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

i. **Weight density** :- It is a ratio of weight to volume. $\frac{W}{V}$ unit KN/M^3 01 Marks

Kinematic viscosity :- It is a ratio of dynamic viscosity to mass density. 01 Marks

$V = \frac{\varphi}{P}$ Unit M^2/S

ii. **Discharge** – $Q = =$ M^3/S 01 Marks

Dynamic viscosity= $\mu = \frac{N-S}{M^2}$ 01 Marks

iii. Weight density of oil --?

Specific gravity of oil = $\frac{weight\, density\, of\, oil}{weight\, density\, of\, water}$ 01 Marks

There for 0.8= $\frac{woil}{9.81}$ $woil = 0.8x9.81$

$= 7.848KN/M^3$ 01 Marks

iv. a) Bourdon's pressure gauge. **01 Marks**

b) Manometer. 01 Marks

v. Bernoulli's equation :-

$z + \frac{p}{w} + \frac{v^2}{2g} = coustant$ where $z =$ potential head

$\frac{p}{w}$ = pressure head

$\frac{v^2}{2g}$ = kinetic head

vi. 1) Type of energy at inlet 01 Marks

a) Impulse turbine
b) Reaction turbine

2). Direction flow through runner :- 01 Marks

a) Tangential flow b) Radial flow.

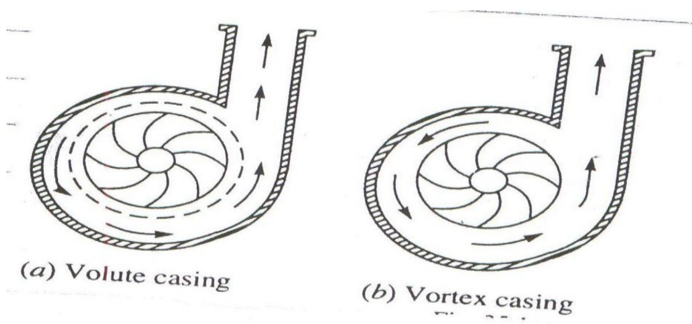
c) Axial flow d) Mixed flow.

vii. Slip :- It is difference between theoretical discharge and actual discharge 01 Marks

$QTh - Qact$

Negative Slip :- When $(Qact)$ actual discharge is more than theoretical discharge than Slip is known as negative Slip 01 Marks

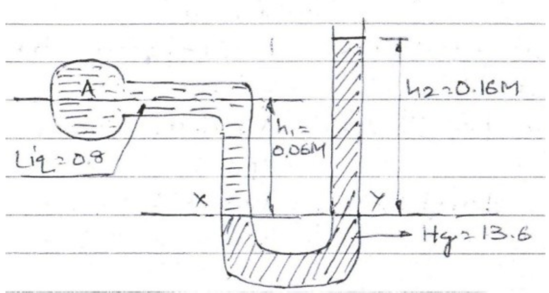
viii. 02 Marks



(a) Volute casing (b) Vortex casing

Q.1 b) Attempt any two

i. Find the pressure of liquid in pipe.



Let h_A - pressure head at A in pipe in terms of water column by manometric principle we have, total pressure head at = total pressure head at y.

$h_A + 0.06x0.8 = 13.6x0.16$ 01 Marks

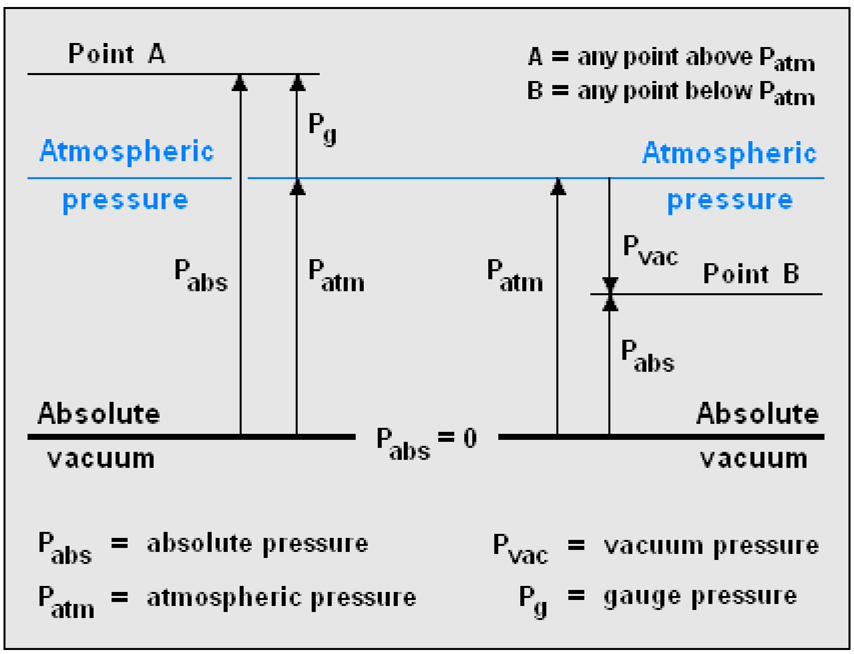
h_A = 2.176-0.048 02 Marks

= 2.128M of water

$PA = 2.128x9.81$

$PA = 20.87KN/M^2$

ii. Sketch shows the relation between absolute vacuum, gauge pressure and atm. Pressure. **(Sketch 2M, Explain 2M)**



