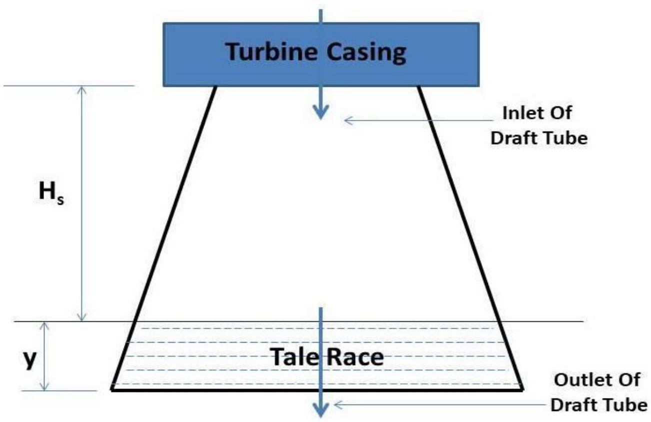
SUMMER – 19 EXAMINATION

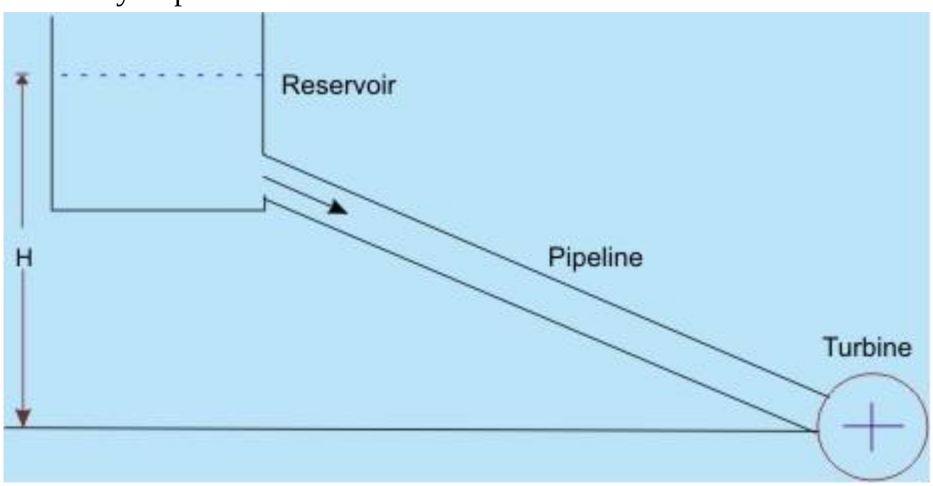
Subject Name: FLUID MECHANICS AND MACHINERY **Model Answer** **Subject Code:** 17411

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.

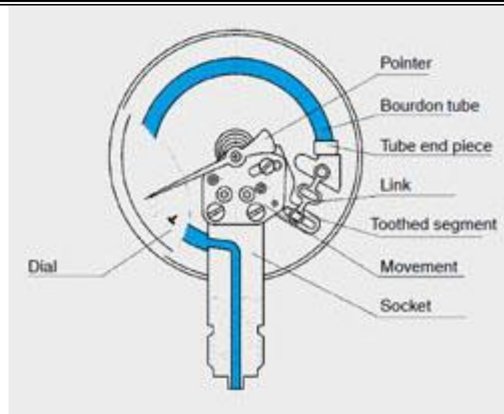
Q.1.		**Attempt any SIX of the following:**	**12 Marks**
a)	**i)**	**Dynamic viscosity** is the force needed by a fluid to overcome its own internal molecular friction so that the fluid will flow. In other words, dynamic viscosity is defined as the tangential force per unit area needed to move the fluid in one horizontal plane with respect to other plane with a unit velocity while the fluid's molecules maintain a unit distance apart. Dynamic viscosity is directly proportional to the shear stress and has the SI units of N s/m2 (Newton second per square meter) kinematic viscosity-A measure used in fluid flow studies, usually expressed as the dynamic viscosity divided by the density of the fluid.	**01** **01**
	ii)	$P= \rho_{Hg}.g.H_{hg}= \rho_w x g x h_w$ $= (13.6x1000)x9.81x0.760= 1000x9.81x\ h_W$ h_W= 10.336 m of water column	**01** **01**
	iii)	**Steady Flow:** Velocity, pressure and other properties of fluid flow can be functions of time (apart from being functions of space). If a flow is such that the properties at every point in the flow do not depend upon time, it is called a steady flow. **Unsteady or non-steady flow**: is one where the properties do depend on time. It is needless to say that any start up process is unsteady.	**01** **01**
	iv)	**F= force exerted by the jet = ρ. A.** V^2 **ρ= density of fluid** **A= area of jet** **V= velocity of fluid**	**02**

	v)	**Rate of flow-The rate at which a liquid or other substance flows through a particular channel, pipe etc. Quantity of fluid flowing per unit time** **Continuity equation** $Q=A_1 v_1 = A_2 v_2$ **This equation can be written in general form as->** **A v = constant** **Q is the volume flow rate, the above equation can be expressed as->** **Q = A v = constant**	**01** **01**
	vi)	Slip in reciprocating pump is the measure of difference between theoretical discharge and actual discharge. Slip = Qth – Qact When actual discharge delivered by reciprocating pump is less then theoretical discharge then that difference is called as Positive Slip.Actual discharge becomes less than theoretical discharge due to leakages while operation.	**02**
	vii)		**02**
	Viii)	**NPSH-** The margin of pressure over vapor pressure, at the pump suction nozzle, is Net Positive Suction Head (NPSH). NPSH is the difference between suction pressure (stagnation) and vapor pressure. In equation form: NPSH = Ps - Pvap Where: NPSH = NPSH available from the system, at the pump inlet, with the pump running Ps = Stagnation suction pressure, at the pump inlet, with the pump running	**02**
b	**i)**	**Attempt any TWO** Area = bxd = 3x2 = 6 m^2 X = 1.5+ 1.5 = 3.0m Force = wA x = 9810x 6x3=176580N Centre of pressure h = Ig /A x + x Ig = bd3/12 = 2 x 3^3/12 = 4.5m^4 h= 4.5/6x3+3=3.25m	 **01** **01** **01** **01**

