SHEME OF VALUATION

REVISION :2015 **COURSE CODE :6022**

COURSE TITLE: HYDRAULIC MACHINES

SCORING INDICATORS
PART- A

1. Efficiency, $\eta = \frac{2u[V-u]}{V^2}$

   Where, u=Velocity of vane

   V=Velocity of jet

2. a) Tangential flow turbine b)Radial flow turbine c)Axial flow turbine d)Mixed flow turbine
3. (1) In Francis turbine runner the water enters radially, where as in Kaplan turbine the water enters axially.

   (2) In Francis turbine runner the number of blades is generally 16 to 24 where as in Kaplan turbine it is generally 3 to 8

4.NPSH,the net positive suction head may be defined as the net head(in meters) that is required to make the liquid flow through the suction pipe from sump to the impeller.

OR

Difference between the net inlet head and the head corresponding to the vapour pressure of the liquid.

5. Slip is the difference between the actual discharge and the theoretical discharge .It is usually expressed in percentage .

PART- B

II.(1)

Data given

Diameter the jet, d=2.5cm =0.025cm

Velocity of the jet, V =10 m/s

Weight of plate, W=98.1 N

Area of jet, $a=\frac{\pi}{4}d^2$

$=\frac{\pi}{4}x(0.025)^2=0.00049m^2$

Angle through the plate will swing is given by

$\text{Sin}\theta=\frac{\rho aV^2}{W} =$

$=1000x\ \frac{0.00049x10^2}{98.1}$

$\text{Sin}\theta = 0.499$

$\theta =29.96$

II (2)

Let,

V - Velocity of jet in m/s

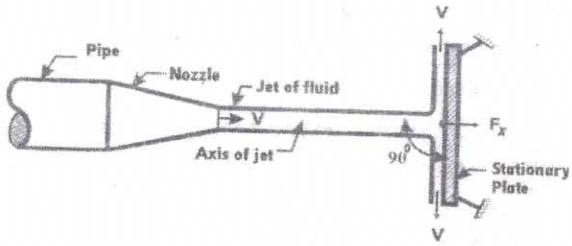
d - Diameter of the jet, m

a - Area of Cross Section, m^2

ρ - Density of water, kg/m^3

m - Mass flow rate

$m = \rho a V$



The force exerted by the jet on the plate in the direction of the jet (X - direction),

F_x = Rate of change of momentum in the direction of force

$$= \frac{\text{Initial momentum} - \text{Final momentum}}{\text{Time}}$$

$$= \frac{\text{Mass} \times \text{Initial velocity} - \text{Mass} \times \text{Final velocity}}{\text{Time}}$$

$$= \frac{\text{Mass}}{\text{Time}} (\text{Initial velocity} - \text{Final velocity})$$

$$= m(V-0)$$

$$= \rho a V(V-0) = \rho a V^2$$

[Fig. 2 + data 1 + 3 = 6]

[6]

II(3)

No: of jet, $n = 2$

Head, $H = 50m$

Power, $P = 90 kW$

Efficiency, $\eta = 90\% = 0.9$

$C_V = 0.96$

Using Over all $\eta = \frac{P}{\omega Q H}$

Discharge, $Q = \frac{P}{\omega H \eta}$

$= \frac{90}{9.81 \times 50 \times 0.9}$

$= \underline{\underline{0.2039\ m^3/s}}$

Velocity of jet, $V = C_V \sqrt{2gH}$

$= 0.96 \times \sqrt{2 \times 9.81 \times 50}$

$= \underline{\underline{30.0681\ m/s}}$

Discharge through the jet;

$Q = \frac{\pi}{4} d^2 n \times V$

Diameter of jet, $d = \sqrt{\frac{4Q}{\pi n V}}$

$d = \sqrt{\frac{4 \times 0.2039}{\pi \times 2 \times 30.068}}$

$= 0.0657\ m$

$= \underline{\underline{65.7\ mm}}$

[Data = 1 + 5]

[6]

II(4) <u>Unit speed(Nu)</u> is defind as the hypothetical speed of of the turbine operating under one meter head.

