S.Y. Diploma : Sem. IV
[CE/CS/CR/CV]

Hydraulics

Solution of Prelim Paper

Q.1 Attempt any TEN of the following : [20]

Q.1(a) Define weight density and state its S.I. unit. [2]

Ans.: It is defined as weight per unit volume of a liquid at standard temperature and pressure. [1 mark]

OR

It is defined as ratio of weight to volume. SI unit N/m^3 [1 mark]

Q.1 (b) Why mercury is used in manometer? [2]

Ans.: Following are the reasons due to which mercury is used in manometers :

(i) Specific gravity of mercury is greater than the other liquids.
(ii) Mercury is immiscible with other liquids.
(iii) It does not stick to the surface in contact. [1 marks each any two]

Q.1 (c) What is the principle of manometer? [2]

Ans.: **principle of manometer** [2 marks]

Manometer measure the pressure at a point in fluid by balancing the column of fluid by same or another column of fluid.

Q.1 (d) Express a pressure intensity of 5 kg (f)/cm^2 in metres of head of water and mercury. [2]

Ans.: $P = 5$ kgf/cm^2

1 kgf = 9.81 N

$P = 49.05$ N/cm^2

$P = 49.05 \times 10^4$ N/m^2

Head of water,

$P = \gamma_w.h_w$

$49.05 \times 10^4 = 1 \times 9810 \times h_w$

$h_w = 50$ m of water [1 mark]

Head of mercury

$P = \gamma_w \,.\, h_w$

$49.05 \times 10^4 = 1 \times 9810 \times h_m$

$h_m = 3.67$ m of mercury [1 mark]

Q.1 (e) What is venna-contracta? [2]

Ans.: **Venna-contracta** [2 marks]

It is the section of jet of liquid in flow though orifice at which the cross sectional area is minimize and stream line are straight and parallel to each other

Q.1 (f) State four application of Hydraulics in environmental engineering. [2]

Ans.: Four applications of Hydraulics in environmental engineering [1 mark each]

(i) To design water distribution system from reservoir.
(ii) To determine the pressure head of water supply system.
(iii) To determine the power required for pumps.
(iv) To measure the pressure at a point.
(v) To design the pipe diameter of water supply line as well as sewer system.

Q.1 (g) Define ideal fluid and real fluid. [2]

Ans.: Ideal Fluid [1 mark]

A fluid, which does not posses viscosity, surface tension and compressibility is known as ideal fluid.

Real Fluid [1 mark]

A fluid, which possess viscosity, surface tension and compressibility is known as real fluid.

Q.1 (h) State Newton's law of viscosity. [2]

Ans.: Newton's law of viscosity [2 marks]

It states that "The shear stress on a layer of a fluid is directly proportional to the rate of shear strain".

$$\varsigma = (v/y) = \mu \times (v/y)$$

Q.1 (i) Mention necessity of inverted manometer. [2]

Ans.: (1) To measure low and negative pressure differences in two pipe. [1 mark]
(2) To measure sensitive pressure [1 mark]

Q.1 (j) Define Froude's number. [2]

Ans.: Froude Number

The Froude number (Fr) is a dimensionless number defined as the ratio of a characteristic velocity to a gravity wave velocity. It may equivalently be defined as the ratio of a body's inertia to gravitational forces. [2 marks]

Q.1 (k) State 'Pascal's Law' of liquid pressure. [2]

Ans.: Statement : "Pascal's law state that at a point in a fluid at rest intensity pressure acts equally in all direction".

Explanation: Consider one particle of a liquid on a jar the pressure exerted on that point all direction is same. [2 marks]

Q.1 (l) Define Reynold's number. **[2]**

Ans.: Definition: The Reynolds number is defined the ratio of inertia force to viscous force.

$$Re = \frac{\text{inertial forces}}{\text{viscous forces}} = \frac{\rho v L}{\mu} = \frac{vL}{\nu}$$ [1 mark]

Where,

Re - Reynold's Number.

ρ - Is the mass density of the fluid (kg/m^3).

μ is the dynamic viscosity of the fluid ($Pa \cdot s$ or $N \cdot s/m^2$ or $kg/(m \cdot s$ ν (nu) is the kinematic viscosity ($\nu = \mu/\rho$) (m^2/s) [1 mark]

Q.1 (m) Define 'Hydraulic Meandepth' and its units. **[2]**

Ans.: The hydraulic Mean depth is the ratio of the weighted area to the weighted perimeter. Therefore, [1 mark]

$$R = \frac{A}{P}$$

Where,

R = Hydraulic mean depth, (m).

A = Weighted Area, (m^2).

P = weighted perimeter, (m). [1 mark]

The unit of hydraulic mean depth is 'm'.

Q.1 (n) What is the difference between a 'notch' and a 'weir' ? **[2]**

Ans.: [1 mark each]

No.	Notch	Weir
(1)	Notch is of small sizes.	Weir is of bigger sizes.
(2)	Notch is made in plate.	Weir is made in masonry and Concrete.

