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

Hydraulics

Prelim Question Paper Solution

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1. (a) **Mass Density:** The mass density of a liquid may be defined as the mass per unit volume at standard temperature. [1 mark]
SI unit : kg/m^3 [1 mark]

1. (b) **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.

1. (c) **Ideal Fluid:** A fluid, which does not posses viscosity, surface tension and compressibility is known as ideal fluid. [1 mark]

Real Fluid : A fluid, which possess viscosity, surface tension and compressibility is known as real fluid. [1 mark]

1. (d) **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".

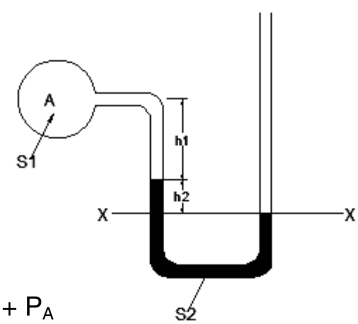
$\varsigma = (v/y) = \mu \times (v/y)$

1. (e) **Given Data :** $d_p = 1.2$ pa. N/m^2, V = 650 litres, $d_v = 1.5$ litres

Bulk Modulus $= K = -(dP/(dv/V))$ [1 mark]
$= -(1.2/(1.5/650))$
$= -520\ N/m^2$ [1 mark]

1. (f) **Pressure** [1 mark]
Pressure at a point due to a liquid is defined as the force acting per unit area.
SI unit : N/m^2 [1 mark]

1. (g) Mercury in the U-tube is deflected by h_2 due pressure at point A, as deflection occurs in the left limb indicates that, pressure at A is negative (vacuum), pressure above the horizontal datum x-x in the left and right limb of the manometer should be same [1 mark]



Pressure above x-x in the left limb = $S_1h_2 + S_1h_1 + P_A$
Pressure above x-x in the right limb = 0

$P_A = (S_1h_2 + S_1h_1)$ [1 mark]

1. (h) The Reynolds number is the ratio of inertia force to the viscous force. [1 mark]
R_N = (Inertia Force/Viscous Force) [1 mark]

1. (i) (i) To measure low and negative pressure differences in two pipe. [1 mark]
(ii) To measure sensitive pressure [1 mark]

1. (j) **Modified Darcy-Weisbach Equation** [2 marks]

$$hf = \frac{fLQ^2}{12.1D^5}$$

1. (k) **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.

1. (l) **Four uses of pitot tube** [½ mark each]
(i) The pitot tube is a simple and convenient instrument to measure the difference between static, total and dynamic pressure (or head).
(ii) To measure the velocity in cannel.
(iii) To measure the velocity at a point in flow steam.
(iv) Pitot-static tube can measure the fluid flow velocity by converting the kinetic energy in the fluid flow into potential energy.

2. (a) **Pascal's Law** [2 marks]
Pascal's Law states that the pressure or intensity of pressure at a point in a static fluid is equal in all directions

Application [2 marks]
Law is applied in the construction of machines used for multiplying forces e.g. hydraulic jack, hydraulic pressure, hydraulic lift, hydraulic crane, hydraulic river, etc.

2. (b) **Given Data :**
d = 1.5 m
x = 2.5 m

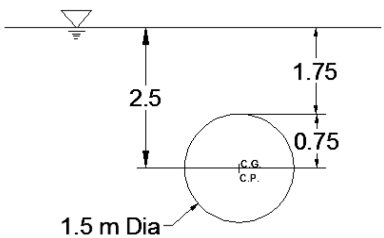
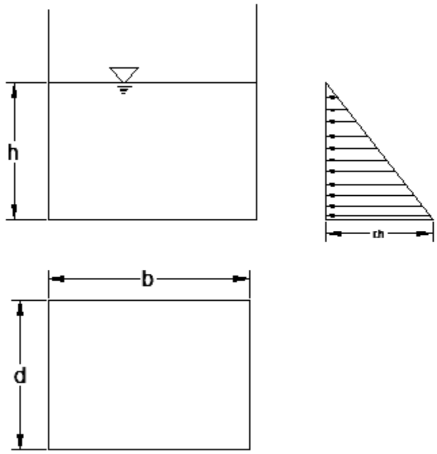