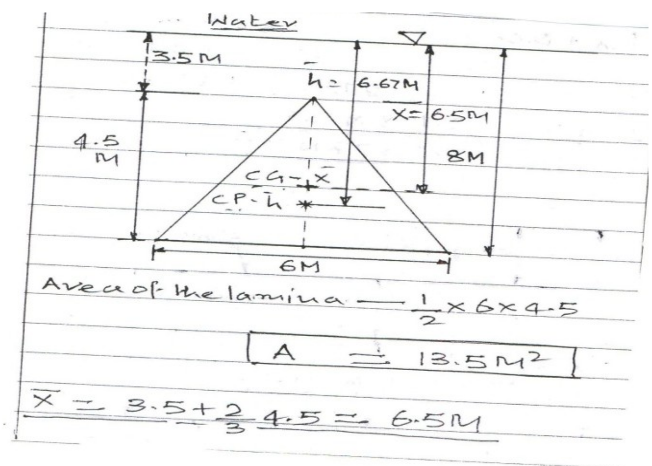
Explanation: Absolute vacuum is the absolute zero or datum value. Gauge pressure is pressure indicated by gauge. Atm. Pressure is the pressure of atmosphere. When pressure indicated by the gauge is above atmospheric pressure then it is positive pressure. When pressure indicated by the gauge is below atmospheric pressure then it is negative pressure or vacuum. Pressure measured from absolute zero or vacuum line is called absolute pressure or absolute vacuum.

iii. Key points/Detailed Solution

Pelton Turbine	Francis Turbine	
i. Impulse turbine ii.Requires high speed iii.Tangential flow turbine iv.Low specific speed v.Constant pressure turbine	i. Reaction Turbine ii. Requires medium speed iii. Radial flow turbine iv. medium specific speed v. Variable pressure turbine	Any four One mark each=04

Q.2 Attempt any Four

a)



Area of the lamina$-\frac{1}{2}x6x4.5$

$A = 13.5M^2$

$x = 3.5 + \frac{2}{3}4.5 = 6.5M$ 01 Mark

Q.02 a)

Total pressure= $P = WAX$

$P = 9.81x13.5x6.5$

$P = 860.82\text{KN}$ 01 Mark

Position of Centre pressure

$h = \frac{IGG}{AX} + X$

$IGG - \frac{bh^3}{36} = \frac{6x(4.5)^3}{36}$

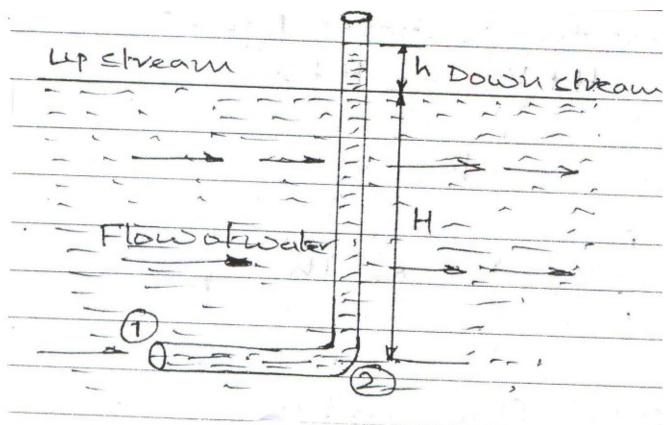
$IGG = 15.1875M^4$ 01 Mark

$h = \frac{15.1875}{13.5x6.5} + 6.5$

$= 0.1730 + 6.5$

$h = 6.673$m 01 Mark

b) Working of pilot tube **(Sketch 01 M, Explain 2M, equation 1M)**



Construction details are as shown in the sketch. It is used to determine velocity of flow at required point in a pipe or a stream. It consists of glass tube bent through 90^0 as shown in the sketch.

The lower end of the tube faces the direction of flow. The liquid vises up in the tube due to pressure exerted by the flowing fluid. By measuring the vise of liquid in the tube (h) we can find out velocity of flow

- Let h −height of liquid in the Pitot tube
- Dynamic pressure head

H- height of liquid in the tube below the surface

- Static pressure head
  V- Velocity of flow
  Applying Bernoulli's theorem from the sections 1 and 2
- $H + \frac{v^2}{2g} = H + h$

OR

$$h = \frac{v^2}{2g}$$

$$\boxed{V = \sqrt{2gh}}$$

c) Steady Flow :- A flow in which quantity of liquid or flow parameters of flowing liquid remains constant w.r.t time. 01 Marks

i.e. $\frac{dp}{dt} = 0$ Where P-Flow parameter.

Non uniform Flow :- A flow in which flow parameters of flowing liquid does not remain Constant w.r.t specified region 01 Marks

i.e $dp/ds \neq 0$ Where S- specified region.

Laminar flow :- A flow in which each liquid particle has a definite path & the paths of Individual particles do not cross each other. 01 Marks

Relational flow :- A flow, in which the fluid particles also rotate about their own axes while flowing 01 Marks

d) Length of pipe – 3 km = 3000 m

Diameter of pipe – 200 MM = 0.2 m

Pressure of water – 1500 KPa

OR

Pressure head = $\frac{1500}{9.81}$ m

H = 152.90 M 01 Marks

Darcy's coefficient of friction = $f.001$ since maximum power is to be transmitted we have

$$hf = \frac{H}{3}$$

where hf—Head loss due to friction

$hf = \frac{152.90}{3}$ =50.96 m 01 Marks

Let Q- Discharge through pipe. Now we know that

$$hf = \frac{flQ^2}{3d^5}$$

$$50.96 = \frac{0.01x3000xQ^2}{3x(0.2)^5}$$

$$50.96 = \frac{30xQ^2}{0.00096}$$

$$Q^2 = 0.0016$$

$$Q = 0.04M^3/s$$ 01 Marks

Maximum power that can be transmitted

$$= power = wxQx(H - hf)$$

$$= 9.81x0.04(152.90 - 50.96)$$

$$P = 40.001KW$$

$$P \approx 40kw$$ 01 Mark

e) Darcy's equation ---

$$hf = \frac{4LV^2}{2gd}$$

Where $hf = Head\ loss\ due\ to\ friction$

$f = Darcy's\ coefficient\ of\ friction.$

$L = Lenght\ of\ pipe.$

$V = Velocity\ of\ Flow$

$d = Diameter\ of\ pipe$

Chezy's equation-- $V = C\sqrt{mi}$ 01 Mark

Where $L = Lenght\ of\ pipe.$

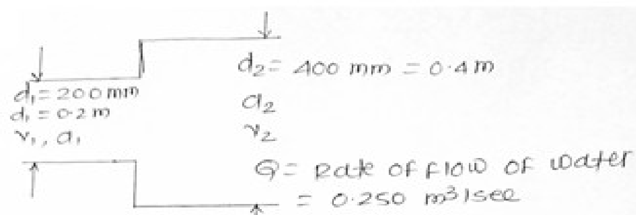
$C = Chery's\ coustant$

$m = Hydrolic\ mean\ depth$

$i = Loss\ of\ head\ per\ unit\ length$

f) Laws of fluid friction for turbulent flow – The frictional resistance for turbulent flow is-

