WINTER– 14 EXAMINATION

Subject Code: **17411 (FMM)** **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.

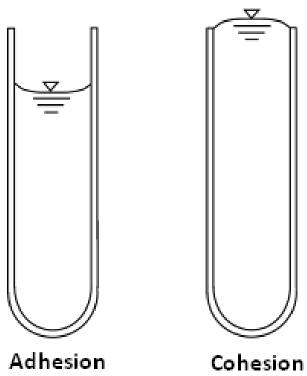
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q1A a) Cohesion and Adhesion **02 marks**

Cohesion means inter-molecular attraction between molecules of the same liquid. Surface tension is caused by the force of cohesion at the free surface.

Adhesion means attraction between the molecules of a liquid and the molecules of a solid boundary surface in contact with the liquid. Capillarity rise or fall is due to the combined effect of adhesion and cohesion.



Q1A b) Any liquid that does not evaporate under the temperature and pressure that manometer exposed to can be used in a manometer. Use of mercury is more practicable. Since mercury has a density that is 13.6 times more than water, use of mercury instead of water can reduce the size (Height) of a manometer by more than 10 times. **02 marks**

Q1A c) Continuity equation:

Based on the principle of conservation of mass a fluid flowing through the pipe at all cross section the quantity of fluid per second is constant.

Equation $\rho_1 A_1V_1=\rho_2A_2V_2=\rho_3A_3V_3$

$A_1V_1=A_2V_2= A_3V_3$

02 marks

Q1A d)

$\therefore$ The forces exerted by the jet of water on curved plate at the centre in the directions of x and y are

$$F_x = \rho aV[V_{1x} - V_{2x}] = \rho aV[V\cos\theta - (-V\cos\phi)]$$
$$= \rho aV[V\cos\theta + V\cos\phi]$$
$$= \underline{\rho aV^2 [\cos\theta + \cos\phi]}$$
$$F_y = \rho aV[V_{1y} - V_{2y}] = \rho aV[V\sin\theta - V\sin\phi]$$
$$= \underline{\rho aV^2 [\sin\theta - \sin\phi]}.$$

Q1A e)

i) Steady flow : The type of flow in which the fluid characteristics like velocity, pressure , density etc at a point do not change with time is known as steady flow.

ii) Unsteady flow: The type of flow in which the fluid characteristics like velocity, pressure, density etc at a point changes with time is said to be unsteady flow. **02 marks**

Q1A f)

i) Slip: The difference of theoretical discharge and actual discharge is known as slip of the pump.

ii) Negative slip : The difference of theoretical discharge and actual discharge. If actual discharge is more than the theoretical discharge the slip of the pump will become negative. Occurs when delivery pipe is short, suction pipe is long; pump is running at high speed. **02 marks**

Q1A g) Types of draft Tubes

1. Conical draft tube
2. Simple elbow type draft tube
3. Circular inlet and rectangular outlet draft tube
4. Moody spreading tube draft tube **02 marks**

Q1A h)

NPSH: NET POSITIVE SUCTION HEAD is defined as the net head in meters of liquid required to force the liquid into the pump though suction pipe. It is given as the atmospheric pressure head minus vapour pressure head minus frictional head minus velocity head in the suction pipe.

Mathematically

NPSH = Atmospheric pressure head- vapour pressure head- frictional head- velocity head

$= H_a - H_v - h_s - h_{fs}$ **02 marks**

Q1B a)

i. Absolute pressure: The pressure which is measured with reference to absolute vacuum pressure **01 mark**

ii. Gauge pressure: The pressure which is measured with help of a pressure measuring instrument in which the atmospheric pressure is taken as datum. **01 mark**

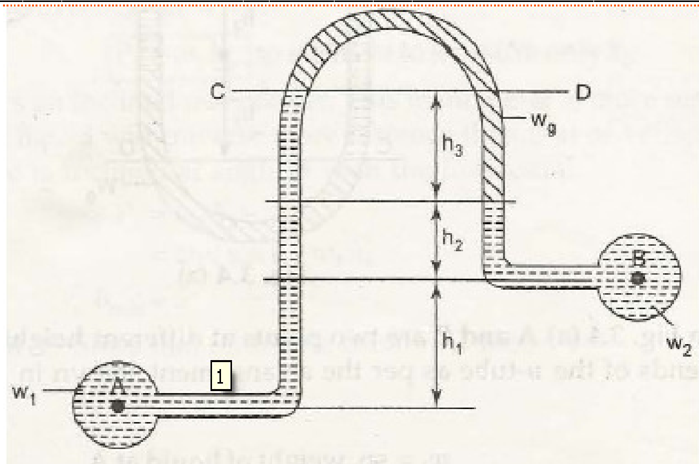
iii. Vacuum pressure: It is defined as the pressure below the atmospheric pressure. **01 mark**

iv. Atmospheric pressure: The pressure which is exerted due to the weight of air above earth's surface.