Q.2 Attempt any FOUR of the following : **[16]**

Q.2(a) A simple U tube manometer is used to measure water pressure in pipe. The left limb of manometer is connected to pipe and right limb is open to atmosphere. The mercury level in left limb is 80 mm below centre of pipe and in right limb 40 mm above the centre of pipe. Calculate water pressure in pipe. **[4]**

Ans.: $S_1 = 1$

$h_1 = 80mm = 0.08m$

$S_2 = 13.6$

$h_2 = 120\ mm = 0.12\ m$

$h_A + (S_1 \times h_1) = (S_2 \times h_2)$ [1 mark]

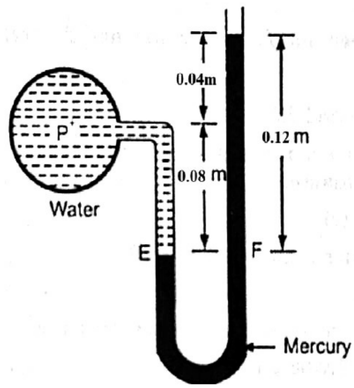
$h_A = (13.6 \times 0.12) - (1 \times 0.08)$

$h_A = 1.552\ m$ [1 mark]

$P_A = \gamma_w \times h_A$

$P_A = 9.81 \times 1.552$

$P_A = 15.225\ kN/m^2$ [1 mark]



[1 mark]

OR

$$\frac{P_A}{\gamma_w} + (0.08 \times 1) - (0.12 \times 13.6) = 0$$ [2 marks]

$$\frac{P_A}{\gamma_w} = 1.552 \text{ m}$$

$P_A = 1.552 \times \gamma_w$

$P_A = 15.225 \text{ kN/m}^2$ [2 marks]

Q.2(b) A partition wall 3 m long divides storage tank. On one side there is turpentine of Sp. Gr. 0.87 upto a depth of 3.5 m. On the other side there is paraffin oil of Sp. Gr. 0.8 stored to a depth of 2.5 m. Determine resultant pressure on partition wall. **[4]**

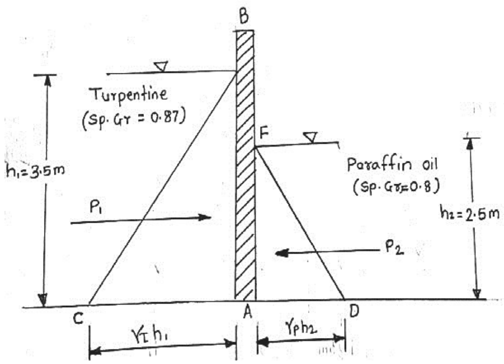
Ans.: Pressure due to Turpentine

$$P_1 = \frac{1}{2} \times \gamma_L \times h_1 \times h_1$$ [1 mark]

$$P_1 = \frac{1}{2} \times S_L \times \gamma_w \times h_1^2$$

$$P_1 = \frac{1}{2} \times 87 \times 9.81 \times 3.5^2$$

$P_1 = 52.275 \text{ kN/m}$ [1 mark]



Pressure due to Paraffin oil

$$P_2 = \frac{1}{2} \times \gamma_L \times h_2 \times h_2$$

$$P_2 = \frac{1}{2} \times S_L \times \gamma_w \times h_2^2$$

$$P_2 = \frac{1}{2} \times 80 \times 9.81 \times 2.5^2$$

P_2 = 24.525 kN/m [1 mark]

Resultant pressure

$P = P_1 - P_2$

P = 52.275 − 24.525

P = 27.75 kN/m [1 mark]

And for 3 m length pressure will be

P = 3 × 27.75 = 83.25 kN.

Q.2(c) State Bernoulli's theorem. State any two applications of it. [4]

Ans.: **Statement :** It states that in an incompressible frictionless fluid, when the flow is steady and continuous the energy of each particle of the fluid is the same.

OR

Statement : It states that in an incompressible fluid, when the flow is steady and continuous the sum of pressure energy, kinetic energy and potential energy (or datum) energy along a stream line. [2 marks]

Mathematically,

$$\frac{P}{\gamma} + \frac{V^2}{2g} + z = \text{Constant}$$

Where,

$\frac{P}{\gamma}$ = Pressure energy

$\frac{V^2}{2g}$ = Kinetic energy

z = Datum

Application : [Any Two - 1 mark each]

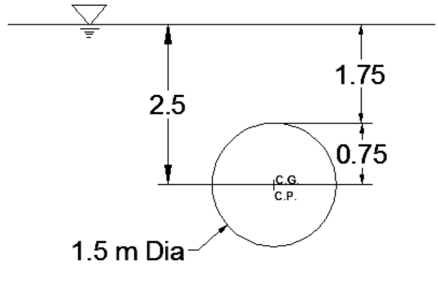
1) To find the total energy at any section.
2) To find the head loss in the system.
3) To find the pressure difference at any given two points.
4) Practical applications to the following measuring devices
   (a) Venturimeter (b) Orifice meter (c) Pitot tube

Q.2(d) A circular plate 1.5 m diameter is placed vertically in water so that the centre plate is 2.5 m below the free surface. Determine the total pressure on the plate and depth of centre of pressure. [4]

Ans.: Given Data :

d = 1.5 m

x = 2.5 m



Diagram

$$\text{Area} = A = \left(\frac{\pi}{A}\right)\times d^2$$

$$= \left(\frac{\pi}{A}\right)\times 1.5^2 = 1.767 \text{ m}^2$$

(i) Total Pressure on gate

F = w.AX [1 mark]

X = Distance of C.G. from free surface of water = 2.5 m

F = 9810 × 1.767 × 2.5

F = 43.34 × 10^3 N = 43.34 KN [1 mark]

(ii) Centre of Pressure

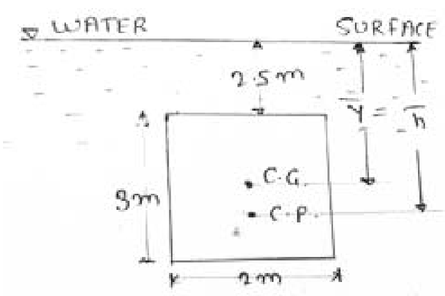
h = X + I.G./AX [1 mark]

$$\text{I.G.} = \left(\frac{\pi}{64}\right)\times d^4 = \left(\frac{\pi}{64}\right)\times 1.5^4 = 0.2485 \text{ m}^4$$

$$h = 2.5 + \left[\frac{0.2485}{(1.767\times 2.5)}\right] = 2.5 + 0.0563 = 2.556 \text{ m}$$ [1 mark]

Q.2(e) A rectangular plane surface is 2 m wide and 3 m deep. It lies in vertical plane in water. Determine the total pressure and position of centre of pressure on the plane surface when its upper edge is horizontal and 2.5 m below the free water surface. [4]

Ans.:



[1 mark]

Given:

B = 2m D = 3m

D = 2.5 + 1.5 = 4m

Total Pressure = ?