$Nu = \frac{N}{\sqrt{H}}$, N= Speed under, H.
H = Head

<u>Unit Discharge (Qu)</u> It is defind as the discharge passing through a turbine which is working under a unit ~~H~~ head.

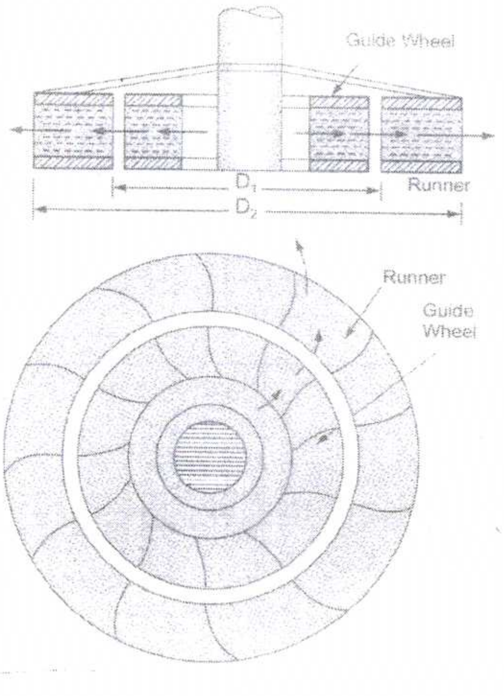
$Qu = \frac{Q}{\sqrt{H}}$, Q is the discharge under H.

<u>Unit Power (Pu)</u> it is defined as the power devoloped by a turbine working under a unit head.

$Pu = \frac{P}{H^{3/2}}$ P is the Power, uner, H.

[2+2+2] [6]

II(5)



: Outward Radial Flow Turbine

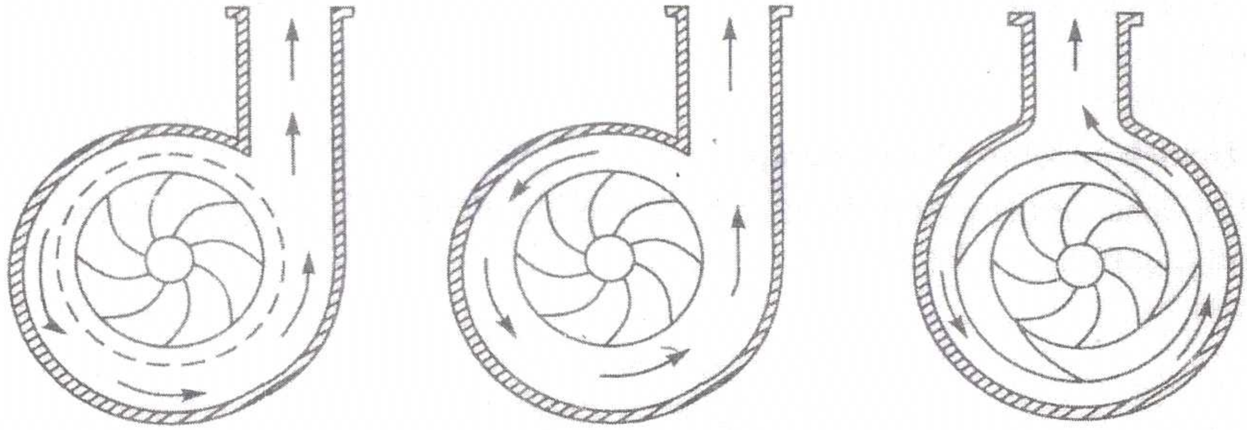
Water from casing enters the stationary guide wheel. guid wheel consists of guide vane which direct the water to enter the runner which around the guide wheel.
water flows through the vanes of the runner in the outward radial direction and is discharged at the outer diameter of the runner.

[3+3] [6]

35

1. <u>Casing with guide blade</u>: In this type impeller is surrounded by a series of guide blades, mounted on a ring, known as diffuser.