Diagram
Area = A = (π/A) x d^2
= (π/4) x 1.5^2 = 1.767 m^2

(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 x 1.767 x 2.5
F = 43.34 x 10^3 N = 43.34 KN [1 mark]

(ii) Centre of Pressure
h = X + I.G./AX [1 mark]
I.G. = (π/64)x d^4 = (π/64) x 1.5^4 = 0.2485 m^4
h = 2.5 + [0.2485/(1.767 $\times$ 2.5)] = 2.5 + 0.0563 = 2.556 m [1 mark]

2. (c)

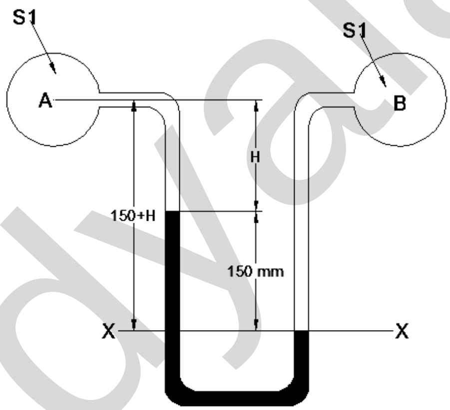


[2 marks]

The pressure on side of the tank = ½ x γ h^2, [1 mark]
The pressure on bottom of the tank = γ h x plan area of tank [1 mark]

2. (d) $p = \gamma_L h = S_L \gamma w\, h$ [1 mark]
$0.5 = 0.7 \times 9.81 \times 10^{-6} \times h$ [1 mark]
$h = 72812$ mm
$h = 72.812$ m [2 marks]

2. (e) **Given :** $S_1 = 0.8$, h = 15 cm = 150 mm, Sm = 13.6



[1 mark]

The pressure head in the right limb above X-X
$= h_B + S_1(H + 150)$ mm of water [1 mark]
$= h_B + S_1H + 150\, S_1$ mm of water

The pressure head in he left limb above X-X
$= h_A + S_1H + Sm \times 150$ mm of water.

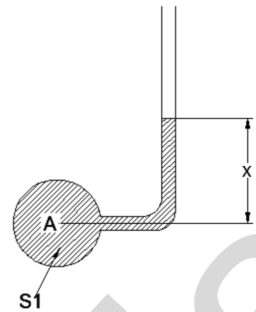
Equating both pressure
$h_B + S_1H + 150S_1 = h_A + S_1H + Sm \times 150$ [1 mark]
$h_A - h_B = 150\, Sm - 150\, S_1$
$= 150\,(Sm - S_1)$

$= 150(13.6 - 0.8)$
$= 1920$ mm of water = 1.92 m of water

Difference of pressure $= w(h_A - h_B)$
$= 9810 \times 1.92 = 18.835 \times 10^3$ N/m^2 [1 mark]

2. (f) Piezometer

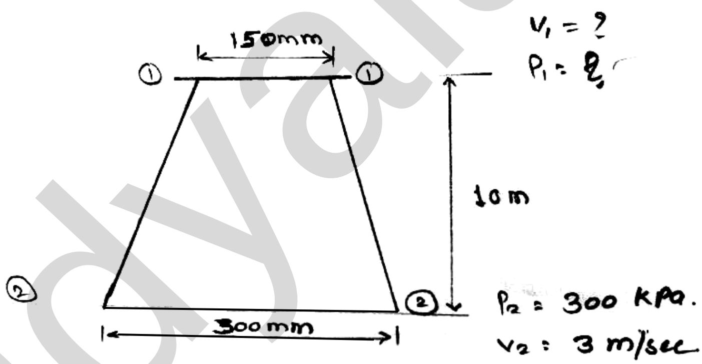
A piezometer tube is the simplest form of instrument, used for measuring moderate pressures. It consists of a tube one end of which is connected to the pipe line in which the pressure is required to be found out. The other end is open to the atmosphere in which the liquid can rise freely without overflow. The height to which the liquid rises up in the tube gives the pressure head directly.
[2 marks]



[1 mark]

Use: To measure pressure at a point in the pipe. [1 mark]

3. (a)



$Q = a_1 v_1 = a_2 v_2$

$Q = \frac{\pi}{4} \times 0.3^2 \times 3 = \frac{\pi}{4} \times 0.15^2 \times v_1$ [1 mark]