Position of centre of pressure = ?

1. Total Pressure $= P = W_1$ AD.

Area $= A = 2 \times 3 = 6\ m^2$ [1 mark]

$W_1 = 9.81\ KN/m^3$

Hence,

Total Pressure $= 9.81 \times 6 \times 4$

$P = 235.44$ KN [1 mark]

2. Position of centre of pressure $= h = \dfrac{IG}{A\bar{y}} + \bar{y}$

$$IG = \frac{bd^{\wedge}3}{12} = \frac{2 * 3^{\wedge}3}{12} = 4.5\ m^4.$$

Area $= A = b * d = 2 * 3 = 6m^2$

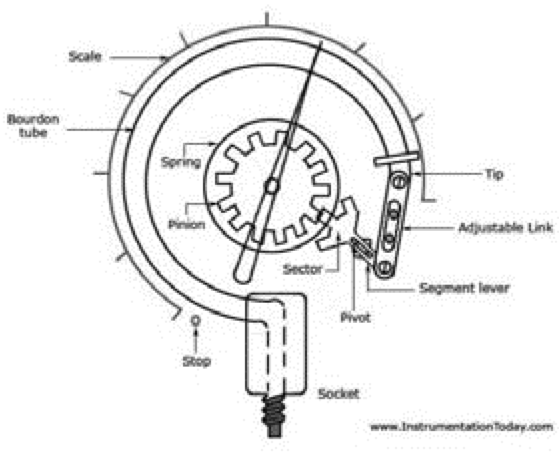
Hence,

$$Th = \frac{4.5}{6 * 4} + 4$$

$Th = 4.1875$ m. [1 mark]

Q.2(f) Explain briefly the working principle of Bourdon pressure gauge with a neat sketch. **[4]**

Ans.:



Bourdon Tube Pressure Gauge

[2 marks]

Working :

The pressure to be measured is connected to the fixed open end of the bourdon tube. The applied pressure acts on the inner walls of the bourdon tube. Due to the applied pressure, the bourdon tube tends to change in cross – section from elliptical to circular. This tends to straighten the bourdon tube causing a displacement of the free end of the bourdon tube. This displacement of the free closed end of the bourdon tube is proportional to the applied pressure. As the free end of the bourdon tube is connected to a link – section – pinion arrangement, the displacement is amplified and converted to a rotary motion of the pinion. As the pinion rotates, it makes the pointer to assume a new position on a pressure calibrated scale to indicate the applied pressure directly. As the pressure in the case containing the bourdon tube is usually atmospheric, the pointer indicates gauge pressure. [2 marks]

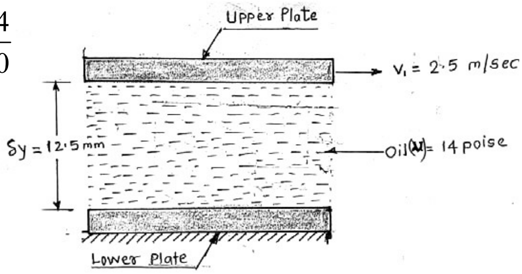
Q.3 Attempt any FOUR of the following : [16]

Q.3(a) Two horizontal plates are placed 12.5 mm apart. The space between them being filled with oil of viscosity 14 poise. Calculate shear stress in oil if upper plate moves with velocity 2.5 m/sec. [4]

Ans.: $\delta_y = 12.5\text{mm} = 12.5 \times 10^{-3}$ m

Viscosity, $\mu = 14 \text{ Poise} = \dfrac{14}{10}$ [1 mark]

$\mu = 1.4$ N–S/m^2



Lower plate fixed,

$V_0 = 0$

Upper plate moveable,

$V_1 = 2.5$ m/sec [1 mark]

Change in velocity,

$\delta_v = V_1 - V_0 = 2.5$ m/sec

$\delta_v = 2.5$ m/sec

By Newton's law viscosity [1 mark]

Shear stress

$$\tau = \mu \,.\, \frac{\partial v}{\partial y} = 1.4 \times \frac{2.5}{12.5 \times 10^{-3}}$$

$\tau = 280$ N/m^2 [1 mark]

Q.3(b) Differentiate between Laminar flow and turbulent flow. [4]

Ans.: [Any Four - 1 mark each]

	Flow Laminar	Turbulent Flow
(1)	Each particle moves in a definite path and do not cross each other.	The fluid particle continuously and cross each other
(2)	It occurs at low velocity of flow	It occurs at high velocity of flow.
(3)	This flow occurs in viscous fluids.	This flow occurs in fluid having very less viscosity.
(4)	Reynolds number is less than 2000.	Reynolds number is more than 4000.
(5)	Fluid particle move in layers with one layer over other.	Fluid particle moves in disorderly manner, they cross the path of each other.
(6)	**Example :** a) Blood flowing through veins. b) Oil flowing through pipes. c) Water flowing through tap at low velocities.	**Example :** a) Water flowing through river. b) Flood flow

Q.3(c) What are stream lines an equipotential lines. State any two uses of flow net? [4]

Ans.: **Stream Line:** [1 mark]

A stream line is defined as a continuous line in a fluid which shows the direction of velocity of fluid at each point along line.