01 mark

Q1B b) Inverted U tube Differential Manometer

Differential manometers are used to measure the pressure difference between two points in a pipe or in two different containers. It consists of a inverted u-tube, containing a heavy liquid. The two ends are connected to two different points whose pressure difference is to be measured. It is used for measuring difference between low pressures.



Pressure at C (left limb) = Pressure at D (right limb)

$P_A - w_1 (h_1 + h_2 + h_3) = P_B - w_2 h_2 - w_g h_3$

Or $P_A - P_B = w_1 (h_1 + h_2 + h_3) - w_2 h_2 - w_g h_3$

Difference in pressures between A & B.= $w_1 h_1 + h_2 (w_1 - w_2) + h_3 (w_1 - w_g)$ **04 marks**

Q1 B c) iii) Laws of fluid frictional for turbulent flow. (Stating laws 04 marks)

- Frictional resistance is proportional to square of velocity of flow.
- Frictional resistance is independent of pressure.
- Frictional resistance is proportional to density of fluid.
- Frictional resistance slightly varies with temperature.
- Frictional resistance is proportional to surface area of contact.

Q2 a) Advantages of Mechanical Gauges

i) These pressure gauges give accurate results
ii) They costs low
iii) They are simple in construction
iv) They can be modified to give an better electrical outputs
v) They are safe even for high pressure measurement
vi) Accuracy is high especially at high pressure **04marks**

Q2 b) Hydraulic coefficients are the multiplication factors used to rectify the theoretical values to practical values.

1. coefficient of velocity, Cv
2. coefficient of contraction, Cc
3. coefficient of discharge , Cd They are given as

Cv=(actual velocity of jet at vena contracta) / (Theoretical velocity)
Cc= (area of jet at vena contracta) / area of orifice
Cd= (actual velocity x actual area) / (Theoretical velocity x Theoretical area) **04 marks**

Q2 c)

Efficiency of the jet (η) $= \dfrac{\text{Output of the jet per second}}{\text{Input of the jet per second}}$

Diameter of the jet, $d = 10$ cm $= 0.1$ m

$\therefore$ Area, $a = \frac{\pi}{4} d^2 = \frac{\pi}{4} (.1)^2 = .007854$ m^2

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

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

(*i*) The force exerted by the jet on a moving flat vertical plate is given by equation

$$F_x = \rho a (V - u)^2$$
$$= 1000 \times .007854 \times (15 - 6)^2 \text{ N} = \mathbf{636.17\ N.}$$

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

$$= F_x \times u = 636.17 \times 6 = \mathbf{3817.02\ Nm/s.}$$

where output of jet/sec = Work done by jet per second = 3817.02 Nm/s

input per second = Kinetic energy of the jet/sec

$$= \frac{1}{2}\left(\frac{\text{mass}}{\text{sec}}\right) V^2 = \frac{1}{2}(\rho a V) \times V^2 = \frac{1}{2} \rho a V^3$$

$$= \frac{1}{2} \times 1000 \times .007854 \times 15^3 \text{ Nm/s} = 13253.6 \text{ Nm/s}$$

