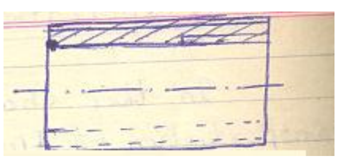
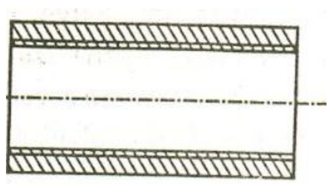
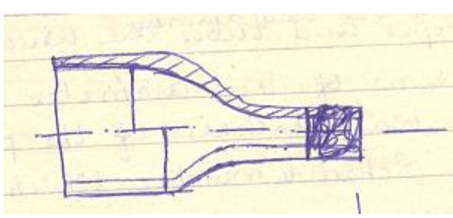
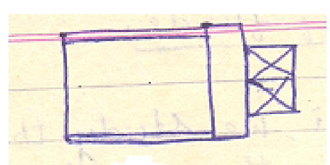
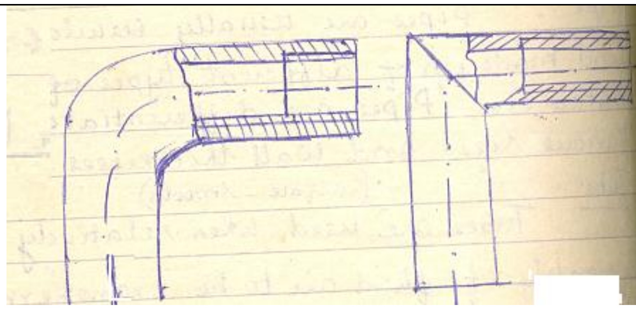
SUMMER-17 EXAMINATION

Model Answer

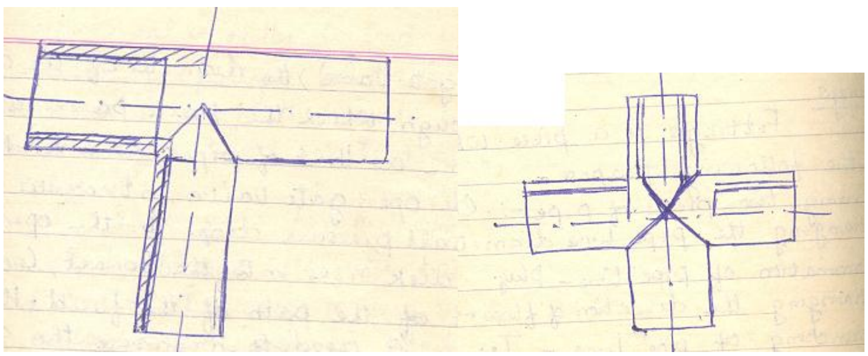
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q No.	Answer	Marks
1A	**Attempt any SIX of the following**	**12**
1A-a	**Absolute Viscosity:** Absolute viscosity or dynamic Viscosity is the property of the fluid by virtue of which it offers resistance to the movement of one layer of fluid over an adjacent layer.	1
	Kinematic viscosity It is the ratio of viscosity of the fluid to its density.	1
1A-b	NRe = 15000 Since NRe is greater than 4000, flow is turbulent	
	For turbulent flow: $f = 0.078/(N_{Re})^{0.25}$	1
	F= **7.048 *10^{-3}**	1
1A-c	**Diagram of pipe fittings**  Nipple  Socket  Reducer  Plug	½ mark each for any 4



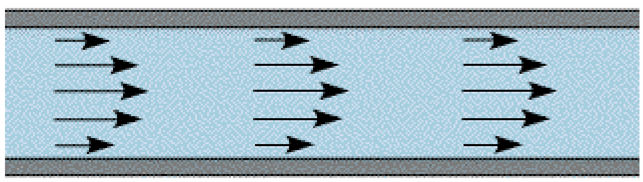
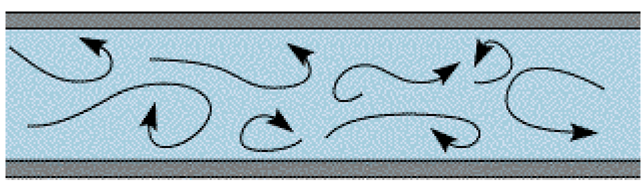
Bend Elbow

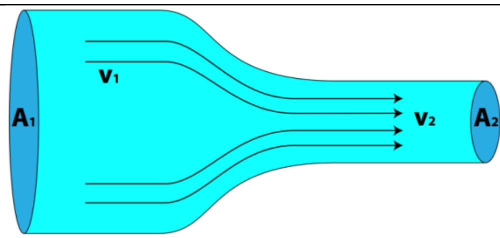


Tee Cross

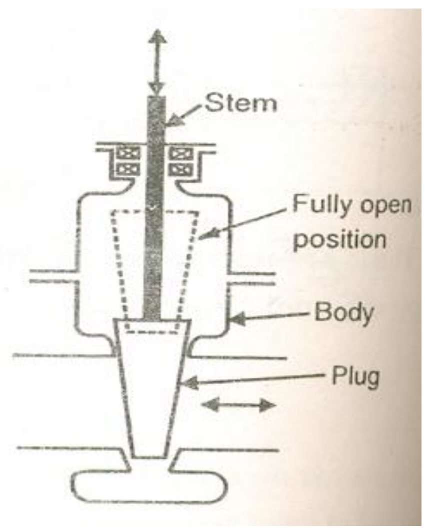
1A-d	**Significance of Reynold's Number** It is a dimension less number which indicates the nature of flow. It is the ratio of inertial force to viscous force.	2

1A-e	**Classification of pumps**
	Pumps
	- Positive displacement pump
	  - Reciprocating: Single acting, Double acting, Duplex, Triplex
	  - rotary: gear, lobe, screw
	- non positive
	  - centrifugal
	  - Regenerative
	- special pump
		2

