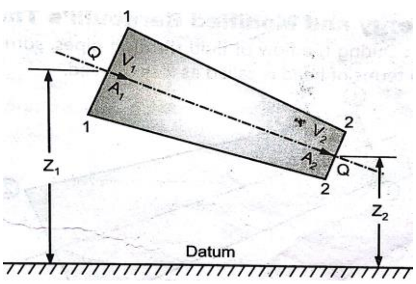
Model Answer: Summer 2017

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

Important Instructions to examiners:

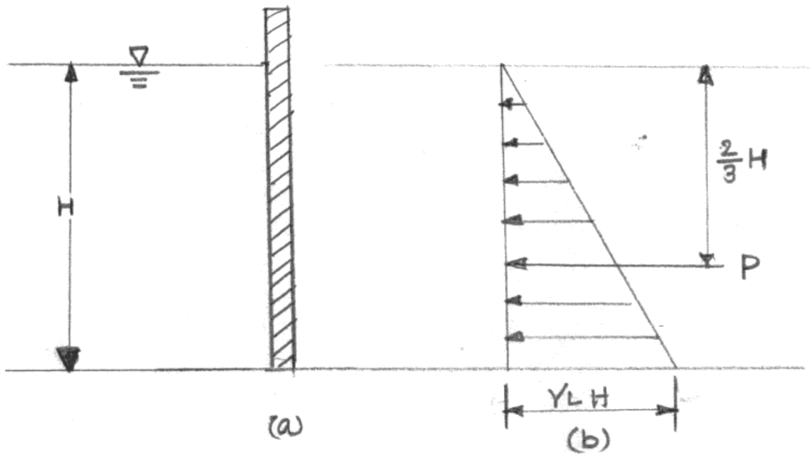
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
1		**Attempt any TEN:**		20
	a)	**Define weight density and state its S.I unit.**		
	Ans.	It is defined as weight per unit volume of a liquid at standard temperature and pressure.		
		OR	01	
		It is defined as ratio of weight to volume.		02
		SI unit N/m^3	01	
	b)	**Define dynamic viscosity and kinematic viscosity.**		
	Ans.	**Dynamic Viscosity: -**		
		It is defined as the shear stress required to produce unit rate of shear strain.	01	
		Kinematic Viscosity: -		
		It is the ratio of dynamic viscosity of a liquid to its mass density.		02
		OR	01	
		It is ratio of absolute viscosity to its mass density.		

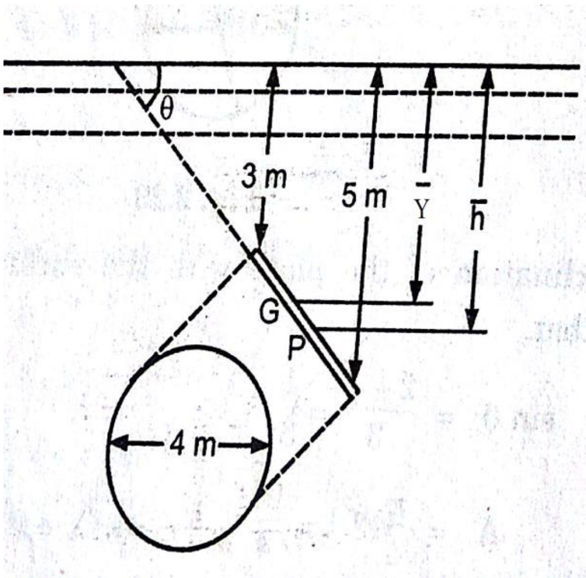
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
	c)	**Why mercury is used in manometer?**		
	Ans.	Following are the reasons due to which mercury is used in manometers :- (i) Specific gravity of mercury is greater than the other liquids. (ii) Mercury is immiscible with other liquids. (iii) It does not stick to the surface in contact.	**01 mark each (any two)**	**02**
	d)	**State the advantages of simple U tube manometer over a piezometer.**		
	Ans.	1. It is suitable for measurement of high pressure & negative pressure. 2. It requires a short U tube containing mercury in it.	**02**	**02**
	e)	**State Bernoulli's theorem and write modified Bernoulli's equation with meaning of each term.**		
	Ans.	It states that in an ideal incompressible fluid when the flow is steady and 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) **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. 	**01**	**02**

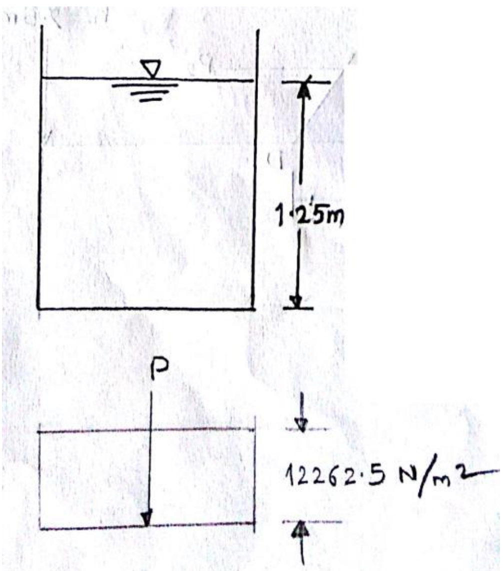
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
		$\frac{P_1}{\gamma_L}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\gamma_L}+\frac{V_2^2}{2g}+Z_2+h_L$ Where, $\frac{P_1}{\gamma_L}$ and $\frac{P_2}{\gamma_L}$ = Pressure head or Pressure Energy per unit weight at section 1-1 and 2-2 $\frac{V_1^2}{2g}$ and $\frac{V_2^2}{2g}$ = 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	**01**	
	f) **Ans.**	**What is flow net? State its uses.** It is a graphical representation of stream lines & equipotential lines. **OR** A set of stream lines and equipotential lines constitutes flow net. **Uses: -** 1. To determine seepage pressure. 2. To find exit gradient. 3. To design efficient boundary shapes. 4. To check the problems of flow under hydrostatic structure like dam.	**01** **½ mark each (any two)**	**02**
	g) **Ans.**	**What is 'Energy of Flowing Liquid'?** Energy of a flowing fluid is defined as ability of a liquid to do work by virtue of its velocity, position & existing pressure.	**02**	**02**
	h) **Ans.**	**State two uses of syphon.** 1. To connect two reservoirs at different levels separated by a high hill or by a valley. 2. To take out water from drum. 3. To take out water from a channel without outlet. 4. To drain out water from a channel without outlet. 5. To supply water to a town over a ridge.	**1 mark each (any two)**	**02**

