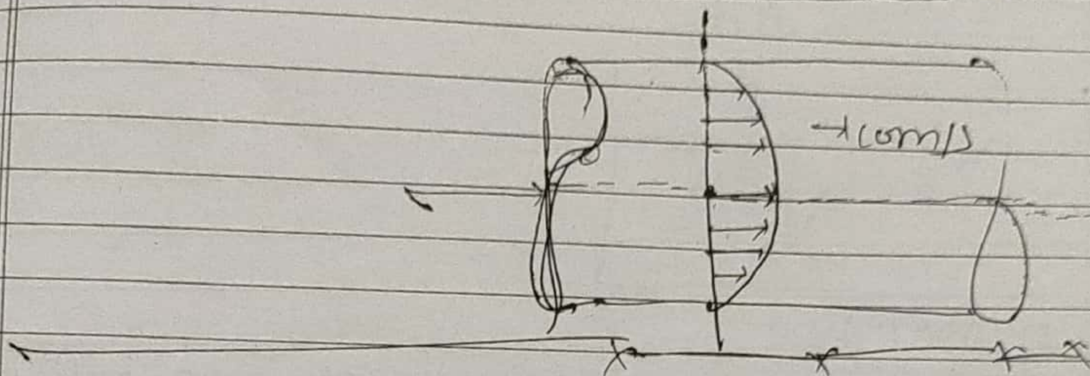
Kinetic energy correction & ~~Momentum correction factor~~



Flow through pipes.

When fluid flows through pipes it has to over come various losses and this losses are major loss and minor losses.

Major Loss → head loss due to friction is known as major loss. It is also known as frictional head loss. and indicated by h_L or h_f. These losses are calculated by using

(i) Darcy weisbach equation
(ii) chezy equation

(i) Darcy weisbach equation

$$\boxed{h_L = \frac{f l V^2}{2gd}} \quad \text{--- (1)}$$

where f = friction factor

$$Q = AV$$

$$V = Q/A$$

$$h_L = \frac{f l \left(\frac{Q}{A}\right)^2}{2gd}$$

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$\frac{fl\,Q^2}{\frac{\pi}{16}d^4 \times d^5}$

$$= \frac{fl\left(\frac{Q}{\frac{\pi}{4}d^2}\right)^2}{2gd} = \frac{frl\,Q^2}{12d^5}$$

$$= \frac{frl\,\frac{Q^2}{\frac{22}{7}d^4}}{2 \times 9.81 \times d}$$

$$= \frac{frl \cdot Q^2}{12d^5}$$

(ii) Chezy equation

$V = C\sqrt{mi}$

m = hydraulic mean depth

C → chezy's constant

i = hydraulic slope

* $m = \frac{A}{P}$ — A – cross sectional area of pipe

P → ~~pressure~~ perimeter of circular pipe

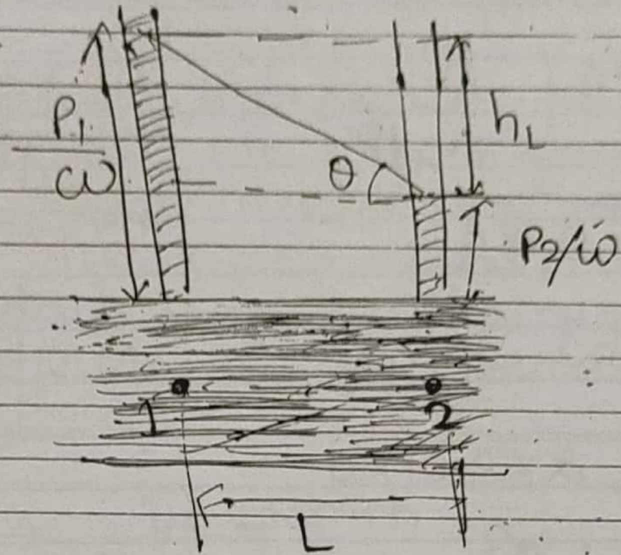
for circular pipe

$A = \frac{\pi}{4}d^2$

$P = \pi d$

$m = \frac{A}{P} = \frac{d}{4}$

$$\boxed{m = \frac{d}{4}}$$



$i = \tan\theta$

$i = \dfrac{h_L}{L}$

Putting the value of m and i in chezy formula we get,

$V = C\sqrt{mi}$

$V = C\sqrt{\dfrac{d}{4} \times \dfrac{h_L}{L}}$

$v^2 = c^2\left(\dfrac{d}{4} \times \dfrac{h_L}{L}\right)$

$$\boxed{h_L = \frac{4Lv^2}{c^2 d}} \quad \text{— (2)}$$

From equation (1) and (2),
we get,

$$\frac{f\cancel{L}v^2}{2g\cancel{d}} = \frac{\cancel{4}Lv^2}{c^2\cancel{d}}$$

$$c^2 = \frac{8g}{f}$$

$$\boxed{c = \sqrt{\frac{8g}{f}}}$$

minor loss:

→ minor losses are following

(i) losses due to sudden expansion or enlargement.