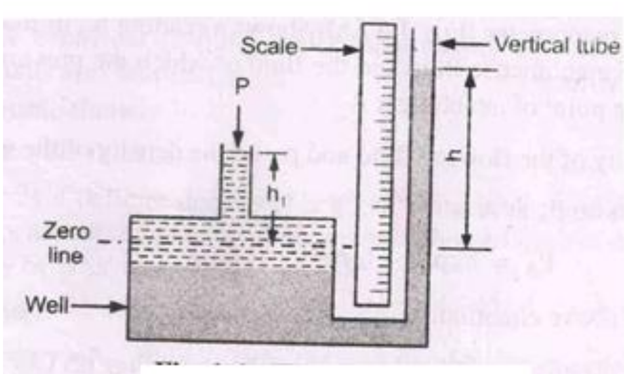
	diaphragm	
1A-f	**Laminar flow and turbulent flow:** Laminar flow:  In laminar flow, the fluid flows without any lateral mixing. Ie flow is in the form of parallel streams which do not mix with each other. Turbulent flow:  It is characterized by eddies and cross currents in random direction. The fluid layers overlap with each and there will be lateral mixing.	1 1
1A-g	**Vacuum:** Pressure below atmospheric pressure is known as vacuum.	2
1B	**Attempt any TWO of the following**	**8**
1B-a	**Derivation of equation of continuity:** Mass balance states that for a steady state flow system, the rate of mass entering the flow system is equal to that leaving the system provided accumulation is either constant or nil.	

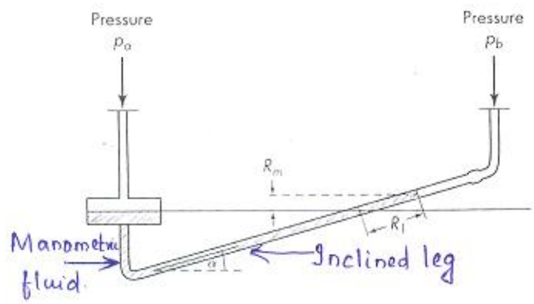
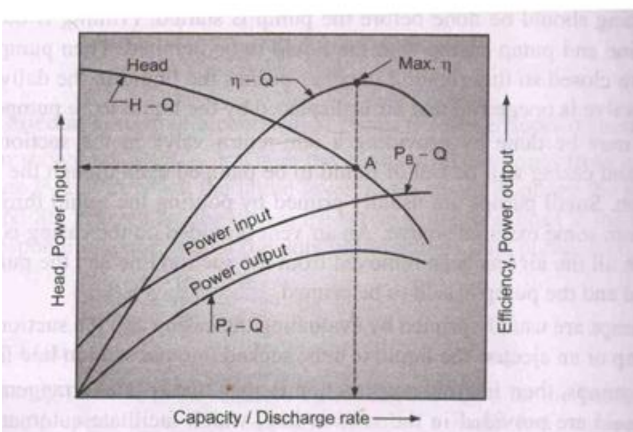
<table>
<tr><td></td><td>

Let v_1, ρ_1& A_1 be the avg. velocity, density& area at entrance of tube & v_2 , ρ_2& A_2 be the corresponding quantities at the exit of tube.
Let $\dot{m}$ be the mass flow rate
Rate of mass entering the flow system = $v_1 \rho_1 A_1$
Rate of mass leaving the flow system = $v_2 \rho_2 A_2$
Under steady flow conditions
$\dot{m} = \rho_1 v_1 A_1 = \rho_2 v_2 A_2$
$\dot{m} = \rho v A$ = constant .... **Equation of continuity**</td><td>2

2</td></tr>
<tr><td>1B-b</td><td>Diagram of Gate valve:

</td><td>4</td></tr>
<tr><td>1B-c</td><td>Difference between positive displacement pump and centrifugal pump</td><td></td></tr>
</table>

		Positive displacement pump	**Centrifugal pump**	1 mark each for any 4 points
	1) Mode of delivery	Pulsating	Continuous	
	2)Priming	Not required	Required	
	3)Efficiency	More	Less	
	4) Liquids with solids suspended	Cannot handle	Can handle	
	5) Construction	Complex	Simple	
	6) Discharge ratio	More	Less	
	7) Suitability	Higher head but low discharge	Smaller head but larger discharge	
	8) Floor area requirement	More	Less	
	9)Wear and tear	More	Less	
	10) Maintenance cost	More	Less	
	11) Speed	Cannot run at higher speed	Higher speed	
2	**Attempt any FOUR of the following**			**16**
2-a	**Well type manometer**			



	Inclined tube manometer 	2 2
2-b	**Characteristic curves of a centrifugal pump :**  The characteristics curve shows the relationship between discharge and the various parameters like head, power and efficiency. From the H-Q curve, it is clear that head increases continuously as the capacity is decreased. The head corresponding to zero or no discharge is known as the shut off head of the pump. From H-Q curve, it is possible to determine whether the pump will handle the necessary quantity of liquid against a desired head or not and the effect of increase or decrease of head. The η-Q curve shows the relationship between pump efficiency and capacity. It is clear from η-Q curve that efficiency	2 2

	rises rapidly with discharge at low discharge rate, reaches a maximum in the region of the rated capacity and then falls. The duty point ie the point where the H-Q curve cuts the ordinate through the point of maximum efficiency shows the optimum operating conditions. The P_B- Q curve gives us an idea regarding the size of motor required to operate the pump at the required conditions and whether or not motor will be overloaded under any other operating conditions.	
2-c	**Difference between Diaphragm valve & Ball valve:**	2 marks each

	Diaphragm Valve	Ball Valve
1. Pressure Drop	More	less
2.Application	Corrosive Liquids	Complete(shut-off)on /off service

2-d **Derivation of Hagen Poiseuille's Equation :**

As per Newton's law of viscosity $\mu = -\frac{\tau}{\frac{du}{dr}}$ …. (1)

The negative sign in the above equation is due to the fact that in a pipe velocity decreases with increase in radius.