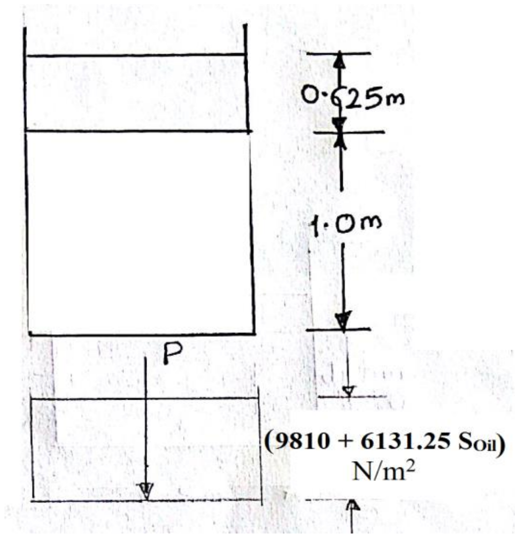
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
1	i)	**What is most economical channel section? Write conditions for rectangular channel section to be economical.**		
	Ans.	**Most Economical Channel Section:** - A channel which gives max. discharge for a given c/s area & bed slope and coefficient of roughness is called as Most Economical Channel Section.	01	02
		Condition for rectangular channel: - i) b = 2d ii) R = d/2	01	
	j)	**Define: (i) Wetted perimeter** **(ii) Hydraulics radius**		
	Ans.	i) **Wetted Perimeter:** - It is the perimeter of the section getting wet during the flow.	01	02
		ii) **Hydraulic Radius: -** It is the ratio of wetted area to the wetted perimeter. R = A/P	01	
	k)	**Define C_c, C_v, C_d and state relation between them.**		
	Ans.	**1) Coefficient of discharge (C_d)** The ratio of the actual discharge to the theoretical discharge is called as the coefficient of discharge. **2) 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. **3) 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. **4) Relation:-** $C_d = C_v \times C_c$	½ mark each	02
	l)	**Write the use of foot valve in the pump.**		
	Ans.	i) To permit upward flow only towards the pump. ii) To hold the water in suction pipe when the pump is closed.	02	02

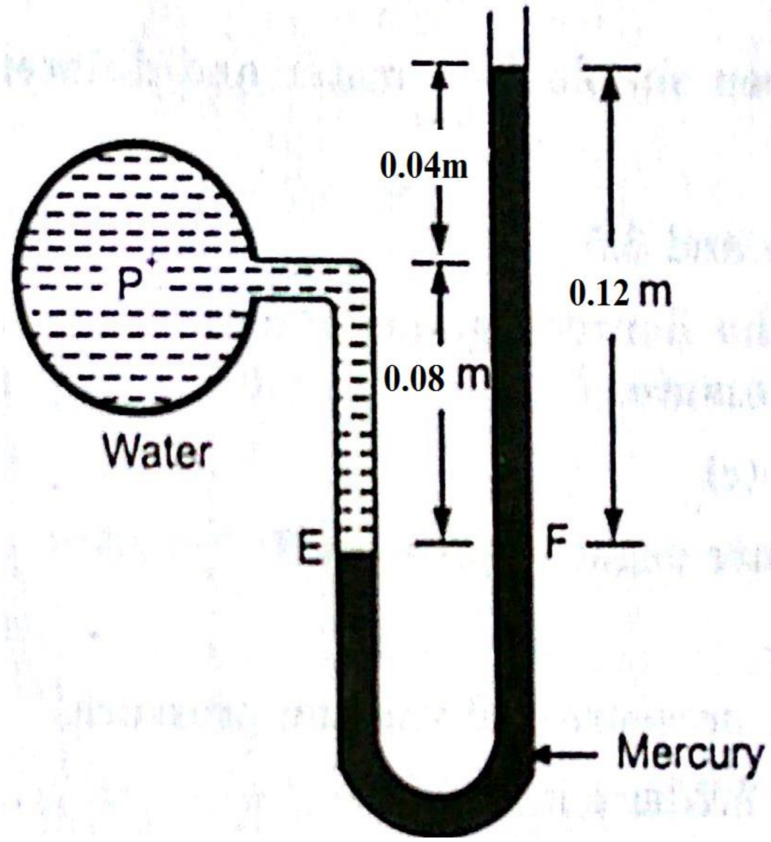
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
2		**Solve any FOUR:**		**16**
	a)	**Define pressure diagram for vertical contact surface with neat sketch and mention two application of it.**		
	Ans.	Pressure diagram is defined as "It gives the variation of pressure on the surface with depth". The 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.	**01**	
			**01**	**04**
		Applications: 1) To Calculate pressure due to liquid on the 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.	**01 mark each (any two)**	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
2	b)	**A circular plate of 4m diameter is immersed in water such that its greatest and least depth below the free surface of water are 5m and 3m respectively.** **Calculate:** **(i) Total pressure on one face of plate.** **(ii) The position of center of pressure.**		
	Ans.	$A=\frac{\pi}{4}\times4^2$ $A=4\times\pi$ $\boxed{A=12.566\ m^2}$ $\bar{y}=\frac{5+3}{2}$ $\boxed{\bar{y}=4m}$ $\sin\theta=\frac{2}{4}$ $\theta=\sin^{-1}(\frac{1}{2})$ $\boxed{\theta=30^0}$	01	
		$I_G=\frac{\pi}{64}\times D^4$ $I_G=\frac{\pi}{64}\times4^4$ $\boxed{I_G=12.57\ m^4}$	01	04
		$P=\gamma_w\times A\times\bar{y}$ $P=9.81\times12.566\times4$ $\boxed{P=493.10\,kN/m^2}$	01	
		$\bar{h}=\frac{I_G\sin^2\theta}{A\bar{y}}+\bar{y}$ $\bar{h}=\frac{12.57\times\sin^2 30^0}{12.566\times4}+\bar{y}$ $\boxed{\bar{h}=4.0625m}$	01	

