of water discharged at the outlet of the impeller is converted into pressure energy before the casing and enters the delivery pipe. **3. Suction pipe with a foot valve and a strainer**: A foot valve which is a non- return valve or one any type of valve is fitted at the lower end of the suction pipe. The foot valve opens only in the upward direction. A strainer is also fitted at the lower end of the suction pipe. **4. Delivery pipe:** A pipe whose one end is connected to the outlet of the pump and other delivers the water at the required height is known as delivery pipe.	**2** **2**	**4**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	**f) Ans.**	**Define : Turbine and state its necessity and types.** **Turbine-** A turbine is defined as machine that converts hydraulic energy into mechanical energy. **Necessity-** Turbines are quite essential to convert water power into mechanical power . Mechanical power further converted into electric power using generator. Hydroelectric project provide cheap electric power. **Types-** 1. Francis Turbine 2. Pelton wheel 3. Kaplan Turbine.	**1** **1** **2**	**4**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6	**a)** **Ans.**	**Attempt any TWO of the following:** **Explain construction and working of Bourdon's pressure gauge with a neat sketch.**  Bourdon Tube Pressure Gauge ***(Note: 2 marks for sketch and 2 marks for labeling.)*** **Construction and Working:** Bourdon tube pressure gauge is used to measure high pressure. It consists of tube as shown in fig. having elliptical cross section. This tube is called as Bourdons Tube. One end of this tube is connected the point whose pressure is to be measured and other end free. When fluid enters in the tube elliptical cross section of tube becomes circular. Due to this the free end of tube shifts outward. This motion is transferred through link and pointer arrangement. The pointer moves over a calibrated scale, which directly indicates the pressure in terms of N/m^2 or m head of mercury. As the pressure in the case containing the bourdon tube is usually atmospheric, the pointer indicates gauge pressure.	**4** **4**	**(16)** **8**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6	**b)**	**Two reservoirs are connected by siphon pipe, the vertex of which is 2 m above the level of water in the higher reservoir. The length of pipe from inlet to vertex is 600 m and from vertex to outlet is 800 m. The pipe diameter is 1000 mm. If the pressure at the vertex is 2.5 m of water absolute. Find the discharge and level difference between the reservoir. Take f = 0.04. The pressure is 10.33 m of water absolute.**		
	Ans.		**1**	
		Pressure at vertex 2.5 m water absolute = 2.5 – 10.33 = -7.83 m gauge	**1**	**8**
		Applying Bernoulli's equation between P and C $0 = -7.83 + 2 + \frac{v^2}{2g} + \frac{0.04 \times 600 \times v^2}{2g}$	**1**	
		$7.83 - 2 = \frac{v^2}{2g} + \frac{24\,v^2}{2g}$		
		$5.83 = \frac{25\,v^2}{2g}$		
		$\frac{5.83 \times 2 \times 9.81}{25} = v^2$		
		$4.575 = v^2$	**1**	
		V = 2.138 m/s		
		Considering all losses $H = \frac{flv^2}{2gD} + \frac{v^2}{2g}$	**1**	
		$H = \frac{0.04 \times 1400 \times 2.138^2}{2 \times 9.81 \times 1} + \frac{1^2}{2 \times 9.81}$		
		H = 13.05 + 0.05 = 13.10 m	**1**	
		Discharge = Q = A.V	**1**	
		$Q = \frac{\pi}{4} \times 1^2 \times 2.138$		
		Q = 1.68 m^3/s	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6	**c)**	**Design a section of an unlined channel to carry a discharge of 6 m^3/sec with bed slope of 1 to 3600 and side slope 1.5 H :1 V . The average velocity of flow is not to exceed 0.667m/s. Take N = 0.025.**		
	Ans.	Given, Q = 6 m^3/sec V = 0.667 m/s N = 1.5/ 1 We know Q = A.V 6 = A x 0.667 A = 9 m^2	**1**	
		But, Area of trapezoidal A = bd + nd^2 9 = d(b + nd) ……(1)		
		Now, We know Manning's equation $V = \frac{1}{N} R^{\frac{2}{3}} S^{\frac{1}{2}}$	**1**	
		$0.667 = \frac{1}{0.025} \times R^{\frac{2}{3}} \times (\frac{1}{3600})^{\frac{1}{2}}$	**1**	
		$R^{\frac{2}{3}} = 1$ R = 1 But, $R = \frac{A}{P}$ $1 = \frac{9}{P}$		
		P = 9	**1**	
		But, $P = b + 2d\sqrt{1+n^2}$ $9 = b + 2d\sqrt{1+1.5^2}$ $9 = b + 3.6d$		
		b = 9 – 3.6d……(2)	**1**	
		Putting value of b from equation 2 in equation 1 d (9 – 3.6d + 1.5d) = 9 d (9-2.1 d) = 9	**1**	
		9d – 2.1 d^2 = 9 2.1d^2- 9d + 9 = 0	**1**	
		$d = \frac{9 \pm \sqrt{9^2 - 4 \times 2.1 \times 9}}{2 \times 2.1}$ d =2.68 m or d = 1.595 But if we put d = 2.68 in equation 2 becomes negative d=1.595 m b = 1.8 x 1.595 = 3.25m	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6	**c)**	**OR** If student consider the section as most economical then, Sloping side = ½ x Top width and R = d/2	**1**	**8**
		$d\sqrt{1+n^2} = \frac{b+2nd}{2}$	**1**	
		$d\sqrt{1+1.5^2} = \frac{b+2\times1.5\times d}{2}$		
		1.8d = (b +3d) / 2 b = 0.6d	**1**	
		$Area = bd + nd^2$		
		$A = 2.1d^2$	**1**	
		Applying Manning's formula		
		$V = \frac{1}{N}R^{\frac{2}{3}}S^{\frac{1}{2}}$	**1**	
		$0.667 = \frac{1}{0.025}\times\frac{d^{\frac{2}{3}}}{2}\times(\frac{1}{3600})^{\frac{1}{2}}$	**1**	
		$\frac{0.667\times0.025\times1.58}{0.016} = d^{\frac{2}{3}}$		
		$1.654 = d^{\frac{2}{3}}$	**1**	
		d = 2.12 b = 1.272 **(Note : Base width to depth ratio is not given in numerical therefore students may solve the problem by considering most economical channel section. Consider this and give appropriate marks.)**	**1**	