	ii)	**1)Atmospheric pressure:** sometimes also called barometric pressure is the pressure within the atmosphere of Earth (or that of another planet). The standard atmosphere is a unit of pressure defined as 1013.25 mbar (101325 Pa), equivalent to 760 mm Hg atm unit is roughly equivalent to the mean sea-level atmospheric pressure on Earth, that is, the Earth's atmospheric pressure at sea level is approximately 1 atm. **2)Gauge pressure:** is zero-referenced against ambient air pressure, so it is equal to absolute pressure minus atmospheric pressure. **3)Absolute pressure:** is zero-referenced against a perfect vacuum, using an absolute scale, so it is equal to gauge pressure plus atmospheric pressure. **4)Vacuum pressure**:-vacuum pressure is the difference between the atmospheric pressure and the absolute pressure. Pressure(vac) = pressure(atm) - pressure(abs)	**01 mark each**
	iii)	**Power Transmission By A Pipeline** In certain occasions, hydraulic power is transmitted by conveying fluid through a pipeline. The hydrostatic head of water is thus transmitted by a pipeline. Let us analyse the efficiency of power transmission under this situation.  	**01**
		Consider a pipe AB connected to the tank as shown in fig. Head available at the outlet of the turbine = head at inlet- head loss due to friction= H-hf $=H-flV^2/2gd$ weight of water flowing through pipe/sec W= ρ gx volume of water per sec $= \rho x g x \pi/4\ d^2 X v$ Power transmitted at the outlet of the pipe = weight of water flowing through pipe/sec x head at outlet $= \rho x g x \pi/4\ d^2 X v\ (H - flV^2/2gd)$ watt	**03**

2	**a**	**Attempt any four** $h + s_1h_1 = s_2h_2$ $h = s_2h_2 - s_1h_1$ $= 13.6 \times 0.1 - 1 \times 0.05$ $= 1.36 - 0.05$ $h = 1.31$ m of water $p = wh$ $p = 9810 \times 1.31 = 12851.1\ N/mm^2$	**01** **02** **01**
	b	**Bernoulli's theorem,** in fluid dynamics, relation among the pressure, velocity, and elevation in a moving fluid (liquid or gas), the compressibility and viscosity (internal friction) of which are negligible and the flow of which is steady, or laminar. The theorem states, in effect, that the total mechanical energy of the flowing fluid, comprising the energy associated with fluid pressure, the gravitational potential energy of elevation, and the kinetic energy of fluid motion, remains constant. Bernoulli's theorem is the principle of energy conservation for ideal fluids in steady, or streamline, flow and is the basis for many engineering applications. $p/w + v^2/2g + z = \text{constant}$ where p/w = pressure energy, $v^2/2g$ = kinetic energy z = datum energy Assumptions-Frictionless, steady, constant density(incompressible), along a streamline	**01** **02** **01**
	c	$V = C_v\sqrt{2gh}$ $= 0.95 \times \sqrt{2 \times 9.81 \times 50}$ $= 29.5$ m/s Mass flow rate $= m = av = 1000 \times \Pi/4 \times 0.05^2 \times 29.5$ $= 57.92$ kg/s Force exerted by the jet $F_x = m(V-u)$ $= 57.92\,(29.5-0)$ $= 1708.73$ N	**1** **1** **1** **1**
	d	**Darcy's equation-** $H_f = flv^2/2Dg$ Where: h_f = Friction head loss	**01** **01**

		f = Darcy resistance factor L = Length of the pipe D = Pipe diameter V = Mean velocity g = acceleration due to gravity **Chezy's equation-** v= c√(mi) where v is average velocity [m/s], C is Chezy's coefficient [m½/s], m is the hydraulic radius, which is the cross-sectional area of flow divided by the wetted perimeter (for a wide channel this is approximately equal to the water depth) [m], and i is the hydraulic gradient, which for normal depth of flow equals the bottom slope [m/m].	**01** **01**
	e	**For laminar flow-** i)The frictional resistance is proportional to velocity of flow. ii) The frictional resistance is independent of iii) The frictional resistance is proportional to the surface area in contact iv) The frictional resistance is varies with changes in temperature **For turbulent flow-In turbulent flow,** i) The frictional resistance is proportional to square of velocity of flow ii) The frictional resistance is independent of pressure iii) The frictional resistance is slightly varieswith change in temperature of fluid iv) The frictional resistance is proportional to the density of fluid flow	**02** **02**
	f	**Bourdon tube pressure gauges** are used for the measurement of relative pressures from 0.6 ... 7,000 bar. They are classified as mechanical pressure measuring instruments, and thus operate without any electrical power. **Bourdon tube pressure gauge** Bourdon tubes are radially formed tubes with an oval cross-section. The pressure of the measuring medium acts on the inside of the tube and produces a motion in the non-clamped end of the tube. This motion is the measure of the pressure and is indicated via the movement. The C-shaped Bourdon tubes, formed into an angle of approx. 250°, can be used for pressures up to 60 bar. For higher pressures, Bourdon tubes with several superimposed windings of the same angular diameter (helical tubes) or with a spiral coil in the one plane (spiral tubes) are used.	**02**