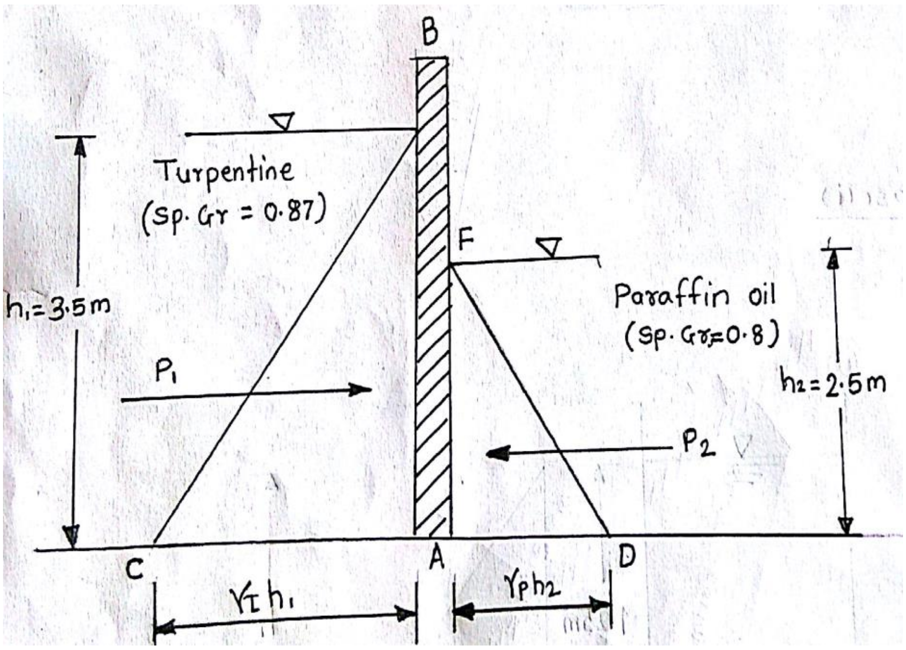


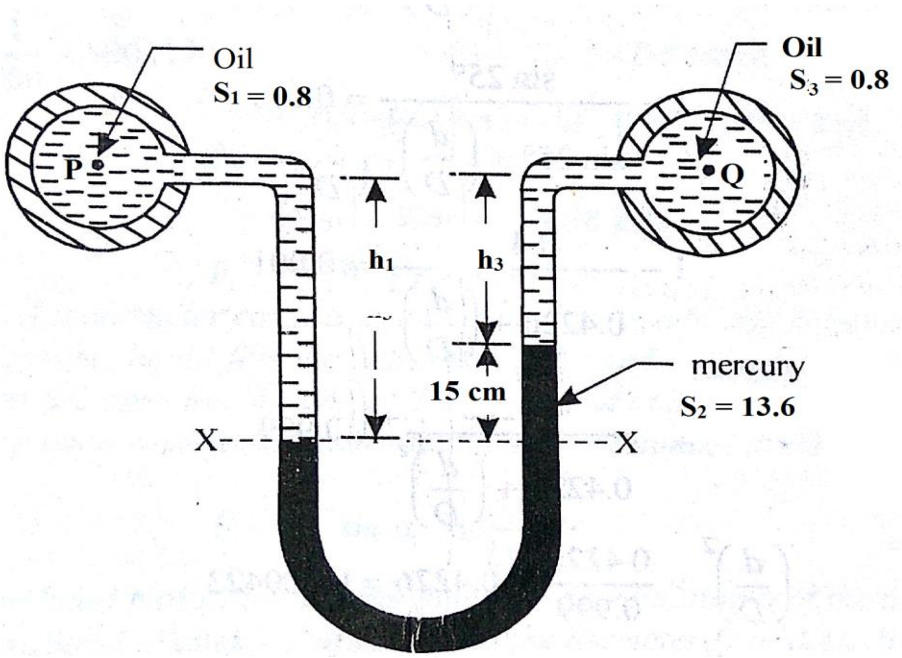
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
2	**c)**	**Find the intensity of pressure in N/m^2 on the base of container when,** **(i) Water stands to a height of 1.25 m in it.** **(ii) When oil for 0.625 m ht. stands on water of 1 m.ht. Draw pressure diagrams to all cases.**		
	Ans.	Case i) Water stands to a height of 1.25m $P =$ Pressure intensity at bottom $P = \gamma_w \times h$ $P = 9.81 \times 1.25$ $P = 12.2625\, kN/m^2$ $P = 12262.5\, N/m^2$	**01**	
		 Case (i)	**01**	
		Case ii) When oil for 0.625 stands on a water of 1m height *for* Water, $P =$ Pressure intensity at bottom $P = w_w \times h$ $P_1 = 9.81 \times 1$ $\boxed{P_1 = 9.81 kN/m^2}$ $\boxed{P_1 = 9810\ N/m^2}$		**04**

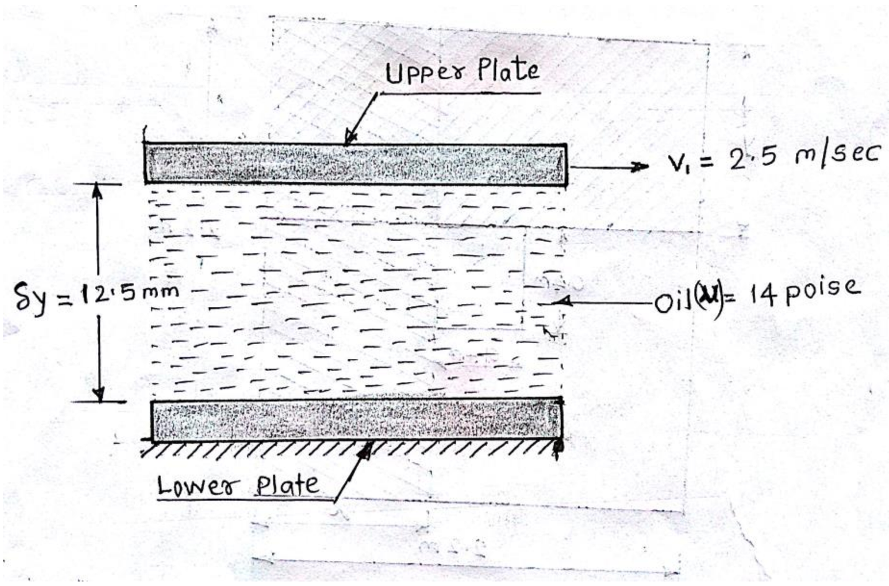
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
2		*for Oil*, P_2 = Pressure intensity at bottom $P_2 = w_{oil} \times h$ $P_2 = S_{oil} \times w_{water} \times 0.625$ $\boxed{P_2 = 6.13125\ S_{oil}\ kN/m^2}$ $\boxed{P_2 = 6131.25\ S_{oil}\ N/m^2}$ $P = P_1 + P_2$ $\boxed{P = (9810 + 6131.25 S_{oil}) N/m^2}$	01	
		 Case (ii)	01	
	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 80mm below center of pipe and in right limb 40mm above the center of pipe. Calculate water pressure in pipe.**		
	Ans.	$S_1 = 1$ $h_1 = 80mm = 0.08m$ $S_2 = 13.6$ $h_2 = 120mm = 0.12m$ $h_A + (S_1 \times h_1) = (S_2 \times h_2)$	01	