Rearranging the eq.1

$$\frac{du}{dr} = -\frac{\tau}{\mu} \quad \ldots\ldots..(2\ )$$

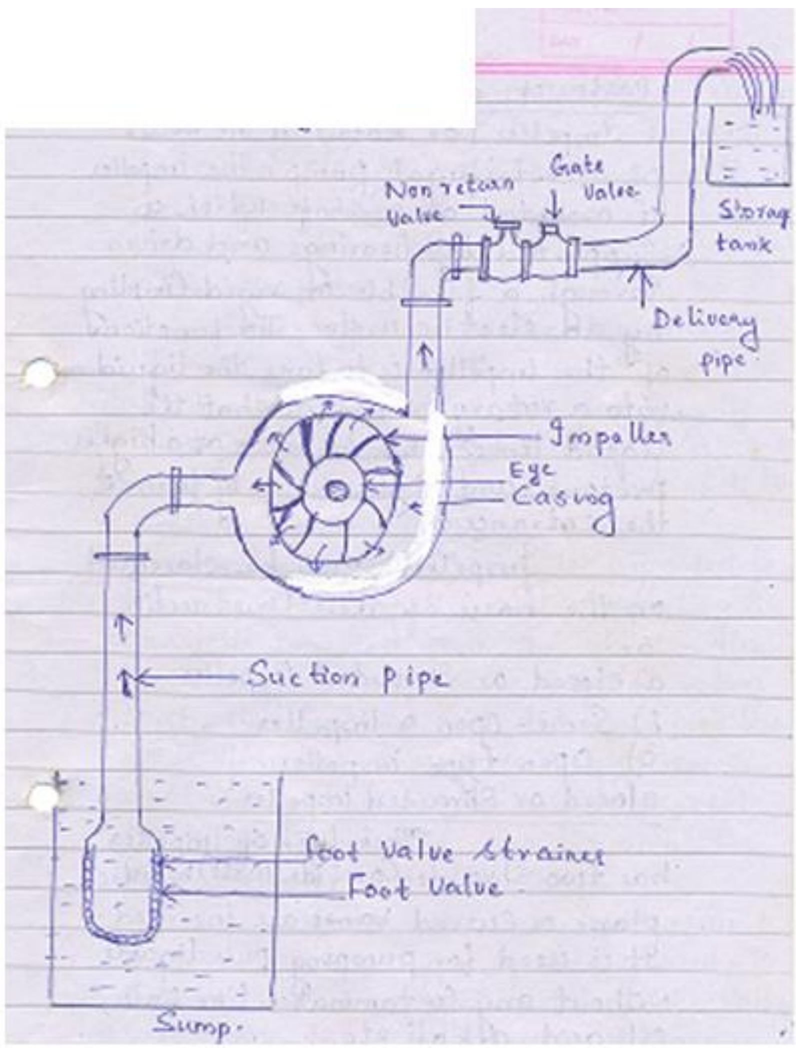
As the linear relation between shear stress (τ) and radius (r) is

$$\frac{\tau_w}{r_w} = \frac{\tau}{r}$$

Therefore $\tau = \frac{\tau_w}{r_w}.r \quad \ldots\ldots.(3)$

Substituting value of τ $from\ eq.3\ in\ eq.2,$

	$$\frac{du}{dr} = \frac{\tau_w}{r_w.\mu}.r$$ $$du = \frac{\tau_w}{r_w . \mu}.r.dr \qquad ......(4)$$ Integrating eq.4 with the boundary condition ,at r = $r_{w.}$: u = 0 we get $$\int_0^u d_u = -\frac{\tau_w}{r_w . \mu}\int_{r_w}^{r} r.dr$$ $$u = -\frac{\tau_w}{r_w.\mu}\left[\frac{r^2}{2}\right]_{r_w}^{r}$$ $$u = \frac{\tau_w}{2.r_w . \mu}[r_w^2 - r^2] \qquad .....(5)$$ At the center of the pipe : r = 0 $.u = u_{max.}$ $$u_{max.} = \frac{\tau_w r_w}{2.\mu} \qquad ......(6)$$ Substituting the value of shear stress as $\tau_w = \frac{\Delta P.r_w}{2\Delta L}$ in eq.6 $$u_{max.} = \frac{\Delta P.r_w^2}{4.\mu.\Delta L}$$ As D = r_w /2 $$u_{max.} = \frac{\Delta P.D^2}{16.\mu.\Delta L}$$ But average velocity v is 0.5 times the maximum velocity Therefore $\frac{v}{u_{max.}}$ = 0.5 $$v = \frac{\Delta P.D^2}{32.\mu.\Delta L} \qquad ......(7)$$ Equation 7 can be rearranged as $$\Delta P = \frac{32\ \Delta L\mu v}{D^2}$$	2

	ΔL *can be replaced as* L $$\Delta P = \frac{32\, L\, \mu\, v}{D^2} \quad \ldots..(8)$$ Equation(8) is called as Hagen Poiseuille's equation which is used for determining viscosity of a fluid by measuring the pressure drop and the volumetric flow rate of a tube of a given length and diameter.	2
2-e	**Construction of centrifugal pump** 	4

