3. Loss of head at the entrance to pipe h_i الفواقد في مدخل الانبوب

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

$V =$ **Velocity of liquid in pipe**

4. Loss of head at the exit to pipe h_o الفواقد في مخرج الانبوب

$$h_0 = \frac{V^2}{2g}$$

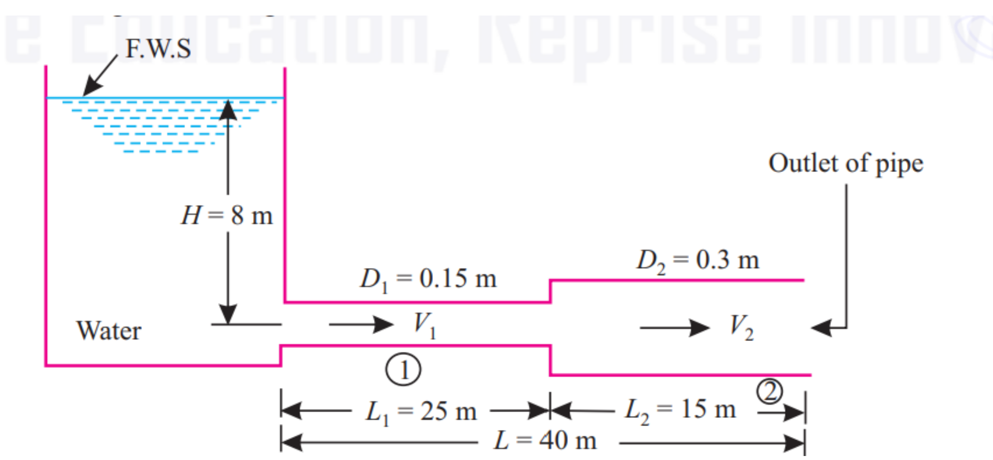
$V =$ **Velocity at outlet of a pipe**

Example

A horizontal pipeline $40\ m$ long is connected to a water take at one end and discharge freely into the atmosphere at the other end. For the first $25\ m$ of its length from the tank, the pipe is $150\ mm$ diameter and its diameter is suddenly enlarged to $300\ mm$. The height of water level in the tank $8\ m$ above the center of the pipe. Considering all losses of head which occur.

1. **Determine the rate of flow**
2. **Draw the hydraulic gradient and total energy lines**

Take $f = 0.01$ for both pipes.



1. **B.E. between 1 and 2**

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + all\ losses$$

$$0+0+8 = 0 + \frac{V_2^2}{2g} + 0 + h_i + h_{f1} + h_e + h_{f2}$$

$$h_i = Loss\ of\ head\ at\ entrance = 0.5\ \frac{V_1^2}{2g}$$

$$h_f = Head\ lost\ due\ to\ friction = \frac{4fLV^2}{2g \times D}$$

$$h_e = Loss\ of\ head\ due\ to\ sudden\ enlargement = \frac{(V_2 - V_1)^2}{2g}$$

$$Q_1 = Q_2 \quad \rightarrow \quad A_1 . V_1 = A_2 . V_2$$

$$V_2 = \frac{A_2 \times V_1}{A_1} = \frac{\frac{\pi}{4} \times D_2^2 \times V_2}{\frac{\pi}{4} \times D_1^2} = \left(\frac{D_2}{D_1}\right)^2 \times V_2$$

$$= \left(\frac{0.3}{0.15}\right)^2 \times V_2 = 4V_2$$

$$h_i = \frac{0.5\, V_1^2}{2g} = \frac{0.5 \times (4V_2)^2}{2g} = \frac{8V_2^2}{2g}$$

$$h_{f1} = \frac{4fL_1V_1^2}{2g \times D_1} = \frac{4 \times 0.01 \times 25 \times (4V_2)^2}{0.15 \times 2g} = 106.6 \times \frac{V_2^2}{2g}$$

$$h_e = \frac{(V_1 - V_2)^2}{2g} = \frac{(4V_2 - V_2)^2}{2g} = \frac{9V_2^2}{2g}$$

$$h_{f2} = \frac{4fL_2V_2^2}{2g \times D_2} = \frac{4 \times 0.01 \times 15 \times V_2^2}{0.3 \times 2g} = 2 \times \frac{V_2^2}{2g}$$

$$8 = \frac{V_2^2}{2g} + \frac{8V_2^2}{2g} + \frac{106.6V_2^2}{2g} + \frac{9V_2^2}{2g} + \frac{2V_2^2}{2g}$$