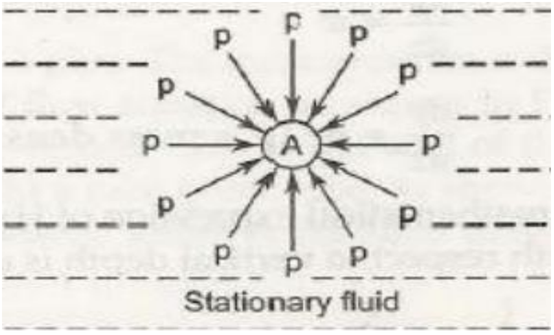
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
2			01	04
		$h_A = (13.6 \times .0.12) - (1 \times 0.08)$	01	
		$\boxed{h_A = 1.552 m}$		
		$P_A = \gamma_w \times h_A$		
		$P_A = 9.81 \times 1.552$		
		$\boxed{P_A = 15.225 kN/m^2}$	01	
		OR	OR	
		$\frac{P_A}{\gamma_w} + (0.08 \times 1) - (0.12 \times 13.6) = 0$	02	
		$\frac{P_A}{\gamma_w} = 1.552 m$		04
		$P_A = 1.552 \times \gamma_w$	02	
		$\boxed{P_A = 15.225 kN/m^2}$		
	e)	**State four different types of flow of liquid with one practical example of each.**		
	Ans.	**Classification of fluid flow :-**		
		(1) Gravity Flow		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
2		(2) Pressure Flow (3) Steady and Unsteady Flow (4) Uniform and Non-uniform Flow (5) Laminar and Turbulent Flow (6) Rotational and Irrotational flow (7) Laminar and Turbulent Flow	½ mark each (any four)	
		Practical example: - **Steady flow –** Water flowing through a tap. **Unsteady flow –** Flow controlled by regulator. **Uniform flow –** Channel flow/canal flow having uniform c/s area. **Non uniform flow –** Flow in convergent &divergent section. **Laminar flow –** Flow of oil through a tube. **Turbulent flow –** River flood. **Rotational flow –** Tea in a cup. **Irrotational flow –** Giant wheel motion. **Gravity flow –** Flow through channel. **Pressure flow –** Pipe flow under pressure.	½ mark each (any four)	04
	f)	**A partition wall 3 m long divides storage tank. On a side there is turpentine of Sp. Gr. 0.87 upto a depth of 3.5 m. On the other side there is paraffin oil of Sp. Gr. 0.8 stored to a depth of 2.5 m. Determine resultant pressure on partition wall.**		
	Ans.	Pressure due to Turpentine $P_1 = \frac{1}{2} \times \gamma_L \times h_1 \times h_1$ $P_1 = \frac{1}{2} \times S_L \times \gamma_w \times h_1^{\ 2}$ $P_1 = \frac{1}{2} \times .87 \times 9.81 \times 3.5^2$	01	
		$\boxed{P_1 = 52.275 kN/m}$	01	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
2		 Pressure due to Paraffin oil $P_2=\frac{1}{2}\times\gamma_L\times h_2\times h_2$ $P_2=\frac{1}{2}\times S_L\times\gamma_w\times h_2^2$ $P_2=\frac{1}{2}\times.80\times9.81\times2.5^2$ $\boxed{P_2 = 24.525 kN/m}$ Resultant Pressure $P = P_1 - P_2$ $P = 52.275 - 24.525$ $\boxed{P = 27.75\ kN/m}$ And for 3 m lenght pressure will be $P = 3\times 27.75 = 83.25 kN$	 01 01	04

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
3.		**Solve any FOUR:**		**16**
	a)	**A differential U tube mercury manometer connected at two points P and Q on horizontal pipe carrying liquid of Sp. Gr.0.8. It shows a difference in mercury level as 15 cm. Find the difference in pressure at the two points in N/m².**		
	Ans.		01	
		$h_2 = 0.15m$ $\quad S_1 = S_3 = 0.8$ $h_3 = (h_1 - 0.15)m$ $\quad S_2 = 13.6$ Pressure in left limb = Pressure in right limb $h_P + h_1 S_1 = h_Q + h_2 S_2 + h_3 S_3$	01	
		$h_P - h_Q = 0.15 \times 13.6 + ((h_3 - h_1) \times S_1)$ $h_P - h_Q = 0.15 \times 13.6 + ((h_1 - 0.15 - h_1) \times S_1)$ $h_P - h_Q = 2.04 - 0.12$ $\boxed{h_P - h_Q = 1.92m}$	01	
		$P_P - P_Q = \gamma_L (h_P - h_Q)$ $P_P - P_Q = \gamma_w (h_P - h_Q)$ $P_P - P_Q = 9810 \times 1.92$ $\boxed{P_P - P_Q = 18.835 N/m^2}$	01	

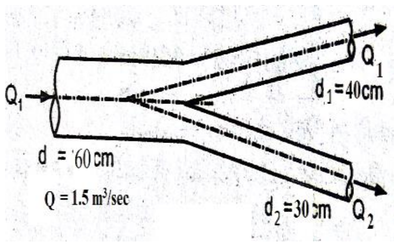
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
3	b)	**Two horizontal plates are placed 12.5 mm apart. The space between them being filled with oil of viscosity 14 poise. Calculate shear stress in oil if upper plate moves with velocity 2.5 m/sec.**		
	Ans.			
		$\delta_y = 12.5mm = 12.5\times10^{-3} m$ $Viscosity,\ \mu = 14\text{ Poise} = \frac{14}{10}$ $\mu = 1.4 N-S/m^2$	01	
		Lower plate fixed, $V_0 = 0$ Upper plate moveable , $V_1 = 2.5m/\sec$	01	
		Change in velocity, $\delta_v = V_1 - V_0 = 2.5m/\sec$ $\boxed{\delta_v = 2.5m/\sec}$	01	04
		By Newton's law viscosity, Shear stress $\tau = \mu.\frac{\partial v}{\partial y} = 1.4\times\frac{2.5}{12.5\times10^{-3}}$ $\boxed{\tau = 280\text{ N/m}^2}$	01	