$v_1 = 12$ m/s
$z_1 = 10$ or $z_2 = 0$

considering flow in upward direction

$$\frac{P_1}{\rho_w} + \frac{v_1^2}{2g} + z_1 + h_f = \frac{P_2}{\rho_w} + \frac{v_2^2}{2g} + z_2$$ [1 mark]

$$\frac{P_1}{9810}+\frac{12^2}{2\times 9.81}+10+2 = \frac{300\times 10^3}{9810}+\frac{3^2}{2\times 9.81}+0$$ [1 mark]

$$\frac{P_1}{9810} + 19.339 = 31.039$$

P_1 = (31.039 − 19.339) × 9810

P_1 = 114772.59 N/m^2 [1 mark]

P_1 = 114.772 KPa

OR

if flow in downward direction

$$\frac{P_1}{9810}+\frac{12^2}{2\times 9.81}+10 = \frac{300\times 10^3}{9810}+\frac{3^2}{2\times 9.81}+2$$ [1 mark]

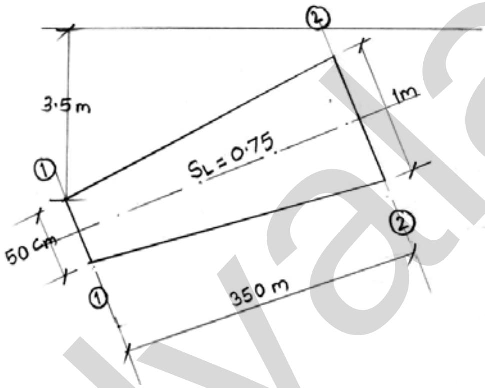
$$\frac{P_1}{9810} + 17.339 = 33.039$$ [1 mark]

P_1 = (33.039 − 17.339) × 9810 [1 mark]

P_1 = 154017 N/m^2 [1 mark]

P_1 = 154 KPa

3. (b)



Q = discharge = 48000 lpm = 48m^3/min

$= \frac{48}{60}$ m^3/sec = 0.8 m^3/sec

P_1 = 1200 kN/m^2 = 1200 × 10^3 N/m^2

P_2 = ?

finding velocities at 1-1 and 2-2

Q = $a_1 v_1$

$0.8 = \frac{\pi}{4}\times 0.5^2 \times v_1$

$v_1 = \frac{0.8}{0.196} = 4.07$ m/sec [1 mark]

Q = $a_2 v_2$

$0.8 = \frac{\pi}{4}\times 1^2 \times v_2$

$v_2 = \dfrac{0.8}{0.785} = 1.01$ m/sec [1 mark]

$z_1 = 0$, $v_1 = 4.07$ m/sec, $P_1 = 1200 \times 10^3$ N/m^2
$z_2 = 3.5$, $v_1 = 1.01$ m/sec, $P_2 = ?$

using Bernoulli's theorem

$$z_1 + \frac{v_1^2}{2g} + \frac{P_1}{w} = z_2 + \frac{v_2^2}{2g} + \frac{P_2}{w}$$

$$0 + \frac{4.07^2}{2 \times 9.81} + \frac{1200 \times 10^3}{0.75 \times 9810} = 3.5 + \frac{1.01^2}{2 \times 9.81} + \frac{P_2}{w}$$

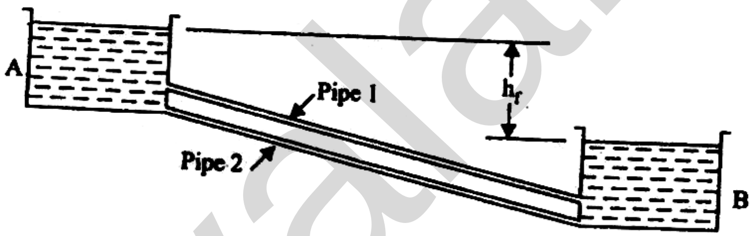
$$0.844 + 163.09 = 3.5 + 0.051 + \frac{P_2}{w}$$ [1 mark]

$$\frac{P_2}{w} = 160.38$$

$$P_2 = 1180.017 \text{ KN/m}^2$$ [1 mark]

3. (c) **(i) Pipes in parallel**

Consider two tanks connected by parallel pipes of same lengths.