$$\eta \text{ of the jet} = \frac{3817.02}{13253.6} = 0.288 = \mathbf{28.8\%}.$$

04 marks

Q2 d) Given data

d = 200 mm = 0.2m L= 500 m hf = 4 m of water f = 0.009

$hf = \frac{4 f l v2}{2gd}$

$4 = 4 \times 0.009 \times 500 \times V^2 / 0.2 \times 2 \times 9.81$

V= 0.934m/s **02 marks**

Q =Velocity x Area

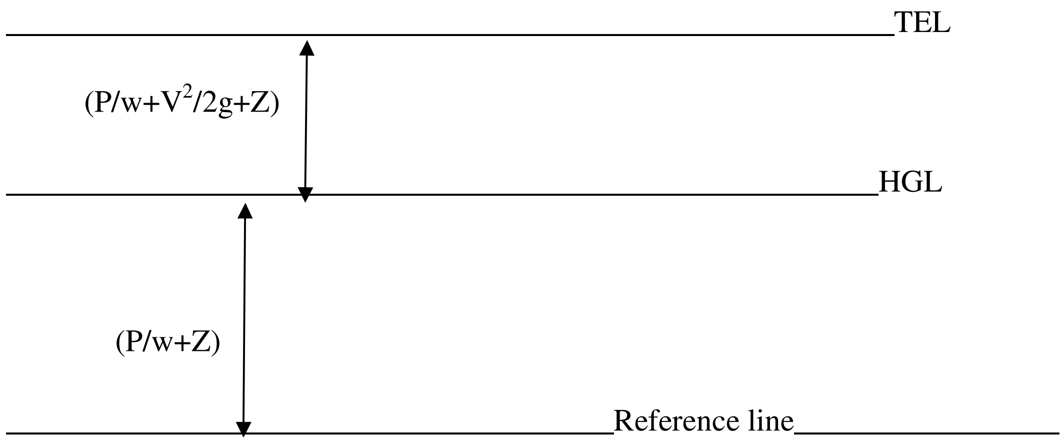
$= 0.934 \times \frac{\pi}{4} (d)^2$

$= 0.934 \times \frac{\pi}{4} (0.2)^2$

Q = 0.0293 m^3/sec

=29.3 litres/sec **02 marks**

Q2 e) i) Hydraulic gradient line (HGL) : It is defined as the line which gives the sum of pressure head (p/w) and datum head (z) of flowing fluid in a pipe with reference to some reference line. It showing the pressure head of a flowing fluid in a pipe from the centre of the pipe. HGL may rise or fall depending upon the pressure changes.



ii) Total Energy Line: (TEL)

Total energy line is the line which gives sum of pressure head, datum head and kinetic head of flowing fluid in a pipe with respect to some reference line. When fluid flows along the pipe, there is loss of head and total energy decreases in the direction of flow. It obtained by joining the tops of all vertical ordinates showing sum of pressure head, kinetic head and datum head (z) from centre of the pipe.

$$TEL = \frac{P}{W} + \frac{v^2}{2g} + z$$

(**Sketch 1Mark, Description 3 Marks)**

Q2 f) **04 marks**

Given :

Height of water, $Z_1 = 2$ m

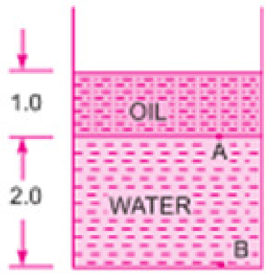
Height of oil, $Z_2 = 1$ m

Sp. gr. of oil, $S_0 = 0.8$

Density of water, $\rho_1 = 1000$ kg/m^3

Density of oil, $\rho_2 =$ Sp. gr. of oil $\times$ Density of water

$= 0.8 \times 1000 = 800$ kg/m^3



pressure intensity at any point is given by

$$p = \rho \times g \times Z.$$

pressure At the bottom, *i.e.*, at *B*

$$p = \rho_2 \times g Z_2 + \rho_1 \times g \times Z_1 = 800 \times 9.81 \times 1.0 + 1000 \times 9.81 \times 2.0$$

$$= 7848 + 19620 = 27468 \text{ N/m}^2 = \frac{27468}{10^4} \text{ N/cm}^2 = 2.7468 \text{ N/cm}^2.$$

Q. No. 3 Attempt any four of the following

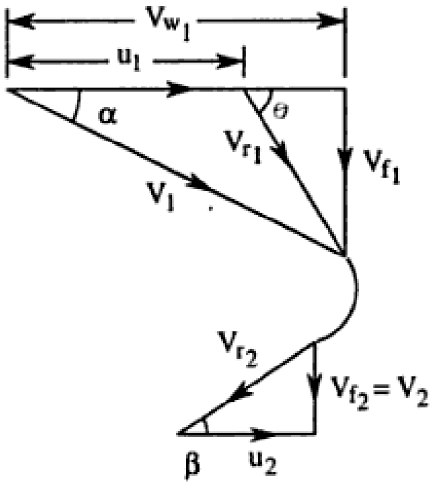
a) Difference between impulse turbine and reaction turbine. (04 Marks)

Sr. No.	Impulse Turbine	Reaction Turbine
1	All the available pressure head is converted into velocity head.	Only part of the pressure head is converted into velocity head.
2	First water flows through the nozzles and then impinges on the buckets.	The water is first guided by the guide blades and then flows over the runner vanes.
3	Pressure of the flowing water remains unchanged and is atmosphere pressure.	The pressure of the flowing water decreases after flowing over the vanes.
4	Wheel must not run full of water as there is access for air between the vanes and wheel.	The runner must run full of water in a closed conduit as there is no access for air to enter the turbine.
5	Water may be admitted over a part or whole of the wheel circumference.	Water must be admitted over the whole circumference of the runner.
6	It is possible to regulate the flow without loss of efficiency.	It is not possible to regulate the flow without loss of efficiency.
7	Running speed is slow	Running speed is high.
8	Repair is easy.	Repair is difficult.