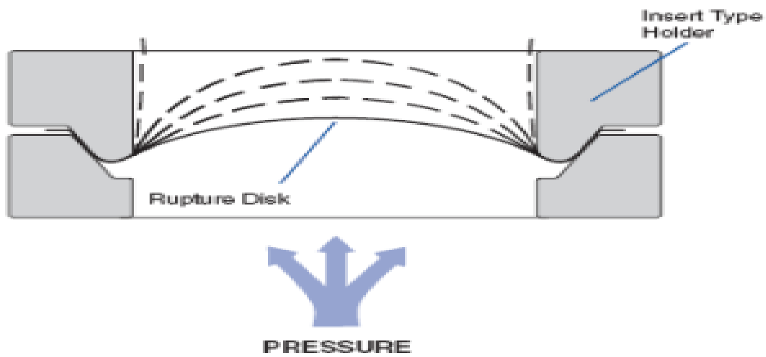
	The parts of a centrifugal pump are (i) Impeller: It is the heart of a centrifugal pump. It is mounted on a shaft. The function of impeller is to force the liquid in to a rotary motion so that the liquid leaves the impeller at a higher velocity than at the entrance. (ii) Casing: It is provided for housing the impeller and it has provision for connecting with the delivery and suction pipe lines. (iii) Suction pipe: It is a pipe whose upper end is connected with the pump on suction side and lower end is submerged in the liquid in the sump. The lower end is fitted with a foot valve and strainer. (iv) Delivery pipe: it connects the discharge end of the pump and supply end of the reservoir.	
2-f	**Significance of terms used in Bernoulli's equation.** $\frac{P}{\rho} + gZ + \frac{u^2}{2}$ = constant Where $\frac{P}{\rho}$ is the pressure energy in J /kg gZ is the potential energy in J /kg $\frac{u^2}{2}$ is the kinetic energy in J /kg. Pressure energy is the work that must be done in order to introduce the fluid into the system without change in volume. Potential energy is the work that must be done on the fluid in order to raise it to a certain position from some arbitrarily chosen datum level. Kinetic energy is the energy of the fluid by virtue of its motion with reference to some arbitrarily chosen body.	1 1 1 1
3	**Attempt any FOUR of the following**	16
3-a	**Newton's law of viscosity** Newton law of viscosity states that shear stress is proportional to shear rate and	

	the proportionality constant is the viscosity of the fluid Mathematical expression is $\frac{F}{A}=\mu\frac{dv}{dx}$ Where $\frac{F}{A}$ = Shear stress μ = viscosity $\frac{dv}{dx}$ = Shear rate. A fluid, which does not obey Newton's law of viscosity is known as Non-Newtonian Fluid.	2 2
3-b	**Industrial application of** **Blower:** 1. For combustion air supplies 2. On cooling and drying systems 3. For fluid bed aerators 4. With air conveyor systems, 5. For sewage aeration 6. Filter flushing 7. for moving gases of all kinds in the petrochemical industries **Compressor:** 1. Aerospace 2. Automotive 3. Chemical Manufacturing 4. Electronics 5. Food and Beverage 6. Glass Manufacturing 7. Mining 8. Pharmaceuticals 9. Plastics	½ mark each for any 4 ½ mark each for any 4

10. Power Generation
11. To power pneumatic tools like pneumatic drills and hammers on construction site

3-c **Rupture disc:**

Diagram:



(2)

Working

The ultimate safety device used in pressure vessel to avoid accident is rupture disc. Rupture disc, is a non-reclosing pressure relief device. A rupture disc is a one-time-use membrane. They can be used as single protection devices or as a backup device for a conventional safety valve; if the pressure increases and the safety valve fails to operate (or can't relieve enough pressure fast enough), the rupture disc will burst. Rupture discs are very often used in combination with safety relief valves, isolating the valves from the process, thereby saving on valve maintenance and creating a leak-tight pressure relief solution. The membrane is generally made up of metal.

(2)

3-d **Differentiate between variable head meter and variable area meter:**

(1 mark each for any 4 points)

	Variable head meter	Variable area meter
i. Area of flow	Constant with flow rate	Varies with flow rate
ii)Pressure drop	Varies with flow rate	Constant with flow

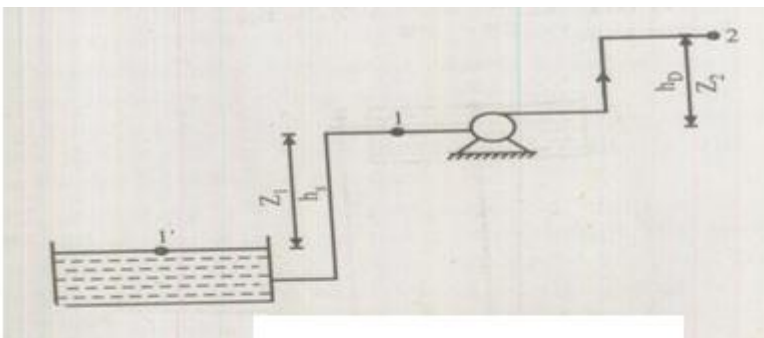
				rate		
		iii) Measurement of flow rate	Cannot give volumetric flow rate directly	Can give volumetric flow rate directly		
		iv) Cost	Cheap	Costly		
		v)Ease of handling	difficult	easy		
		vi) Requirement of straight pipe	Needs straight pipe before and after the meter	Does not need.		

3-e **Derivation for NPSH**.

NPSH stands for Net positive Suction Head. It is the amount by which the pressure (sum of velocity and pressure head) at the suction point of the pump is in excess of vapour pressure of the liquid.

$$NPSH = \frac{u_1^2}{2g} + \frac{P_1}{\rho g} - \frac{P_v}{\rho g} \ldots\ldots(1)$$

where Pv = vapour pressure of liquid at pumping temp.



2

The Bernoulli equation in terms of m of liquid between stations 1' & 1 is

$$\frac{P_1'}{\rho g} + \frac{u_1'^2}{2g} + Z_1' = \frac{P_1}{\rho g} + \frac{u_1^2}{2g} + Z_1 + h_{fs}$$

where h_{fs} = head loss due to friction in suction line

If $Z_1' = 0$ & $u_1' = 0$

$$\frac{P_1'}{\rho g} = \frac{P_1}{\rho g} + \frac{u_1^2}{2g} + Z_1 + h_{fs}$$

Rearranging we get

$\frac{P_1}{\rho g} + \frac{u_1^2}{2g} = \frac{P_1'}{\rho g} - Z_1 - h_{fs}$…..(2)

Comparing (1) and (2)

$$NPSH + \frac{P_v}{\rho g} = \frac{P_1'}{\rho g} - Z_1 - h_{fs}$$

$$NPSH = \frac{P_1'}{\rho g} - \frac{P_v}{\rho g} - Z_1 - h_{fs}$$

Where,

Z_1 = height of pump from the level of liquid in the tank

P_1'= Pressure at the liquid surface in the tank.