Equipotential lines: [1 mark]

It is an imaginary line in a fluid flow helping to better understand the flow. These are the lines running orthogonally (perpendicular) to the stream lines.

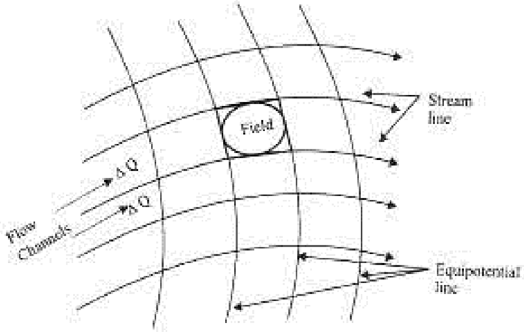


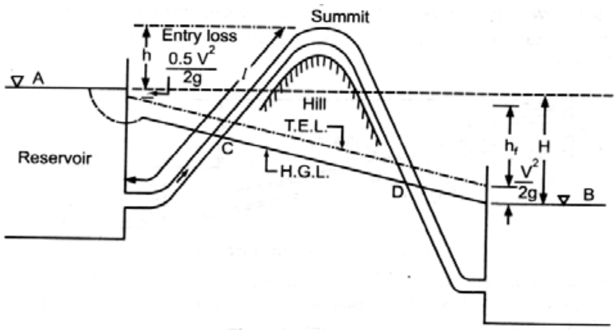
Fig.: Flow Net

Uses of flow net: [Any Two - 1 mark each]

1) To check the problems of flow under hydrostatic structure like dams etc.
2) To determine of seepage pressure.
3) To find exit gradient.
4) A flow net analysis assists in the design of an efficient boundary shapes.

Q.3(d) Explain syphon pipe with sketch. [4]

Ans.: Syphon is long bent pipe which is used to transfer the liquid from reservoir at a higher level to another reservoir at a lower level to another reservoir at a lower level. When two reservoirs are separated by a hill or high level ground as shown in figure. [1 mark]



[2 marks]

The point C which is at the highest of the syphon is called as summit. The above point C is above the free water surface point A, the pressure at point C is less than atmospheric pressure. Maximum up to 2.7m water absolute. Syphon is used to carry water from one reservoir to another reservoir. [1 mark]

Q.3(e) Find the loss of head when a pipe of diameter 200 mm is suddenly enlarged to a diameter of 400 mm. The rate of flow of water through the pipe is 250 lit/sec. **[4]**

Ans.: Given

$d_1 = 200\text{mm} = 0.2\text{m}$

$d_2 = 400\text{mm} = 0.4\text{m}$

$Q = 250\text{LPS} = 250 \times 10^{-3}\ \text{m}^3/\text{s}$

$\mathbf{a_1} = \pi/4 \times (0.2)^2 = 0.031\text{m}^2$ [1 mark]

$\mathbf{a_2} = \pi /4 \times (0.4)^2 = 0.125\text{m}^2$

$Q = a_1 \times v_1$

$250 \times 10^{-3} = 0.03 \times v_1$

$\mathbf{V_1 = 8.06\ m/s}$ [1 mark]

$Q = a_2 \times v_2$

$250 \times 10^{-3} = 0.125 \times v_2$

$\mathbf{V_2 = 2\ m/s}$ [1 mark]

$H = (v_1 - v_2)^2 /2g$

$\quad = (8.06 - 2)^2 / 2 \times 9.81$

$\mathbf{H = 1.871m}$ [1 mark]

Q.3(f) Explain HGL and TEL with sketch. **[4]**

Ans.: **HGL** [1½ mark]

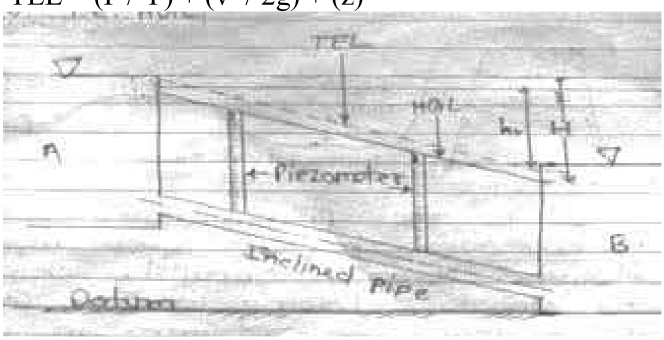
1) Due to friction the pressure head decreases gradually from section of the pipe in the direction of flow.
2) If the pressure head at the different section of the pipe are plotted to the scale as vertical ordinate above the axis of the pipe.
3) All the points are joint by the straight line, we get a straight sloping line. This line is known as "Hydraulic Gradient line"

TEL: [1½ mark]

1) When the total energy at the various points along the axis of the pipe is plotted and joint by the line, the line obtained is called as "Total Energy line"(TEL) or Total energy gradient (TEG)

Total energy line is the line which gives sum pressure head, datum head and kinetic head of a flowing fluid.

TEL = (P / Y) + (v² / 2g) + (z)



[1 mark]

Q.4 Attempt any FOUR of the following : [16]

Q.4(a) Define friction factor and state any four factors affecting friction factor. [4]

Ans.: Friction factor [2 marks]

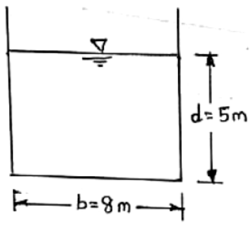
A dimension less quantity depends upon the roughness inside the pipe, viscosity of liquid flowing throw pipes which affects head loss is known as friction factor.