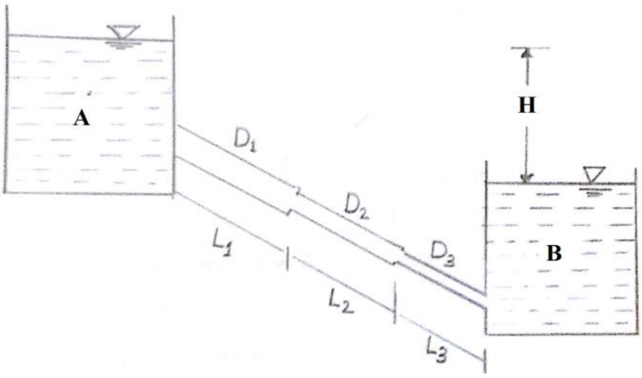
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
3	c)	**State Pascal's law and its practical applications.**		
	Ans.	**Pascal's Law:-** It states that the pressure intensity or pressure at a point in a static fluid is equal in all directions. 	02	
		Applications:- Pascal's Law is applied in the construction of machines used for multiple forces. a) Hydraulic Jacks b) Hydraulic Press c) Hydraulic Lifts d) Hydraulic Crane e) Braking system of motor f) Artesian well g) Dam	**½ mark each (any four)**	04
3	d)	**A liquid weigh 25 kN and occupies 3.75 m^3 find its specific weight, mass density, specific gravity and specific volume.**		
	Ans.	Weight of liquid $W = 25kN = 25\times10^3 N$ Volume of liquid $V = 3.75m^3$ 1. Specific weight $(\gamma_L) = \frac{\text{weight}}{\text{volume}}$		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
3		$\gamma_L = \frac{W}{V} = \frac{25\times10^3}{3.75}$		
		$\boxed{\gamma_L = 6666.66 N/m^3}$	01	
		2. Specific Gravity (S)= $\frac{\text{Sp.weight of liquid}}{\text{Sp.weight of pure water}}$		
		S= $\frac{V_L}{\gamma_w} = \frac{6666.66}{9810}$	01	
		$\boxed{S = 0.679}$		
		3. Specific Volume$(V_s) = \frac{\text{Volume}}{\text{Weight}}$		
		$V_s = \frac{1}{\gamma} = \frac{1}{6666.66}$		
		$\boxed{V_s = 1.5\times10^{-4} m^3/N}$	01 OR	04
		OR		
		$V_s = \frac{V}{W} = \frac{3.75}{25\times10^3}$	01	
		$\boxed{V_s = 1.5\times10^{-4} m^3/N}$		
		4. Mass density (ρ)		
		$\gamma = \rho\times g$		
		$6666.66 = \rho\times 9.81$	01	
		$\boxed{\rho = 679.577 kg/m^3}$		
	e)	**Explain Reynold's number with its equation and give significance.**		
	Ans.	The Reynolds number is defined as the ratio of inertia force to viscous force. Reynolds number is dimensionless number. It is used to determine the laminar or turbulent flow type.	02	
		$Re = \frac{\text{inertial force}}{\text{viscous force}} = \frac{F_i}{F_v}$	01	
		$Re = \frac{\rho V d}{\mu}$ OR $Re = \frac{V d}{\vartheta}$		04
		where, Re= Reynolds number ρ = Mass density of fluid in (kg/m^3)		

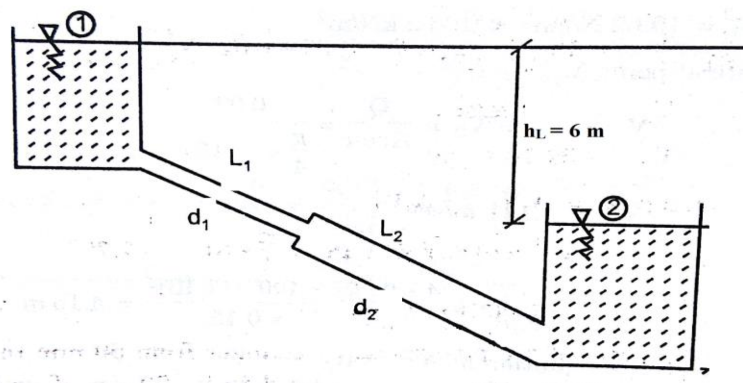
<table>
<tr><th>Que. No.</th><th>Sub. Que.</th><th>Model Answer</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>3</td><td></td><td>V = Velocity of flow in (m/sec)
d = Diameter of pipe in (m)
μ = Dynamic viscosity(N-s/m^3)
ϑ = Kinematic viscosity (m^3/s)

Significance for pipe flow,
If Re < 2000, Flow is laminar flow
If 2000 < Re < 4000, Flow is in transition state &
if Re > 4000, Flow is turbulent Flow</td><td>01</td><td></td></tr>
<tr><td></td><td>f)</td><td>Differentiate between Laminar flow and Turbulent flow.</td><td></td><td></td></tr>
<tr><td></td><td>Ans.</td><td>
<table>
<tr><th>Flow Laminar</th><th>Turbulent Flow</th></tr>
<tr><td>1. Each particle moves in a definite path and do not cross each other.</td><td>1. The fluid particle continuously mix and cross each other.</td></tr>
<tr><td>2. It occurs at low velocity of flow</td><td>2. It occurs at high velocity of flow.</td></tr>
<tr><td>3. This flow occurs in viscous fluids.</td><td>3. This flow occurs in fluid having very less viscosity.</td></tr>
<tr><td>4. Reynolds number is less than 2000.</td><td>4. Reynolds number is more than 4000.</td></tr>
<tr><td>5. Fluid particle move in layers with one layer over other.</td><td>5. Fluid particle moves in disorderly manner, they cross the path of each other.</td></tr>
<tr><td>6. e.g.
a) Blood flowing through veins.
b) Oil flowing through pipes.
c) Water flowing through tap at low velocities.</td><td>6. e.g.
a) Water flowing through river.
b) Flood flow</td></tr>
</table>
</td><td>1 mark each (any four)</td><td>04</td></tr>
</table>

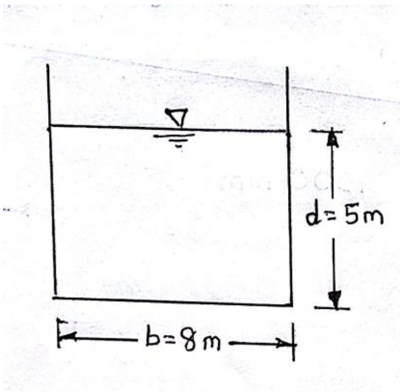
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
4		**Solve any FOUR :**		**16**
	a)	**A pipe line of 60 cm diameter bifurcates into two branches 40 cm and 30 cm diameter. If the rate of flow in main pipe is 1.5m³/sec. and velocity of flow in 30 cm diameter pipe is 7.5m/sec. Determine rate of flow in 40 cm diameter pipe.**		
	Ans.	Given: d = 60cm=0.6m $d_1 = 40cm = 0.4m$ $d_2 = 30cm = 0.3m$ $Q = 1.5m^3/\sec$ $V_2 = 7.5m/\sec$ $Q = Q_1 + Q_2$	01	
		By continuity equation Q=AV, $Q_1 = A_1V_1$, $Q_2 = A_2V_2$	01	
		$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(0.3)^2 = 0.0706m^2$  $Q_2 = A_2V_2 = 0.0706 \times 7.5$ $\boxed{Q_2 = 0.530m^3/sec}$	01	04
		$Q = Q_1 + Q_2$ $Q_1 = Q - Q_2$ $Q_1 = 1.5 - 0.530$ $\boxed{Q_1 = 0.97m^3/sec}$	01	
	b)	**A compound pipe having following sections, 45 cm diameter for 1000m, 30 cm dia. for 750m and 15 cm dia. for 500m is required to replace by a pipe of uniform diameter. Find the diameter of new pipe assuming length to remain the same. Also determine the discharge through the pipe. Take f = 0.01 and pressure head at inlet is 45m of water while at the delivery end is 5m of water.**		
	Ans.	D_1= 45cm=0.45m D_2=30cm=0.3m D_2=15cm=0.15m		