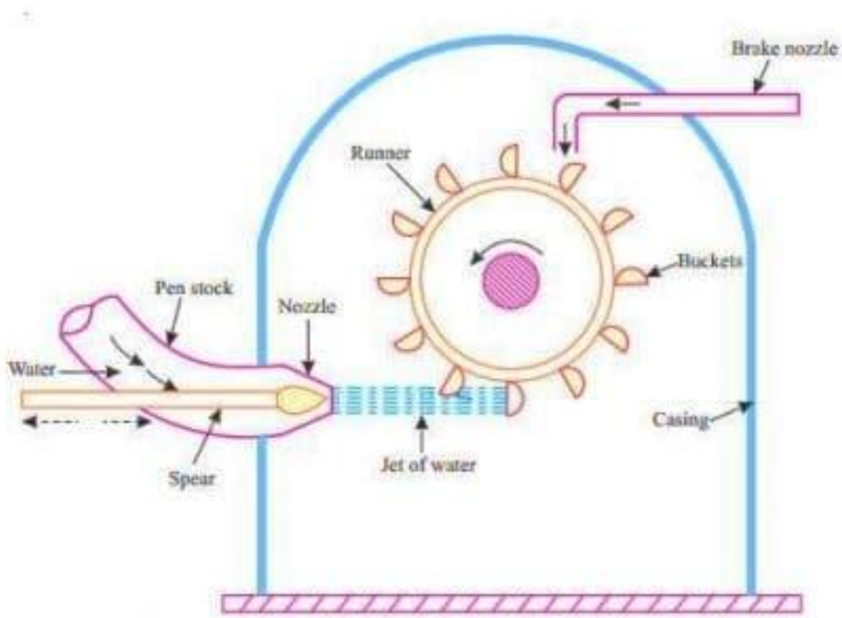
			02 marks for fig

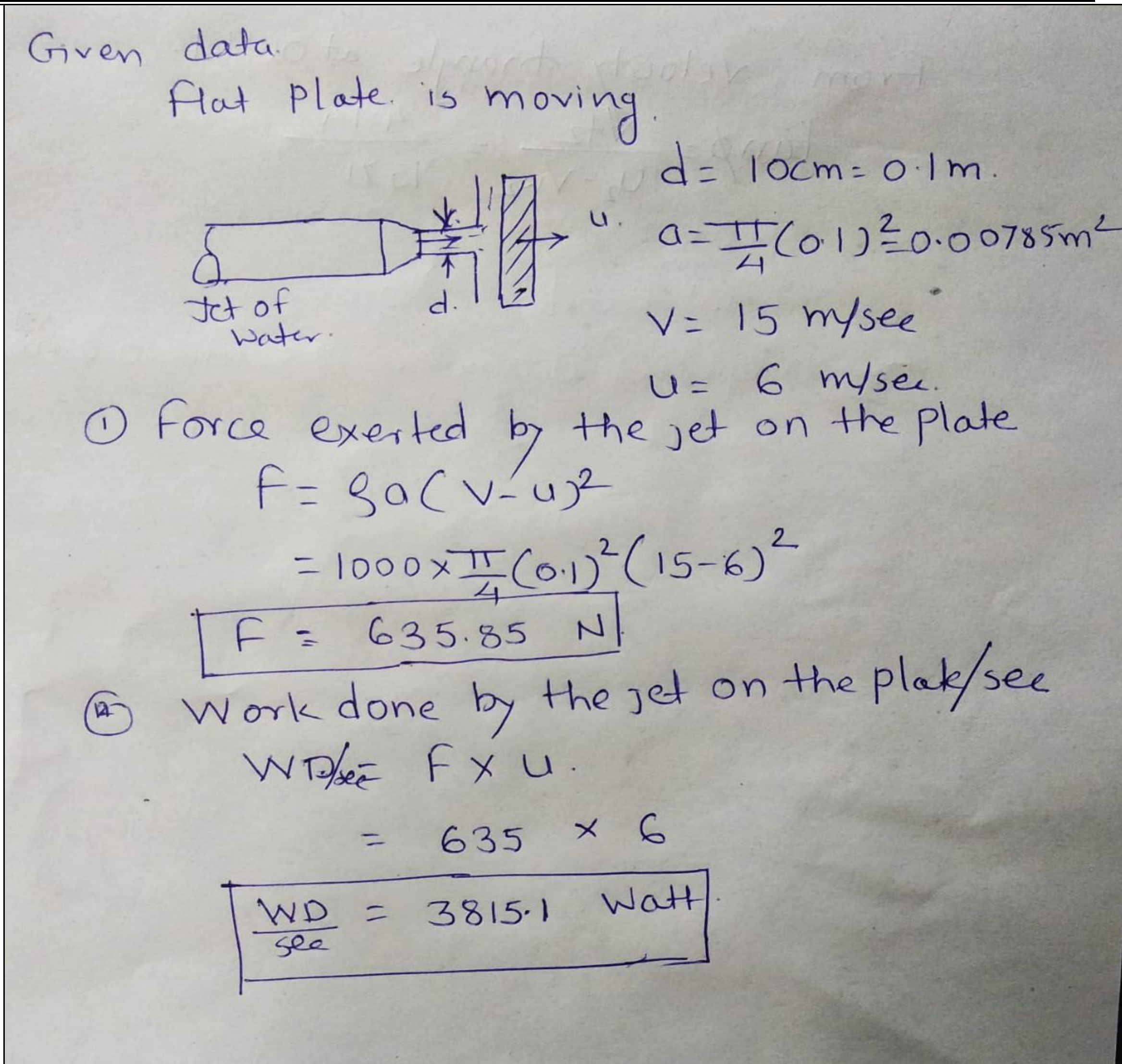
3		**Attempt any FOUR**	**16**
	(a)	**Differentiate between impulse turbine and reaction turbine**	

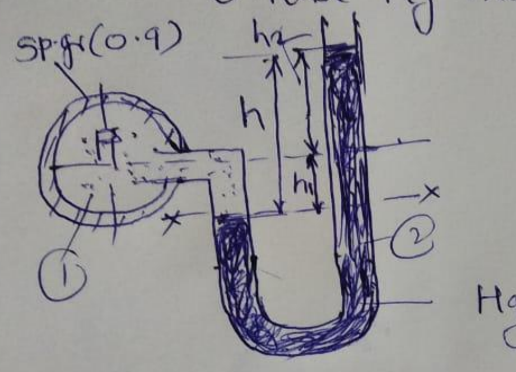
	Impulse turbine	**Reaction turbine**	
Ans.	1. The entire available energy of the water is converted into kinetic energy.	1. Only a portion of the fluid energy is converted into kinetic energy before the fluid enters the turbine runner.	**Any four points** **04 Marks**
	2. The work is done only by the change in the kinetic energy of the jet	2. The work is done partly by the change in the velocity head, but almost entirely by the change in pressure head.	
	3. Flow regulation is possible without loss.	3. It is not possible to regulate the flow without loss.	
	4.. Unit is installed above the tailrace.	4. Unit is entirely submerged in water below the tailrace.	
	5. Casing has no hydraulic function to perform, because the jet is unconfined and is at atmospheric pressure. Thus, casing serves only to prevent splashing of water.	5. Casing is absolutely necessary, because the pressure at inlet to the turbine is much higher than the pressure at outlet. Unit has to be sealed from atmospheric pressure.	
	6. It is not essential that the wheel should run full and air has free access to the buckets	6. Water completely fills the vane passage.	
	7. Pelton wheel Turbine	7.Frances Turbine, Kaplan Turbine	
	8.No need of draft tube	8. Draft tube required	
	8.High head	8. Low or medium head	

	(b)	**Two jet strike the bucket of a pelton turbine which is having shaft power as 15500 kw. The diameter of each jet is 200 mm. if net available head on the turbine is 400 m . find overall efficiency of the turbine Cv=1.0**	