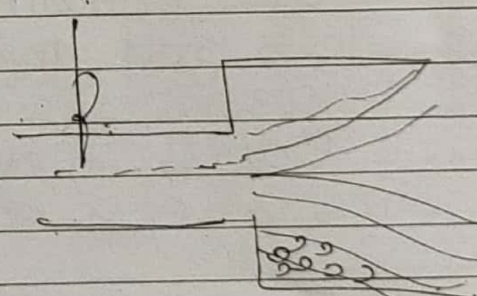
(ii) losses due to sudden contraction

(iii) losses at the entrance of the pipe.

(iv) losses at the exit of the pipe

(v) losses due to bend or bend losses.

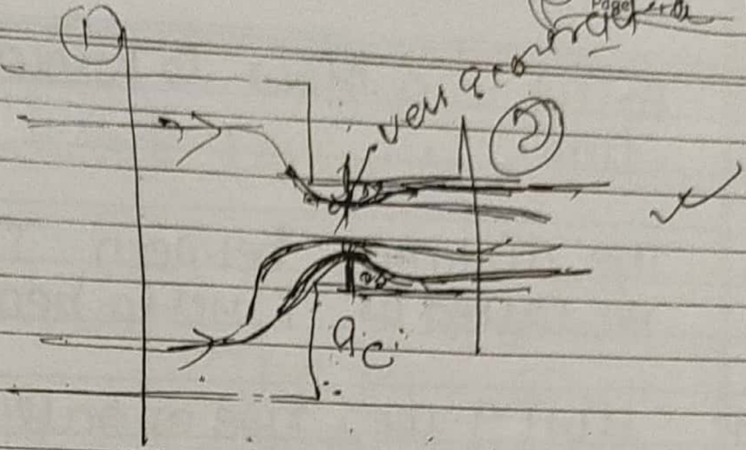
① $h_L = \frac{(V_1 - V_2)^2}{2g}$



$a_1 V_1 = a_2 V_2$

$$\boxed{V_2 = \frac{a_1 V_1}{a_2}}$$

② losses due to sudden contraction:→



(ii) coefficient of contraction

$$C_c = \frac{\text{Area at vena contracta}}{\text{Area of orifice}}$$

$$C_c = \frac{A_c}{A_2}$$

$$A_c = C_c \cdot A_2$$

$$A_c V_c = A_2 V_2$$

$$V_2 = \frac{A_c}{A_2} \cdot V_c$$

$$= C_c \cdot V_c$$

Now,

$$h_L = \frac{(V_c - V_2)^2}{2g}$$

$$= \frac{\left(\frac{V_2}{C_c} - V_2\right)^2}{2g}$$

$$= \frac{V_2^2 \left(\frac{1}{C_c} - 1\right)^2}{2g}$$

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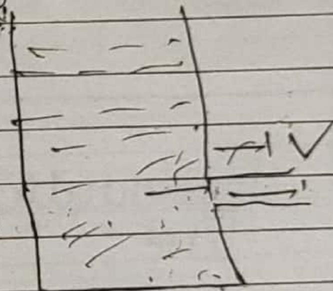
$$\boxed{h_L = \frac{V_2^2}{2g}\left[\frac{1}{C_c} - 1\right]^2}$$

If C_c is not given then

$$\boxed{h_L = 0.5\frac{V_2^2}{2g}}$$ V_2 = velocity in smaller diametre pipe.

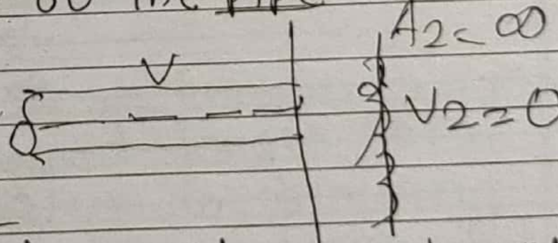
(iii) losses at the entrance of the pipe →