[1 mark]

l = length of both pipes
d_1, d_2 = Diameter of the pipes

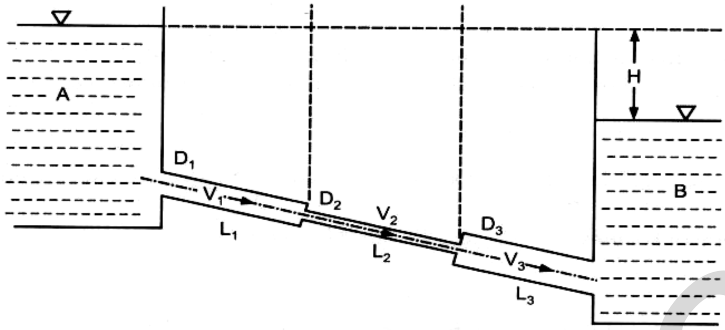
In above arrangement loss of head in both the pipes is same.
Loss of head in pipe 1 = Loss of head in pipes

$$\frac{f_1 l v_1^2}{2gd_1} = \frac{f_2 l v_2^2}{2gd_2}$$ [1 mark]

$$\frac{f_1 v_1^2}{d_1} = \frac{f_2 v_2^2}{d_2}$$

(ii) Equivalent pipe

If the two tanks are connected by pipes of different lengths and diameters. It is called as compound pipe. If this compound pipe is replaced by a single pipe of same diameter it is called as equivalent pipe.



[1 mark]

It's diameter is calculated by equation,

$$\frac{l}{d^5} = \frac{l_1}{d_1^5} + \frac{l_2}{d_2^5} + \frac{l_3}{d_3^5}$$ [1 mark]

3. (d) **Given :** $f_1 = f_2 = f_3$ and $l_1 = l_2 = l_3$

$d_1 = 250$ mm, $d_2 = 100$ mm, $d_3 = 75$ mm

$d_1 = 0.25$m, $d_2 = 0.100$m, $d_3 = 0.075$m

Total $Q = 0.75\ m^3/s, Q_1 = ?$ $Q_2 = ?, Q_3 = ?$

for pipes connected parallel, head loss is equal

$$\frac{f_1 l_1 v_1^2}{2gD_1} = \frac{f_2 l_2 v_2^2}{2gD_2} = \frac{f_3 l_3 v_3^2}{2gD_3}$$

But $f_1 = f_2 = f_3$ and $L_1 = L_2 = L_3$

V_1, V_2 and V_3 are the velocities through pipe 1, 2, 3.

$$\frac{v_1}{d_1} = \frac{v_2}{d_2} = \frac{v_3}{d_3}$$

$$v_1^2 = \frac{d_1}{d_2} \times v_2^2$$

$$v_1^2 = \frac{0.25}{0.1} \times v_2^2$$

$v_1 = 1.58\ v_2$ [1 mark]

$v_2 = 0.63 v_1$

also, $\frac{v_1^2}{d_1} = \frac{v_3^2}{d_3}$

$$v_3^2 = \frac{d_3}{d_1} \times v_1^2$$ [1 mark]

$v_3 = 0.54\ v_1$

$$Q_1 = a_1 v_1 = \frac{\pi}{4} \times 0.25^2 \times v_1 = 0.049 v_1$$

$$Q_2 = a_2 v_2 = \frac{\pi}{4} \times 0.1^2 \times 0.63 v_1 = 0.0049 v_1$$

$$Q_3 = a_3 v_3 = \frac{\pi}{4} \times 0.0.75^2 \times 0.54 v_1 = 0.0023 v_1$$

$$Q = Q_1 + Q_2 + Q_3$$

$$0.75 = 0.049 v_1 + 0.0049 v_1 + 0.0023 v_1$$

$$0.75 = 0.0562 v_1$$ [1 mark]

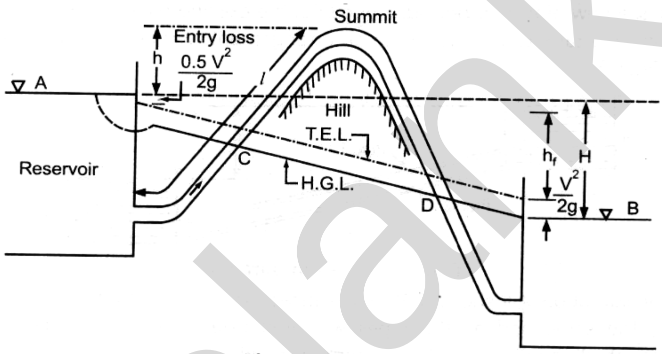
$v_1 = 13.34$ m/sec,

$v_2 = 8.40$ m/sec,

$v_3 = 7.2$ m/sec

$Q_1 = 0.65 m^3$/sec, $Q_2 = 0.065\ m^3$/sec, $Q_3 = 0.0318\ m^3$/sec [1 mark]