Factors affecting friction factor: [Any four - ½ mark each]

1. Nature of surface of pipe material.
2. Pipe diameter
3. Length of pipeline
4. Head loss
5. Square of the velocity of flow.

Q.4(b) Water is flowing through a rectangular channel of width 8 m and bed slope 1 in 1000. Depth of flowing channel is 5 m. Find the discharge through channel. Take C = 50. [4]

Ans.:



Given : Rectangular channel

Width, b = 8 m

Depth d = 5m C = 50

Bed Slope $S = \frac{1}{1000}$

By Chezy's formula = $C\sqrt{RS}$

$$Q = AC\sqrt{RS}$$

Cross-section area of channel,

$A = b \times d$

$A = 8 \times 5 = 40\ m^2$ [1 mark]

Hydraulic mean depth $R = \frac{A}{P}$

Perimeter P = b + 2d

$$R = \frac{A}{b+2d} = \frac{40}{8+2\times 5} = \frac{40}{18}$$ [1 mark]

$R = 2.22$ m

$Q = AC\sqrt{RS}$

$$Q = 40\times 50\sqrt{2.22\times\frac{1}{1000}}$$ [1 mark]

$Q = 94.276\ m^3/sec$

Discharge through channel,

$Q = 94.276\ m^3/sec$ [1 mark]

Q.4(c) The daily record of rainfall over a catchment is 0.2 million cubic meter. Out of this 80% rain water reaches the storage reservoir and passes over a rectangular weir. What should be its length if water level do not rise more than 400 mm above the crest. Take $C_d = 0.61$. **[4]**

Ans.: **Given:** Daily rainfall over a catchment is 0.2 million cubic meter = $0.2 \times 10^6 m^3$

Daily discharge $Q_R = 0.2 \times \dfrac{10^6}{24} \times 60 \times 60$ [1 mark]

$= 2.314 m^3/sec$

Daily discharge reaches a reservoir over a rectangular weir

$Q_1 = 80\%\ Q_R$

$Q_1 = 0.80 \times 2.314 = 1.85\ 12\ m^3/sec$ [1 mark]

Head over rectangular weir h = 400mm = 0.4m

$C_d = 0.61$ [1 mark]

For rectangular weir

$Q = 2/3\ C_d . L\sqrt{2g}\ h^{3/2}$

$1.8512 = 2/3 \times 0.61 \times L\sqrt{2 \times 9.81}\ (0.4)^{3/2}$

$1.8512 = 0.406\ L \times 4.429 \times 0.252$

$L = 1.8512/0.406 \times 4.429 \times 0.252$ [1 mark]

$L = 4.085m$

Length of rectangular weir is 4.085m

Q.4(d) A tank has two identical orifices in one of its vertical sides. The upper orifice is 2 m below the water surface and lower orifice is 4 m below the water surface. Find the point at which two jets will intersect, if the coefficient of velocity is 0.92 for both orifices. **[4]**

Ans.: **Given :** $C_v = 0.92$ We have, for top orifice, y = y + 2 & H = 2

$$C_v = \sqrt{\frac{x^2}{4yH}} = \sqrt{\frac{x^2}{4(y+2)\times 2}}$$ [1 mark]

for bottom orifice, H = 2

$$C_v = \sqrt{\frac{x^2}{4yH}}$$ [1 mark]

As C_v is same for both orifice,

$$\sqrt{\frac{x^2}{4(y+2)\times 2}} = \sqrt{\frac{x^2}{4yH}}$$ (H=4 for bottom orifice)

$y = 2m$ [1 mark]

Substituting y in equation 2

$$0.92 = \sqrt{\frac{x^2}{4\times2\times4}}$$

The two jets will intersect at x = 5.2m

Q.4(e) A rectangular channel 2.0 m wide has a discharge of 250 lit/sec., which is measured by a right-angled 'V' notch weir. Find the position of the apex of the notch from the bed of channel if maximum depth of water is not to exceed 1.3 m. Take c_d = 0.62. **[4]**

Ans.: Given :

b = 2m Q = 250 × 10^−3 ϕ = 90°

Max d = 1.3 m = H′

$Q = (8/15) \times Cd \times \sqrt{(2g)} \times \tan(\phi/2) \times H^{5/2}$ [1 mark]

$250 \times 10^{-3} = (8/15) \times 0.62 \times \sqrt{(2 \times 9.81)} \times \tan(90/2) \times H^{5/2}$

$250 \times 10^{-3} = 1.465 \times H^{5/2}$ [1 mark]

$250 \times 10^{-3} / 1.465 = H^{5/2}$

$H^{5/2} = 0.170$ [1 mark]

$H = 0.493$ m

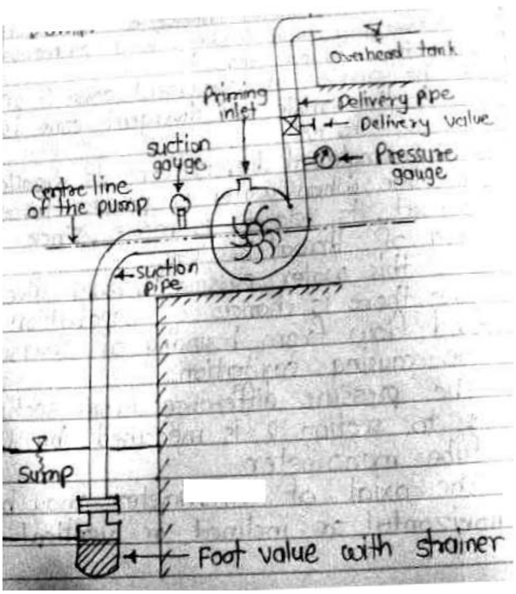
Apex height = 1.3 − 0.493 [1 mark]

= 0.806 m

Q.4(f) With a neat sketch, explain the principle and working of a centrifugal pump. **[4]**

Ans.: Principle [1 mark]

When certain mass of liquid is made to rotate by an external force it is thrown away from the central axis of rotation and a centrifugal head is impressed which enables it to rise to higher level.