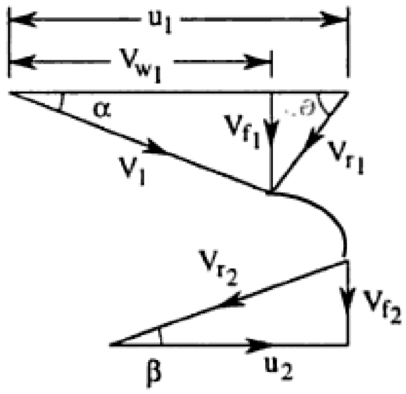
Q. No. 3 b) Classification of Hydraulic turbines (04 Marks)

1. According to the type of energy at inlet- Impulse turbine and Reaction turbine
2. According to the direction of flow through runner- Tangent flow turbine, Radial flow turbine, Axial flow turbine and mixed flow turbine
3. According to the head at the inlet of the turbine- High head , medium head and low head
4. According to specific speed of the turbine- Low specific speed , Medium specific speed and High specific speed turbine

Q. No. 3 c) Inlet and outlet velocity triangles for Francis turbine. (02 Marks each along with meaning)



OR



Vw1- velocity of whirl at inlet

u1- Tangential velocity of wheel at inlet

V1- absolute velocity of water at inlet

Vr1-relative velocity of water at inlet

Vf1-axiale velocity of water at inlet

Vw2- velocity of whirl at outlet

u2- Tangential velocity of wheel at outlet

V2- absolute velocity of water at outlet

Vr2-relative velocity of water at outlet

Vf2-axiale velocity of water at outlet

Q. No. 3 d) H= 25 m, F= 2.2 kN = 2.2 x 1000 N, C_v= 0.99, Dia. of jet d=?

Velocity of jet, $V=C_v \sqrt{2\ g\ H} = 0.99 \times \sqrt{2 \times 9.81 \times 25}$

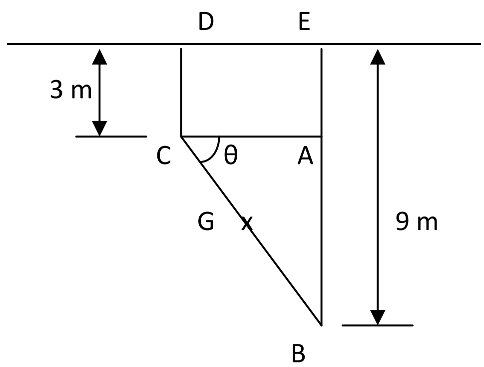
V= 21.95 m/sec **02 marks**

Force on the plate, $F = w\ a\ V^2 / 2\ g$

$2.2 \times 1000 = 1000 \times (\pi / 4) \times d^2 \times (21.95)^2$

Dia of jet d = 0.076 m **02 marks**

Q. No. 3 e) Given data



Circular plate d=6 m $A = \frac{\pi}{4} d^2 = 7.0685\ m^2$

Distance DC = 3 m BE = 9 m

Distance of C.G. from free surface

h=CD+ GC sin θ = 3+3 sinθ

Sinθ = AB /BC= BE- AE / BC = 4-DC/3 =9 -3 / 6 = 1

$h = 3 + 3 \times 1 = 6$ m

Total Pressure (F)

$F = \rho \times g \times A \times h = 1000 \times 9.81 \times 7.0685 \times 1 =$ **69341.985 N** **02 marks**

Centre of pressure (h*)

$h^* = (I_G \sin^2\theta / Ah) + h$ $I_G = (\pi / 64) \times d^4 = 63.63\ m^4$

$h^* = (63.63 \times 1) / (7.0685 \times 6) + 6$ **$h^* = 1.5 + 6 = 7.5$ m** **02marks**