3. (e) 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]

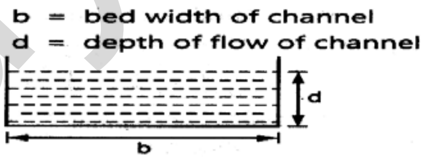


[2 marks]

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]

3. (f) **(i) Rectangular channel**

This is used in case of hard rock strata.



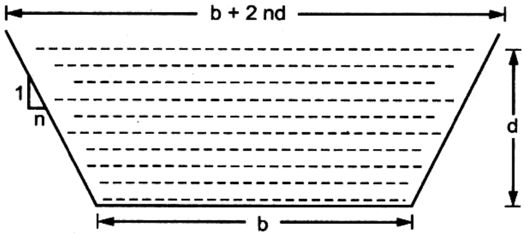
b = width of the channel
d = depth of the flow
m = hydraulic mean depth
Area = b × d
Perimeter = b + 2d

The condition of most economical section is that for a given area the perimeter should be minimum.

b = 2d m = d/2

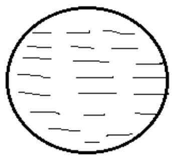
(ii) Trapezoidal channel [1 mark]

This is most commonly used shape because of stability.



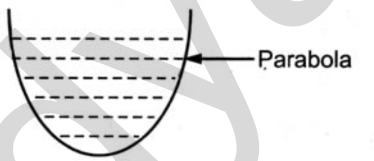
b = width of the channel at bottom
d = depth of the flow
the side slope is given as 1 vertical to n horizontal most economical conditions are :
half of top width = sloping side
m = d/2

(iii) Circular section [1 mark]



d = depth of the flow
r = radius of channel
Though it is closed the pressure on water surface is atmosphere.

(iv) V Shaped channel



d = depth of the flow
θ = angle
The pressure on water surface is atmospheric.

4. (a) **Steady flow:** Flow characteristics like velocity, pressure, temperature and density do not change with respect to time at any point. [1 mark]

Unsteady flow is one in which flow characteristics changes with respect to time [1 mark]

Uniform flow is a one in which the velocity and flow does not change in magnitude and direction at different cross sections. [1 mark]

In non uniform flow the velocity of flow changes at different cross sections.

4. (b) Area of section A = (b + nd)d

$= (3d + 1 \times d)d$ (b = 3d given)

$A = 4d^2$

Wetted perimeter P = $b + 2d\sqrt{n^2 + 1} = 3d + 2d\sqrt{1^1 + 1} = 5.83d$

$R = \frac{A}{P} = \frac{4d^2}{5.83d} = 0.69d$ [1 mark]

Using Mannings formula,

$V = \frac{1}{N} \times R^{\frac{2}{3}} \times S^{\frac{1}{2}} = \frac{1}{0.02} \times (0.69d)^{\frac{2}{3}} \times \left(\frac{1}{4000}\right)^{\frac{1}{2}}$

$V = 0.617d^{\frac{2}{3}}$ [1 mark]

We have, Q = A × V

$5 = 4d^2 \times 0.617d^{\frac{2}{3}}$

d = 1.3m

b = 3d = 3.9m [2 marks]

4. (c) Froude's number [1 mark]

Froude's number is a dimensionless number and is the ration of inertia forces to gravity force.

[1 mark]

In gradually varied flow, the depth of flow changes over a long distance.

[1 mark]

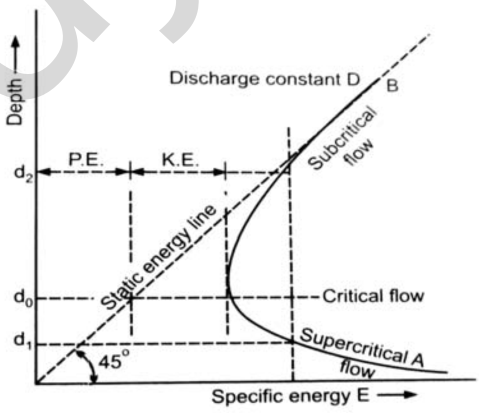
In rapidly varied flow the depth of flow abruptly changes over a short distance.