Working of centrifugal pump is in 3 stages [2 marks]

(i) Priming (ii) Starting (iii) Stoping

(i) Priming

The operation of filling the casing, impeller and suction pipe upto delivery valve is called priming.

(ii) Starting

Before starting first of all check that priming is done and return valve is not in closed condition.

(iii) Stoping

To stop the pump, delivery valve should be closed partly. Motor is switched off and then value is closed fully.

Q.5 Attempt any FOUR of the following : [16]

Q.5(a) Explain the phenomenon of water hammer. [4[

Ans.: Phenomenon of water hammer [4 marks]

When the water flowing in a long pipe is suddenly brought to rest by closing the valve, there will be a sudden rise in pressure due to the momentum of the moving water being destroyed. This causes a wave of high pressure to be transmitted along the pipe which creates noise known as water hammer .The rise in pressure in some cases may be so large that the pipe may even burst. Therefore it is essential to take into account this pressure rise in the design of pipes. The magnitude of pressure rise depends on the speed at which the valve is closed, velocity of flow, length of the pipe and elastic properties of the pipe material as well as flowing fluid.

Q.5(b) Differentiate between centrifugal pump and reciprocating pump. (Any four points) [4]

Ans.: [Any Four - 1 mark each]

	Centrifugal Pump	Reciprocating Pump
1.	For Centrifugal pump discharge is continuous.	For Reciprocating pump discharge is fluctuating.
2.	Suitable for large discharge and small heads.	Suitable for less discharge and higher heads.
3.	Simple in construction because of less number of parts.	Complicated in construction because of more number of parts.
4.	It has rotating elements so there is less wear and tear.	It has reciprocating element, there is more wear and tear.
5.	It can run at high speed.	It cannot run at high speed.
6.	Air vessels are not required.	Air vessels are required.
7.	Starting torque is more.	Starting torque is less.
8.	It has less efficiency.	It has more efficiency.
9.	Suction and delivery valve are not necessary.	Suction and delivery valve are necessary.
10.	Requires less floor area and simple foundation.	Requires more floor area and requires heavy foundation.

Q.5(c) A centrifugal pump delivers water at 30 lit/sec to a height of 18 m thro' a pipe 90 m long and 100 mm in diameter. If overall efficiency of pump is 75% find power required to drive the pump. Take f = 0.012. **[4]**

Ans.: Given:

$Q = 30 \text{ lit/sec} = 30 \times 10^{-3} \text{ m}^3/\text{sec}$

$\eta = 0.75$ $f = 0.012$ $L = 90$ m $d = 0.1$ m

$$\text{Velocity at section} = \frac{Q}{A} = \frac{30\times10^{-3}}{\frac{\pi}{4}\times(0.1)^2}$$

$= 3.819$ m/sec [1 mark]

Now, head loss due to friction

$$hf_d = \frac{f\,L\,V^2}{2g\,D}$$ [1 mark]

$$= \frac{0.012\times90\times(3.819)^2}{2\times9.81\times0.1}$$

$= 8.028$ m

Total Manomentric Head

$h_m = 18 + 8.028$ [1 mark]

$= 26.028$ m

$$P = \frac{\gamma_w Q H_m}{\eta}$$

$$P = \frac{9810\times30\times10^{-3}\times26.028}{0.75}$$

$= 10213.39$ W

$= 10.213$ kW [1 mark]

OR

$$\frac{V^2}{2g}$$ [1 mark]

If suction head is considered Then,

$$h = \frac{V^2}{2g}$$ [1 mark]

$$= \frac{3.819^2}{2\times9.81}$$

$= 0.743$ m

$h_m = 18 + 8.028 + 0.743$

$= 26.771$ m [1 mark]

$$P = \frac{9810 \times 30 \times 10^{-3} \times (26.771)}{0.75}$$

$$P = 10504.94 \text{ W}$$
$$= 10.504 \text{ kW}$$ [1 mark]

Q.5(d) Explain working principle of current meter with sketch. State types of it. [4]

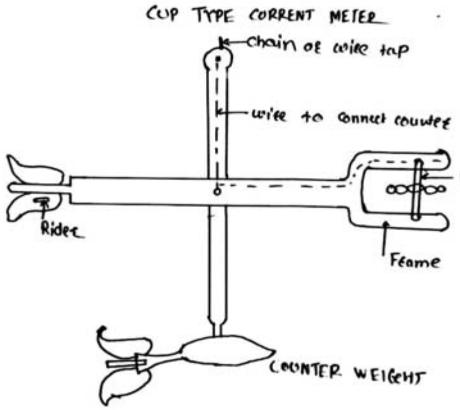
Ans.: Principle: [1 mark]

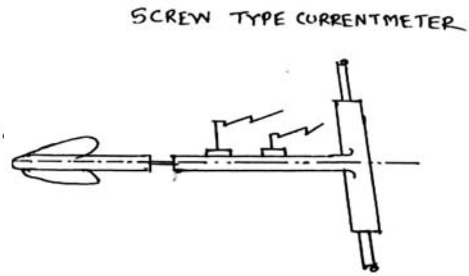
It is small reaction turbine. When placed in flow of water it rotates with speed. The velocity can be calibrated by observing revolutions per minute towing with a carriage mounted on rails, across still water at known velocities.