P_v = Vapour pressure of liquid

h_{fs} =Head loss due to friction on suction side.

Marks: 2

3-f **Distinguish between Newtonian and non-Newtonian fluids** (2 marks each for any two points)

Newtonian fluids	Non-Newtonian fluids
1. Fluids which obey Newton's law of viscosity	Fluids which do not obey Newton's law of viscosity
2. Plot of shear stress vs shear rate or velocity gradient gives a straight line	Plot of shear stress vs shear rate or velocity gradient does not give a straight line
3. τ =μ du / dr	τ # μ du / dr

4 **Attempt any FOUR of the following** — 16

4-a

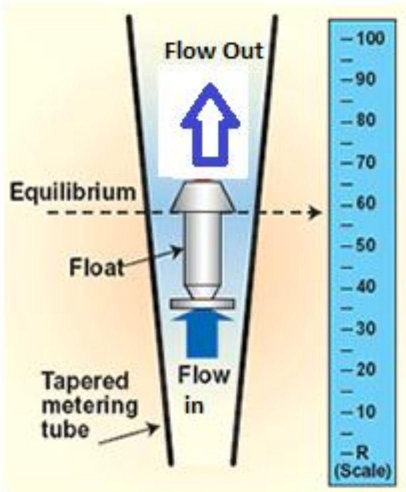
$\Delta hm = 175 * 10^{-3}$ m of Hg

$\rho m = \rho\ Hg = 13600\ Kg / m^3$

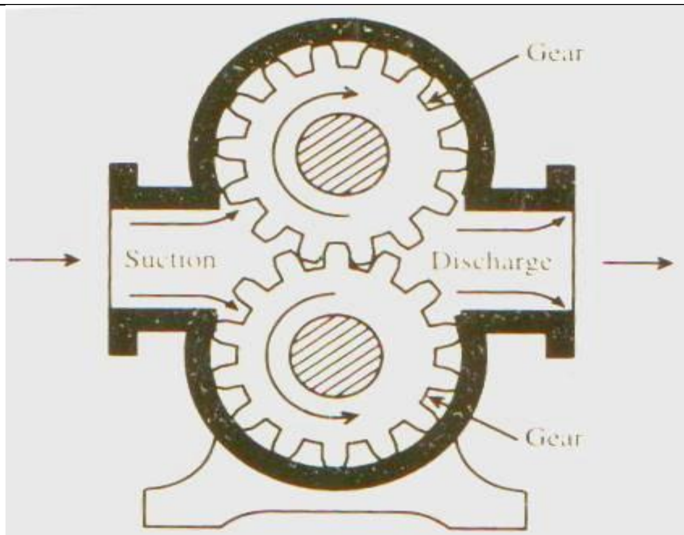
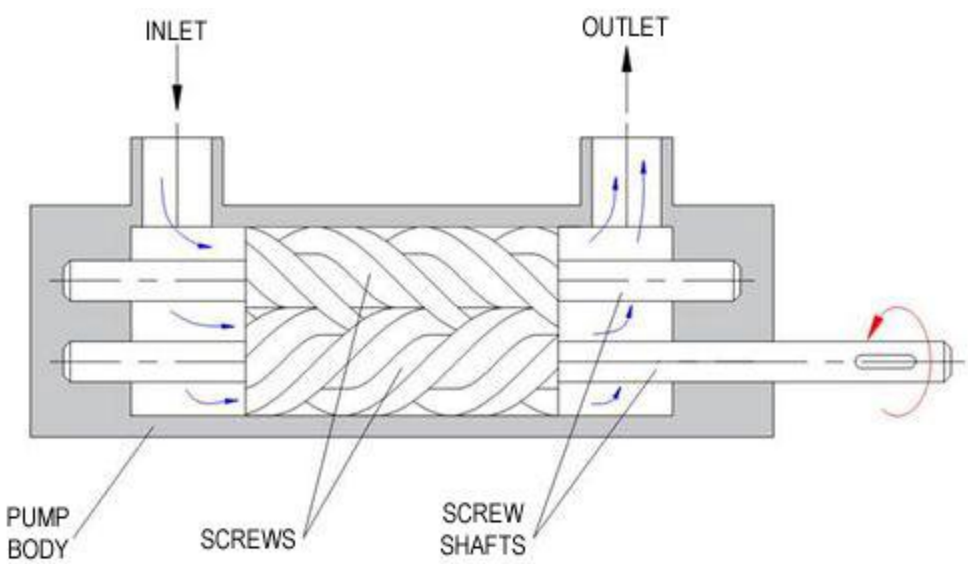
$\rho f = \rho\ CCl_4 = 1600\ Kg / m^3$

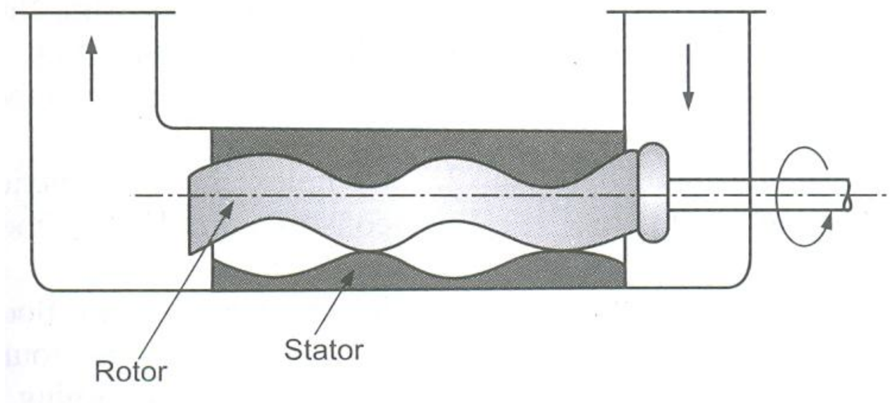
$\Delta P = \Delta hm (\rho m - \rho f) g = 175 * 10^{-3}(13600-1600) * 9.81 =$ $\mathbf{20601\ N/m^2}$.