	Ans.	Given data Pelton wheel. $n = 2$ (No. of jet) Shaft Power = 15500 kW. $d = 200 mm = 0.2 m$. $H = 400 m$. $C_v = 1$. $\eta_{overall} = ?$ Area of jet $= a = \frac{\pi}{4} d^2 = \frac{\pi}{4}(0.2)^2 = 0.0314 m^2$. Velocity of jet $V = C_v \sqrt{2gH}$ $= 1 \sqrt{2 \times 9.81 \times 400} = 88.59$ m/sec Discharge of each jet: $Q_1 = a \times V = 0.0314 \times 88.59$ $Q_1 = 2.78 m^3/sec$ Total dischorge (2 jets) $= 2 \times Q_1 = 2 \times 2.78 = 5.56 m^3/sec$. Power at the inlet of turbine $= wQH$ $= 9810 \times 5.56 \times 400 = 21817440$ watt. $= 21817.44$ kW. Overall efficieny $\eta_o = \frac{SP}{wQH}$ $\eta_o = \frac{15500}{21817.44} = 0.7104 = 71.04\%$. $\eta_o = 71.04\%$	**01 Mark** **01 Mark** **01 Mark** **01 Mark**
	(c)	**Explain working principle ,construction and working of pelton wheel turbine with neat labelled diagram.**	
	Ans.	**(working principle 01 Marh,Construction-01 Mark, working-01Mark and neat labelled diagram-01 Mark)** Working Principle The water flows along the tangent to the path of the runner. Nozzle direct forceful streams of water against a series of buckets mounted around the edge of a wheel. As water flows into the bucket, the direction of the water velocity changes to follow the contour of the bucket. When the water jet contacts the bucket, the water exerts pressure on the bucket and flows out the other side of the bucket at low velocity. In the process, the water's momentum is transferred to the turbine This "impulse "	**04 Marks**

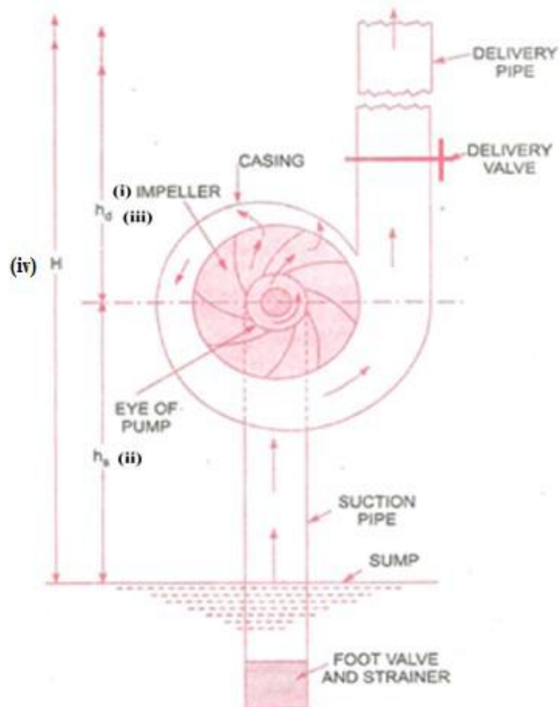
		does work on the turbine.  **Construction:** The main parts of Pelton Wheel turbine: 1. Penstock Nozzle 2. Runner and buckets 3. Casing 4. Breaking jet Working : Impulse turbine changes the velocity of a water jet. The jet impinges on the turbine's curved blades which change the direction of the flow. The resulting changes in momentum (impulse) causes a force on the turbine blades. Since the turbine is spinning, the force acts through a distance (work) and the diverted water flow is left with diminished energy.prior to hitting the turbine blades, the water's pressure (potential energy) is converted to kinetic energy by a nozzle and focused on the turbine. No pressure change occurs at the turbine blades, and the turbine doesn't require hosing for operation.	
	(d)	A jet of water of diameter 10 cm strikes a flat plate normally with a velocity of 15 m/s. The plate is moving with a velocity of 6 m/s in the direction of jet and away from it. Find: (i) Force exerted by the jet on the plate. (ii) Work done by the jet on the plate per second.	

	Ans.	 Given data. Flat plate is moving. Jet of water. d. u. $d = 10cm = 0.1m$. $a = \frac{\pi}{4}(0.1)^2 = 0.00785m^2$ $V = 15$ m/sec $u = 6$ m/sec. ① Force exerted by the jet on the plate $F = \rho a (V-u)^2$ $= 1000 \times \frac{\pi}{4}(0.1)^2 (15-6)^2$ $F = 635.85$ N ② Work done by the jet on the plate/sec WD/sec = F × u. $= 635 \times 6$ $\frac{WD}{sec} = 3815.1$ Watt	**2 Marks** **2 Marks**
	(e)	**Define**	
	Ans.	**i) Specific gravity**: It is the ratio of specific weight of fluid to the specific weight of water/air. No unit. OR It is the ratio of mass density of fluid to the mass density of water/air. ii)**Mass density**: It is the ratio of mass of fluid to the volume of fluid iii)**Surface tension:** The property of the fluid which enables it to resist tensile stresss is called surface tension. iv) **Specific volume:** It is defined as the ratio of volume to unit mass.	**01 Mark** **01 Mark** **01 Mark** **01 Mark**

	(f)	A left limb of a simple U-tube mercury manometer is connected to a pipe in which a fluid of specific gravity 0.9 is flowing. The center of the pipe is 12 cm below the level of mercury in the right limb. Find the pressure of fluid in the pipe if the difference of mercury level in the two limbs is 20 cm.	
	Ans:	Given data U tube Hg manometer  $w_1 = 0.9 \times 9810\ N/m^3$ $w_2 = 13.6 \times 9810\ N/m^3$. $h = 20\ cm = 0.2\ m$. $h_2 = 12\ cm = 0.12\ m$. $h_1 = h - h_2 = 20 - 12 = 8\ cm$ $h_1 = 0.08\ m$. ∴ pressure in Left limb. $= P + w_1 h_1$ $P + 0.9 \times 9810 \times 0.08$ ∴ pressure in Right limb. $= w_2(h_2 + h_1) = w_2 h$. $= 13.6 \times 9810 \times (0.12 + 0.08) = 13.6 \times 9810 \times 0.2$ ∴ Pressure in Left limb = Pressure in Right limb $P + 0.9 \times 9810 \times 0.08 = 13.6 \times 9810 \times 0.2$ $P + 706.32 = 26683.2$ $P = 25976.88\ N/m^2$ $P = 25.976\ kN/m^2$	**Sktech 01 mark** **01 Mark** **01 Mark** **01 Mark**
4	**(A)**	**Attempt any FOUR**	**16**
	(a)	**Explain**	
	Ans.	**i) Classification of Hydraulic Turbine: any four points** **According to the type of energy available at inlet to the turbine**	**1 x 4**

		1) impulse turbine 2) Reaction turbine **According to direction of flow through runner** 1) Tangential flow turbine 2) Radial flow turbine 3) Axial flow turbine 4) Mixed flow turbine **According to the head available at inlet to the turbine** 1)Low head turbine (2 m to 15 m) 2)Medium head turbine (16 m to 70 m) 3)High head turbine (71 m and above) **According to the specific speed of the turbine** 1)Low specific speed 2)Medium specific speed 3)High specific speed **ii) Important of draft tube in reaction turbine:** Draft tube is necessary in reaction turbine for the following reasons, 1. By providing draft tube, it is possible to install the turbine above the tail race without loss of head. This makes the inspection and maintenance of turbine easy. 2. By providing draft tube, the velocity is largely reduced at the exit of draft tube. Thus the kinetic head is gained. In reaction turbines like Kaplan or Francis, both pressure and kinetic energy are used to make the rotor run. At the exit of the runner of these turbines, there is a negative pressure developed which is less than the atmospheric pressure. So to improve the work done this kinetic energy is converted to pressure energy again by the means of the draft tube. And the water also moves out to tailrace. **Types of draft tube:** i. Conical draft tube ii. Simple elbow draft tube iii. Moody spreading draft tube iv. Elbow draft tube with circular cross section at inlet and rectangular at outlet	**04 Marks** **04 Marks**
	(b)	**Explain principle , construction and working of centrifugal pump with neat sketch.**	

Ans.