For, GVF, Fr < 1 [1 mark]

RVF, Fr > 1

4. (d) Specific Energy [1 mark]

The specific energy of a flowing liquid is defined as the energy per unit weight with respect to the bed of the canal as datum.



[1 mark]

: **Specific energy diagram**

[2 marks]

In specific energy diagram, the graph is plotted between depth(Y axis) and specific energy(X axis).The depth corresponding to minimum specific energy is called critical depth. Apart from this for every other specific energy there will be two depths. Supercritical and Sub critical depth.

4. (e) **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 Cv 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

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

The two jets will intersect at x = 5.2m [1 mark]

4. (f) Inlet area, $A_1 = \frac{\pi}{4}\times 30^2 = 706.86 cm^2$

Throat area, $A_2 = \frac{\pi}{4}\times 15^2 = 176.17 cm^2$

Gauge deflection interms of oil

$$h = 30\left(\frac{13.9-0.9}{0.9}\right) = 423.3 \text{cm of oil}$$ [1 mark]

$$Q = \frac{Cd\times a_1\times a_2\times\sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

$$Q = \frac{0.98\times 706.86\times 176.71\times\sqrt{2g\times 423.3}}{\sqrt{706.86^2 - 176.71^2}}$$

$Q = 163000 cm^3/s$ [1 mark]

Q = 163lps

$Q = A_1V_1 = A_2V_2$ [1 mark]

$V_1 = 230.6 cm/s$

$V_2 = 922.4 cm/s$

Applying Bernoulli's therem at inlet and throat

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

$$0+\frac{P_1}{\gamma}+\frac{230.6^2}{2g}=50+\frac{P_2}{\gamma}+\frac{922.4^2}{2g}$$ [1 mark]

$$\frac{P_1-P_2}{\gamma}=456.53\text{cm}$$

5. (a) Principle: [1 mark]

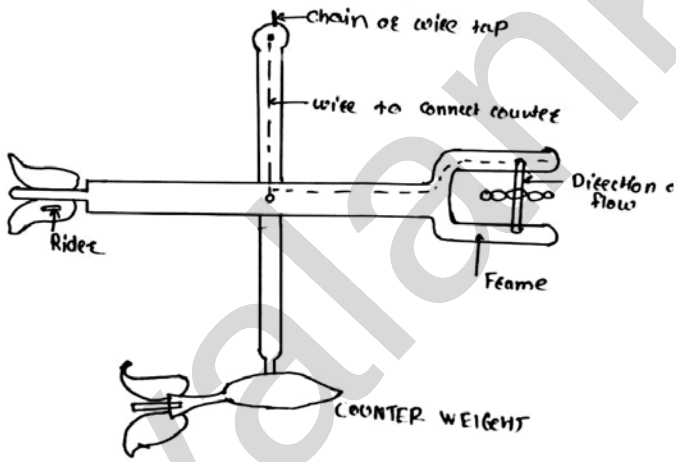
It is small reaction turbine. When placed in flow of water it rotates with speed. The velocity can be calibrated by observing revolutions per minute towing with a carriage mounted on rails, across still water at known velocities.

Types of current meter [1 mark]

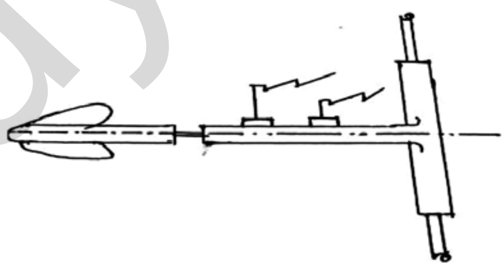
(1) Cup type current meter
(2) Propeller or screw type current meter

CUP TYPE CURRENT METER

[2 marks]



SCREW TYPE CURRENTMETER



5. (b) For Case I - Length = 6m Head = 70 cm = 0.7m

Francis formula

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

$Q = 1.84 \text{ x} (6 - 0.1 \text{x} 2 \text{x} 0.7) \text{x} 0.7\ 2^{\frac{3}{2}}$