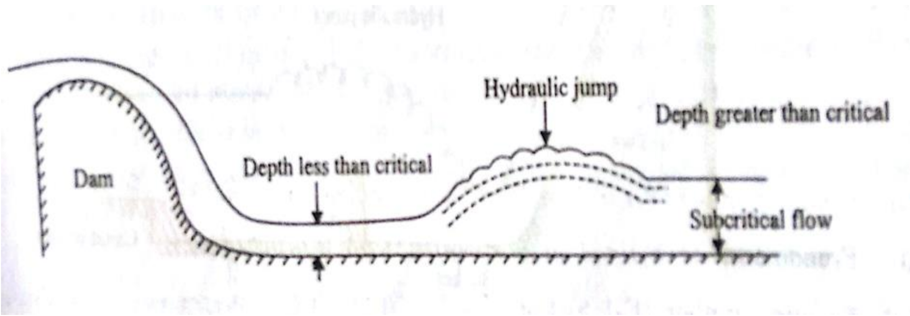
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
4		 L_1=1000m L_2=750m L_3=500m Total Length $L = L_1 + L_2 + L_3$ L = 1000+750+500 L = 2250m By Dupit's equation Equivalent diameter of pipe $\frac{L}{D^5} = \frac{L_1}{D_1^5} + \frac{L_2}{D_2^5} + \frac{L_3}{D_3^5}$ $\frac{2250}{D^5} = \frac{1000}{(0.45)^5} + \frac{750}{(0.30)^5} + \frac{500}{(0.15)^5}$ $\frac{2250}{D^5} = 54192.28 + 308641.97 + 6584362.14$ $\frac{2250}{D^5} = 6.947 \times 10^6$ $D^5 = \frac{2250}{6.947 \times 10^6}$ $D = 0.2m$ .....Diameter of new pipe The pressure head loss from inlet of pipe to delivary end = Pressure at inlet - pressure of delivary $h_f = 45 - 5 = 40m$ *Neglect* minor losses *By* Darcy modified equation $h_f = \frac{f\ L\ Q^2}{12.1\ D^5}$	½ 01 01 ½	 04

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
4		$40 = \frac{0.01 \times 2250 \times Q^2}{12.1 \times (0.2)^5}$ $Q^2 = 0.0829 m^3/\sec$ $\boxed{Q = 0.0829 m^3/\sec}$ Dicharge through pipe Q is $0.0829 m^3/sec$	**01**	
	c)	**Define friction factor and state any four factors affecting friction factor.**		
	Ans.	Friction factor: A dimension less quantity depends upon the roughness inside the pipe, viscosity of liquid flowing throw pipes which affects head loss is known as friction factor.	**02**	
		Factors affecting friction factor: 1. Nature of surface of pipe material. 2. Pipe diameter 3. Length of pipeline 4. Head loss 5. Square of the velocity of flow.	**½ mark each (any four)**	**04**
	d)	**What are the component parts of centrifugal pump? Explain the function of each part.**		
	Ans.	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	**02**	
		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.		**04**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
4		**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.	**02**	
		4. Delivery pipe: A pipe whose on end is connected to the outlet of the pump and other delivers the water at the required height is known as delivery pipe.		
	e)	**Two reservoirs are connected by a pipe line consisting of two pipes one of 15 cm. diameter and length 6m and other of 22.5 cm. diameter and 16 meter length. If the difference of water level in two reservoirs is 6 m. Calculate discharge.**		
	Ans.	Given- h_L =6m d_1=15cm=0.15m d_2=22.5cm=0.225m L_1=6m L_2=16m ***Assuming value of friction factor = 0.01*** 		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
4		Q= discharge flowing through pipe Total head loss = Entrance loss + Friction loss + Sudden expansion loss + Friction loss +Exit loss	**01**	
		By continuity equation, $A_1V_1 = A_2V_2$ $\frac{\pi}{4}d_1^2V_1 = \frac{\pi}{4}d_2^2V_2$ $V_1 = \frac{d_2^2}{d_1^2} \times V_2$ $V_1 = \frac{0.225^2}{0.15^2} \times V_2$ $V_1 = 2.25V_2$ $Now, h_l = \frac{0.5V_1^2}{2g} + \frac{fL_1V_1^2}{2gd_1} + \frac{(V_1 - V_2)^2}{2g} + \frac{fL_2V_2^2}{2gd_2} + \frac{V_2^2}{2g}$		
		Assume friction factor f $= 0.01$ $6 = \frac{0.5V_1^2}{2\times 9.81} + \frac{0.01\times 6\times V_1^2}{2\times 9.81\times 0.15} + \frac{(2.75V_2 - V_2)^2}{2\times 9.81} + \frac{0.01\times 16\times V_2^2}{2\times 9.81\times 0.225} + \frac{V_2^2}{2\times 9.81}$ $6 = 0.025V_1^2 + 0.020V_1^2 + 0.0796V_2^2 + 0.0362V_2^2 + 0.0509V_2^2$ $6 = 0.045V_1^2 + 0.1667V_2^2$ $6 = 0.045(2.25V_2)^2 + 0.1667V_2^2$ $6 = 0.2278V_2^2 + 0.1667V_2^2$ $6 = 0.3945V_2^2$ $V_2^2 = 15.209$ $V_2 = 3.90 m/\sec$	**01**	**04**
		$V_1 = 2.25V_2$ $V_1 = 2.25\times 3.90$ $\boxed{V_1 = 8.775 m/\sec}$	**01**	
		Discharge, $Q = A_1V_1$ *Or* $Q = A_2V_2$ $Q = \frac{\pi}{4}d_1^2 \times V_1$ *Or* $Q = \frac{\pi}{4}d_2^2 \times V_2$ $Q = \frac{\pi}{4}0.15^2 \times 8.775$ *Or* $Q = \frac{\pi}{4}0.225^2 \times 3.90$ $\boxed{Q = 0.155 m^3/\sec}$ *Or* $\boxed{Q = 0.155 m^3/\sec}$ (***Note: Answer may vary assuming other value of friction factor. 'f'***)	**01**	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
4	f) Ans.	**Water is flowing through a rectangular channel of width 8m and bed slope 1 in 1000. Depth of flowing channel is 5m. Find the discharge through channel. Take C=50.**  Given- Rectangular channel Width, b = 8m Depth d = 5m C =50 Bed Slope S = $\frac{1}{1000}$ $By\ Chezy's\ formula = C\sqrt{RS}$ $Q = AC\sqrt{RS}$ Cross-section area of channel, $A = b \times d$ $A = 8 \times 5 = 40m^2$ Hydraulic mean depth R= $\frac{A}{P}$ $Perimeter P = b + 2d$ $R = \frac{A}{b+2d} = \frac{40}{8+2\times5} = \frac{40}{18}$ $R = 2.22m$ $Q = AC\sqrt{RS}$ $Q = 40 \times 50\sqrt{2.22 \times \frac{1}{1000}}$ $Q = 94.276m^3/\sec$ Discharge through channel, $\boxed{Q = 94.276m^3/\sec}$	 01 01 01 01	04