08 Marks

Principle: Centrifugal Pump is a hydraulic machine which converts mechanical energy into hydraulic energy (pressure energy) by the action of centrifugal force acting on the fluid.The flow of liquid takes place in radial outward direction which is reverse of the inward radial flow reaction turbine. It works on the principle of forced vortex flow. The forced vortex flow means when a certain mass of fluid or liquid is allowed to rotate by an external torque than there is a rise in pressure head of the rotating liquid takes place. This rise in pressure head is used to deliver water from one location to another. It is centrifugal force acting on the fluid that makes it to flow within the casing.

Construction :

The different **parts of the centrifugal pump** are listed below.

1. Suction pipe
2. Impeller
3. Casing
4. Delivery Pipe

Suction Pipe with a foot valve and strainer

- The suction pipe has two ends.
- One end is connected to the inlet of the pump and the other dips into the water in a sump.
- A foot valve fits at the lower end of the suction pipe. The foot valve is the one-way type of valve which only opens in an upward direction.
- A strainer is also fitted at the end of the suction pipe to prevent the entry of foreign bodies into suction pipe.

Impeller

- It is consist of a series of backward curved vanes.
- It is mounted to the shaft of an electric motor.
- An impeller is a rotating part of the centrifugal pump.
- It enclosed in a watertight casing.

Casing

- It is an airtight passage surrounding the impeller.
- It is designed in such a way that the kinetic energy of the water discharged at the outlet is converted into pressure energy before the water leaves the casing and enters the delivery pipe.
- The casing works as a cover to protect the system.

Delivery valve

- The delivery valve has two ends.
- One end is connected to the outlet of the pump and the other end delivers the water at a required height.

Working of centrifugal pump:

As the electric motor starts rotating, it also rotates the impeller. The rotation of the impeller creates suction at the suction pipe. Due to suction created the water from the sump starts coming to the casing through the eye of the impeller.

From the eye of the impeller, due to the centrifugal force acting on the water, the water starts moving radially outward and towards the outer of casing.

Since the impeller is rotating at high velocity it also rotates the water around it in the casing. The area of the casing increasing gradually in the direction of rotation, so the velocity of the water keeps on decreasing and the pressure increases, at the outlet of the pump, the pressure is maximum.Now form the outlet of the pump, the water goes to its desired location through delivery pipe.

(Principle 1 Mark,Construction 2 Marks,Working 2 Marks and neat sketch 3 Marks).

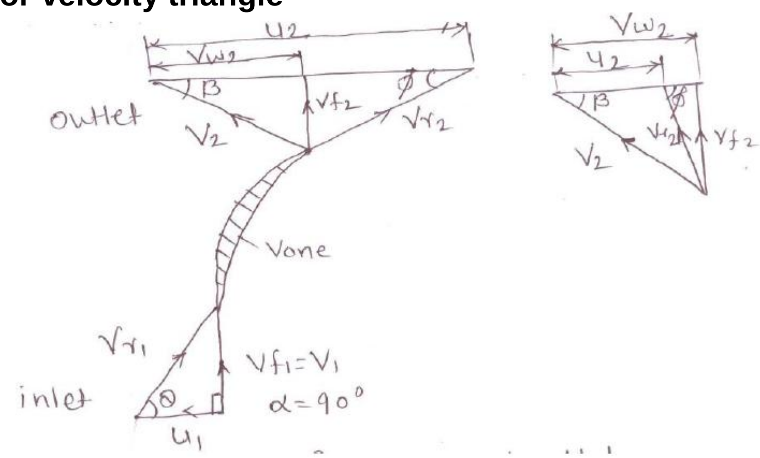
(c) A centrifugal pump is to discharge 0.130 m^3/s at a speed of 1200 rpm against a total head of 20 m. The impeller diameter is 250 mm, its width at outlet is 40 mm and manometric efficiency is 75%. Determine the vane angle at the outer periphery of the impeller.

Ans. Given date Centrifugal pump

$Q = 0.130\ m^3/sec$ N= 1200 rpm H=20m $\eta_{man} = 75\%$

D2=Impeller diameter at outlet =0.25m B2= width at outlet =0.04m

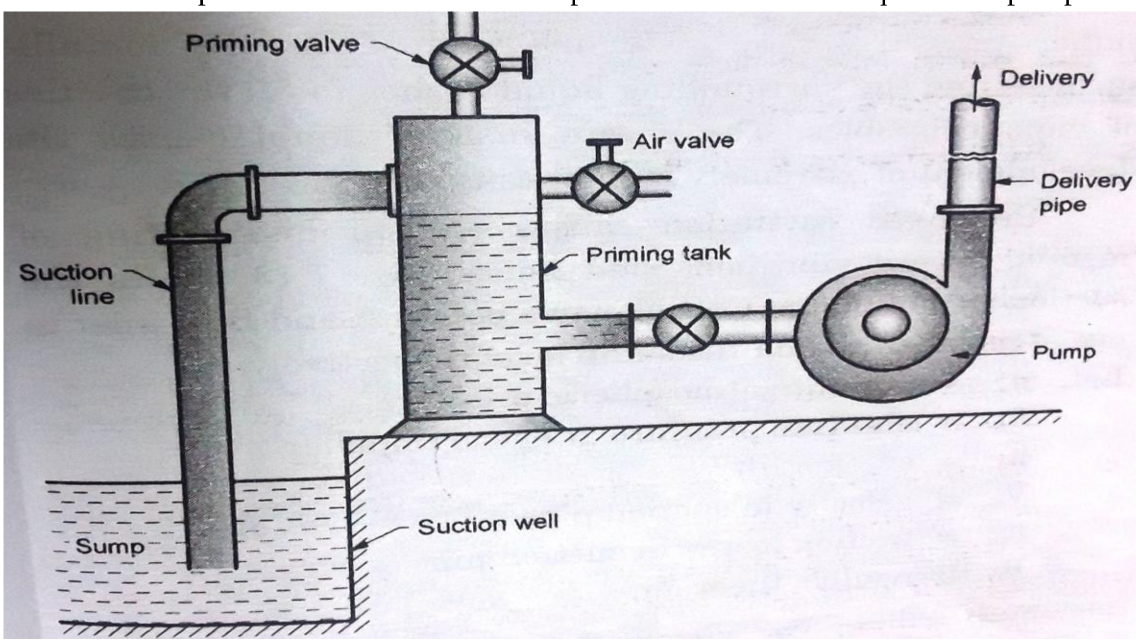
For velocity triangle



01 Mark Diagram

i)Tangential velocity of impeller at outlet u_2

$= \Pi\ D2\ N/\ 60 = (\Pi \times 0.25 \times 1200)/60 = 15.71\ m/sec$ **01 Mark**