Q. No. 3 f) Capillary tube dia. = 2 mm = .002 m, Sp. gravity = 0.8, h = 15 mm = 0.015, $\theta = 25^0$,

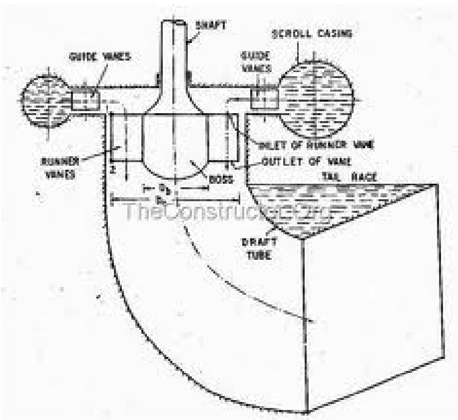
Density $\rho = 0.8 \times 1000 = 800$ **01 Marks**

$h = 4\,\sigma \cos\theta / \rho\, g\, d$

$0.015 = 4 \times \sigma \times \cos 25 / 800 \times 9.81 \times .002$ $\sigma = 0.65$ N/m **03 Marks**

Q. No. 4 Attempt any Two of the following

a) Kaplan Turbine **(Sketch 3 Marks, Construction & Working 3 Marks)**

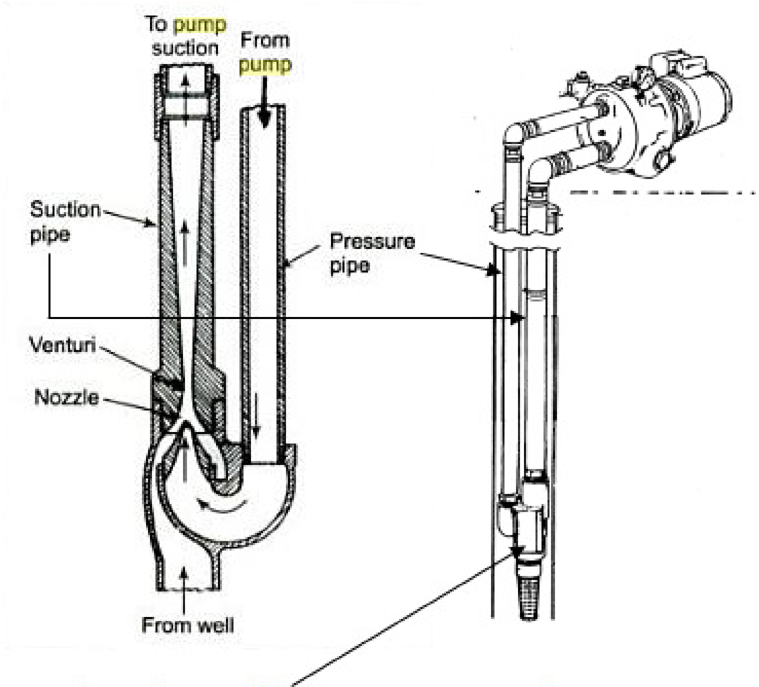


Working: it is a axial flow reaction turbine. It consists of main parts scroll casing, Guide vanes mechanism, hub with vanes or runner of the turbine and draft tube.

The water from penstock enters the scroll casing and then moves to the guide vanes. From the guide vanes, the water turns through 90 ^{o} and flows axially through the runner .During the flow of water through runner a part of pressure energy is converted into kinetic energy.

Q. No. 4 b) Jet pump: **(Sketch-03 marks, Explanation- 03 marks)**

Fig. shows a jet pump set up which consists of jet unit, suction pipe, pressure pipe and a centrifugal pump. A jet unit is consists of a pipe having a convergent end at the bottom. The upper end of the pipe leads to the required height. Now water under pressure is introduced from pressure pipe through a nozzle as shown in fig. The pressure energy of water is converted into kinetic energy, as it passes through the nozzle. As a result of this, the pressure in the convergent portion of the pipe is considerably reduced and water is sucked into the pipe. This sucked water after coming in contact with the jet is carried into the pump suction pipe.