II(6)



(a) Vortex casing **(b) volute casing** **(c) Casing with guide blade**

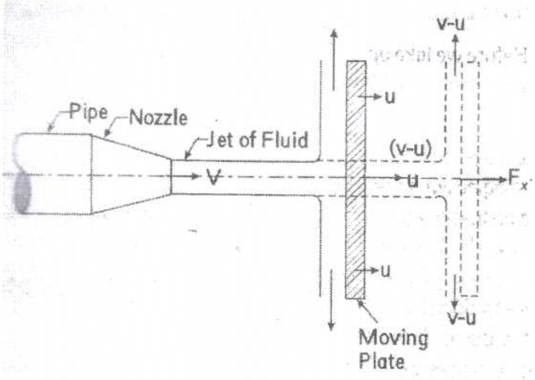
2. <u>Volute casing</u>: It surrounds the impeller. In this type of casing area of flow gradually increases from impeller outlet to delivery pipe.
3. <u>Vortex Casing</u>: If a circular chamber [vortex chamber] is provided between the impeller and the volute chamber it is known as Vortex casing.

II(7)

S. No.	*Centrifugal pump*	*Reciprocating pump*
1.	Simple in construction, because of less number of parts.	Complicated in construction, because of more number of parts.
2.	Total weight of the pump is less for a given discharge.	Total weight of the pump is more for a given discharge.
3.	Suitable for large discharge and smaller heads.	Suitable for less discharge and higher heads.
4.	Requires less floor area and simple foundation.	Requires more floor area and comparatively heavy foundation.
5.	Less wear and tear.	More wear and tear.
6.	Maintenance cost is less.	Maintenance cost is high.
7.	Can handle dirty water.	Cannot handle dirty water.
8.	Can run at higher speeds.	Cannot run at higher speeds.
9.	Its delivery is continuous.	Its dilivery is pulsating.
10.	No air vessels are required.	Air vessels are required.
11.	Thrust on the crankshaft is uniform.	Thrust on the crankshaft is not uniform
12.	Operation is quite simple.	Much care is required in operation.
13.	Needs priming.	Does not need priming.
14.	It has less efficiency.	It has more efficiency.

4

III(a)



Let,
V – absolute Velocity
a – area of Cross Section of jet, m^2
u – Velocity of plate
V_r – Relative Velocity
$V_r = V - u$
$m = \rho a(V - u)$

Force, $F_x = \frac{mass}{sec}$ [initial velocity – Final veloci]

$F_x = m[(V-u) - 0]$

$F_x = \rho a(V-u)[(V-u) - 0]$

$F_x = \rho a (V-u)^2$

work done, W = Force x Distance

$W = F_x \times u$

$= \rho a (V-u)^2 \times u$

work done per sec:
$W = \rho a (V-u)^2 \times u$. Watts [8]

Fig: 3, data - 1, derrivation: 4

III(b)

Diameter of the jet, $d = 7.5$ cm $= 0.075$ m

∴ Area, $a = \frac{\pi}{4}(.075)^2 = 0.004417$ ✓

Velocity of the jet, $V = 20$ m/s

Velocity of the plate, $u = 8$ m/s

Angle of deflection of the jet $= 165°$

∴ Angle made by the relative velocity at the outlet of the plate,

$$\theta = 180° - 165° = 15°.$$

(*i*) Force exerted by the jet on the plate in the direction of the jet is given by equation (17.17) as

$$F_x = \rho a(V-u)^2(1 + \cos\theta)$$
$$= 1000 \times .004417 \times (20-8)^2 [1 + \cos 15] = \mathbf{1250.38\ N.}$$ **Ans.**

(*ii*) Work done by the jet on the plate per second

$$= F_x \times u = 1250.38 \times 8 = 10003.04 \text{ N m/s}$$ ✓

[7]

5

IV(a)

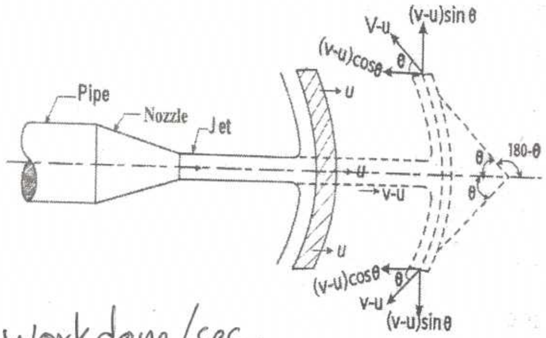
Let,

V – Absolute velocity of jet

a – A/c of jet, m²

u – Velocity of curved plate

θ – Angle of the vane at the tip



Relative Velocity $V_r = (V-u)$

$m = (V-u) \cdot \rho a$.