		ii)Rate of flow $Q=\Pi .D_2.B_2.Vf_2$ $Vf_2= 0.130/(3.14 \times 0.25 \times 0.04) = 4.14$ m/sec iii)$\eta_{man}= gHm/Vw_2\ u_2$ $Vw_2= 9.81 \times 20 / 0.75 \times 15.71 =16.65$ m/sec iv) From velocity triangle at outlet $\tan \Phi= \frac{Vf2}{(Vw2-u2)} = 4.14/(16.65-15.71)=4.14/0.94 =4.4$ $\Phi= \tan^{-1} (4.4) =77^o22”$ Vane angle at outlet $\Phi= 77^o22”$	02 Mark 02 Mark 02 Marks
Q.5		**Attempt any FOUR of the following:**	
a)		**What is priming? Explain self-priming method with neat diagram.**	**16 Marks**
	Sol.	Priming of Centrifugal pump is the operation in which the suction pipe, casing of the pump & a portion of the delivery pipe up to the delivery valve is completely filled by the liquid. Thus the air from these parts is removed and whole space is filled with the liquid to be pumped.  **Self-priming Device**	**Sketch 02 Marks**

Self priming:

It consists of a priming tank between the suction line & the pump. It is provided with an air valve and a priming valve at its top. Suction line is connected at the top of priming tank as shown in fig. Initially the priming tank is filled with water through priming valve with an open air valve. Then both valves are closed.

When pump is started it draws water from priming tank. The water level in it falls. Space created by flow of water to pump is filled by expanding air in the priming tank. It creates vaccum due to which water rushes into the priming tank through suction line. The priming tank remains full of water even when pump stops.

02 Marks

b) **Differentiate between centrifugal pump and reciprocating pump**

Sol.

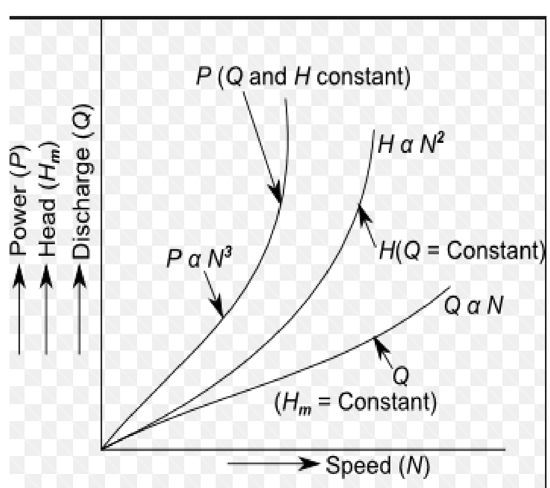
Sr. No.	**Centrifugal Pump**	**Reciprocating Pump**
1	It is a type of Rotodynamic pump.	It is a positive displacement pump.
2	Simple in construction because of less number of moving parts.	Complicated in construction because of more number of moving parts.
3	Suitable for large discharge and small heads.	Suitable for less discharge and high heads.
4	Balancing is proper.	Balancing is not proper.
5	Maintenance cost is less.	Maintenance cost is more.
6	Suction and delivery valves are not necessary.	Suction and delivery valves are necessary.
7	Air vessel is not required.	Air vessel is required.
8	It can run at high speed.	It can't run at high speed.

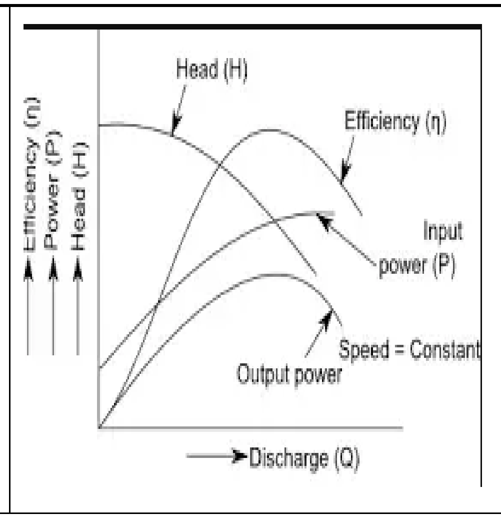
(Any 04 Point)

01 Marks Each Point

c) **Draw performance and operating characteristics curves of a centrifugal pump**

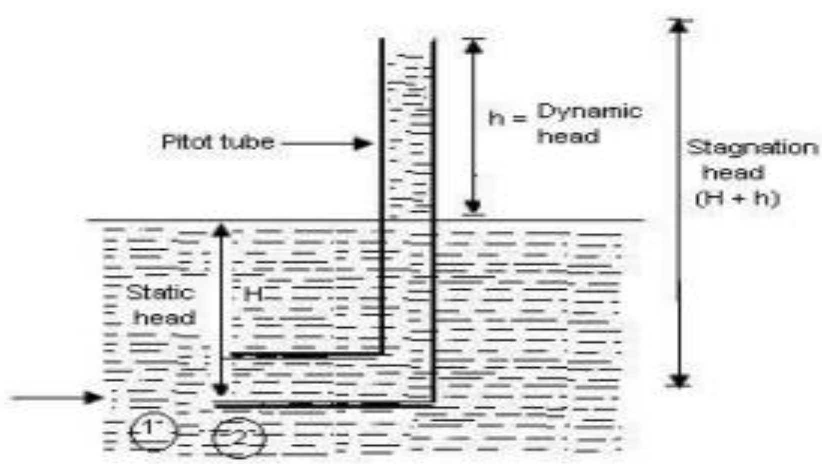
Sol.