4-b **Diagram of rotameter**

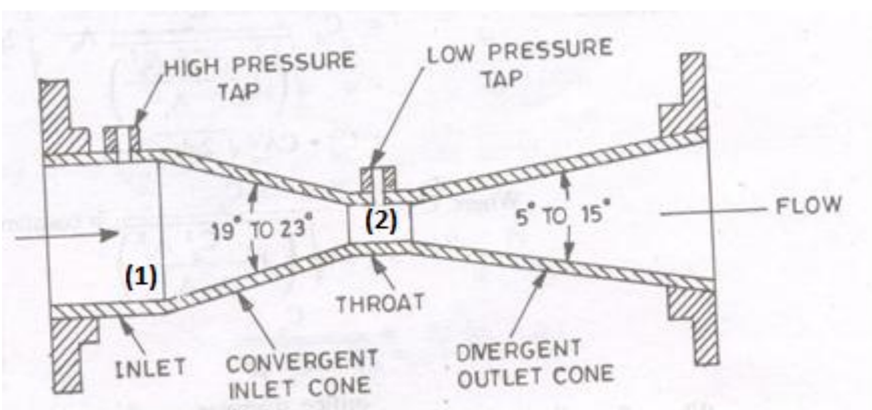
	 	2
	Construction : It consists of a tapered glass tube mounted vertically with smaller end on the lower side. A float is installed in the tube after the meter is mounted in the flow line. Floats are usually made of corrosion resistant metals like aluminium, bronze, Monel, nickel etc. Flow scale is marked on the glass tube. Rotameter is installed in the pipeline by means of flanges or threads along with the inlet and outlet piping supported in bracket.	1
	Working: Fluid is allowed to flow through the rotameter. The entire fluid stream passes through the annular space between the float and the tube wall. The reading of the meter is obtained from the scale reading at the reading edge of the float, which is taken as the largest cross section of the float. Greater the flow rate, higher the float rides in the tube.	1
4-c	**Friction loss due to sudden contraction:** The frictional loss due to sudden contraction is proportional to velocity head of the fluid in the small diameter pipe.	

	$h_{fc} = K_c \frac{V_2{}^2}{2g}$ $K_c = 0.4\left(1 - \frac{A_2}{A_1}\right)$ Where h_{fc} is the head loss due to sudden contraction. A_1- area of larger pipe . A_2- area of smaller pipe . V_2- velocity of fluid in the small diameter pipe.	2 2
4-d	**Specific application of** **Tee:** For branching the pipe line in 3 directions **Elbow:** Changing direction of flow. **Cross** : For branching the pipe line in 4 directions **Plug:** Termination of pipe line.	1 mark each
4-e	**Air Binding** : The pressure developed by the pump impeller is proportional to the density of fluid in the impeller. If air enters the impeller, the pressure developed is reduced by a factor equal to the ratio of the density of air to the density of liquid. Hence, for all practical purposes the pump is not capable to force the liquid through the delivery pipe. This is called Air binding **Priming:** Removal of air from the suction line and pump casing and filling it with the liquid to be pumped is called priming. It is done by providing a non-return valve in the suction line so that suction line and pump casing will be filled with the liquid to be pumped when the pump is in shut down condition. If the non-return valve is not functioning, priming has to be done from an external source.	2 2
4-f	**Gear Pump:** **Diagram:**	

		2
	Screw pump  Or	2



5	**Attempt any TWO of the following**	16
5-a	**Derivation for calculating volumetric flow rate using venturimeter:**	



Let P_1 ,P_2 & u_1 & u_2 be the pressures &velocities at section 1 & 2 respectively.

Let A_1 & A_T be the flow areas at section 1 & 2 respectively.

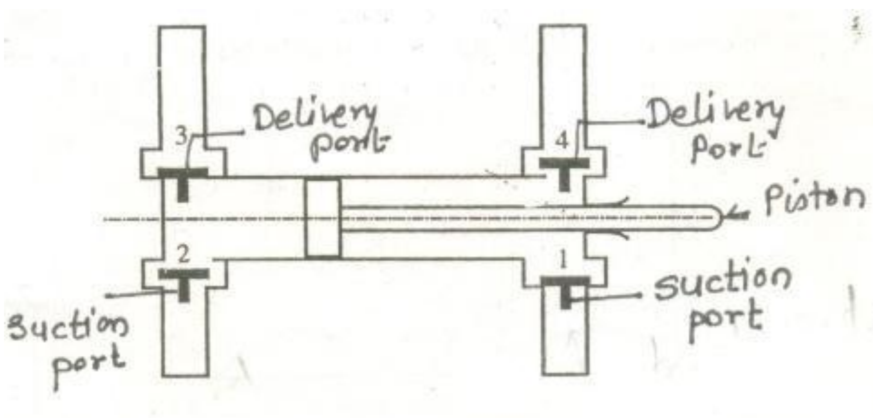
Section 1 is at the pipe & section 2 is at the throat.

