



QUESTION BANK OF CHAPTER – 3
FLOW THROUGH PIPES

Program Name: Diploma in Mechanical Engineering

Program Code: ME

Name of Subject & Code : Fluid Mechanics and Machinery (313309)

Semester : THIRD

Instructions: (1) Illustrate your answers with neat sketches wherever necessary.

Q.1.	Two marks questions.	Previous Exam	CO PO Mapping
1.	Write Chezy's equation for frictional losses and list all the terms involved in it.		C03-TL03.2 -R
2.	State the laws of fluid friction for turbulent flow.	S25-1.e W24-4.b	C03-TL03.1 -R
3.	State laws of fluid friction for laminar flow.	S25-1.c	C03-TL03.1 -R
Q.2.	Four marks questions.	Previous Exam	CO PO Mapping
1.	Explain water hammer phenomenon and state the causes, remedial measures to avoid it.	W24-3.b S25-4.d W25-1.c	C03-TL03.6 -U
2.	A 3000 m long pipeline is used for transmission of power. 145 kW power is to be transmitted through the pipe in which water having a pressure of 4000 KN/m ² at inlet is flowing. If the pressure drop over the length of pipe is 800 KN/m ² and $f = 0.006$, find - i) Diameter of the pipe, and ii) Efficiency of transmission.	W24-4.a	C03-TL03.5 -A
3.	Explain the various energies possessed by a flowing fluid.	S25-2.d	C03-TL03.4 -U
4.	Find maximum power can be transmitted by power station through a hydraulic pipe 5 km long and 0.25 m diameter. The intensity of pressure available is 70 bars. Take $f = 0.0075$.	S25-5.a	C03-TL03.5 -A
5.	A pipe of a diameter 300 mm and length 3500 m is used for the transmission of power by water. The total head at the inlet of the pipe is 500 m. Find the maximum power available at the outlet of the pipe, if the value of $f = 0.006$.	W25-3.c	C03-TL03.5 -A
6.	With the help of a neat sketch explain Hydraulic gradient line and total energy line.	W25-3.a S25-3.b W24-1.c	C03-TL03.4 -A
7.	State the meaning of minor losses and list the various minor losses in flow through pipes with appropriate formulae	W25-3.b	C03-TL03.3 -U



The Shirpur Education Society's

R. C. Patel College of Engineering & Polytechnic, Shirpur

8.	Determine discharge through a pipe of diameter 200 cm when the difference of pressure head between two ends of pipe 500 m apart is 4 m of water ($f = 0.009$)	S25-3.c	C03-TL03.2 -A
9.	Find the maximum power that can be transmitted by a power station through a pipe 3 km long and 0.2m diameter. The pressure at power station is 60 bars ($f = 0.078$).	S25-5.c	C03-TL03.5 -A
10.	Find the loss of head, when pipe of diameter 30 cm is suddenly enlarged to a diameter of 40 cm. The rate of flow of water through the pipe is 300 lit/sec.	W14, W17	C03-TL03.2 -A
11.	A pipe 800 m long connects two reservoirs; whose level difference is 60 m. find the discharge in pipe in lit/sec, if diameter of pipe is 0.5 m. Take all losses into account. Assume $f = 0.01$	W16	C03-TL03.2 -A
12.	Find the diameter of a pipe of length 9km, when rate of flow of water through the pipe is 255 litre/sec. and head loss due to friction is 6.5m. Take $C = 55$ for Chezy's formula.		C03-TL03.2 -A
* **Best of Luck** *			

Mr. J. N. Chaudhari
Subject Teacher

08/10/2026

Mr. A. D. Patil
HOD(ME)

Dr. N. G. Haswani
Principal

* Fluid Mechanics & Machinery *

Chapter 3: Flow Through Pipes,

3.1 Laws of Fluid friction for laminar & turbulent flow:

Laws of fluid friction for Laminar flow	Laws of fluid friction for turbulent flow
<p>1. Frictional resistance does not depend upon pressure of flowing fluid.</p>	<p>1. Frictional resistance does not depend upon press. of flowing fluid.</p>
<p>2. Frictional resistance is directly proportional to wetted surface area, $F \propto A$</p>	<p>2. Frictional resistance is directly proportional to wetted surface area $F \propto A$</p>
<p>3. Frictional resistance is proportional to velocity, $F \propto v$</p>	<p>3. Frictional resistance is proportional to square of velocity, $F \propto v^2$</p>
<p>4. Frictional resistance varies considerably with temp.</p>	<p>4. Frictional resistance varies slightly with temp.</p>
<p>5. Frictional resistance does not depend upon surface roughness.</p>	<p>5. Frictional resistance depends upon surface roughness.</p>

Laws of fluid friction
for laminar flow

Laws of fluid friction
for turbulent flow.