i. Proportional to V^N where N varies from 1.5 to 2.0
ii. Proportional to density of fluid.
iii. Proportional to the area of surface in contact.
iv. Independent of pressure.
v. Dependent on nature of surface in contact.

Ques. No.	Answer Key	Marks
3	**Attempt Any FOUR:**	**16**
a)	 Area, $a_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(0.2)^2 = 0.314\ m^2$ Area, $a_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(0.4)^2 = 0.1256\ m^2$ ....(1M) velocity, $v_1 = \frac{\text{Discharge (Q)}}{\text{Area }(a_1)} = \frac{0.250}{0.314} = 0.796$ m/sec ....(1M) velocity, $v_2 = \frac{\text{Discharge (Q)}}{\text{Area }(a_2)} = \frac{0.250}{0.1256} = 1.99$ m/sec ....(1M) Now, Head loss due to sudden enlarge, $he = \frac{(v_1 - v_2)^2}{2g}$ $\therefore he = \frac{(0.796 - 1.99)^2}{2 \times 9.81} = 0.07262$ m. Loss of Head due to sudden enlargement $he = 0.07262$ m ....(1M)	04

b)

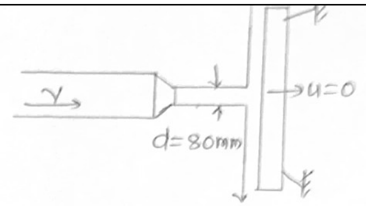


plate is stationary
u=0 m/sec

Force exerted by jet of water, $F_x = 1.8$ kN $= 1800$ N
Jet diameter, $d = 80$ mm $= 0.08$ m
Area of Jet, $a = \frac{\pi}{4} d^2 = \frac{\pi}{4}(0.08)^2$
$= 5.026 \times 10^{-3}$ m^2 ....(1M)
velocity of Jet, $V = ?$
Force exerted by jet of water on the plate in the direction of Jet,
$F_x = \rho a V^2$ ....(1M)
$1800 = 1000 \times 5.026 \times 10^{-3} V^2$
$V = 198.94$ m/sec ---- ($\rho = 1000$ kg/m^3 density for water)
∴ velocity of Jet $V = 198.94$ m/sec ....(2M)

04

c)

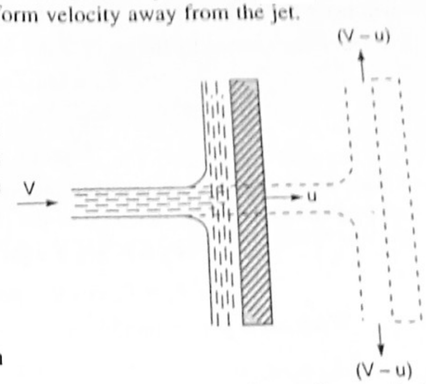
Force on Flat Vertical Plate Moving in the Direction of Jet. Fig. shows a jet of water striking a flat vertical plate moving with a uniform velocity away from the jet.

Let V = Velocity of the jet (absolute),
a = Area of cross-section of the jet,
u = Velocity of the flat plate.

In this case, the jet does not strike the plate with a velocity V, but it strikes with a relative velocity, which is equal to the absolute velocity of jet of water minus the velocity of the plate.

Hence relative velocity of the jet with respect to plate
$= (V - u)$

Mass of water striking the plate per sec
$= \rho \times$ Area of jet $\times$ Velocity with which jet strikes the plate
$= \rho a \times [V - u]$ ....(1M)



Jet striking a flat vertical moving plate. ....(1M)

∴ Force exerted by the jet on the moving plate in the direction of the jet,

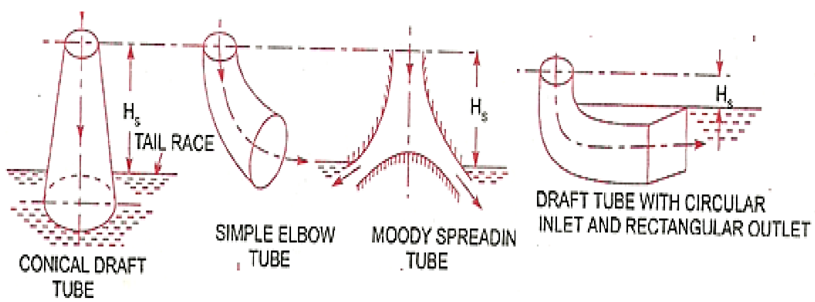
F_x = Mass of water striking per sec × [Initial velocity with which water strikes – Final velocity]
$= \rho a(V - u)\,[(V - u) - 0]$ (∵ Final velocity in the direction of jet is zero)
$= \rho a(V - u)^2$ ....(1M)

In this case, the work will be done by the jet on the plate, as plate is moving. For the stationary plates, the work done is zero.