Force exerted by the jet, F_x

$$F_x = \frac{\text{mass}}{\text{sec}} [\text{initial } V - \text{Final } V]$$

$$= \rho a(V-u)[(V-u) - -(V-u)\cos\theta]$$

$$= \rho a (V-u)[(V-u) + (V-u)\cos\theta]$$

$$= \rho a (V-u)^2 [1 + \cos\theta]$$

Workdone/sec.

$W = F_x \times$ Distance travelled/sec.

$$= F_x \times u$$

$$= \rho a (V-u)^2 [1 + \cos\theta] \times u.$$

[8]

Fig-3, data-1, Analysis-4

IV(b)

Data given:

Diameter of the jet, $d = 100\,mm = 0.1\,m$

Velocity of jet, $V = 15$ m/s

Velocity of plate, $u = 6$ m/s

Force exerted on the plate, $F_x = \rho a (V-u)^2$

$$= 1000 \times \frac{\pi}{4}(0.1)^2 (15-6)^2$$

$$= \underline{636.17\ N}$$

Workdone per sec, $W = F_x \times u$

$$W = 636.17 \times 6$$

$$= \underline{3817.02\ Nm/s}$$

[7]

[Data, 1 + 4 + 2]

6

V(a)

Data

Head, H = 250 m

Power, P = 6000 kW

Speed, N = 600 RPM

Overall, η_o = 90% = 0.9

Jet ratio = $d/D = 1/8$

Jet diameter = $1/8 \times$ wheel dia = $\frac{D}{8}$

Cv = 0.98

Speed ratio = 0.46

(1) Rate of flow, $Q = \frac{P}{w H \eta_o}$

$$Q = \frac{6000}{9.81 \times 250 \times 0.9}$$

$= 2.72\ m^3/s$

[Data, 2 + 2 + 2 + 2]

7

Velocity of jet, $V = C_v \sqrt{2gH}$

$V = 0.98\sqrt{2 \times 9.81 \times 250} = 68.64\ m/s$

Velocity of wheel, $u = 0.46 \times V$

$u = 0.46 \times 68.64 = 31.57\ m/s$

(2) Wheel Dia, $D = \frac{60u}{\pi N} = \frac{60 \times 31.57}{\pi \times 600}$

$= 1.005\ m$

Dia of jet, $d = D/8 = \frac{1.005}{8} = 0.1256\ m$

$= 125.6\ mm$

(3) No. of jet, $n = \frac{4Q}{\pi d^2 V}$

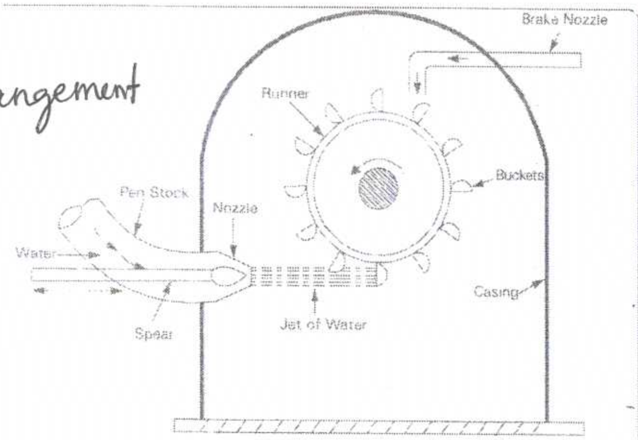
$n = \frac{4 \times 2.72}{\pi (0.1256)^2 \times 68.64} = 3.2$ say - 4

[8]

V(b)

Components:

1. Nozzle & flow regulating arrangement
2. Runner & buckets
3. Water tight casing
4. Braking nozzle
5. Governor



Working

- Water comes out of the nozzle in the form of high velocity jet and strikes the bucket fixed around circumference of the runner. The runner is mounted on the horizontal shaft.
- The quantity of water coming out of the nozzle can be controlled by regulators.
- The impact of water on the surface of the bucket produces a force causes the runner to rotate.
- After doing the work water is discharged into the tail-race.