$8 = \frac{V_2^2}{2g}[1 + 8 + 106.6 + 9 + 2] = 126.6\ \frac{V_2^2}{2g}$

$V_2 = 1.11\ m/s$

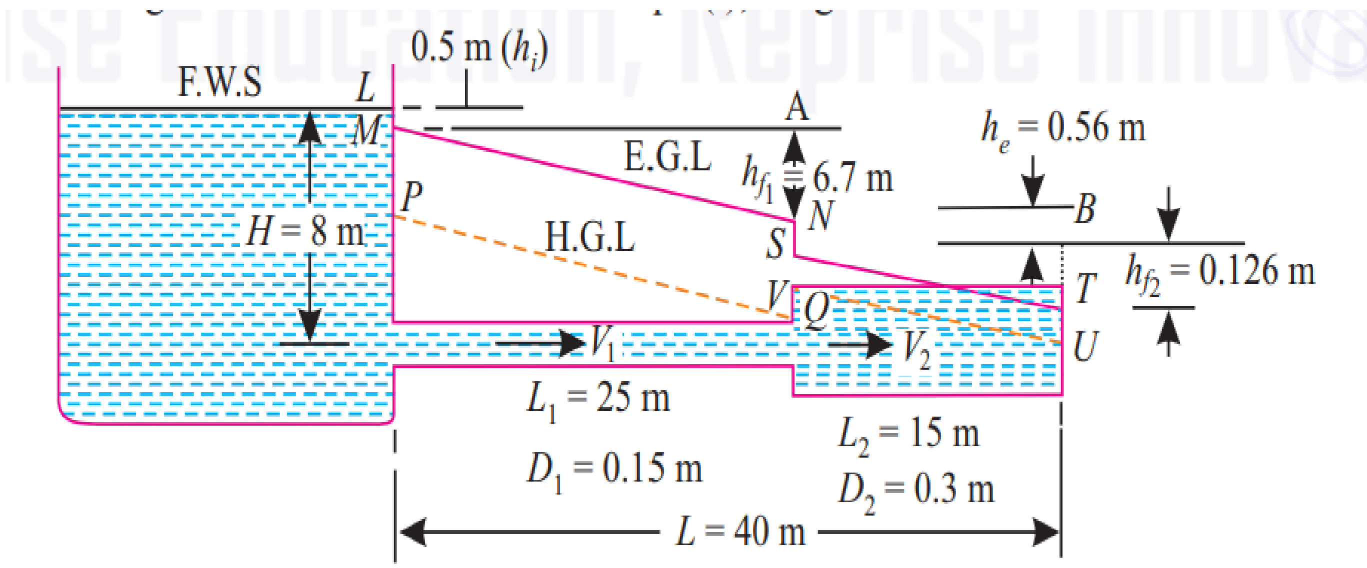
$Q = A_2 \times V_2 = \frac{\pi}{4} \times (0.3)^2 \times 1.11 = 0.078\ \ m^3/s$

2. $h_i = \frac{8V_2^2}{2g} = \frac{8 \times (1.11)^2}{2 \times 9.81} = 0.5\ \ m$

$h_{f1} = \frac{106.6V_2^2}{2g} = \frac{106.6 \times (1.11)^2}{2 \times 9.81} = 6.7\ \ m$

$h_e = \frac{9V_2^2}{2g} = \frac{9 \times (1.11)^2}{2 \times 9.81} = 0.56\ \ m$

$h_{f2} = \frac{2V_2^2}{2g} = \frac{2 \times (1.11)^2}{2 \times 9.81} = 0.126\ \ m$



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Total Energy Line (T.E.L)

The point L lies on water surface free (F.W.S)

- **Take $LM = h_i = 0.5\ m$**
- **From M draw a horizontal line. Taking MA equal to the length of the pipe L_1 and draw a vertical line downward from the point A.**

Cut $AN = h_{f1} = 6.7\ m$

- **Join MN**
- **From N, draw a line NS vertically downward = $h_e = 0.56\ m$**
- **From S, draw SB horizontal line. Taking BT = $h_{f2} = 0.126\ m$**
- **Join ST**
- **The line MNST is the total energy line T.E.L.**

Hydraulic Gradient Line (H.G.L)

- **From M, take $MP = \frac{V_1^2}{2g} = \frac{(4\times 1.11)^2}{2\times 9.81} = 1\ m$**
- **Draw the line PQ parallel to the line MN. Join MN**
- **From the point U (which U is lying on the center of the pipe), draw a line UV parallel to the line TS.**
- **Join QV**
- **The line PQVU is the hydraulic gradient line H.G.L.**

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