∴ Work done per second by the jet on the plate

$$= \text{Force} \times \frac{\text{Distance in the direction of force.}}{\text{Time}}$$

$$= F_x \times u = \rho a(V - u)^2 \times u$$ ....(1M)

d)	Types of draft tube (2M) i) Conical draft tubes ii) Simple elbow draft tubes iii) Moody spreading draft tubes iv) Elbow draft tubes with circular inlet and rectangular outlet. **Explanation of any one with sketch (2M)** .... **Conical diffuser or straight divergent tube**-This type of draft tube consists of a conical diffuser with half angle generally less than equal to 10° to prevent flow separation. It is usually employed for low specific speed, vertical shaft Francis turbine. Efficiency of this type of draft tube is 90%. 	04

e)	Working head of Pelton wheel, $H = 50\ m$ Shaft power $= 8\times10^3$ watt Speed, $N = 240$ rpm Overall efficiency, $\eta_o = 78\% = 0.78$ $C_v = 0.98$ Diameter of jet, $d = ?$ Velocity of jet $(V_1) = C_v\sqrt{2gH}$ $= 0.98\sqrt{2\times9.81\times50}$ $= 30.69\ m/sec$ ....(1M) Overall efficiency $(\eta_o) = \frac{\text{Shaft Power}}{\text{Water Power}}$ $0.78 = \frac{S.P}{\rho g Q H} = \frac{8\times10^3}{1000\times9.81\times Q\times50}$ $\therefore Q = 0.0209\ m^3/sec$ ....(1M) By continuity equation, $Q = aV_1 = \frac{\pi}{4}d^2 V_1$ ....(1M) $0.0209 = \frac{\pi}{4}d^2\times(30.69)$ $d = 0.02946\ m$ $d = 29.46\ mm$ $\therefore$ Diameter of jet, $d = 29.46\ mm$. ....(1M)	04
f)	**Cavitation** is the phenomenon in which the vapour bubbles are formed when vapour pressure of liquid (Water) falls below atmospheric pressure. The subsequent collapsing of vapour bubbles in high pressure region of turbine, creates high stresses on metallic body of runner, casing and draft tube this produces cavities on such surfaces. Cavitation reduces efficiency of turbine. (2M) **Prevention Methods** **(2M)** i) The design of turbine should be such that the pressure of flowing liquid in any part of turbine should not be allowed to fall below vapour pressure of liquid. ii) The special materials or coatings such as aluminum, bronze and stainless steel should be used as a cavitation resistant.	**04**

4	**Attempt Any FOUR:**	**16**
a)	Given data:- Rate of water flow, $Q = 0.03\ m^3/sec$ Height, $H_s = h_s + h_d = 18 m$ Diameter of pipe, $D_s = D_d = 100 mm = 0.1 m$ Length of pipe, $L_d + L_s = L = 90 m$ overall efficiency, $\eta_o = 75\% = 0.75$ coeff. of friction $f = 0.012$ Power required to drive pump, $P = ?$ velocity of water in pipe, $V_s = V_d = V = \frac{\text{Discharge}}{\text{Area of Pipe}}$ $= \frac{0.03}{\frac{\pi}{4}(0.1)^2}$ $= 3.18\ m/sec$ ....(1M) Frictional head loss in pipe, $(h_{fs} + h_{fd}) = \frac{4fLV^2}{2gd}$ $= \frac{4 \times 0.012 \times 90 \times (3.18)^2}{2 \times 9.81 \times 0.1}$ $= 22.26\ m$ ----2 M Manometric head, $H_m = (h_s + h_d) + (h_{fs} + h_{fd}) + \frac{V_d^2}{2g}$ $= 18 + 22.26 + \frac{(3.18)^2}{2 \times 9.81}$ $= 40.77\ m$ ....(2M)	**08**

Overall efficiency, $\eta_o = \dfrac{\left(\frac{W H_m}{1000}\right)}{\text{Shaft power (kW)}}$

$$\eta_o = \frac{\rho g Q H_m}{1000 \times S.P.}$$

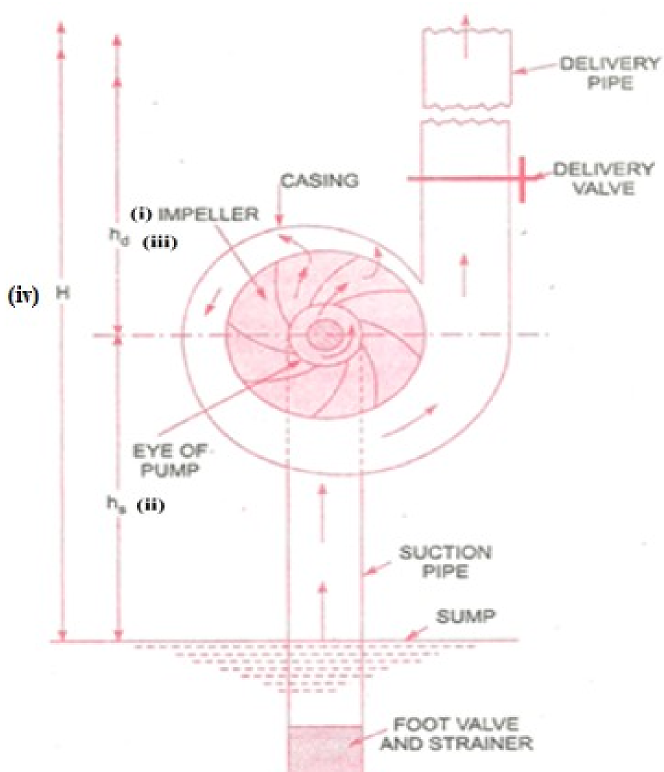
$$0.75 = \frac{1000 \times 9.81 \times 0.03 \times 40.77}{1000 \times S.P.}$$

$\therefore S.P. = 15.99$ kwatt ....(2M)