It is similar to sudden contraction and hence losses at the entrance is equal to $.5\frac{V^2}{2g}$ where V is velocity



where $\boxed{h_L = 0.5\frac{V^2}{2g}}$

(iv) losses at the exit of the pipe

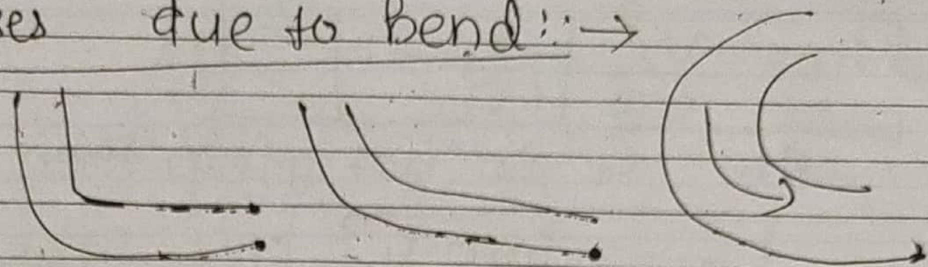


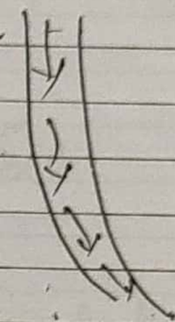
$$h_L = \frac{(V_1 - V_2)^2}{2g}$$ in sudden enlargement

$$= \frac{(V - 0)^2}{2g}$$

$$\boxed{h_L = \frac{V^2}{2g}}$$ where: V = velocity in pipe

(V) losses due to Bend :→

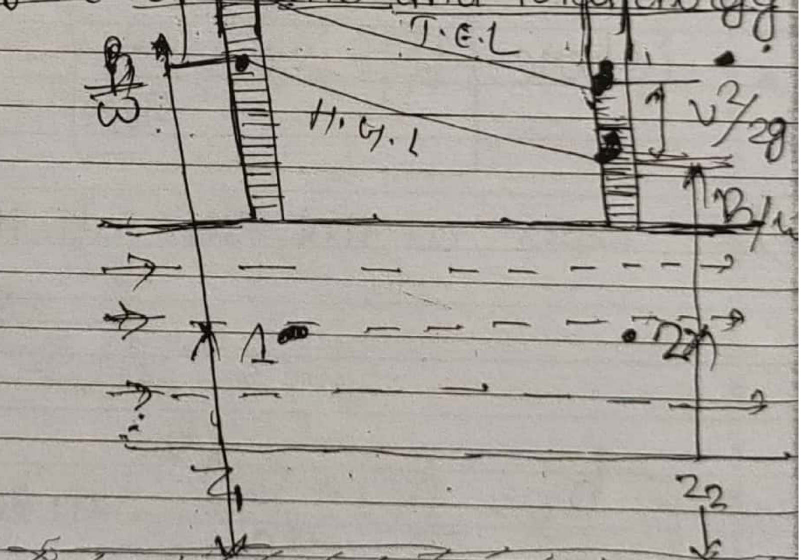




$$\boxed{h_L = \frac{kv^2}{2g}}$$

k : Bending coefficient

Hydraulic gradient line and total energy line.



The line which joins piezometric heads at various points in a flow is known as hydraulic gradient line.

The line which joins total energy $\left(\frac{P_1}{\omega} + Z + \frac{v^2}{2g}\right)$ at various

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point in a flow is known as Total energy line.

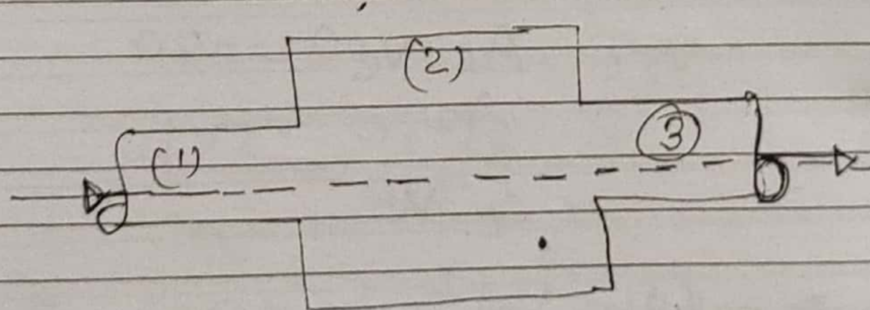
* The distance between TEL and HGL is called as Kinetic head.

<u>Note</u> HGL can rise or fall in a flow but the total energy line will rise only when there is some external energy input (in case of pump or compressor)

combination of pipes:→

- → series combination of pipes
- → parallel combination of pipes

* <u>Series combination of pipes.</u>



$Q = Q_1 = Q_2 = Q_3$

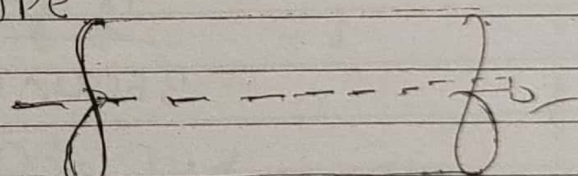
$h_L = h_{L_1} + h_{L_2} + h_{L_3}$

In series combination of pipe the discharge will remain same through each pipe and total head loss is equal the summation of

~~Equivalent~~ :
head loss in individual pipe.