Case II Length = 6m

Approch velocity = Q/A

= 6.31/(7 × 1.5)

Va = 0.6m/s [1 mark]

Head due to velocity approach = $Va^2/2g$

$= 0.6^2/2 \times 9.81$

= 0.0184m

Discharge considering velocity approach

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

$$Q = 1.84 \times 5.86 \times \left[(0.7 + 0.0184)^{\frac{3}{2}} - (0.0184)^{\frac{3}{2}}\right]$$

Q = 10.78 × [0.597]

= 6.43 m^3/s [1 mark]

5. (c) Area = 30 km^2 = 30 × $10^6 m^2$

Discharge = (30 × 10^6 × 2.5) / (100 × 60 × 60)

= 208.33 m^3/s [1 mark]

Discharge over weir 45% = 45/100 × 208.33

= 93.75 m^3/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 x (L - 0.16)

71.20 = (L - 0.16)

L = 71.36 m [1 mark]

5. (d) Difference between centrifugal and reciprocating pump

	Centrifugal pump	**Reciprocating pump**
(i)	For Centrifugal pump discharge is continuous.	For Reciprocating pump discharge is fluctuating
(ii)	Suitable for large discharge and small heads.	Suitable for less discharge and higher heads.
(iii)	simple in in construction because of less number of parts.	Complicated in construction because of more number of parts.
(iv)	It has rotating elements so there is less wear and tear.	It has reciprocating element, there is more wear and tear.
(v)	It can run at high speed.	It cannot run at high speed.

(vi)	Air vessels are not required.	Air vessels are required.
(vii)	Starting torque is more.	Starting torque is less.
(viii)	It has less efficiency.	It has more efficiency.
(ix)	Suction and delivery valve are not necessary.	Suction and delivery valve are necessary.
(x)	Requires less floor area and simple foundation.	Requires more floor area and requires heavy foundation.

5. (e) List of operating troubles and remedial measures in centrifugal pump

[Any 4 - 1 mark each]

	Troubles	Remedies
(i)	Pump does not primed	Reprime the pump
(ii)	Total static head more than design head.	Use multistage pump
(iii)	Direction of rotation of impeller is wrong.	Check the poles of motor.
(iv)	Clogging of impeller.	Clean impeller.
(v)	Suction lift is more.	Lower the setting of pump.
(vi)	Clogging of strainer.	Clean strainer.
(vii)	Speed is low.	Wait till voltage becomes proper.
(viii)	Other troubles.	Contact maintenance person.

5. (f) Q = 50 lps = 0.05m3/s, D = 150mm = 0.15m

L = 120 m Efficiency %η = 75%

$$\text{Head loss} = \frac{FLQ^2}{12.1D^5}$$ [1 mark]

$$\text{Head loss} = \frac{1.487 \times 10^{-3}}{0.15^5}$$

Head loss = 19.5 m

Total head = 20 + 19.5 + 0.35

39.85 m [1 mark]

Power required

$$P = \frac{w \times Q \times H_m}{\eta}$$ [1 mark]

$$P = \frac{9.81 \times 0.05 \times 39.85}{0.75}$$

P = 26.06 Kw [1 mark]

6. (a) Submersible Pump

- A submersible pump as a name indicates consists of electric motor and pump both are submerged in the water.
- By submerging electric motors, pumps, large economy can be and achieved by avoiding long shaft, large number of bearings and large sized rising main etc.

- The complications due to thrusts are also avoided.
- As it is a submersible pump, the only problem is to prevent the motor windings and other electrical connections to be spoiled by water coming in contact.
- For this purpose a special protection by suitable type of insulation is provided to prevent the flow of supporting water inside the assembly.
- These pumps are vertical centrifugal pumps with radial or mixed flow impellers. All the metallic bearings are water lubricated and protected against the sand.
- A non-return valve is fitted to a flange at the top of the pump.
- The suction housing of pump is situated between the pump and motor and provide with a performed strainer.
- Motor of the submersible pumps are wet squirrel cage type and are completely filled with water. Thrust bearings are provided for absorbing the axial thrust.
- The pump shaft is connected to motor shaft by muff coupling. Gate valve is provided at the top of the pump as a non-return valve to discharge the water.
- The total efficiency of these pumps is superior to conventional deep well pumps at much cheaper costs.