[3½ + 3½]

[7]

VI(a)

Power developed, $P = 2000\,kW$

Working head, $H = 100\,m$

Efficiency, $\eta_o = 85\% = 0.85$

$C_v = 0.98$

$$\eta_o = \frac{P}{\omega Q H}$$

Discharge, $Q = \dfrac{P}{\omega H \eta_o}$

$$= \frac{2000}{9.81 \times 100 \times 0.85}$$

$Q = \underline{2.3985\ m^3/s}$

Velocity, $V = C_v\sqrt{2gH}$

$$= 0.98\sqrt{2 \times 9.81 \times 100}$$

$$= 43.4086\ m/s$$

Diameter of the nozzle, d

$$= \sqrt{\frac{4Q}{\pi V}} = \sqrt{\frac{4 \times 2.3985}{\pi \times 43.4086}}$$

$$= 0.2652\,m$$

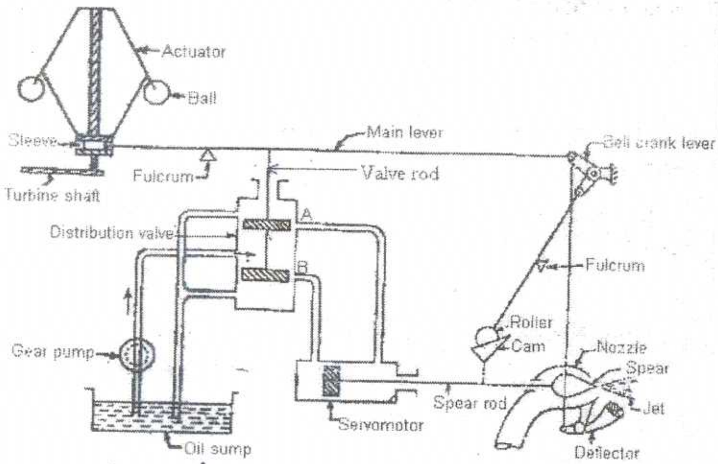
$d = \underline{265.2\,mm}$ [8]

data, 1 + 7

VI(b)

main parts:

Centrifugal governor
control valve
gear pump
oil pump
spear or needle.



- The centrifugal governor is driven from the main shaft of the turbine.
- control valve controls the direction of flow of liquid
- The servomotor or relay valve has a piston (whose motion towards left or right, depends up on the pr. of liquid flowing through the pipe A or B) is connected to a spear or needle. [7]

8

[Fig: 4 + 3]

VII(a)

Head, $H = 25\,m$
Speed, $N = 200$ rpm
Disch: $Q = 9\ m^3/s$
Effici: $\eta_o = 90\%$
$= 0.9$

1. Power generated, $P = \eta_o \times \omega g Q H$

$= 0.9 \times 9.81 \times 1000 \times 9 \times 25$

$= 1986525\ W.$

$= 1986.5\ kW$

2. Specific speed of the turbine, N_s

$$N_s = \frac{N\sqrt{P}}{H^{5/4}} = \frac{200\sqrt{1986.5}}{(25)^{5/4}}$$

$= 159.4$ rpm

[8]

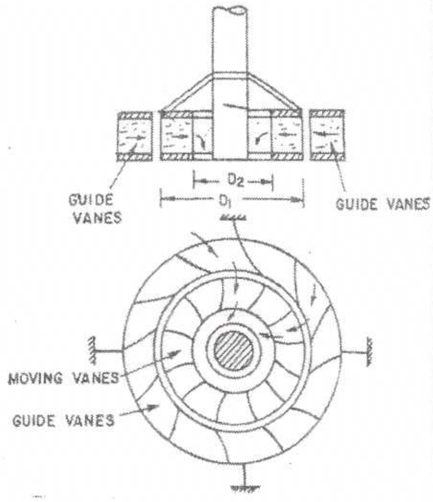
3. Type of turbine:

As the specific speed lies between 80 & 400, The turbine is Francis turbine.

data-1 + 7

VII(b)

In an inward radial flow turbine the water from the casing enters the stationary guide wheel. The guiding wheel consists of guide vanes which direct the water to enter the ~~of~~ runner which consists of moving vanes.