Jet unit assembly   Jet pump set up

Q. No. 4 c)

Discharge Q = 110 lits/sec, Speed = 1450 rpm,
Head Hm = 13 m, Impellor dia. D_2 = 250 mm = .25 m,
width B_2 = 50 mm, Mano. Efficiency η_{mano} = 75 % = 0.75

Let vane angle at outlet = ø = ?
Tangential Velocity of impellor at outlet,

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.25 \times 1450}{60} = 18.98 \text{ m/s}$$

Discharge is given by $Q = \pi D_2 B_2 \times V_{f_2}$

$$\therefore \quad V_{f_2} = \frac{Q}{\pi D_2 B_2} = \frac{0.110}{\pi \times 0.25 \times .05} = 2.80 \text{ m/s.}$$

Using equation (19.8), $\eta_{man} = \dfrac{gH_m}{V_{w_2} u_2} = \dfrac{9.81 \times 13}{V_{w_2} \times 18.98}$

$$\therefore \quad V_{w_2} = \frac{9.81 \times 13}{\eta_{man} \times 18.98} = \frac{9.81 \times 13}{0.75 \times 18.98} = 8.95$$

From outlet velocity triangle, we have

$$\tan \phi = \frac{V_{f_2}}{(u_2 - V_{w_2})} = \frac{2.80}{(18.98 - 8.95)} = 0.279$$

$$\phi = \tan^{-1} 0.279 = 15.58 \text{ or } 15°35'. \textbf{ Ans.}$$

Q. 5 a)

Given Data :-

$V = 2.5 \text{ m/sec}$

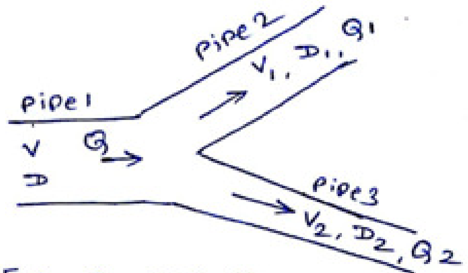
$D = 30\text{cm} = 0.3\text{m}$

$V_1 = 2 \text{ m/s}$

$D_1 = 20 \text{ cm} = 0.2 \text{ m}$

$V_2 = ?$

$D_2 = 15 \text{ cm} = 0.15 \text{ m}$



[Q_1, Q_2 and Q_3 are the Discharges in pipe 1, 2, and 3 respectively]

$$\therefore \; A = \frac{\pi}{4} D^2 = \frac{\pi}{4} \times (0.3)^2 = 0.07068 \text{ m}^2$$

* Discharge through pipe, $Q = AV$

$$= 0.07068 \times 2.5$$

$$\boxed{Q = 0.1767 \text{ m}^3/\text{sec}}$$ **02 marks**

* To find velocity in 15 cm pipe (i.e. V_2) :-

According to continuity equation

$$Q = Q_1 + Q_2$$

$$Q_1 = A_1 V_1$$

$$= \frac{\pi}{4} (D_1)^2 \times V_1 = \frac{\pi}{4} (0.2)^2 \times 2$$

$$= 0.0628 \text{ m}^3/\text{sec}$$

From continuity equation, $Q = Q_1 + Q_2$

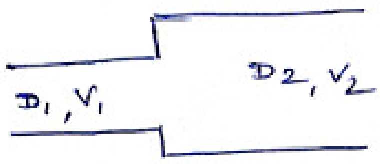
$$0.1767 = 0.0628 + \left(\frac{\pi}{4} (0.15)^2 \times V_2\right)$$

$$\boxed{\therefore V_2 = 6.4454 \text{ m/s}}$$ **02 Marks**

b) Given Data :-

$D_1 = 25\ cm = 0.25\ m$

$D_2 = 50\ cm = 0.5\ m$



$Q = 350\ lit/sec$

$= 0.350\ m^3/sec$

$$V_1 = \frac{Q}{A_1} = \frac{0.35}{\frac{\pi}{4}(0.25)^2} = 7.1283\ m/s$$

$$V_2 = \frac{Q}{A_2} = \frac{0.35}{\frac{\pi}{4}(0.5)^2} = 1.783\ m/s$$

* Head loss Due to Sudden expansion (he)

$$he = \frac{(V_1 - V_2)^2}{2g}$$

$$= \frac{(7.1283 - 1.783)^2}{2 \times 9.81}$$

$$\boxed{he = 1.4565\ m\ of\ water}$$

(02+02 marks)

Q5 c) water hammer effect:-

Effects of water hammer:- **(02 marks)**

1) Due to rise in pressure the pipe may burst.
2) Erosion of inside surface of pipe.
3) Pressure drop in pipe

Remedies for water hammer: **(02 marks)**

1) Controlling Velocity of flow
2) Use of appropriate length of pipe
3) Elastic properties of pipes

Q5 d) **(04 Marks)**

Self priming devices

Self priming devices are separate devices that can be attached to the pump for automatic priming of pump. The pumps having such attachment are called self priming **pumps.** The following are the commonly used attachments for self priming:

(i) An air pump may be fitted to the suction side, which can be allowed to run in parallel with the centrifugal pump. It exhausts air from the suction pipe and discharges to delivery pipe which is open. Because of the continuous sucking action of the air pump, water from the sump also will get sucked and get delivered in the delivery pipe. It flows and fills the pump casing, thus starting delivery from the pump.