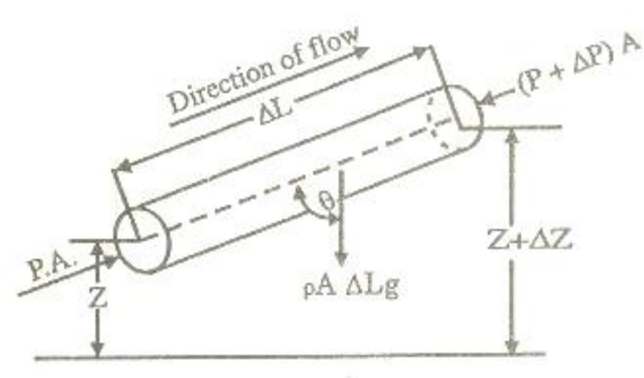
Let the fluid be incompressible & no frictional losses between station 1 &2 . 2

Applying the Bernoulli equation between the shown stations (1) and (2) along

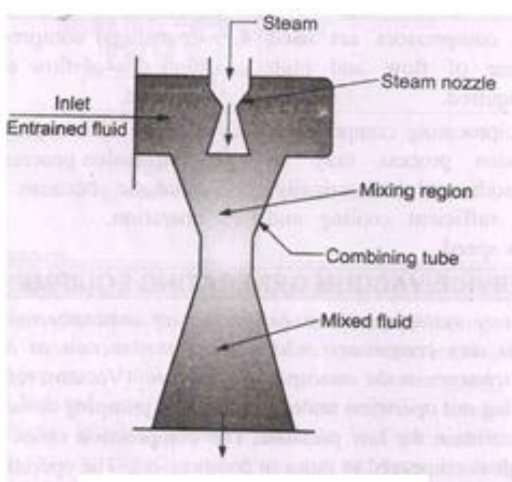
	the center we get: $$\frac{P_1}{\rho}+\frac{\alpha_1 . u_1^2}{2}+gZ_1 = \frac{P_2}{\rho}+\frac{\alpha_2 . u_2^2}{2}+gZ_2$$ The venturimerer is connected in a horizontal pipe ,so $Z_1 = Z_2$ $$\frac{P_1}{\rho}+\frac{\alpha_1 . u_1^2}{2}=\frac{P_2}{\rho}+\frac{\alpha_2 . u_2^2}{2} \quad \dots\dots \quad eq1$$ From equation of continuity $$\dot{m} = \rho u_1 A_1 = \rho u_2 A_2$$ Where $A_1 = \pi/_4 \; D^2$ & $A_T = \pi/_4 \; D_T^2$ D & D_T are the diameter of pipe & throat . $$u_{1(\pi/_4 . D^2)} = u_{2(\pi/_4 . D_T^2)}$$ Let $\frac{D_T}{D} = \beta$ $u_1 = \beta^2 u_2$ ………… eq2 Putting value of u_1 from eq 2 in eq 1, we get $$\frac{P_1}{\rho}+\frac{\alpha_1 . (\beta^2 u_2)^2}{2}=\frac{P_2}{\rho}+\frac{\alpha_2 . u_2^2}{2}$$ Rearranging we get $$\frac{\alpha_2 u_2^2}{2}-\frac{\alpha_1 \beta^4 u_2^2}{2} = \frac{P_1 - P_2}{\rho}$$ $$\alpha_2 u_2^2 - \alpha_1 \beta^4 u_2^2 = \frac{2(P_1 - P_2)}{2}$$ $$\alpha_1\left[\frac{\alpha_2}{\alpha_1}u_2^2 - \beta^4 u_2^2\right] = \frac{2(P_1 - P_2)}{\rho}$$ As $\frac{\alpha_2}{\alpha_1} = 1$ $$\alpha_{1[u_2^2 - \beta^4 u_2^2]} = 2\left(\frac{P_1 - P_2}{\rho}\right)$$ $$u_2 = \left[\frac{2(P_1-P_2)}{\rho} * \frac{1}{\alpha(1-\beta^4)}\right]^{1/2} \dots\dots\dots\dots \text{ eq 3}$$	3

	The above equation is corrected by introducing an empirical factor Cv & writing $u_2 = Cv\left[\frac{2(P_1-P_2)}{\rho} * \frac{1}{\alpha(1-\beta^4)}\right]^{1/2}$ eq3 Cv = Coefficient of venturimeter & it takes into account the error introduced by assuming no frictional losses & As $\frac{\alpha_2}{\alpha_1} = 1$ & $\alpha_1 = 1$ Volumetric flow rate Q is given by $Q = u_2 A_T$ …….. eq4 From eq3 & eq4 $Q = A_T\, Cv\left[\frac{2(P_1-P_2)}{\rho} * \frac{1}{(1-\beta^4)}\right]^{1/2}$ $Q = \frac{C_v A_T}{\sqrt{(1-\beta^4)}}\sqrt{\frac{2(P_1-P_2)}{\rho}}$ Q = Actual discharge If pressure is measured by U-tube manometer, then discharge is calculated as $Q = \frac{C_v A_T}{\sqrt{(1-\beta^4)}}\sqrt{2g\Delta H}$ Where $\Delta H = \Delta h(\frac{\rho_M-\rho}{\rho})$ ΔH = Difference in head across venture in terms of meters of flowing fluid. Δh= Difference in head across venture in terms of meters of manometric fluid	3
5-b	L= 100m D =50mm = 0.05m Density ρ =1050 kg/m^3 Kinematic Viscosity = μ / ρ = 2.35*10^{-6} m^2 / S Volumetric flow rate Q = 1.5m^3 / min = 0.025m^3 / S Area A= $\frac{\pi D^2}{4} = \frac{3.14*0.05^2}{4}$ = 1.9625*10^{-3} m^2 Velocity V = $\frac{Q}{A}$ = 0.025 / 1.9625*10^{-3} = 12.738 m / S	3