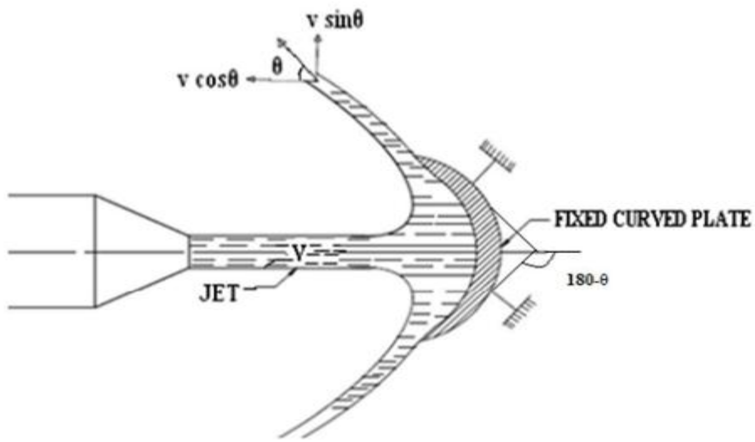


Performance and Operating Characteristics Curves of A Centrifugal Pump

02 Marks Each Curve

d)		**Enlist various minor losses in flow through pipes. Write equations of any four losses.**	
	Sol.	**Minor Losses:-** (i) Loss of head at Entry. $H_L = 0.5 (V^2/2g)$ (ii) Loss of head at Exit. $H_L = (V^2/2g)$ (iii) Loss of head due to sudden enlargement. $H_L = (V_1-V_2)^2 / 2g$ (iv) Loss of head due to sudden contraction $H_L = (1/Cc-1)^2 (V^2/2g)$ (v) Loss of head due to sudden obstruction. $H_L = \frac{v^2}{2g}\left[\frac{A}{C_c(A-a)}\right]^2$ (vi) Loss of head due to bend or Elbow, $H_L = K (V^2/2g)$	**(Any 04 Losses)** **01 Marks Each Point**
e)		**Explain working principal, construction of pitot tube. How pitot tube is used for measuring local velocity of flowing fluid?**	
	Sol.	**Pitot tube-** It is used for measuring velocity of flow of fluid flowing through the channel **Construction:-** It consists of a glass tube, bent at right angle as shown in figure. The diameter of glass tube is large enough to nullify the effect of capillary action. The tube dipped vertically in the flowing fluid with its lower end which is bent at 900 , facing the flow & other open end projecting above fluid surface.  **Fig.** Pitot Tube	**01 Marks** **01 Marks** **01 Marks**

		Working- The fluid enters the tube from lower end facing the stream & the level of liquid in the tube rises above the level of fluid in surrounding stream. This is due to the fact that lower end of tube is a stagnation point where fluid is at rest. At a stagnation point the kinetic energy will get converted in to pressure energy causing the fluid in the tube to rise above the surrounding fluid surface by a height which corresponds to the velocity of flow of fluid approaching the lower end of tube. This pressure at stagnation point is called as stagnation pressure. $V = C_v\sqrt{2gh}$ V= velocity of flow, C_v= Coefficient of velocity, h= Dynamic Pressure head	**01 Marks**
f)		**Find Loss of head when a pipe of diameter 30 cm is suddenly enlarged to diameter of 40 cm. The rate of flow of water through pipe is 300 liter/sec.**	
		$d_1 = 30\ cm = 0.30\ m$ $d_2 = 40\ cm = 0.40\ m$ $Q = 300\ Lit/sec = 0.3\ m^3/sec$ $Q = a_1 V_1 = \frac{\pi}{4} d_1^2 V_1$ $0.3 = \frac{\pi}{4}(0.30)^2 \times V_1$ $\therefore V_1 = 4.24\ m/s$ $Q = a_2 V_2 = \frac{\pi}{4} d_2^2 V_2$ $0.3 = \frac{\pi}{4}(0.40)^2 \times V_2$ $\therefore V_2 = 2.38\ m/s$ Now, Loss of head due to sudden enlargement = $h_L = \frac{(V_1 - V_2)^2}{2g} = \frac{(4.24 - 2.38)^2}{2 \times 9.81}$ $\therefore h_L = 0.1763\ m$	**01 Mark** **01 Mark** **01 Mark** **01 Mark**
		Attempt any <u>TWO</u> of the following	**16 Marks**

Q.6			
a)	(i)	**Derive expression for force exerted by jet on fixed symmetrical curved blade, when jet strikes the blade normally.**	
		Let, jet of water strikes a fixed curved plate at the center as shown in fig. The jet after striking the plate comes out with same velocity if the plate is smooth and there is no loss of energy due to impact of jet. The velocity at outlet of the plate can be resolved into two components , one in the direction of jet and other perpendicular to direction of jet. Component of velocity in the direction of jet after striking plate = $- V \cos\theta$ Component of velocity perpendicular to the direction of jet after striking plate = $V \sin\theta$  **Fig.** Jet Striking On Fixed Symmetrical Curved Blade Normally Force exerted by the jet in the direction of jet, $F_x = \text{Mass per sec} \times [V_{1x} - V_{2x}]$ where V_{1x} = Initial velocity in the direction of jet = V V_{2x} = Final velocity in the direction of jet = $-V\cos\theta$ $\therefore \quad F_x = \rho a V[V - (-V\cos\theta)] = \rho a V[V + V\cos\theta]$ $= \rho a V^2[1 + \cos\theta]$ Similarly, $F_y = \text{Mass per sec} \times [V_{1y} - V_{2y}]$ where V_{1y} = Initial velocity in the direction of $y = 0$ V_{2y} = Final velocity in the direction of $y = V\sin\theta$ $\therefore \quad F_y = \rho a V[0 - V\sin\theta] = -\rho a V^2 \sin\theta$	**01 Marks For diagram** **03 Marks For Expression**
	(ii)	**Draw a neat labeled diagram of layout of hydroelectric power plant**	