(ii) A separate chamber attached to the casing can be provided. When the pump operates the chamber gets filled with liquid. When the pump is started again, the water stored in the chamber flows to the impeller. When the pump starts, a mixture of water and air is formed in the casing which gets discharged into a separator (a widened portion) where air gets separated and flows out through the delivery pipe. The airfree liquid, then flows back to the casing. The process continues till whole of the air is evacuated from the casing. The pump will then start functioning normally.

Q5 e) Centrifugal pump: **(01 marks each)**

i) **Static head (H_s):-** the sum of suction head and delivery head is known as static head.

$H_s = h_s + h_d$

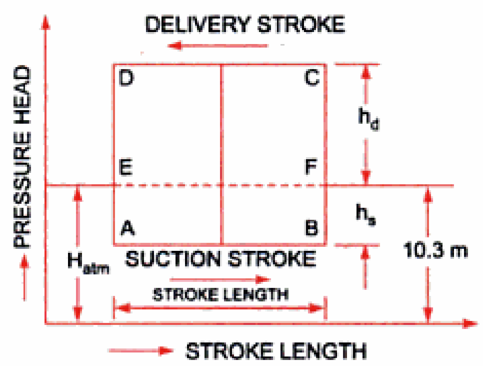
ii) **Manometric Head (H_m) :-** It is the head against which centrifugal pump has to work.

iii**) Mechanical Efficiency:-** It is the ration available at the impeller to the power at the shaft of the centrifugal pump is known as mechanical efficiency.

iv)**Mechanical Efficiency :-**It is the ration of the manometric head to the head imparted by the impeller to the water is known as manometric efficiency.

Q5 f) Ideal Indicator Diagram of Reciprocating pump:- **(sketch-02 Marks, Explaination-02 Marks)**

The graph between pressure head in the cylinder and stroke length of the piston for one complete revolution of the crank under ideal condition is known as ideal indicator diagram. Fig. shows the ideal indicator diagram in which line EF represents the atmospheric pressure head equal to 10.3 m of water.



Let H_{atm} = atmospheric pressure head=10.3 m of water

L = length of stroke

h_s=suction head

h_d=Delivery head

During suction stroke the pressure head in the cylinder is constant and equal to suction head, which is below the atmospheric pressure head by a height of h_s. the pressure head during suction stroke is represented by a horizontal line AB which is below the line EF by a height of h_s .

During delivery stroke the pressure head in the cylinder is constant and equal to delivery head which is above the atmospheric head by a height of ($h_{d)}$.Thus, the pressure head during delivery stroke is represented by a horizontal line CD which is above the line EF by a height of $h_{d.}$ thus for one complete revolution of the crank, the pressure head in the cylinder is represented by the diagram A-B-C-D-A. this diagram is known as ideal indicator diagram.

We know that the work done by the pump per second

$= \rho * g*ALN/60 * (h_s + h_d)$

$= K * L(h_s + h_d)$ where , $K = \rho * g*AN/60$

W. D. per second α $L * L(h_s + h_d)$

From fig, area of indicator diagram,

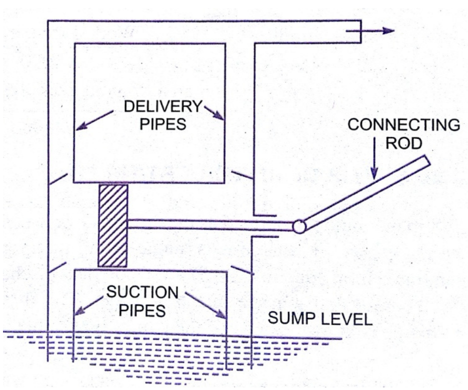
$= Ab* BC = Ab * (BF+FC) = L(h_s + h_d)$