6. Frictional resistance
is proportional viscosity
of fluid.

$$F \propto \mu$$

6. Frictional resistance
is proportional to
density of fluid.

$$F \propto \rho$$

3.2. Darcy's Equation & Chezy's Equation for
Calculation of frictional losses.

* Darcy's Weisbach Equation :-

$$h_f = \frac{4 \cdot f \cdot l \cdot v^2}{2 g d}$$

where,

h_f = head loss

f = coeff. of friction or friction factor or
function of Reynold's no.

l = length of pipe

d = diameter of pipe

v = velocity of fluid

g = gravitational accelⁿ

* Chezy's Equation :-

$$v = C \sqrt{m \cdot i}$$

where,

V = mean velocity

C = Chezy's constant

m = hydraulic mean depth = $\frac{A}{P}$

$$\therefore m = \frac{A}{P} = \frac{\frac{\pi \cdot d^2}{4}}{\pi \cdot d} = \frac{d}{4} \quad \text{--- (for circular pipe)}$$

i = loss of head per unit length of pipe

$$= \frac{h_f}{L}$$

3.3 Minor losses in fittings & valves

* Types of losses :-

1. Major loss:

It is the loss due to friction between layer of water & pipe.

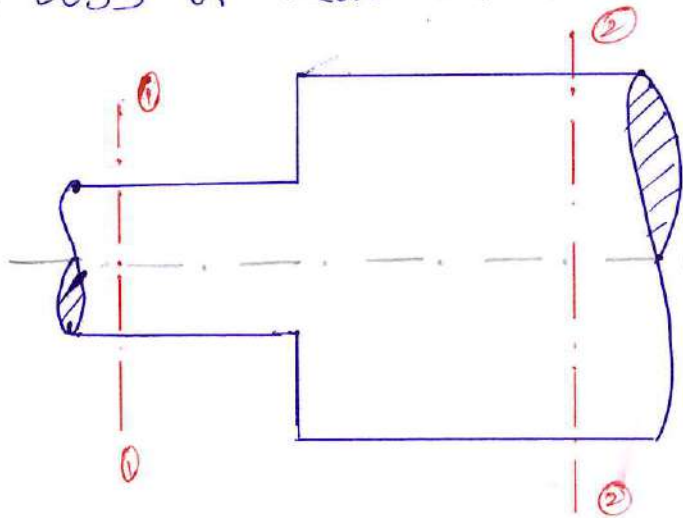
2. Minor loss:

It is the loss due to change in velocity of flowing fluid in magnitude or direction.

Major Loss	Minor Loss
Calculated by 1. Darcy's eqn 2. Chezy's eqn	1. Head loss due to sudden enlargement 2. Head loss due to sudden contraction 3. Head loss at inlet of pipe. 4. Head loss at exit of pipe. 5. Head loss due to bend. 6. Head loss due to pipe fittings. 7. Head loss due to obstruction in pipe.

* Types of Minor Losses :-

1. Loss of head due to sudden enlargement :-



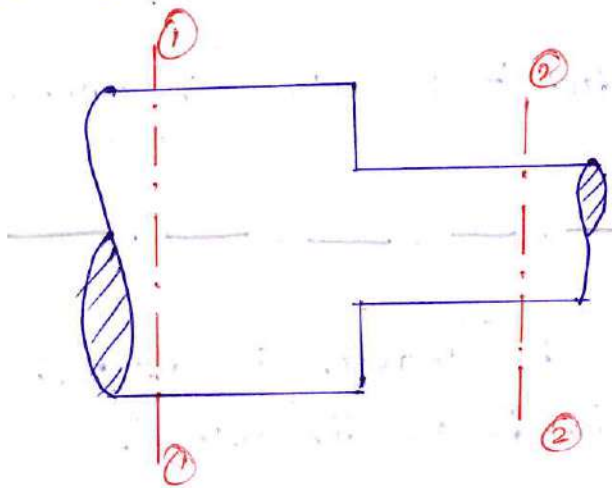
$$h_e = \frac{(V_1 - V_2)^2}{2g}$$

where V_1 = Velocity at
sect. 1-1

V_2 = Velocity at
sect. 2-2

As a result of sudden enlargement liquid flow forming eddies at corner. This eddies causes loss of head.

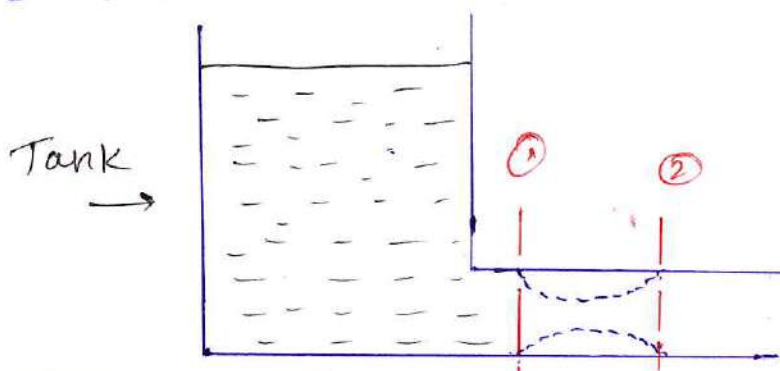
2. Loss of head due to sudden contraction :-



$$h_c = \frac{0.5 V_2^2}{2g}$$

This is the loss due to sudden decrease in area.