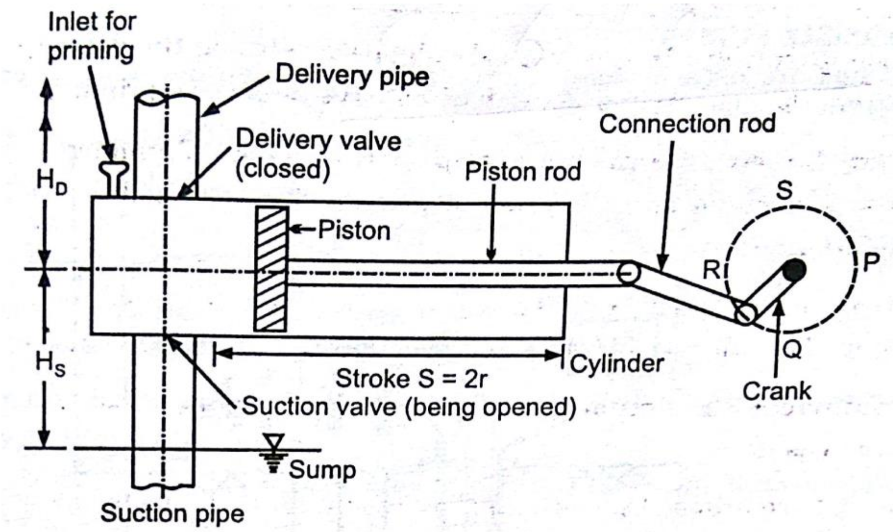
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
5.		**Solve any FOUR:**		**16**
	a)	**Explain the phenomenon of water hammer.**		
	Ans.	When the water flowing in a long pipe is suddenly brought to rest by closing the valve, there will be a sudden rise in pressure due to the momentum of the moving water being destroyed. This causes a wave of high pressure to be transmitted along the pipe which creates noise known as water hammer .The rise in pressure in some cases may be so large that the pipe may even burst. Therefore it is essential to take into account this pressure rise in the design of pipes. The magnitude of pressure rise depends on the speed at which the valve is closed, velocity of flow, length of the pipe and elastic properties of the pipe material as well as flowing fluid.	**04**	**04**
	b)	**Explain with sketch, hydraulic jump. State its uses.**		
	Ans.	In an open channel when rapidly flowing stream abruptly changes to slowly flowing stream, a distinct rise or jump in the elevation of liquid surface takes place, this phenomenon is known as hydraulics jump. Or The hydraulics jump is defined as the sudden and turbulent passage of water from super-critical state to sub-critical state.	**01**	
			**01**	**04**
		Hydraulic jump forms on a horizontal floor of canal and downstream side of dam.		
		Uses:		
		(1) Energy dissipation below spillway. (2) Mixing of chemical. (3) Regaining head.	**1 mark each (any two)**	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
5	**c)**	**A rectangular notch 2.5m long is discharging water under a head of 22 cm. Find the discharge in lit/sec. over the notch. Take C_d=0.6**		
	Ans.	L = 2.5m h = 22cm = 0.22m C_d = 0.6 $Q = \frac{2}{3} \times C_d \times L \times \sqrt{(2g)} \times (h)^{\frac{3}{2}}$	**02**	**04**
		$= \frac{2}{3} \times 0.6 \times 2.5 \times \sqrt{(2 \times 9.81)} \times (0.22)^{\frac{3}{2}}$ $Q = 0.457\ m^3/s$	**01**	
		Q = 457 lit/s	**01**	
	d)	**Differentiate between open channel flow and pipe flow.**		
	Ans.	(see table below)	**1 mark each (any four)**	**04**

Open Channel	**Pipe Flow**
1. Flow is due to bed slope under effect of gravity.	1. Flow is due to difference in total head between two points.
2. It has top free surface.	2. It has no top free surface.
3. Flow is under atmospheric pressure.	3. Flow is under pressure.
4. Channels have falling gradients.	4. Gradient must be rise or fall. For rising gradients pumps are required.
5. Discharge is calculated by Manning's or Chezy's formula.	5. Discharge is calculated by Darcy-Weisbach equation.