S.P. is the power required to drive the centrifugal pump. = 15.99 kwatt.
.............(1M)

b) Parts of Centrifugal Pump

i) Impeller ii) Suction pipe iii) Delivery pipe iv) Suction and Delivery Gauge



--- 4 Marks

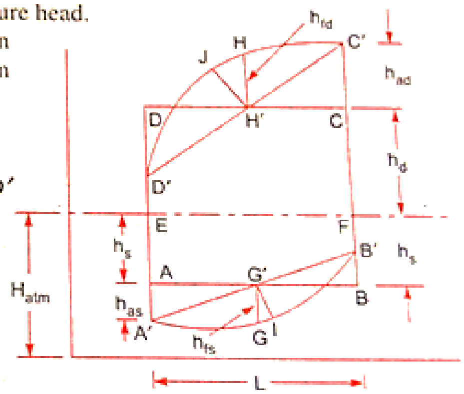
	i) Total Head (Static Head) H:-The sum of Suction Head and Delivery Head is called Static Head. $H = Hs + Hd$ ii) Manometric Head (Hm):-It is the head against which centrifugal pump has to work. $H_m = h_s + h_d + h_{f_s} + h_{f_d} + \frac{V_d^2}{2g}$ where h_s = Suction head, h_d = Delivery head, h_{f_s} = Frictional head loss in suction pipe, h_{f_d} = Frictional head loss in delivery pipe, V_d = Velocity of water in delivery pipe. ---- 4 marks	**08**
c)	**Indicator diagram for a reciprocating pump** is the graph between pressure head in cylinder and distance travelled by piston from inner dead centre for one revolution of the crank. The pressure head in the cylinder during suction and delivery strokes due to the effect of acceleration and friction in suction and delivery pipes on indicator diagram as follows; *(i)* At the beginning of the suction stroke, $\theta = 0$ and hence h_{as} from equation is equal to $\frac{l_s}{g} \times \frac{A}{a_s} \omega^2 r$. But $h_{fs} = 0$. Thus the pressure head in the cylinder will be $(h_s + h_{as})$ below the atmospheric pressure head. *(ii)* At the middle of the suction stroke, $h_{as} = 0$ but $h_{fs} = \frac{4 \times f \times l_s}{d_s \times 2g} \times \left(\frac{A}{a_s} \omega r\right)^2$. Thus the pressure head in the cylinder will be $(h_s + h_{fs})$ below the atmospheric pressure head. *(iii)* At the end of the suction stroke, $h_{as} = -\frac{l_s}{g} \times \frac{A}{a_s} \omega^2 r$ but $h_{fs} = 0$. Thus the pressure head in the cylinder will be $(h_s - h_{as})$ below the atmospheric pressure head. *(iv)* At the beginning of the delivery stroke, $h_{ad} = -\frac{l_d}{g} \times \frac{A}{a_d} \times \omega^2 r$ but $h_{fd} = 0$. Thus the pressure head in the cylinder will be $(h_d + h_{ad})$ above the atmospheric pressure head.	**08**

(v) In the middle of the delivery stroke, $h_{ad} = 0$ and $h_{fd} = \frac{4fl_d}{d_d \times 2g} \times \left(\frac{A}{a_d}\omega r\right)^2$. Thus the pressure head in the cylinder will be $(h_d + h_{fd})$ above the atmospheric pressure head.

(vi) At the end of the delivery stroke, $h_{ad} = -\frac{l_d}{g} \times \frac{A}{a_d} \times \omega^2 r$ and $h_{fd} = 0$. Thus the pressure head in the cylinder will be $(h_d - h_{ad})$ above the atmospheric pressure head.

Thus the indicator diagram with acceleration and friction in suction and delivery pipes will become as shown in

Area of the indicator diagram $A'GB'C'HD'$
$= $ Area of $A'G'B'C'H'D'$ + Area of parabola $A'GB'$
+ Area of parabola $C'HD'$



Effect of acceleration and friction on indicator diagram.

Q 5 a) Air vessel is a closed chamber connected in the suction and discharge lines of a reciprocating pump. The vessel contains liquid with air entrapped in the upper part as shown in figure.

[2 Marks]

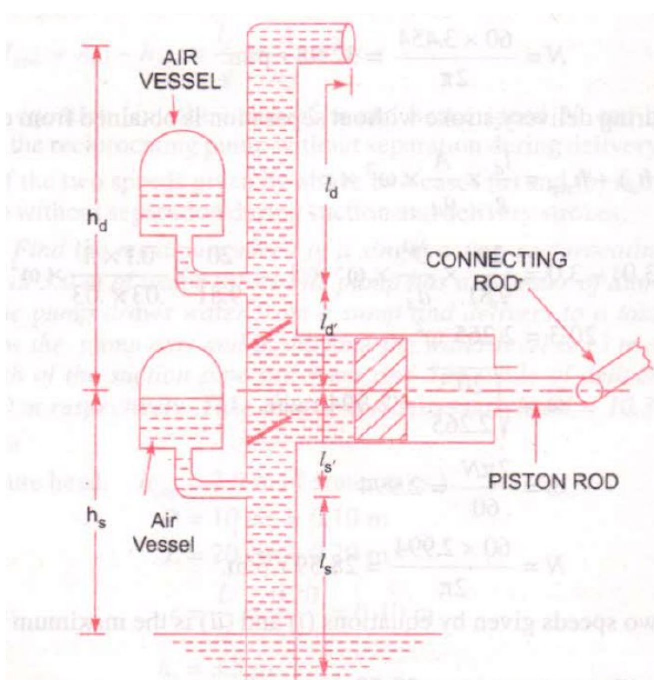


Fig-Air Vessel in the Reciprocating Pump

The functions of the air vessel in the reciprocating pump are; [2 Marks]

1) To reduce peak pressure and flow pulsation in the flow

2) To provide continuous supply of the liquid at the uniform flow rate

3) To save the power required to drive the pump

4) To run the pump at much higher speed without any danger of the separation

Q 5 b) Impulse turbine- The kind of turbine in which entire pressure energy is converted into kinetic energy to get high head discharge tangential to the runner eg. Pelton Wheel.