Types of current meter [1 mark]

(1) Cup type current meter
(2) Propeller or screw type current meter

[2 marks]





Q.5(e) A reservoir has a catchment area of 30 km². The maximum rainfall over the area is 2.5 cm/hour, 45% of which flows to the reservoir over a weir. Find length of the weir. The head over weir is 80 cm. [4]

Ans.: Area = 30 km² = $30 \times 10^6 \text{m}^2$

Discharge = $(30 \times 10^6 \times 2.5) / (100 \times 60 \times 60)$
= $208.33 \text{ m}^3/\text{s}$ [1 mark]

Discharge over weir 45% = $45/100 \times 208.33$
= $93.75 \text{ m}^3/\text{s}$ [1 mark]

We know

$$Q = 1.84 \times (L - 0.1nH) H^{\frac{3}{2}}$$ [1 mark]

$$93.75 = 1.84 \times (L - 0.1 \times 2 \times 0.8) \times (0.8)^{\frac{3}{2}}$$

$$93.75 = 1.84 \times (L - 0.16) \times 0.715$$

$$93.75 = 1.316 \text{ x } (L - 0.16)$$

$$71.20 = (L - 0.16)$$

$$L = 71.36 \text{ m}$$ [1 mark]

Q.5(f) A siphon of diameter 20 cm connects two reservoirs having a difference in elevation of 20 m. The length of the siphon is 500 m, and the summit is 3.0 m above the water level in the upper reservoir. The length of the pipe from upper reservoir to the summit is 100 m. Determine the discharge through the siphon and also pressure at summit. Neglect minor losses. Take coefficient of friction, f = 0.005. **[4]**

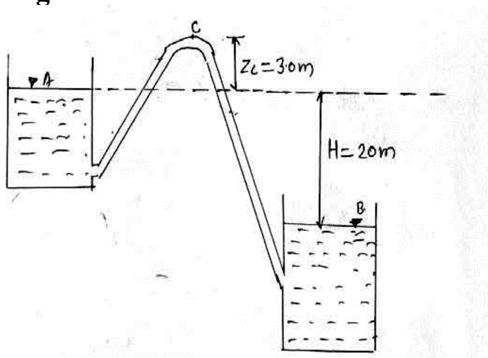
Ans.: Given,

d = 0.2 m, H = 20 m, L = 500 m, $Z_C = 3$m

1 = 100 m as the coefficient of friction is given use f = 0.005

Q = ? P = ?

Diagram:



[1 mark]

$$h_f = \frac{(4f)\,L\,V^2}{2gd}$$ [1 mark]

$$20 = \frac{(4\times0.005)\,500\,V^2}{2\times9.81\times0.2}$$

$20 = 0.637 \times 4V^2$

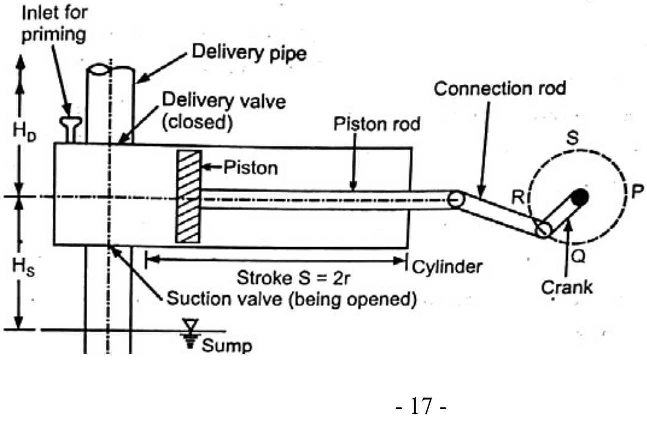
$V^2 = 7.848$ [1 mark]

$V = 2.801$ m/s [1 mark]

Q.6 Attempt any FOUR of the following : **[16]**

Q.6(a) Draw a neat sketch of Reciprocating pump showing its various component parts. Mention function of each component. **[4]**

Ans.: [Sketch & Labelling - 2 marks]



(Note: If the sketch of double acting reciprocating pump is drawn, it should be considered.)

Component part and its function: [2 marks]

1) Cylinder	2) Connecting rod	3) Delivery pipe
4) Delivery valve	5) Suction pipe	6) Rotating Crank

1) **Cylinder:** To guide movement of piston and create negative and positive pressure.
2) **Section pipe:** To connect source of water and the cylinder.
3) **Delivery pipe:** To receive water from cylinder and discharge it at outlet.
4) **Delivery Valve:** To admits flow from the suction pipe into the cylinder and from cylinder into delivery pipe.
5) **Rotating crank:** To give linear displacement to connecting rod.
6) **Connecting rod:** To connects the piston and the rotating crank.

Q.6(b) A trapezoidal most economical channel section has side slopes 1.5 (H) : 1(V). It is required to discharge 20m^3/sec with a bed slope of 1 m in 6.0 km. Design the section using Manning's formula. Take N = 0.015 **[4]**

Ans.: Given side slopes = 1.5/1 = 1.5

Bed slope = s = 1/6000 m

Discharge = 20 m^3/s

N = 0.015

For trapezoidal section most economical condition the formula is

Sloping side = 1/2 (Top width)

$$d\sqrt{1+n^2} = \frac{b+2nd}{2}$$

$$d\sqrt{1.5^2+1} = \frac{b+2\times 1.5\,d}{2}$$ [1 mark]

$$1.8d = b + 3d/2$$
$$3.6d = b + 3d$$
$$0.6d = b$$

Area of trapezoidal section

$$A = bd + nd^2$$
$$= (0.6)\,d + 1.5\,d^2$$
$$A = 2.1\,d^2$$ [1 mark]