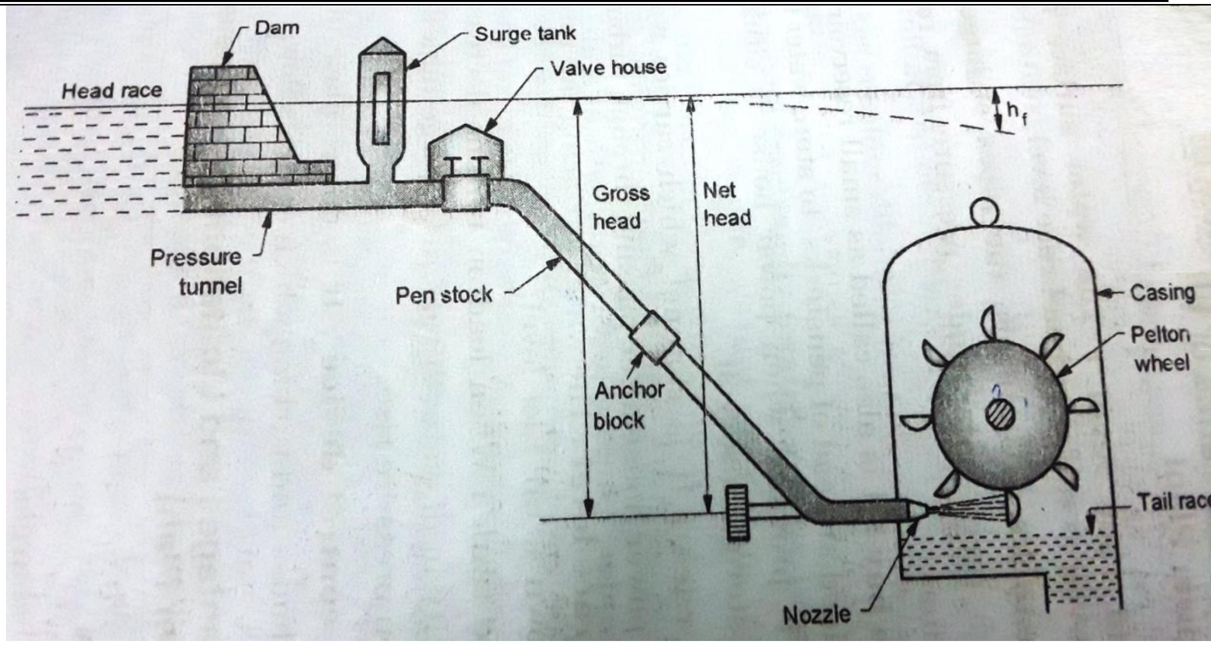


Fig. Layout of Hydroelectric Power Plant

04 Marks For diagram

b) **Water flow down an inclined tapering pipe 45 m long at a slope of 1 in 10. The areas at the upper and lower ends of pipe are 8 m^2 and 3 m^2 resp. If the velocity at lower end is 4.5 m/s and the pressure at upper end is 100 kPa. Calculate the pressure at lower end and rate of flow through pipe.**

Sol.

Let,

(1)–(1) = Lower End

(2)–(2) = Upper End

$A_1 = 3m^2$ $V_1 = 4.5$ m/s

$A_2 = 8m^2$ $P_2 = 100$ kPa $= 100 \times 10^3$ N/m^2

$Z_1 = 0$

$Z_2 = (1/10) \times 45 = 4.5$ m — **01 Mark**

$P_1 = ?$

$Q = ?$

By Continuity Equation,

$A_1 V_1 = A_2 V_2$

$3 \times 4.5 = 8 \times V_2$

$\mathbf{V_2 = 1.68}$ **m/s** — **02 Mark**

$Q = A_1 V_1 = 3 \times 4.5$

$\underline{\mathbf{Q = 13.5\ m^3/s}}$ — **02 Mark**

By Bernoulli's Theorem

Total Head at section (1)–(1) = Total head at section (2)–(2) — **01 Mark**

$$\frac{P_1}{W} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{W} + \frac{V_2^2}{2g} + Z_2$$

$(P_1/9810) + (4.5_2/2 \times 9.81) + 0 = (100 \times 10^3/9810) + (1.687^2/2 \times 9.81) + 4.5$

$P1 = 135442.64\ N/m^2$

P1 = 135.44 kPa — **02 Mark**

c) **Explain working principle, construction and working of double acting reciprocating pump with neat labeled diagram. Also write advantages of double acting reciprocating pump over single acting reciprocating pump**

Sol.

02 Marks for diagram

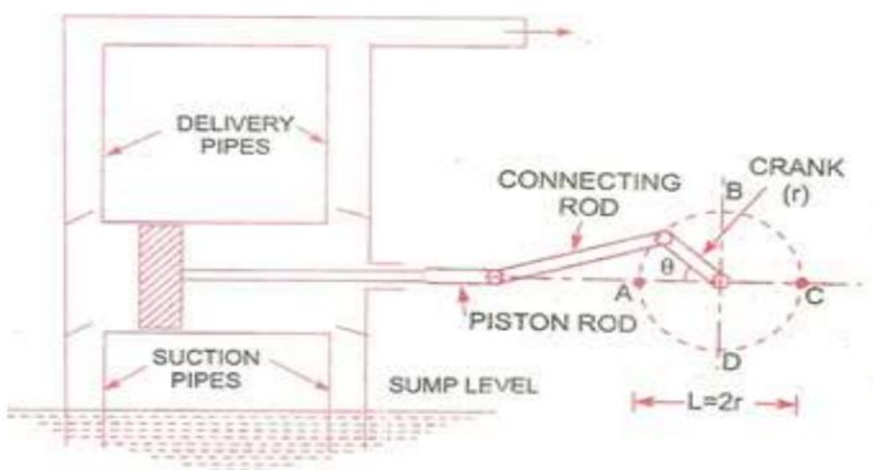


Fig. Double Acting Reciprocating Pump

Construction

02 Marks

(i) **Cylinder –** It is the heart of reciprocating pump. It is made from cast iron, Cast steel or other metal which suitable to handle liquid flowing through it.

(ii) **Piston –** It is fits inside the cylinder and piston rod is connected to crank by connecting rod.

(iii) **Connecting rod and crank –** Connecting rod connects piston to crank. Crank is rotated by engine or electric motor.

(iv) **Valves –** One way valves are provided at inlet and outlet. Inlet valve admits water into cylinder while outlet valve permits exit of water from cylinder.

(v) **Air Vessels** – In order to make uniform discharge I dome shaped metal vessels are fitted on delivery pipe.

		Working: - i) When crank is at A, The piston is at the extreme left position in cylinder. As the crank rotates from A to C (From $\theta=0^0$ to $\theta=180^0$) the piston is moving towards right in cylinder. The movement of piston towards right creates a partial vacuum in cylinder. Due to this suction valve opens and water is sucked in the cylinder in piston end side while delivery takes place on other side. ii) When crank is at C, The piston is at the extreme Right position in cylinder. As the crank rotates from C to A (From $\theta=180^0$ to $\theta=360^0$) the piston is moving towards left in cylinder. Due to this delivery takes place from piston side while suction takes place on other side of piston. During each stroke when suction takes place on one side of the piston, the other side delivers the liquid. Thus for one complete revolution of the crank there are two delivery strokes and water is delivered to the pipes by the pump during these two delivery strokes. **Advantages of Double Acting Reciprocating Pump Over Single Acting Reciprocating Pump:** **(i)** It gives continuous discharge . **(ii)** High delivery head can be obtained. **(iii)** It has high efficiency.	**02 Marks** **02 Marks**