The water flows over the moving vanes in the inward radial direction and is discharged at the inner diameter of the runner.

[7]

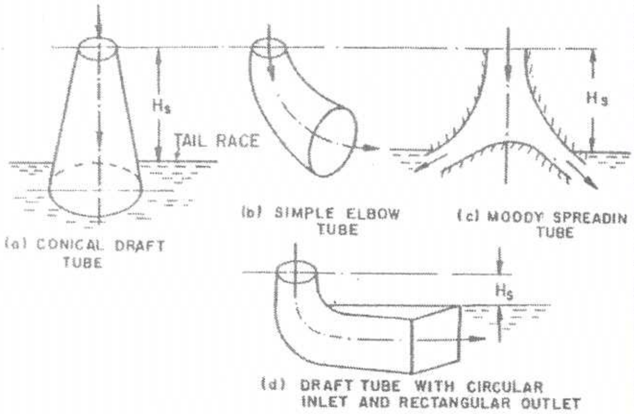
[4 + 3]

9

Types of Draft tubes

VIII(a)

1. Conical Draft tubes
2. Simple elbow
3. Moody Spreading tube
4. Draft tube with circular inlet & ~~the~~ Rectangular outlet.



1. Conical Draft tube. It is a simple straight divergent tube of increasing cross sectional area similar to the frustum of a cone.

2. Simple elbow : This types of tubes have sufficiant increase in area can be made in lesser depth by giving a bend to the tube.

3. Moody spreading tube: It is provided with a short vertical solid central core of conical shape with two long horizontal tubes. [8]

4. This type is useful where larger evacuation is necessary. [4*2]

VIII(b)

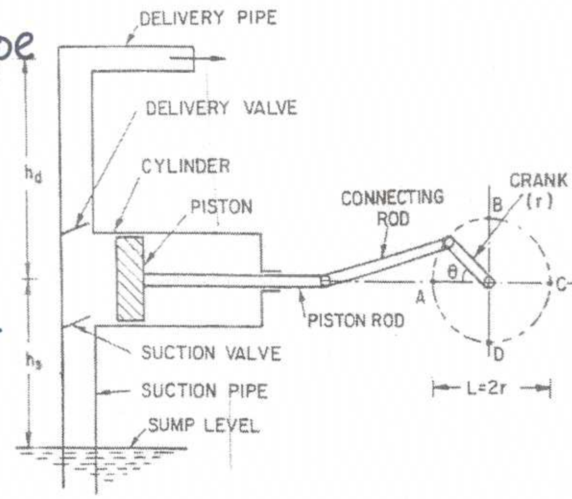
S. No.	Impulse turbine	Reaction turbine
1.	The entire available energy of the water, is first converted into kinetic energy.	The available energy, of the water, is not converted from one form to another.
2.	The water flows through the nozzles and impings on the buckets, which are fixed to the outer periphery of the wheel.	The water is guided by the guide blades to flow over the moving vanes.
3.	The water impinges on the buckets, with kinetic energy.	The water glides over the moving vanes, with pressures energy.
4.	The pressure of the flowing water remains unchanged, and is equal to the atmospheric pressure.	The pressure of the flowing water is reduced after gliding over the vanes.
5.	It is not essential that the wheel should run full. Moreover, there should be free access of air between the vanes and the wheel.	It is essential that the wheel should always run full, and kept full of water.
6.	The water may be admitted over a part of the circumference or over the whole circumference of the wheel.	The water must be admitted over the whole circumference of the wheel.
7.	It is possible to regulate the flow without loss.	It is not possible to regulate the flow without loss.
8.	The work is done by the change in the kinetic energy of the jet.	The work is done partly by the change in the velocity head, but almost entirely by the change in pressure head.