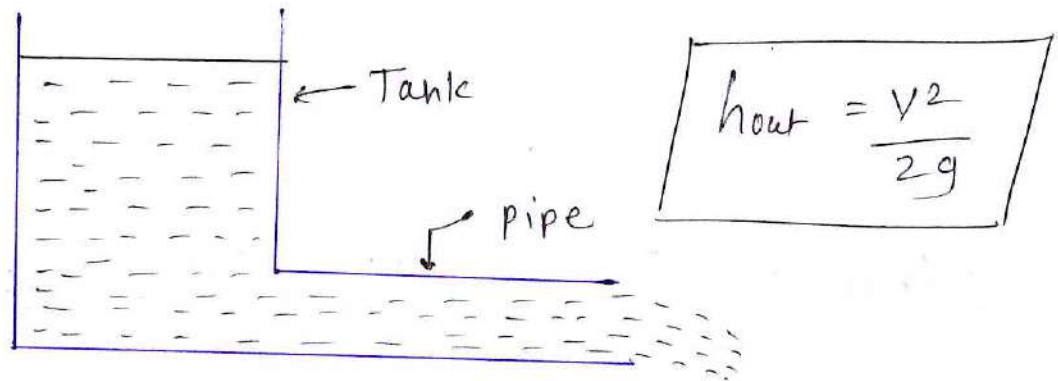
3. Loss of head at entrance or inlet of pipe :-



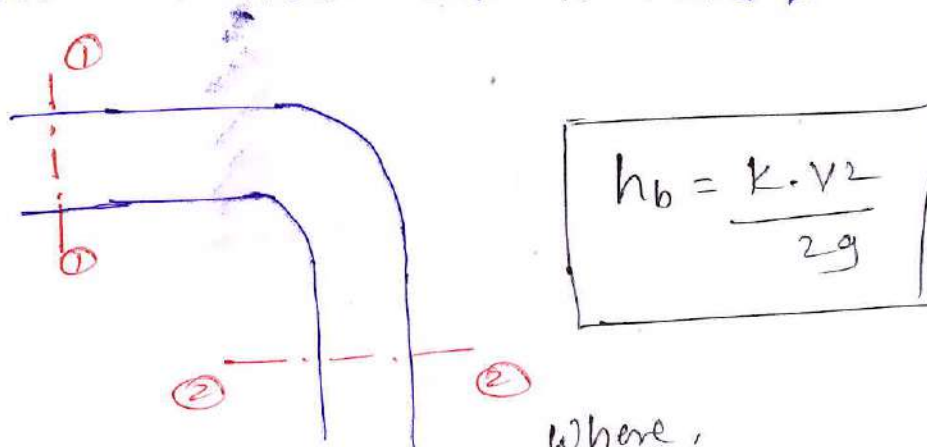
$$h_i = \frac{0.5 V^2}{2g}$$

When liquid enters from large vessel into a pipe sudden contraction is occurred to flow of liquid.

4. Loss of head due to exit or at outlet of pipe:-



5. Loss of head due to bend :-



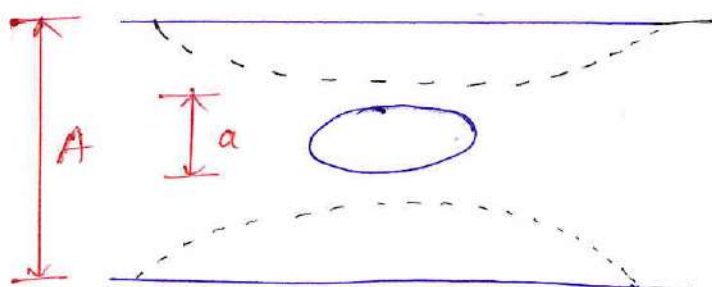
Where,

k = coeff. of bend.

Value of k depends;