1) $\text{Hydraulic Efficiency} = \frac{\text{Work done per second}}{\text{K.E.of jet supplied per second}}, \eta h = \frac{2(V_{w1}+V_{w2})U}{(V_1)^2}$

[1 marks]

Where V_{w1} =Whirl velocity at the Inlet

V_{w2} = Whirl velocity at the outlet

U =Velocity of the blade

V_1 =Velocity of the jet at the inlet [1 Mark]

2) $\text{Mechanical Efficiency} = \frac{\text{Power at the shaft of the turbine}}{\text{Power developed by water to the runner}}$ [1 Mark]

Mechanical Efficiency= $\frac{\text{Shaft Power}}{\text{Runner Power}}$

Where, Runner Power=Work done per second

Runner Power= $\rho a V1 (V_{w1} + V_{w2})u$

Where V_{w1}=Whirl velocity at the Inlet

V_{w2}= Whirl velocity at the outlet

U=Velocity of the blade

(V_1)=Velocity of the jet at the inlet

ρ = Mass density of the fluid [1 Mark]

Q 5 c) Construction and working of the Kaplan Turbine

Kaplan turbine is the axial flow turbine with the adjustable blade. It is suitable for where high discharge at low head is available. (Sketch 1M)

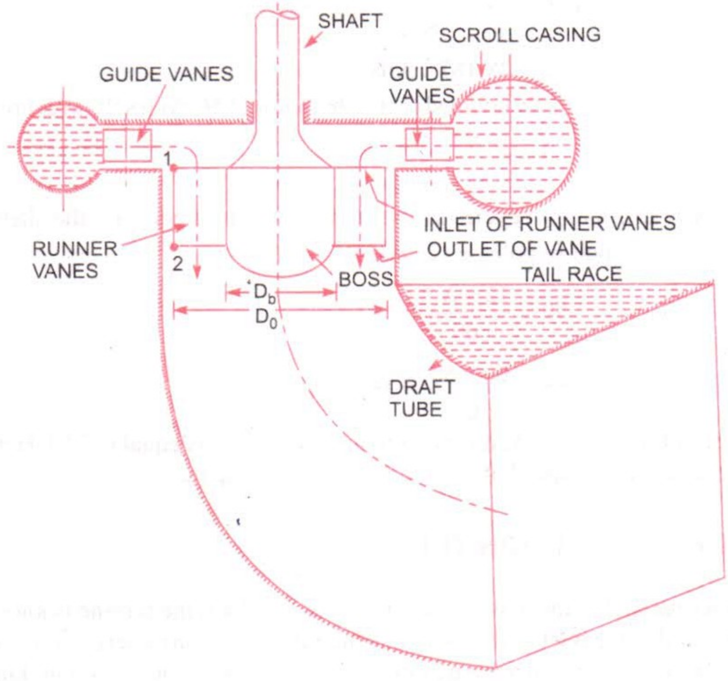


Fig-Kaplan Turbine

Construction-The Kaplan turbine as shown in the figure consists of (i) Scroll casing (ii) Guide Vane Mechanism (iii) Hub with vanes i.e. Runner of the turbine (v) Draft tube

[1½ marks]

The shaft of the turbine is vertical, the lower end of which is made larger known as hub or boss.

The vanes are fixed on the hub so that the hub can act as the runner.

It has adjustable vanes which are generally 3 to 8 in number.

Draft tube is used to discharge the water from runner to the tail race.

Working-

1) The water from the penstock enters the scroll casing and then it moves to the guide vanes.

2) From the guide vanes the water turn through the 90^0 and flows axially through the runner.

3) The discharge through the runner is obtained as $Q=\pi/4(D_o^2-D_b^2)*V_{f1}$

Where, D_o=Outer Diameter of the runner

D_b= Diameter of the hub

V_{f1}=Flow velocity at the Inlet.

4) With the help of the draft tube the water is taken to the tail race from the runner.

[1½ mark]

Q 5 d)-Given= For the horizontal tapered pipe

D_1= Diameter at one end=300mm=0.3m

D_2= Diameter at other end=200mm=0.2m

V_1= Velocity at one end=2.5m/s

V_2= ? .. Velocity at the other end i.e. [1 mark]

Solution- $A_1V_1=A_2V_2$ ----From the equation of the continuity [1 mark]

$\pi/4*D_1^2* V_1 = \pi/4*D_2^2* V_2$

$0.3^2*2.5= 0.2^2* V_2$ --------- π/4 gets cancelled from both sides

$V_2 =(0.3^2*2.5)/(0.2^2)$

V_2= 5.625 m/s

So the velocity at the other end is 5.625 m/s [2 mark]

Q 5 e)-Vertical Micro-manometer

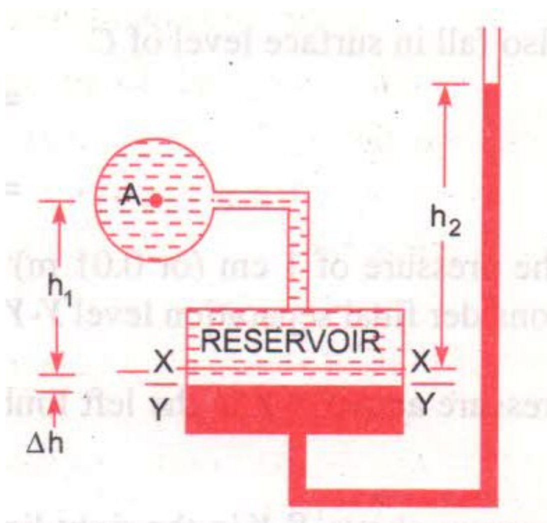


Fig-Vertical Micro manometer

[1 Mark]

Significance-

1) The large cross sectional area of the basin than other limb increases the sensitivity (least count) of manometer.
2) Even a small change in pressure can be easily recognized.
3) Change in level of liquid in reservoir is very smaller than other limb, which may be neglected and thus the pressure is can be given by the height of the liquid column in other limb alone.