	$NRe = \frac{DV\rho}{\mu}$ = 0.05 *12.738 / (2.35*10^{-6}) = 271021 Since NRe > 4000, flow is turbulent f =0.078 / $NRe^{0.25}$ = 0.078 / $271021^{0.25}$ = 3.418 *10^{-3} h_{fs} = 4flV^2 / 2D = 4*3.418 *10^{-3} *100* 12.738^2 / (2*0.05) = 2218.37 J / Kg ΔP = h_{fs} *ρ = 2218.37*1050 = **2329288.5 Pa = 2329.288 KPa**	3 2
5-c	**Double acting reciprocating pump:** **Diagram**  **Working:** Reciprocating pump consists of a piston or plunger which reciprocates in stationary cylinder. Suppose the piston is initially at extreme left position and when crank rotates through 180 ^{0} , piston moves to extreme right position. Therefore due to outward movement of piston, a partial vacuum is created in cylinder, which enables the atmospheric pressure acting on the liquid surface in the sump below to force the liquid up the suction pipe & fill the cylinder by forcibly opening the suction valve(it is called as a suction stroke).When the crank rotates thro further 180 ^{0} ,piston moves inwardly from its extreme right position towards left. The inward movement of piston causes the pressure of liquid in the cylinder to rise above atmospheric pressure, because of which the	3 5

	suction valve closes & delivery valve opens, the liquid is then forced up the delivery valve & raised to the required height.(Delivery stroke) . In case of double acting pump, the liquid is in contact with both the sides of a piston or plunger. This pump has two suction valves & two delivery valves. During each stroke ,the suction takes place on one side of piston & other side delivers the liquid .The liquid is drawn into the pump & discharged from the pump during backward & as well as forward stroke. In the backward stroke , the liquid is drawn into the pump through the suction port (1) & liquid is discharged through the delivery port(3) & in the forward stroke, the liquid is drawn into the pump thro suction port (2) and liquid is discharged thro the delivery port (4) .So in case of double acting pump in one complete revolution of the crank there are two suction strokes & two delivery strokes.	
6	**Attempt any TWO of the following**	16
6-a	**Derivation of Bernoulli's equation:** Statement:" For steady, irrotational flow of an incompressible fluid ,the sum of pressure energy, kinetic energy & potential energy at any point is constant". Bernoulli theorem is derived on the basis of Newton's Second law of motion.(Force = Rate of change of momentum.)  Let us consider an element of length ΔL of a stream tube of	

	constant cross sectional area as shown above. Let us assume that cross-sectional area of element be A & the density of the fluid be ρ. Let u & P be the velocity & pressure at the entrance & (u + Δu), (P +Δ P) are the corresponding quantities at the exit. The forces acting on the element are 1) The force from upstream pressure = P.A (acting in the direction of flow) 2) The force from downstream pressure normal to the cross-section of the tube = (P +Δ P).A(in opposite direction of flow) 3) The force from the weight of fluid (gravitational force acting downward) = ρ.A.ΔL.g The component of this force acting opposite to direction of flow = ρ.A.ΔL.gcosθ The rate of change of momentum of the fluid along the fluid element = $\dot{m}$ [u + Δu – u] = $\dot{m}$Δu As mass flow rate= $\dot{m}$ = ρ. uA . Δu According to Newton's Second law of motion {sum of forces acting in the direction of flow} = {rate of change of momentum of a fluid} P.A - (P +Δ P).A - ρ.A.ΔL.gcosθ = ρ. uA . Δu -Δ P.A - ρ.A.ΔL.gcosθ = ρ. uA . Δu Δ P.A + ρ.A.ΔL.gcosθ + ρ. uA . Δu = 0 Eq.I Dividing each term of eq.I by A.ΔL. ρ we get $$\frac{\Delta P}{\rho \Delta L} + g.cos\theta + \frac{u.\Delta u}{\Delta L} = 0$$ As cosθ = $\frac{\Delta Z}{\Delta L}$,we can write	3 4

	$$\frac{1}{\rho}\frac{\Delta P}{\Delta L} + g\frac{\Delta Z}{\Delta L} + u\,\frac{\Delta u}{\Delta L} = 0 \qquad Eq.II$$ If we express the changes in the pressure, velocity , height etc. in the differential form ,eq .II becomes $$\frac{1}{\rho}\frac{dP}{dL} + g\,\frac{dZ}{dL} + \frac{d\left(\frac{u^2}{2}\right)}{dL}$$ Which can be written as $$\frac{dP}{\rho} + g\,.dZ + d\left(\frac{u^2}{2}\right) = 0 \qquad Eq.III$$ Eq.III is called as Bernoulli Equation. It is differential form of the Bernoulli Equation. For incompressible fluid, density is independent of pressure & hence ,the integrated form of eq.III is $$\frac{P}{\rho} + gZ + \frac{u^2}{2} = constant$$ The Bernoulli Equation relates the pressure at a point in the fluid to its position & velocity.	1
6-b	**Diagram of steam jet ejector** 	4

	Application of steam jet ejector: 1. Used for handling corrosive gases that would damage mechanical vacuum pump. 2. It is used for handling large volume of vapour at low pressure. 3.Crude oil distillation 4. Petrochemical processes 5. Edible oil deodorization 6. Organic motivated systems 7. Fertilizer plant operations 8. Thermal compressors	1 mark each for any 4 application
6-c	.Data: Q = 12 lit/s D= 3 cm =0.03m $\rho = 870\ kg/m^3 = 0.87\ kg/lit$ i) Q in m^3/s Q = 12 lit/s = $\mathbf{12 * 10^{-3}\ m^3/s}$ ii) $(\dot{m})$ in kg/s $(\dot{m}) = Q * \rho = 12 * 10^{-3} * 870 =$ **10.44 Kg / S** iii) U in m/s Q = u * A Area of pipe = $\pi/4 * D^2 = \pi/4 * (0.03)^2 = 7.065 * 10^{-4}\ m^2$ $U = 12 \times 10^{-3} / 7.065 * 10^{-4} =$ **16.98 m / S** iv) G in $kg/m^2.s$ G = Mass flow rate / Area of pipe = $10.44 / 7.065 * 10^{-4} =$ **14777.07 Kg /m^2.S**	 2 2 2 2