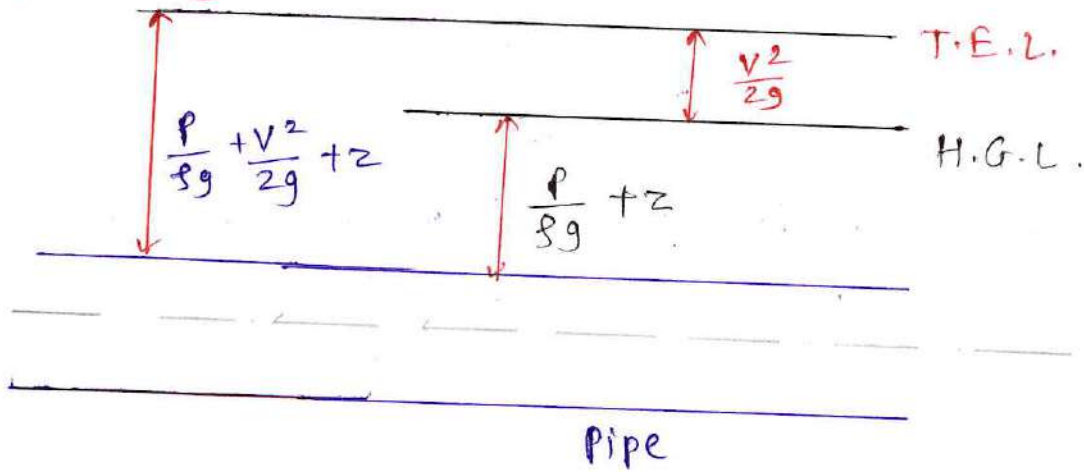
- a) Angle of bend (90°, 60°, 45° etc).
- b) Radius of curvature of bend (r_c)
- c) Diameter of pipe (d).

6. Loss of head due to obstruction in pipe :-



$$h_{obs} = \frac{v^2}{2g} \left(\left(\frac{A}{C_c(A-a)} \right)^2 - 1 \right)$$

3.4 Hydraulic Gradient Line & Total Energy Line:-



* Hydraulic Gradient Line (H.G.L.) :-

HGL is the line of sum of pressure head + datum head only.

$$\text{HGL} = \frac{P}{\rho g} + z$$

• HGL is always below T.E.L.

* Total Energy Line (T.E.L.) :-

TEL is the line of total energy of flowing fluid at any point.

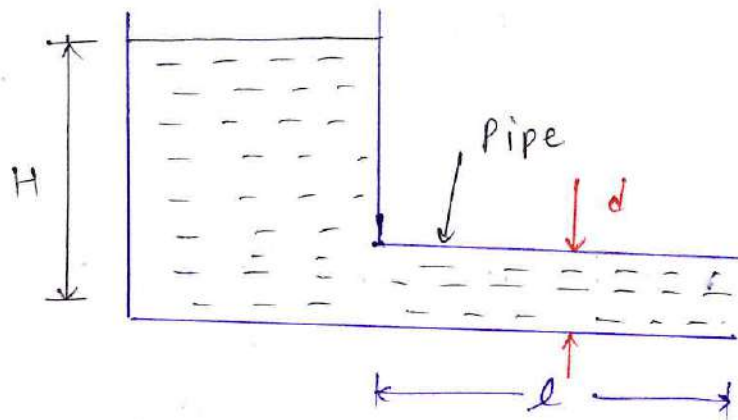
OR
It is the line, sum of kinetic head + pressure head + datum head.

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

$\frac{v^2}{2g}$ = kinetic head , $\frac{P}{\rho g}$ = Pressure head

z = datum head

3.5 Power Transmission through Pipes :-



1. When water flows through a pipe power is transmitted through the pipe & it depends on weight of fluid flowing through pipe.

2. Net head available at outlet of pipe -

Let,

H = Head available at inlet of pipe.

L = length of pipe

d = diam. of pipe.

V = velocity of fluid flow

h_f = head loss due to friction

w = weight density of fluid

f = coeff. of friction.

$$\text{weight of fluid / sec} = w \cdot Q$$

$$\& \text{ Net head} = H - h_f$$

$$\text{Power transmission through pipe} = \text{weight of fluid flowing / sec} \times \text{Net head available at outlet of pipe}$$

$$\therefore P = \omega \cdot Q \cdot (H - h_f)$$

$$P = \omega \cdot a \cdot v \cdot \left(H - \frac{4fL v^2}{2gd} \right) \quad \dots \text{ in watt.}$$

* Condition for maximum efficiency :-
 for achieving the condⁿ take derivative of power w.r.t. 'v' & equate it with zero,

$$\frac{d(P)}{dv} = 0$$

$$\frac{d}{dv} \left(\omega \cdot a \cdot v \cdot \left(H - \frac{4fL v^2}{2gd} \right) \right) = 0$$

$$H - 3 \left(\frac{4fL v^2}{2gd} \right) = 0$$

$$H - 3h_f = 0$$

$$H = 3h_f$$

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

* Maximum efficiency of Power transmission :-

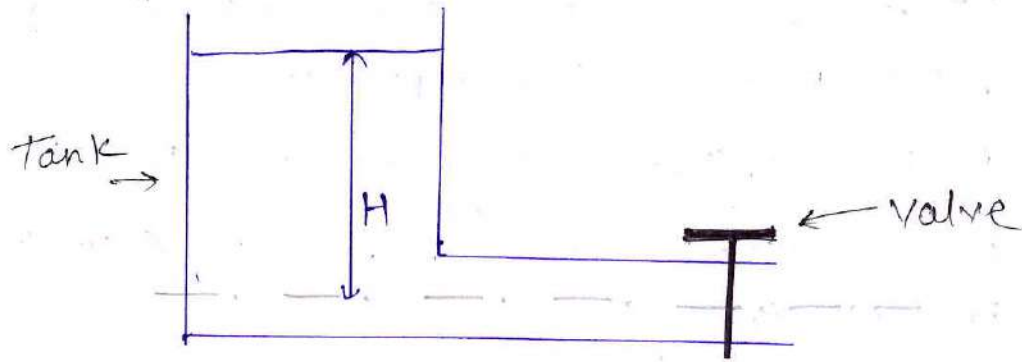
$$\text{efficiency } \eta = \frac{\text{Actual head}}{\text{Total head}} \times 100$$