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
5	e)	**Water discharge at the rate of 0.0982m³/sec. through 12 cm diameter vertical sharp edged orifice placed under a constant head of 10m. A point on the jet measured from vena contract of the jet has co-ordinates 4.5m horizontal and 0.54m vertical. Find the coefficients C_e, C_d and C_v of orifice.**		
	Ans.	Given $Q_a = 0.0982 m^3/s$ d = 12cm = 0.12m h = 10 m x = 4.5m y = 0.54m Solution:- $A = \frac{\pi}{4} \times d^2$ $= \frac{\pi}{4} \times (0.12)^2$ $\boxed{A = 11.30 \times 10^{-3} m^2}$	01	
		$C_d = \frac{Q_a}{Q_t}$ $= \frac{0.0982}{A \times \sqrt{(2gh)}}$ $= \frac{0.0982}{(11.3 \times 10^{-3} \times \sqrt{(2 \times 9.81 \times 10)})}$ $\boxed{C_d = 0.62}$	01	
		$C_v = \frac{x}{\sqrt{(4hy)}}$ $= \frac{4.5}{\sqrt{(4 \times 10 \times 0.54)}}$ $\boxed{C_v = 0.968}$	01	04
		$C_d = C_c \times C_v$ $C_c = \frac{C_d}{C_v} = \frac{0.62}{0.968}$ $\boxed{C_c = 0.640}$	01	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
5	**f)**	**Find the discharge over the triangular notch of an angle of 60^0 when the head over the notch is 20 cm. Take C_d=0.625.**		
	Ans.	Type of notch triangular Angle of notch, $\theta = 60^0$ Head over notch, H = 20 cm = 0.20 m Coefficient of discharge = C_d = 0.625 Discharge, Q =? For triangular notch discharge can be calculated by using formula,		
		$Q = \frac{8}{15} C_d \cdot \sqrt{2g} \tan\frac{\theta}{2} \times H^{5/2}$	**02**	
		$Q = \frac{8}{15} \times 0.625 \times \sqrt{2 \times 9.81} \times \tan\left(\frac{60}{2}\right) \times (0.20)^{5/2}$		**04**
		$Q = 0.01525\ m^3/sec$ Discharge over triangular notch = $0.01525\ m^3/sec$	**02**	
6		**Attempt any TWO:**		**16**
	a)	**A trapezoidal channel of most economical section has side slope 1.5 horizontal to 1.0 vertical. It is required to discharge 16 m^3/sec. with bed slope 0.5 meter in 3.2 km. Design the section using Manning's formula. Take N=0.015.**		
	Ans.	Given:- $Q = 16\ m^3/sec$ $\text{Bed slope}(S) = \frac{0.5}{3200} = \frac{1}{6400}$		
		$n = \frac{1.5}{1} = 1.5$ $\text{Manning's constant}(N) = 0.015$	**01**	
		Most economical condition for trapezoidal section having following condition i) $R = \frac{d}{2}$ ii) $\frac{(b+2nd)}{2} = d\sqrt{(1+n^2)}$	**01**	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
6		$\frac{(b+2nd)}{2} = d \times \sqrt{(1+n^2)}$		
		$b+(2\times1.5\times d) = 2\times d\sqrt{(1+1.5^2)}$		
		$b+3d = 3.606\ d$		
		$\boxed{b = 0.606d}$	01	08
		Manning formula		
		$Q = \frac{A}{N}\times(R)^{\frac{2}{3}}\times(S)^{\frac{1}{2}}$	01	
		$A = bd+nd^2$		
		$= (0.606d)\times d + 1.5d^2$		
		$\boxed{A = 2.106\ d^2}$	01	
		$16 = \frac{(2.106\ d^2)}{0.015}\times\left(\frac{d}{2}\right)^{\frac{2}{3}}\times\left(\frac{1}{6400}\right)^{\frac{1}{2}}$	01	
		$16 = 140.4\times d^2\times0.6299\times d^{\frac{2}{3}}\times0.0125$		
		$(d)^{\frac{8}{3}} = 14.47$		
		$\boxed{d = 2.72\ m}$	01	
		$b = 0.606\times2.72$		
		$\boxed{b = 1.648\ m}$	01	
	b)	**Draw a neat sketch of Reciprocating pump showing its various component parts. Mention function of each component.**		
	Ans.		04	
		(Note: - Two marks for Sketch and Two marks for labeling.)		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		***(Note: If the sketch of double acting reciprocating pump is drawn, it should be considered.)***		
		Component part and its function:-		**08**
		1) Cylinder 2) Connecting rod 3) Delivery pipe 4) Delivery valve 5) Suction pipe 6) Rotating Crank		
		1) **Cylinder: -**To guide movement of piston and create negative and positive pressure. 2) **Section pipe: -**To connect source of water and the cylinder. 3) **Delivery pipe: -**To receive water from cylinder and discharge it at outlet. 4) **Delivery Valve: -**To admits flow from the suction pipe into the cylinder and from cylinder into delivery pipe. 5) **Rotating crank: -**To give linear displacement to connecting rod. 6) **Connecting rod: -**To connects the piston and the rotating crank.	**01 mark each (any four)**	
	c)	**A venturimeter 150 x 75 mm placed vertically with the throat 22.5 mm above the inlet conveys oil of sp. Gr. 0.78 at 29 lit/sec. Calculate the difference of pressure between inlet and throat. Take C_d = 0.96.**		
	Ans.	Given:- $d_1 = 150mm = 0.15m$ $d_2 = 75mm = 0.075m$ $Z_1 = 0$ $Z_2 = 22.5mm = 0.0225m$ Specific gravity (S) = 0.78 Q = 29 lit/s $= 0.029m^3/s$	**01**	
		$a_1 = \frac{\pi}{4}\times d_1^2 = \frac{\pi}{4}\times(0.15)^2 = 0.01767m^2$	**01**	**08**
		$a_2 = \frac{\pi}{4}\times(0.075)^2 = 4.418\times10^{-3}m^2$	**01**	
		$Q = Cd\times\frac{\left(a_1\times a_2\times\sqrt{2gh}\right)}{\sqrt{\left(a_1^2 - a_2^2\right)}}$	**01**	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
6	c)	$0.029 = 0.96\times\frac{\left(0.01767\times\left(4.418\times10^{-3}\right)\times\sqrt{\left(2\times9.81\times h\right)}\right)}{\sqrt{\left(\left(0.01767\right)^2-\left(4.418\times10^{-3}\right)^2\right)}}$	01	
	Ans.	$0.029 = \frac{\left(7.494\times10^{-5}\times\sqrt{\left(2\times9.81\times h\right)}\right)}{\sqrt{\left(2.93\times10^{-4}\right)}}$		
		$0.029\times0.0171 = 7.494\times10^{-5}\sqrt{\left(2\times9.81\times h\right)}$		
		$6.6172 = \sqrt{2\times9.81\times h}$		
		$\boxed{h = 2.2318m}$	01	
		Applying Bernouli's theorem at inlet and throat section,		
		$h = \left(\frac{P_1}{\gamma_L}+Z_1\right)-\left(\frac{P_2}{\gamma_L}+Z_2\right)$	01	
		$2.23 = \left(\frac{\left(P_1-P_2\right)}{\left(0.78\times9810\right)}-0.0225\right)$		
		$2.23+0.0225 = \frac{\left(P_1-P_2\right)}{0.78\times9810}$		
		$\boxed{P_1-P_2 = 17.25\times10^3\ N/m^2}$	01	
			OR	OR
		OR		
		Given data:		
		Diameter at inlet,		
		d_1 = 150 mm = 0.150 m		
		Diameter at throat,		
		d_2 =75 mm = 0.075 m		
		Coefficient of meter,		
		C_d = 0.96		
		Discharge,		
		Q = 29 lit/ sec = 29 $\times$ 10^{-3} m^3/sec	01	
		a_1= area at inlet of venturimeter,		
		$a_1=\frac{\pi}{4}\ d_1^2 = \frac{\pi}{4}\times(0.15)^2$	01	
		$\boxed{a_1 = 1.76\times10^{-2}\ m^2}$		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
6		a_2 = area at throat of venturimeter,		
		$a_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} \times (0.075)^2$		
		$\boxed{a_2 = 4.418 \times 10^{-3}\ m^2}$	**01**	
		Sp gr of oil = 0.78		
		Difference of elevations of the throat section and entrance section = 22.5 mm = 0.0225 m		
		We have continuity eqn.	**01**	
		Q = A V		
		Velocity of oil at entrance ,		
		$Q = A_1 \times V_1$		
		$29 \times 10^{-3} = 1.76 \times 10^{-2} \times V_1$		
		$\boxed{V_1 = 1.65 \text{ m/sec.}}$	**01**	**08**
		Similarly		
		$Q = A_2 \text{ x } V_2$		
		$29 \times 10^{-3} = 4.418 \times 10^{-3} \times V_2$		
		$\boxed{V_2 = 6.564 \text{ m/sec.}}$	**01**	
		Applying Bernoulli's theorem for entrance and the throat section,		
		$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2$	**01**	
		$\frac{P_1}{\gamma} + \frac{1.65^2}{2 \times 9.81} + 0 = \frac{P_2}{\gamma} + \frac{6.564^2}{2 \times 9.81} + 0.0225$		
		$\frac{P_1}{\gamma} - \frac{P_2}{\gamma} = 2.2225 - 0.139$		
		$\frac{P_1}{\gamma} - \frac{P_2}{\gamma} = 2.084$ m of oil		
		$\frac{P_1}{\gamma} - \frac{P_2}{\gamma} = 20.84$ cm of oil		
		$P_1 - P_2 = 15946.3512 N/m^2$		
		$\boxed{P_1 - P_2 = 15.946 kN/m^2}$	**01**	