[1 Mark]

Q 5 f)-Advantages of the hydro electric power plant

[2 Marks for any 4 advantages of the following]

1) Hydroelectric power plants are environment friendly. They do not cause pollution. Therefore hydropower is called green energy.
2) There is no combustion and the no problem of waste disposal like ash.
3) The basic material i.e. water is freely available as compared to coal or other sources. So its operational cost is less.
4) Water is nor consumed during the power generation, it can be used for its primary applications like irrigation, etc.
5) Hydroelectric power plants operate at relatively low temperature so life of the plant is more. Life expectancy of hydropower plant is above 50 years.
6) The hydraulic turbine can be switched on or off in very short time unlike thermal or nuclear power plant where the steam turbine is to be put on the turning gear for two days during start ups and shut down.
7) Being simple in design and operation it does not require the skill operator, manpower requirement is also low.

Limitations of the hydro electric power plant

[2 Marks for any 4 advantages of the following]

1) Power generation is dependent on the supply of water available which may vary from season to season and region to region. So the satisfactory operation of the plant throughout the year is not assured.
2) Water sources with suitable head and discharge are often far from the load centers that need long transmission lines. It increases losses and cost both.
3) Hydro power projects are capital intensive with low rate of return.
4) The gestation period of the hydro projects is quiet large, the gap between foundation and completion of the projects may extend from 10 to 15 years.
5) The transport of basic material i.e. water is very costly, if at all planned.
6) Idle time during low rainfall or draughts is unwarranted and difficult to tackle.

Q 6 a)-Given-For the taper pipe

L=length of the pipe=45m

I=slope=(1/10)

A_1=Area of the pipe at the upper end=8m^2

A_2=Area of the pipe at the lower end=3m^2

V_2=Velocity of the pipe at the lower end=5m/s

P_1=Pressure of the pipe at the upper end=100kPa.

To Find-1) Pressure of the pipe at the lower end (P_2)=?

2)Rate of Flow(Q)=?

Solution-1) **Pressure of the pipe** at the lower end (P_2)=?

From The Bernoulli's Theorem

$(P_1/\rho g)+(V_1^2/2g)+Z_1=(P_2/\rho g)+(V_2^2/2g)+Z_2$ [1 Mark]

Assuming datum to be passing through lower end so $Z_2=0$

$Z_1=(1/10)\times45=4.5m$ [1 Mark]

Also, $A_1V_1=A_2V_2$ -------------From the equation of the continuity

$8\times V_1=3\times5$

$V_1=(3\times5)/8=1.875m/s$ [1 Mark]

$(P_1/\rho g)+(V_1^2/2g)+Z_1=(P_2/\rho g)+(V_2^2/2g)+Z_2$

$(100/9.81)+(1.875^2/2\times9.81)+4.5=(P_2/\rho g)+(5^2/2\times9.81)+0$

$10.19+0.18+4.5=(P_2/\rho g)+1.27$

$14.87=(P_2/\rho g)+1.27$

$(P_2/\rho g)=13.60$

$P_2=13.60\times9.81=133.41kPa$ [2 Mark]

So the Pressure at the lower end is 133.41kPa

2) Rate of Flow(Q)=?

$Q = A_1V_1=8\times1.875=15m^3/s$[3 Mark]

$A_2V_2=3\times5=15m^3/s$

Rate of Flow (Q)= 15m^3/s

Q 6 b)-Given-For the jet of water

D=Diameter of the jet=50mm=0.05m

V=Velocity of the jet=15m/s

u=Velocity of vanes=6m/s

Since Θ is not given assuming vane to be vertical plate having $\Theta=90^0$

To Find:-

1) Force exerted by jet
2) Work done by jet
3) Efficiency of the jet

Solution:-

1) Force exerted by Jet= (Mass of Jet) × (Change in velocity)

Now, Mass of jet(m) $= \rho aV = 1000\times(\pi/4)\times(0.05)^2\times15$

$= 29.452$Kg/s [1 Mark]

And, Change in velocity $= [(V-u)-(-V-u)\cos\Theta]$

$=[(V-u)(1+\cos\Theta]$

$= [(15-6)-(-15-6)\text{Cos } 90]$

$= [(15-6)-(-15-6)\times0]$

$= 9$

$\therefore$ Force exerted by Jet=29.452×9

=265.068N [2 Mark]

2) Work done by jet = Force× Velocity of vane

=265.068×6

=1590.408Nm/s [2 Mark]

3) Efficiency of the jet (η) = (WorkDone/KE supplied)

KE supplied=1/2 m×V^2=1/2×29.452×15^2 [2 mark]

KE supplied=3313.35 Nm/s

$\eta = (1590.408/3313.35)$

=0.48 (48%) [1 Mark]

Q 6 c-i) Minor Losses in the pipes

[1 Marks each for each minor loss 1*4=4mark]