i.e work done by pump α Area of indicator diagram

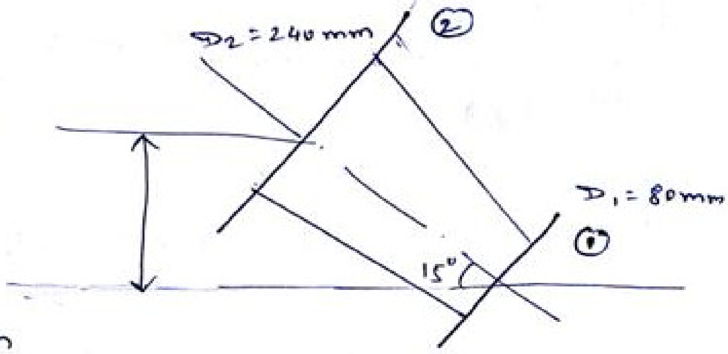
Q. 6 Attempt ant TWO of the following

a) Working of Reciprocating Pump:- **(Sketch-02, explain-02 Marks)**

As shown in fig. a double acting pump has two suction and two delivery pipes with appropriate valves, so that 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.



Q. 6 (b) Given Data



length of pipe $= L = 5$ m

$D_1 = 80$mm $= 0.08$ m

$D_2 = 240$mm $= 0.240$ m

$V_1 = 1$ m/s

$Z_1 = 0$ m [Assuming the datum line is at the centre of pipe at section 1]

$Z_2 = L \sin\theta = 5 \times \sin 15^\circ = 1.2941$ m

$Q = A_1V_1 = A_2V_2$

$$Q = \frac{\pi}{4}(0.08)^2 \times (1) = 0.0050 \text{ m}^3/\text{sec}$$

$\therefore Q = 0.0050$ m³/sec **03 marks**

$$\therefore V_2 = \frac{Q}{A_2} = \frac{0.0050}{\frac{\pi}{4}(0.24)^2} = 0.1105 \text{ m/s}$$ **01 Mark**

Applying Bernoulli's Equation at section ① and ②

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

$$\frac{P_1}{1000 \times 9.81} + \frac{(1)^2}{2 \times 9.81} + 0 = \frac{P_2}{1000 \times 9.81} + \frac{(0.1105)^2}{2 \times 9.81} + 1.2941$$

$$\frac{(P_1 - P_2)}{1000 \times 9.81} = 1.2941 + \frac{(0.1105)^2}{2 \times 9.81} - \frac{(1)^2}{2 \times 9.81}$$

$$(P_1 - P_2) = 12201.678 \text{ N/m}^2$$

$$\therefore (P_1 - P_2) = 12.2016 \text{ kN/m}^2$$ (04 Marks)

Q6 c) i)

Given : $d = 50$ mm $= 0{\cdot}05$ m; $V = 15$ m/s and $v = 6$ m/s.

(a) Force exerted by the jet

We know that cross-sectional area of the jet,

$$a = \frac{\pi}{4} \times (d)^2 = \frac{\pi}{4} \times (0{\cdot}05)^2 = 1{\cdot}964 \times 10^{-3}\ \text{m}^2$$

and force exerted by the jet,
$$F = \frac{waV(V-v)}{g} = \frac{9{\cdot}81 \times (1{\cdot}964 \times 10^{-3}) \times 15\ (15-6)}{9{\cdot}81}\ \text{kN}$$
$$= 0{\cdot}265\ \text{kN} = 265\ \text{N}\quad \textbf{Ans.}$$

02 Mark

(b) Work done by the jet

We know that work done by the jet

$$W = \text{Force} \times \text{Distance} = 265 \times 6 = 1590\ \text{N-m} = 1590\ \text{J}\ \textbf{Ans.}$$

(c) Efficiency of the jet

01 Mark

We also know that efficiency of the jet,

$$\eta = \frac{2\,(V-v)\,v}{V^2} = \frac{2\,(15-6) \times 6}{(15)^2} = 0{\cdot}48 = 48\%\ \textbf{Ans.}$$

01 Mark

ii) **Spear: -** The amount of water striking the buckets (vanes) of the runner is controlled by providing a spear in the nozzle. The spear is a conical needle which is operated either by hand wheel or automatically in an axial direction depending upon the size of the unit. When the spear is pushed forwarded into the nozzle the amount of water striking the runner is reduced. And if the spear is pushed back, the amount of water striking the runner increases.

(02 Marks)

Breaking Jet:- When the nozzle is completely closed by moving the spear in the forward direction. The amount of water striking the runner reduces to zero. But the runner due to inertia goes on revolving for a long time. To stop the runner in a short time, a small nozzle is provided which directs the jet of water on the back of the vanes. This jet of water is called breaking jet.

(02 Marks)