[7]

10

IX(a)

main parts:
Cylinder with Piston,
Sciction pipe, Delivery pipe
Suction valve, Del: valve

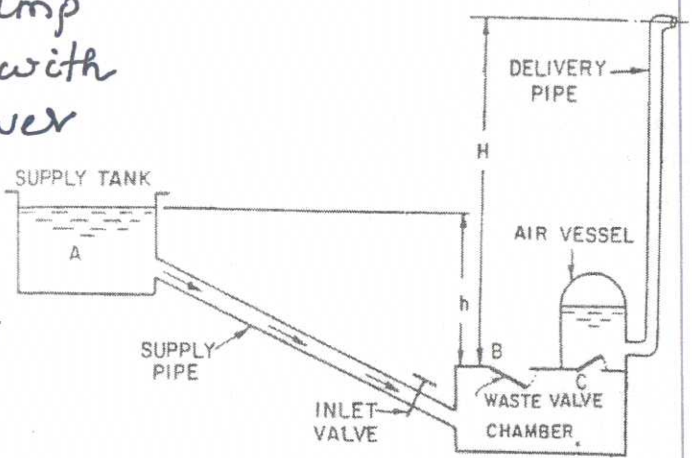


When the crank starts rotating the piston moves two and fro in the cylinder. The movement of piston towards right creates a partial vaccum in the cylinder

The liquid is forced to enter the suction pipe from the sump. This liquid opens the suction valve and enters the the cylinder. movement of the piston towards left causes the delivery valve to open and liquid is forced in to the delivery pipe. (4+4) [8]

IX(b)

Hydraulic ram is a pump which raises water with out any external power for its operation.



When large quantity of water is available at a small hight a small quantity of water can be raised to a greater hight with the help of hydraulic ram.

When the inlet valve opened to the suply pipe is opened water starts flowing from the supply tank to the chamber. As the water is coming in to the chamber from the supply tank the level of water raises in the chamber and waste valve B starts moving upward. At a stage comes when the waste valve B suddently closes. This sudden closure of waste valve creates high pr: inside the chamber. [7]

X(a)

over all $\eta_o = 78\% = 0.78$

Discharge, $Q = 30$ lps $= 0.03\ m^3/s$

dia; $d = 150$ mm $= 0.15$ m

length of pipe, $l = 125$ m

Head, $H = 25$ m

Coefficient of friction $= 0.01$

area, $a = \frac{\pi}{4} d^2$

$= \frac{\pi}{4} (0.15)^2$

$= 0.01767\ m^2$

data: 1 + 7

Velocity $V = \frac{Q}{a} = \frac{0.03}{0.01767}$

$= 1.6978$ m/s

manometric head, H_m

$= H + \frac{4flv^2}{2gd} + \frac{V^2}{2g}$

$= 25 + \frac{4 \times 0.01 \times 125 \times (1.6978)^2}{2 \times 9.81 \times 0.15} + \frac{(1.6978)^2}{2 \times 9.81}$

$= 30.034$

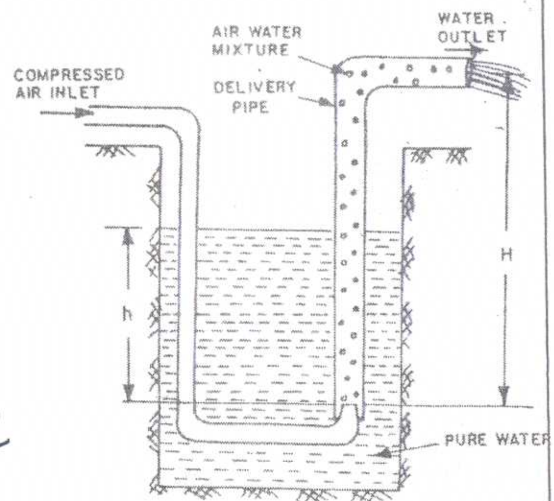
Power $P = \frac{WQH_m}{\eta_o}$

$= \frac{9.81 \times 0.03 \times 30.034}{0.78} = 11.33$ kW

[8]

X(b)

Air lift pump is a device used for lifting water from a well by using compressed air.
Compressed air is made to mix with water.



compressed air is introduced through one or more nozzle at the foot of the delivery pipe.
In the delevery pipe, a mixture of air and water is formed. The density of this air water mixture becomes very less as compared to the density of pure water. Hence a small column of water will balance a very long column of air water mixture. This air water mixture will be discharged out of the delivery pipe.

(7)

12 [3½ + 3½]