$$= \frac{H - h_f}{H} \times 100$$

$$= \frac{3h_f - h_f}{H} \times 100 \Rightarrow \frac{2h_f}{3h_f} \times 100$$

$$\eta_{\text{max}} = \frac{2}{3} \% = 66.66 \%$$

3.6 Water hammer phenomenon in pipes, causes & remedial measures.



Water hammer is phenomenon in which sudden rise in pressure occurs inside a pipe due to rapid change in velocity of flowing water.

When moving water is suddenly stopped or its direction is changed, a pressure wave (shock wave) is generated & travel through the pipe.

• Causes :-

- sudden closing of valve
- Pump failure
- Rapid opening / closing of taps
- High velocity of water.

• Effect :-

- Noise & vibration
- Pipe leakage or bursting
- Damage to valves & fittings.

• Remedial Measures :-

- close valve slowly
- Use air chambers / surge tank
- Install Pressure relief valves.
- Reduce flow velocity

* Numericals on flow through Pipes *

1. A 3000 m long pipeline is used for transmission of power. 145 kW power is to be transmitted through the pipe in which water having a pressure of 4000 kN/m^2 at inlet is flowing. If the pressure drop over the length of pipe is 800 kN/m^2 & $f = 0.006$, find (W-24)

i) Diam. of pipe

ii) Efficiency of transmission.

→ Given data :-

Length of pipe $L = 3000 \text{ m}$

Power $P = 145 \text{ kW} = 145 \times 10^3 \text{ W}$

Inlet pressure $P_1 = 4000 \text{ kN/m}^2 = 4 \times 10^6 \text{ N/m}^2$

Pressure drop $\Delta P = 800 \text{ kN/m}^2 = 8 \times 10^5 \text{ N/m}^2$

$f = 0.006$

Now find discharge (Q).

We know Power (P) = $\Delta P \times Q$

$$\therefore Q = \frac{P}{\Delta P} = \frac{145 \times 10^3}{8 \times 10^5}$$

$$Q = 0.18125 \text{ m}^3/\text{s}$$

Now find head loss due to friction (h_f)

$$h_f = \frac{\Delta P}{\rho g}$$

$$= \frac{8 \times 10^5}{1000 \times 9.81}$$

$$h_f \approx 81.55 \text{ m}$$

we know discharge, $Q = a \cdot v \Rightarrow Q = \frac{\pi}{4} \cdot d^2 \cdot v$.

$$0.18125 = \frac{\pi \cdot d^2 \cdot v}{4}$$

$$\therefore v = \frac{4 \times 0.18125}{\pi \cdot d^2}$$

we have

$$h_f = \frac{4fLv^2}{2gd} = \frac{4 \times 0.006 \times 3000}{2 \times 9.81 \times d} \left(\frac{4 \times 0.18125}{\pi \cdot d^2} \right)^2$$

$$\boxed{d = 0.31 \text{ m} \approx 0.310 \text{ mm}}$$

Efficiency :-

$$\text{Input Power } P_{in} = \Delta P \times Q = 4 \times 10^6 \times 0.18125$$

$$\boxed{P_{in} = 725000 \text{ W}}$$

Now

$$\text{eff: } \eta = \frac{\text{o/p Power}}{\text{i/p Power}} = \frac{145 \times 10^3}{725000} \times 100\%$$

$$\eta = 0.2 \times 100$$

$$\boxed{\eta = 20\%}$$

2. Find maximum power can be transmitted by power station through a hydraulic pipe 5 km long, ϕ 0.25 m diam. The intensity of pressure available is 70 bars. Take $f = 0.0075$. (5-25)