Equivalent pipe →
The pipe of uniform cross sec which is equivalent to the combination of pipes in series i.e, the discharge through equivalent pipe is equal to the discharge through individual pipe and the frictional head loss through equivalent pipe is equal to the summation of frictional head loss in all the pipes of series combination.

For equivalent pipe



$h_{Le} = h_{L_1} + h_{L_2} + h_{L_3}$

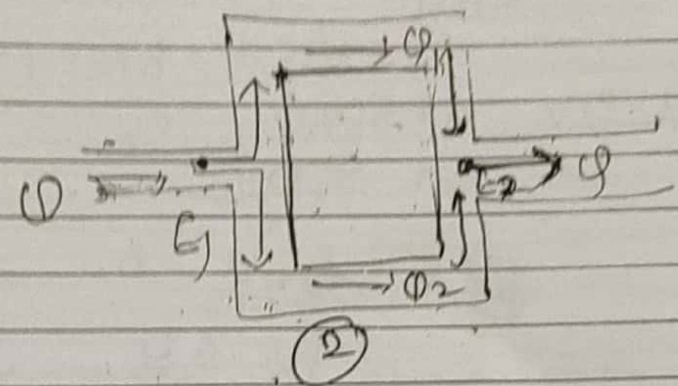
$h_{Le} = h_{L_1} + h_{L_2} + h_{L_3}$

$$= \frac{\cancel{f} L_e Q^2}{\cancel{12} D_e^5} = \frac{\cancel{f} L_1 Q^2}{\cancel{12} D_1^5} + \frac{\cancel{f} L_2 Q^2}{\cancel{12} D_2^5} + \frac{\cancel{f} L_3 Q^2}{\cancel{12} D_3^5}$$

$$\boxed{\therefore \frac{L_e}{D_e^5} = \frac{L_1}{D_1^5} + \frac{L_2}{D_2^5} + \frac{L_3}{D_3^5}}$$

Note: series : $Q = Q_1 = Q_2$: $h_L = h_{L_1} + h_{L_2}$
parallel = $Q_e = Q_1 + Q_2$
$h_{Le} = h_{L_1} = h_{L_2} = h_{Le}$

Pipes in parallel →



In parallel combination of pipe the discharge will be different in all the individuals pipe and head loss will be same.

$$Q = Q_1 + Q_2$$

$$h_{L_1} = h_{L_2}$$

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Q. Find the head lost due to friction in a pipe of diametre 300mm and length 50m, through which water is flowing at a velocity of 3m/sec using
(i) Darcy's formula
(ii) Chezy formula. for which C = 60.
Take ν = for water = 0.01 stoke.
where $f = \frac{64}{Re}$ for laminar flow
$= \frac{0.079}{Re^{1/4}}$ for turbulent flow.

$$h_l = \frac{4flv^2}{2gd}$$

Given, $l = 50m$

$v = 3\ m/s$

$f = \frac{64}{Re}$

$= \frac{64}{\frac{\rho VD}{\mu}} = \frac{64}{\frac{1000 \times 3}{0.01 \times 10^4}}$

$$Re = \frac{\rho VD}{\mu}$$

$= \frac{VD}{\nu} = \frac{3 \times 0.3}{0.01 \times 10^{-4}}$

$= 9 \times 10^5 > 4000$

∴ flow is turbulent

Now for turbulent flow,

$f = \frac{0.079}{Re^{1/4}} = \frac{0.079}{(9 \times 10^5)^{1/4}} = \frac{2.56 \times 10^{-3}}{}0.00256$

from Darcy formula,

$h_f = \frac{4flv^2}{2gd}$

$= \frac{4 \times 0.00256 \times 50 \times 3^2}{2 \times 9.81 \times 0.3}$

$= 0.7828\ m.$

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(ii) from chezy's formula
$V = C\sqrt{mi}$

For circular pipe
$m = \frac{d}{4} = \frac{0.3}{4} = 0.075\,m$

Now
$V = C\sqrt{mi}$

$3 = 60\sqrt{0.075 \times i}$

$\Rightarrow \sqrt{0.075 \times i} = \frac{3}{60}$

$\Rightarrow 0.075 \times i = \frac{9}{3600}$

$i = \frac{9}{3600 \times 0.075} = 0.0333$

i.e. $\frac{h_L}{L} = 0.0333$

$\frac{h_L}{50} = 0.0333$

$h_L = 50 \times 0.0333$

$h_L = 1.6$