Manning's formula,

$$Q = \frac{A}{N} R^{2/3} S^{1/2}$$

$$20 = \frac{2.1d^2}{0.015}\left(\frac{d}{2}\right)^{2/3}\left(\frac{1}{6000}\right)^{1/2}$$

$$= 140\,d^2\,\frac{d^{2/3}}{(2)^{2/3}}\times 0.0129$$ [1 mark]

$$20 = \frac{1.807}{1.587} \times d^{8/3}$$
$$20 = 1.1386 \times d^{8/3}$$
$$d^{8/3} = 17.565$$
$$d = (17.565)^{3/8}$$
$$d = 2.929 \text{ m}$$
$$b = 0.6 \times 2.929 = 1.757 \text{ m}$$ [1 mark]

Q.6(c) What do you mean by most economical section of an open channel? [4]

Ans.: [4 marks]

A section of a channel is said to be most economical when the cost of construction of the channel is minimum. But the cost of construction of a channel depends upon the excavation and the lining. to keep the cost down or minimum, the wetted perimeter, for a given discharge should be minimum. This condition is utilized for determining the dimensions of a economical sections of different form of channels.

Most economical section is also called the best section or most efficient section as the discharge, passing through a most economical section of channel for a given cross−sectional area (A), slope of the bed (i) and a resistance co−efficient, is maximum. But the discharge, Q is given by equation as

$$Q = AC\sqrt{mi} = AC\sqrt{\frac{A \times i}{P}} \qquad \left(\because m = \frac{A}{P}\right)$$

For a given A, i and resistance co−efficient C, the above equation is written as

$$A = K\frac{1}{\sqrt{P}}, \quad \text{where} \quad K = AC\sqrt{Ai} = \text{constant}$$

Hence the discharge, Q will be maximum, when the wetted perimeter P is minimum. The condition will be used for determining the best section of a channel i.e., best dimensions of a channel for a given area.

Q.6(d) Define Prismatic and Non Prismatic channel and critical flow and subcritical flow. [4]

Ans.: Prismatic [1 mark]

A channel is said to be prismatic when the cross section is uniform and the bed slope is constant.

Example − Rectangular, trapezoidal, circular, parabolic.

Non-Prismatic [1 mark]

A channel is said to be non-prismatic when its cross section and for slope change.

Example − River, Streams and Estuary.

Critical Flow [1 mark]

If the Froude no. of the flow-through channel is equal to 1 then it is called critical flow ($F_e = 1$).

Subcritical flow [1 mark]
If the Froude no. of the flow through channel is less than 1 the n it is called subcritical flow ($F_e < 1$).

Q.6(e) State any four practical applications of hydrostatics. **[4]**

Ans.: Application of Hydrostatics [Any Four - 1 mark each]

(i) Mercury Barometer
In Mercury Barometer the height of mercury column is used to find atmospheric pressure.
$P = sgn$

(ii) Cl-tube manometer
It is used to measure unknown pressure in the pipe.

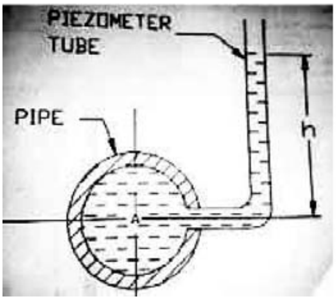
(iii) Pressure head at the outlet of tank.

(iv) Pressure acting on the dams and gates.

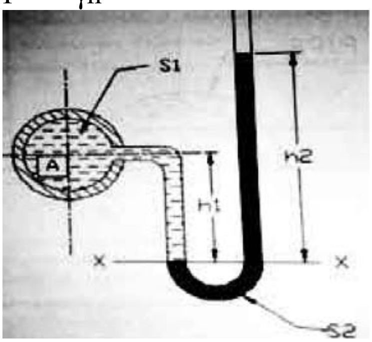
Q.6(f) Explain the following with neat sketches : **[4]**
(i) Simple manometer and its types.
(ii) Differential monometers and its types.

Ans.: (i) Simple manometer and its types [2 marks]
There are two types of simple manometer
1. Piezometer 2. Simple U tube manometer

Piezometer:



$P = \gamma h$

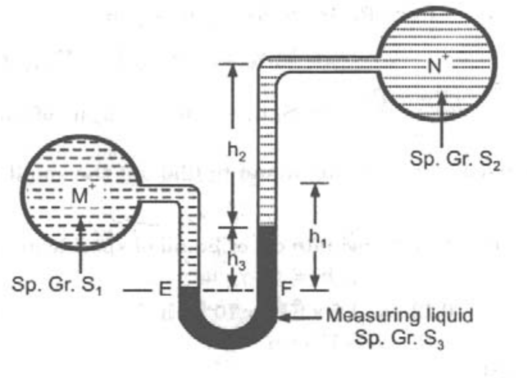


Simple U tube manometer: It is the simplest form of manometer.
$h = h_2S_2 - h_1S_1$ (m of water)
$p = \gamma h$

(ii) Differential U tube monometers [2 marks]

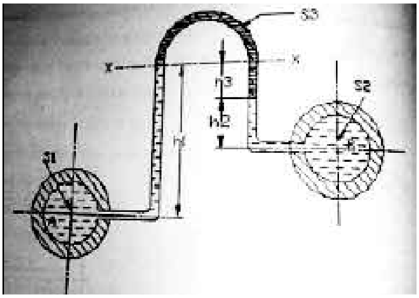
1. Differential U tube manometer
2. Inverted U tube Manometer

Differntrial U tube manometer :



$$H_M - H_N = h_1 s_1 - h_3 s_3 - h_2 s_2$$
$$P_M - P_N = \gamma(H_M - H_N)$$

Inverted U tube Manometer:



$$H_A - H_B = h_1 s_1 - h_2 s_2 - h_3 s_3$$
$$P_a - P_b = w\,(H_A - H_B)$$

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