→ Given data:

$$L = 5 \text{ km} = 5000 \text{ m}$$

$$d = 0.25 \text{ m}$$

$$P = 70 \text{ bar} = 70 \times 10^5 \text{ N/m}^2$$

$$f = 0.0075$$

$$\text{Total head (H)} = \frac{P}{\rho g} = \frac{7 \times 10^6}{1000 \times 9.81}$$

$$H = 713.55 \text{ m}$$

$$\text{Head loss for max power cond}^n \Rightarrow h_f = \frac{H}{3} = \frac{713.55}{3}$$

$$h_f = 237.85 \text{ m}$$

$$\text{We have Darcy's eq}^n \Rightarrow h_f = \frac{4 f l v^2}{2 g d}$$

$$237.85 = \frac{4 \times 0.0075 \times 5000 \times v^2}{2 \times 9.81 \times 0.25}$$

$$v = 2.79 \text{ m/s}$$

$$\text{Now find discharge, } Q = a \cdot v = \frac{\pi}{4} \cdot d^2 \cdot v$$

$$= \frac{\pi}{4} \cdot (0.25)^2 \times 2.79$$

$$Q = 0.137 \text{ m}^3/\text{s}$$

$$\text{Now Maximum Power (P}_{\text{max}}) = \rho \cdot g \cdot Q \cdot (H - h_f)$$

$$P = 1000 \times 9.81 \times 0.137 \times (713.55 - 237.85)$$

$$P_{\text{max}} = 640000 \text{ W}$$

3. A pipe of diam 300 mm & length 3500 m is used for the transmission of power by water. The total head at the inlet of the pipe is 500 m. Find the max^m power available at the outlet of pipe, if the value of $f = 0.006$

(W-25)

→ Given data:

$$d = 300 \text{ mm} = 0.3 \text{ m}$$

$$H = 500 \text{ m}$$

$$l = 3500 \text{ m}$$

$$f = 0.006$$

For max^m power transmission,

$$h_f = \frac{H}{3} = \frac{500}{3} \Rightarrow \boxed{h_f = 166.67 \text{ m}}$$

Now find velocity (v)

$$h_f = \frac{4fLV^2}{2gd} \Rightarrow 166.67 = \frac{4 \times 0.006 \times 3500 \times V^2}{2 \times 9.81 \times 0.3}$$

$$V^2 = 11.67 \Rightarrow \boxed{V = 3.42 \text{ m/s}}$$

Discharge,

$$Q = \frac{\pi}{4} \cdot d^2 \cdot v \Rightarrow \frac{\pi}{4} \times (0.3)^2 \times 3.42$$

$$\boxed{Q = 0.242 \text{ m}^3/\text{s}}$$

Now find max^m power.

$$P_{\max} = \rho \cdot g \cdot Q \cdot (H - h_f)$$

$$= 1000 \times 9.81 \times 0.242 \times (500 - \frac{500}{3})$$

$$\boxed{P_{\max} = 7.9 \times 10^5 \text{ W}}$$

4. Determine discharge through a pipe of diam 200 cm when the difference of pressure head betⁿ two ends of pipe 500 m apart is 4m of water (f=0.009)

→ Given data:

$$d = 200 \text{ cm} = \emptyset 2 \text{ m}$$

$$h_f = 4 \text{ m}$$

$$L = 500 \text{ m}$$

$$f = 0.009$$

Now find velocity (v)

$$h_f = \frac{4fLV^2}{2gd} \Rightarrow 4 = \frac{4 \times 0.009 \times 500 \times V^2}{2 \times 9.81 \times 2}$$

$$v = 2.95 \text{ m/s}$$

Now find discharge (Q),

$$Q = \frac{\pi \cdot d^2}{4} \cdot v = \frac{\pi \times 2^2 \times 2.95}{4}$$

$$Q = 9.26 \text{ m}^3/\text{s}$$

5. Find the max^m power that can be transmitted by a power station through a pipe 3 km long & 0.2 m diam. The pressure at power station is 60 bars. ($f = 0.078$)

(5-25)

→ Given data :

$$f = 0.078$$

$$l = 3 \text{ km} = 3000 \text{ m}$$

$$d = 0.2 \text{ m}$$

$$P = 60 \text{ bar} = 6 \times 10^6 \text{ N/m}^2$$

Now find H,

$$H = \frac{P}{\rho g} = \frac{6 \times 10^6}{1000 \times 9.81} \Rightarrow H = 611.62 \text{ m}$$

Condⁿ for max. power,

$$h_f = \frac{H}{3} = \frac{611.62}{3} \Rightarrow h_f = 203.87 \text{ m}$$

Now find velocity (v);

$$h_f = \frac{4f l v^2}{2g d} \Rightarrow 203.87 = \frac{4 \times 0.078 \times 3000 \times v^2}{2 \times 9.81 \times 0.2}$$

$$v = 0.925 \text{ m/s}$$

Now find discharge (Q)

$$Q = \frac{\pi}{4} \cdot d^2 \cdot v = \frac{\pi}{4} \cdot (0.2)^2 \times 0.925 \Rightarrow Q = 0.029 \text{ m}^3/\text{s}$$

Now find max^m power transmitted.

$$P_{\max} = \rho \cdot g \cdot Q \cdot (H - h_f) = 1000 \times 9.81 \times 0.029 \times (611.62 - 203.87)$$

$$P_{\max} = 1.16 \times 10^5 \text{ W}$$

6. Find the loss of head, when pipe of diam 30 cm is suddenly enlarged to a diam. of 40 cm. The rate of flow of water through the pipe is 300 lit/sec. (W-16, W-17)