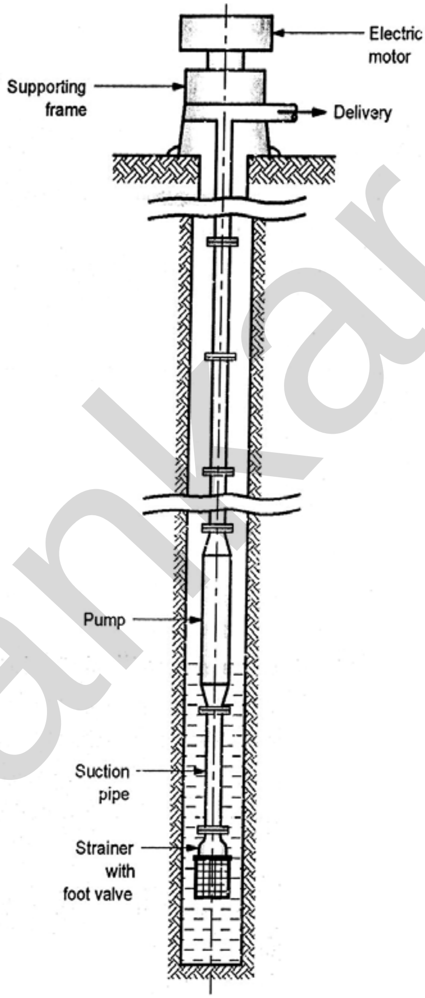


Fig. 1 : Submersible pump

Advantage
It can provide significant lifting force as it does not depend upon external air pressure to lift fluid.

Application
These pumps are used for drainage sewage pumping. Slurry pumping, industrial pumping etc.

Single stage
These are suitable for low heads upto 30 m and have a single impeller.

6. (b) **(i) Coefficient of contraction (C_V)** :

It is defined as the ratio of the area of the jet at vena–contracta to the area of the orifice.

$$C_c = \frac{a_c}{a}$$

(ii) Coefficient of velocity :

It is defined as the ratio between the actual velocity of a jet of liquid at vena contracta to the theoretical velocity of jet.

$$C_v = \frac{V}{\sqrt{2gH}}$$

V = actual velocity
H = pressure head

(iii) Coefficient of discharge (C_d) :

It is defined as the ratio of actual discharge from an orifice to the theoretical discharge from orifice.

$$C_d = \frac{\theta}{\theta_n} = \frac{\theta}{\sqrt{2gH}}$$

$$C_d = C_v \times C_c$$

(iv) Coefficient of resistance (c_r)

The ratio of loss of head in the orifice to the head of water available at the exit is known as coefficient of resistant.

$$C_r = \frac{\text{loss of head in the orifice}}{\text{Head of water}}$$

6. (c) 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

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

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.

6. (d)

$n = 3:2 = 1.5$

$Q = 15 m^3/s$

$V = 2 m/s$

To findout
(i) wetted perimeter
(ii) slope of bed if
const N = 0.014
manning

For most economical section

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

$\Rightarrow \; b + 3d = 3.6d$

$b = 0.6d \quad — (1)$

$Q = A \times V$

$A = \frac{Q}{V} = \frac{15}{2} = 7.5$

$A = (b + nd) \times d = 7.5 \quad — (2)$

$(b + 1.5d) \times d = 7.5$

$(0.6d + 1.5d) \times d = 7.5$

$d = 1.889$ m

$b = 1.133$ m

(i) Wetted perimeter

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

$\boxed{P = 4.733 \text{ m}}$

(ii) To find i if N = 0.014

$Q = AC\sqrt{mi}$

$15 = 7.5 \times 77.12 \times \sqrt{1.584 \cdot i}$

$\therefore i = 4.24 \times 10^{-4} = 0.424 \times 10^{-3}$

$\therefore i = \frac{1}{2358}$

$C = \frac{1}{N} m^{1/6}$

$m = \frac{A}{P} = \frac{7.5}{4.733} = 1.584$

$C = 77.12$

6. (e) **Prismatic:**

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:

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

Example – River, Streams and Estuary.

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

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

6. (f) Application of Hydrostatics

(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.

❑ ❑ ❑ ❑ ❑