1) Loss of head due to sudden enlargement

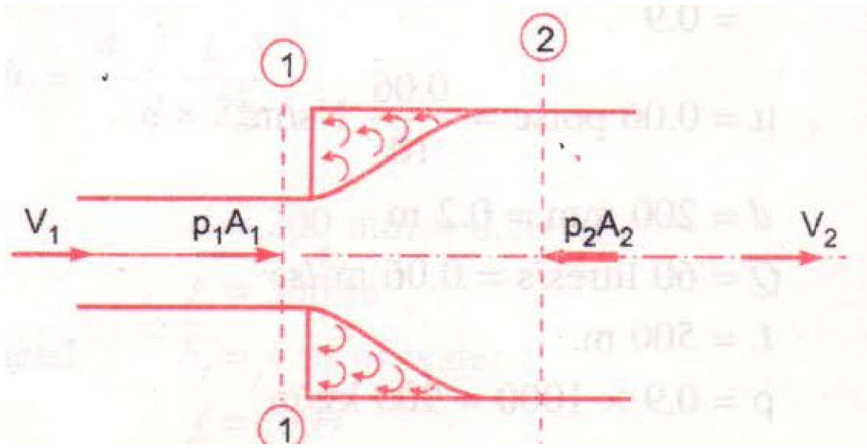


Fig-Head Loss due to sudden Expansion

$h_e=(V_1-V_2)^2/(2g)$

2. Loss of head due to sudden contraction

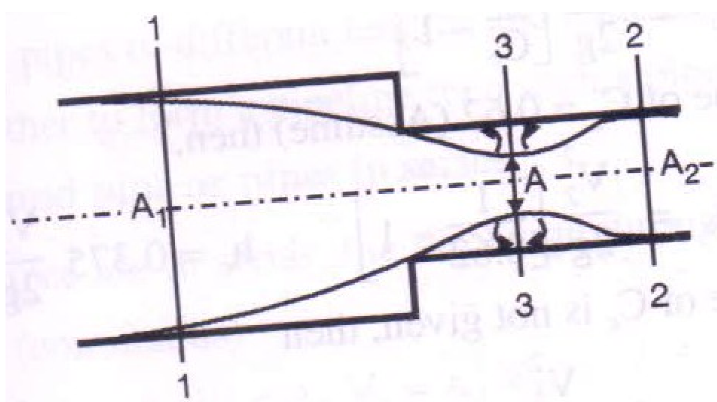


Fig-Loss of head due to sudden contraction.

$h_c=[(1/C_c-1)]^2\times(V_2/(2g)$

If C_c is not given then $h_c= 0.5V_2^2/(2g)$

3. Loss of head at entrance

$h_i= 0.5V^2/(2g)$

4. Loss of head at exit

$h_o= V_2^2/(2g)$

5. Loss of head due to bend & pipe fitting

   $h_b = KV^2/(2g)$

   Where K=Coefficient of bend and pipe fittings.

6. Loss of head due to obstruction in pipe

   $h_b = V^2/(2g) \times \{[A/ C_c (A-a)]-1\}^2$

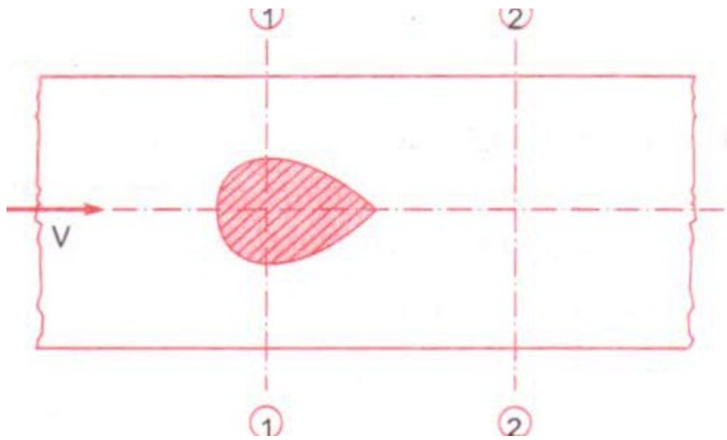


Fig- Loss of head due to obstruction.

Q 6 c-ii) Surface Tension

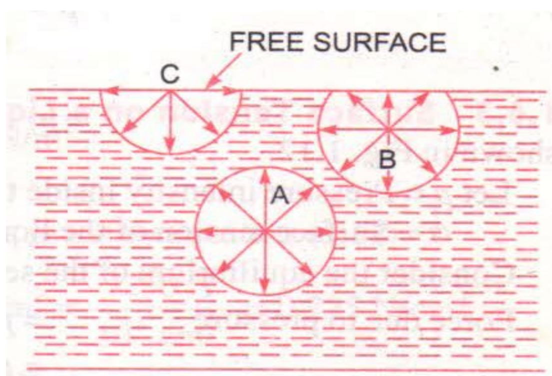


Fig- Surface Tension

[1 Mark]

- It is defined as tensile force acting on the surface of the liquid in contact with the gas. The tensile force between surfaces of two immiscible liquids is called as interfacial tension.
- It is also defined as the property of liquid by virtue of which the liquid tends to have minimum surface area.
- The surface tension is denoted by Sigma (σ) and expressed in N/m or dyne/cm.

- The surface tension of any liquid will have the same value as the surface energy per unit area.
- Surface tension enables the formation of bubbles, droplet, etc. [1 Mark]

Capillarity-

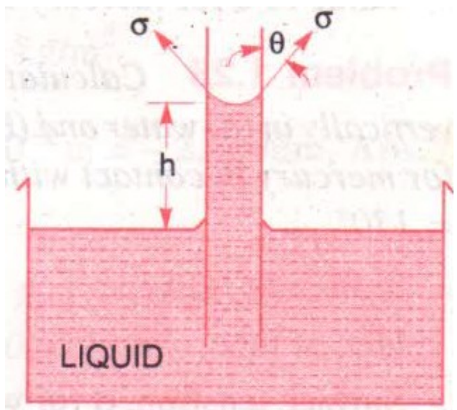


Fig- Capillarity

[1 Mark]

- It is defined as the phenomenon of rise or fall of the liquid surface in the small tube relative to the adjacent general level of liquid when tube is held vertically in the liquid.
- The rise of the liquid surface is called as capillary rise while fall of the liquid surface is known as capillary depression.
- The rise or fall of the liquid level in the capillary depends upon cohesion among the liquid molecules and adhesion between liquid and the material of capillary e.g. water in glass capillary gives rise while mercury in the same capillary gives fall of level.
- Capillarity is expressed in terms of cm or mm of liquid.
- Its value depends on the specific weight of liquid, diameter of the tube and surface tension of liquid.

The rise of liquid (h) is given by,

$h = 4\,\sigma \cos\Theta)/(\,\rho g d)$

Where, $\Theta=128^0$---For mercury & glass tube.

$=0^0$ --- For water and clean glass tube. [1 Mark]