→ Given data:

$$d_1 = 30 \text{ cm} = 0.3 \text{ m}$$

$$Q = 300 \text{ lit/s} = 300 \times 10^{-3} \text{ m}^3/\text{s}$$

$$d_2 = 40 \text{ cm} = 0.4 \text{ m}$$

Now find area.

$$a_1 = \frac{\pi}{4} \cdot d_1^2 = \frac{\pi}{4} \cdot (0.3)^2 = 0.07068 \text{ m}^2$$

$$a_2 = \frac{\pi}{4} \cdot d_2^2 = \frac{\pi}{4} \cdot (0.4)^2 = 0.12566 \text{ m}^2$$

By continuity eqⁿ.

$$a_1 V_1 = a_2 V_2$$

$$V_1 = \frac{Q}{a_1} = \frac{300 \times 10^{-3}}{0.07068} = 4.244 \text{ m/s}$$

$$V_2 = \frac{Q}{a_2} = \frac{300 \times 10^{-3}}{0.12566} = 2.387 \text{ m/s}$$

Head loss due to sudden enlargement.

$$h_e = \frac{(V_1 - V_2)^2}{2g} = \frac{(4.244 - 2.387)^2}{2 \times 9.81} \Rightarrow h_e = 0.1757 \text{ m}$$

7. Find the diam of pipe of length 9 km, when rate of flow of water through the pipe is 255 lit/s. f head loss due to friction is 6.5 m. Take $C = 55$ for Chezy's formula.

→ Given data:

$$L = 9 \text{ km} = 9000 \text{ m}$$

$$h_f = 6.5 \text{ m}$$

$$Q = 255 \text{ lit/s} = 0.255 \text{ m}^3/\text{s}$$

$$C = 55$$

$$\text{Slope (i)} \Rightarrow i = \frac{h_f}{L} = \frac{6.5}{9000} = 0.000722$$

We know Chezy's formula

$$V = C \sqrt{mi} = 55 \sqrt{\frac{d}{4} \times 0.000722}$$

$$V = 55 \sqrt{0.0001805 d}$$

$$\text{Discharge } Q = a \cdot V = \frac{\pi}{4} \cdot d^2 \cdot V$$

$$0.255 = \frac{\pi}{4} \cdot d^2 \times 55 \sqrt{0.0001805 d}$$

$$d = 0.60 \text{ m} \quad \left. \vphantom{d} \right\} \approx 600 \text{ mm}$$

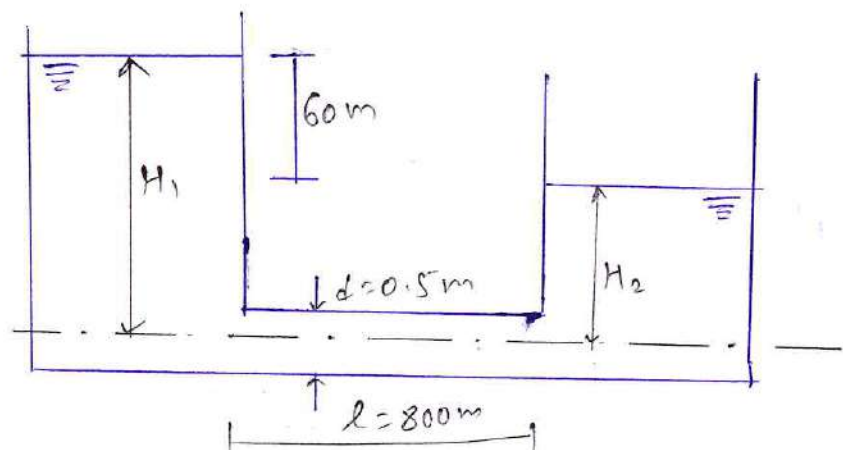
8. A pipe 800 m long connects two reservoirs; whose level diff. is 60 m. Find the discharge in pipe in lit/s, if diam of pipe is 0.5 m. Take all losses into account. Assume $f = 0.01$. (W-16).

→ Given data:

$$L = 800 \text{ m}$$

$$d = 0.5 \text{ m}$$

$$f = 0.01$$



From fig. $H_1 - H_2 = GOM$

Apply Bernoulli's theorem to both tanks,

$$H_1 = H_2 + \text{losses}$$

$$H_1 = H_2 + h_i + h_f + h_o$$

$$H_1 - H_2 = \frac{0.5V^2}{2g} + \frac{4fLV^2}{2gd} + \frac{V^2}{2g}$$

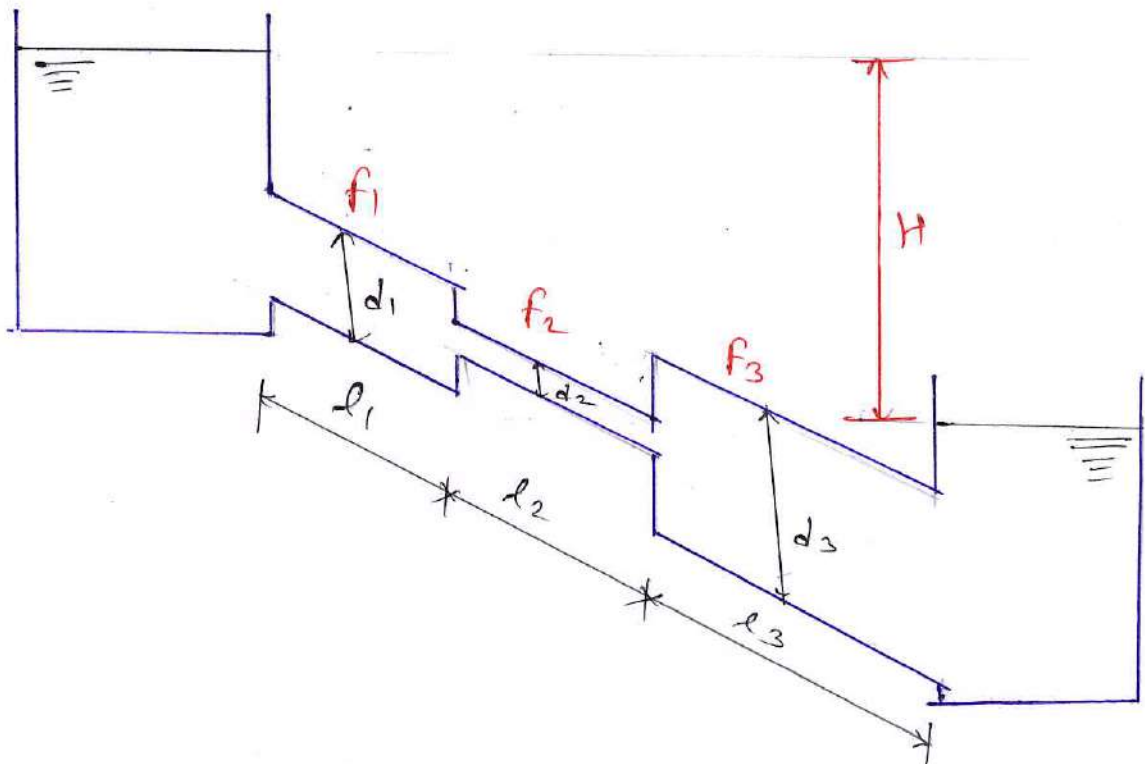
$$60 = \frac{0.5V^2}{2g} + \frac{4 \times 0.01 \times 800 \times V^2}{2g \times 0.5} + \frac{V^2}{2g}$$

$$V = 4.239 \text{ m/s}$$

Now find discharge $Q = a \cdot v = \frac{\pi}{4} (0.5)^2 \cdot 4.239$

$$Q = 0.8323 \text{ m}^3/\text{s}$$
$$Q = 0.8323 \times 10^3 \text{ lit/s}$$

* Pipes in Series or Compound Pipe *



Let l_1, l_2, l_3 = length of pipe ①, ②, ③ resp.

d_1, d_2, d_3 = diam of pipe ①, ②, ③ resp.

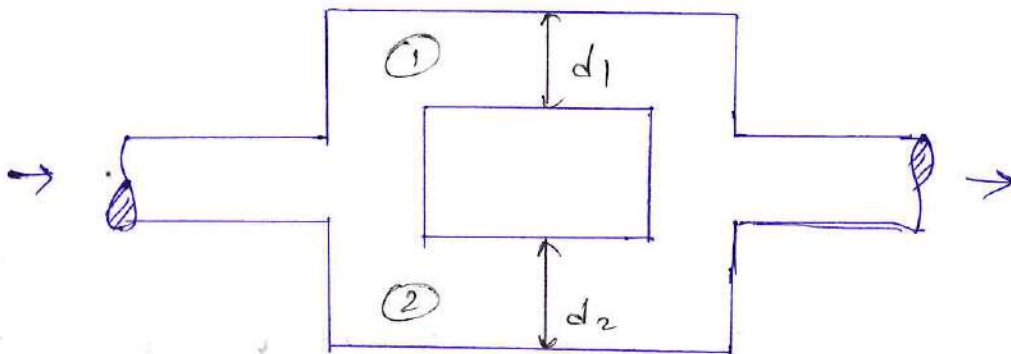
f_1, f_2, f_3 = coeff. of friction in pipe ①, ②, ③ resp.
or friction factor

Major loss $\Rightarrow H = hf_1 + hf_2 + hf_3$

$$H = \frac{4f_1 l_1 V_1^2}{2gd_1} + \frac{4f_2 l_2 V_2^2}{2gd_2} + \frac{4f_3 l_3 V_3^2}{2gd_3}$$

Minor loss = entrance loss + contraction loss + enlargement loss + exit loss.

* Pipes in Parallel *



Discharge

$$Q = Q_1 + Q_2$$

Head loss

$$hf_1 = hf_2$$