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Section B

Fourth Semester

Sub : Fluid Mechanics

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INU PESHAWER

Q No # 01 part (a) Define total energy head and various forms of energy head with mathematical equations?

ANS: **ENERGY Head:**

It is the some of all energy head at a point in a fluid.

There are Three Types of Energy head such as:

Kinetic head: → It is Kinetic energy per unit weight of the Fluid.

$$\Rightarrow \frac{K.E}{W} = \frac{1}{2}\frac{mv^2}{mg} = \frac{1}{2}\frac{v^2}{g} \qquad \therefore W = mg$$

This is also known as velocity head unit is meter.

Potential head: → It is potential energy per unit weight of fluid.

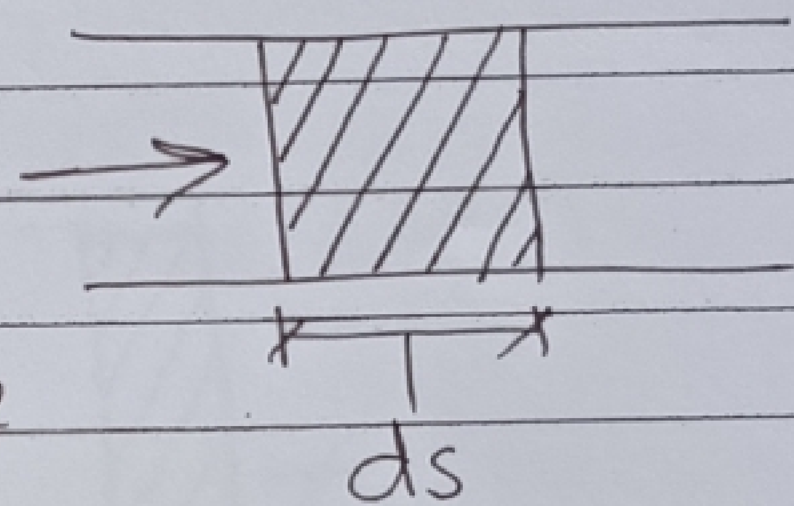
$$\frac{P.E}{W} = \frac{mgh}{mg} = h$$

Pressure head: → The vertical height of a free surface above any point in a liquid at Rest is pressure head. OR level of fluid due to pressure exerted by fluid.

Now

$$\frac{work}{w} = \frac{F \cdot ds}{w}$$

$$\Rightarrow \frac{P \cdot A \cdot ds}{w}$$



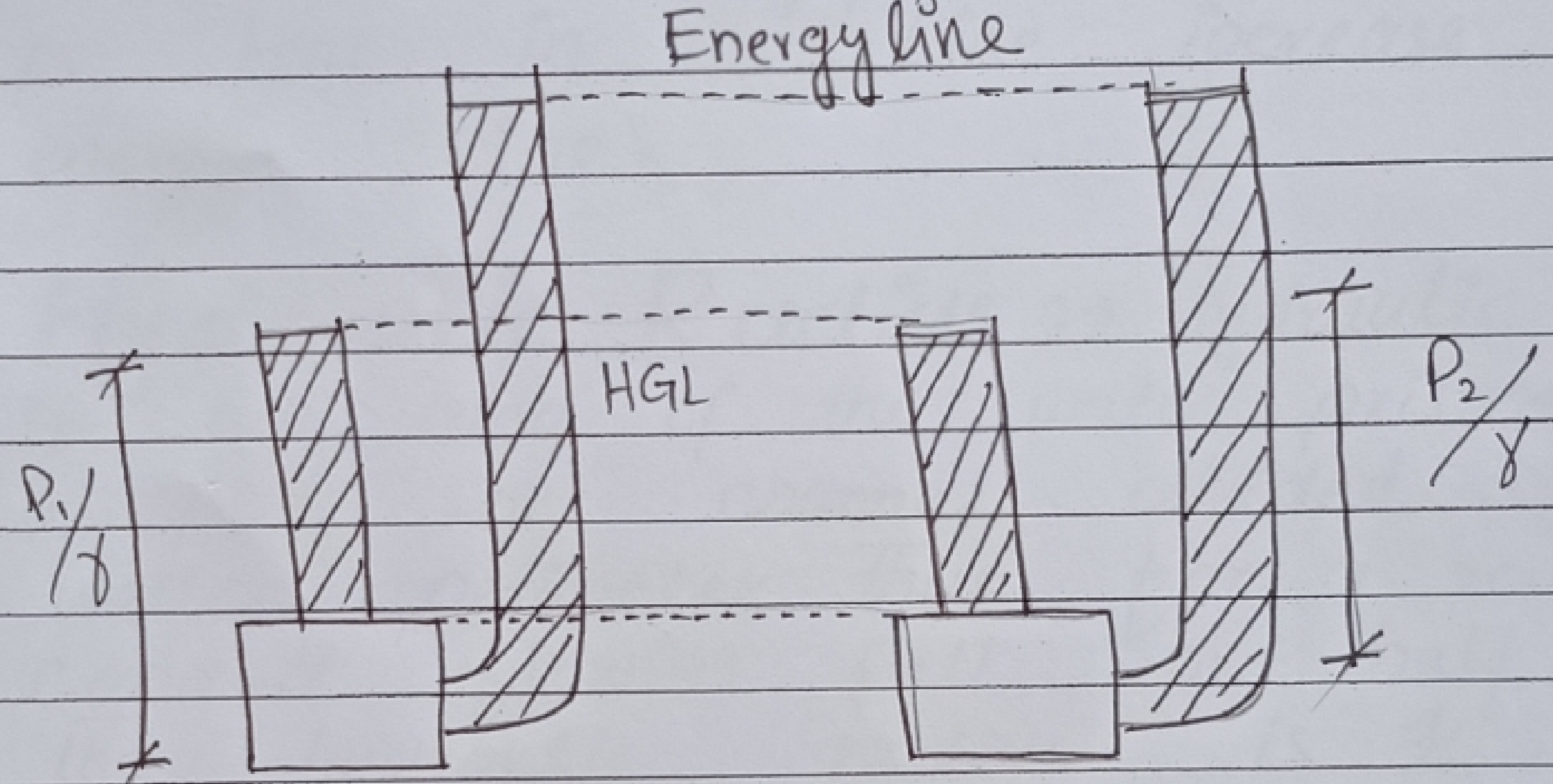
$$\because \frac{P \cdot V}{w} = \frac{P}{\gamma} \text{ is pressure}$$

QNO #01 Part (b) Define hydraulic grade line, Energy line and the Hydraulic Radius.

ANS:→ **HYDRAULIC GRADE LINE :**

It is line showing pressure head and potential head at a point in fluid. The term $P/\gamma + Z$ is static head OR piezometric head because it Represented the level to which liquid will Rise in piezometer tube. The HGL is line drawn throug top of piezometer columns.

The line shown total head of fluid at any point is energy line. Line joining level of tube is energy line.



Energy line:→ Energy line is a line that Represent the total head availible to the fluid and can be expressed as:

$$EL = H = P/\gamma + V^2/2g + h = \text{Constant along}$$

a streamline

EL = Energy line (m fluid column)

Fluid for a fluid flow without any losses due to friction mean major losses OR component (minor losses)

The energy line would be a constant level. In a practical world energy line decrease along the flow due to losses. A turbine in the flow reduces the energy line and a pump or fan in the line increase the energy line.

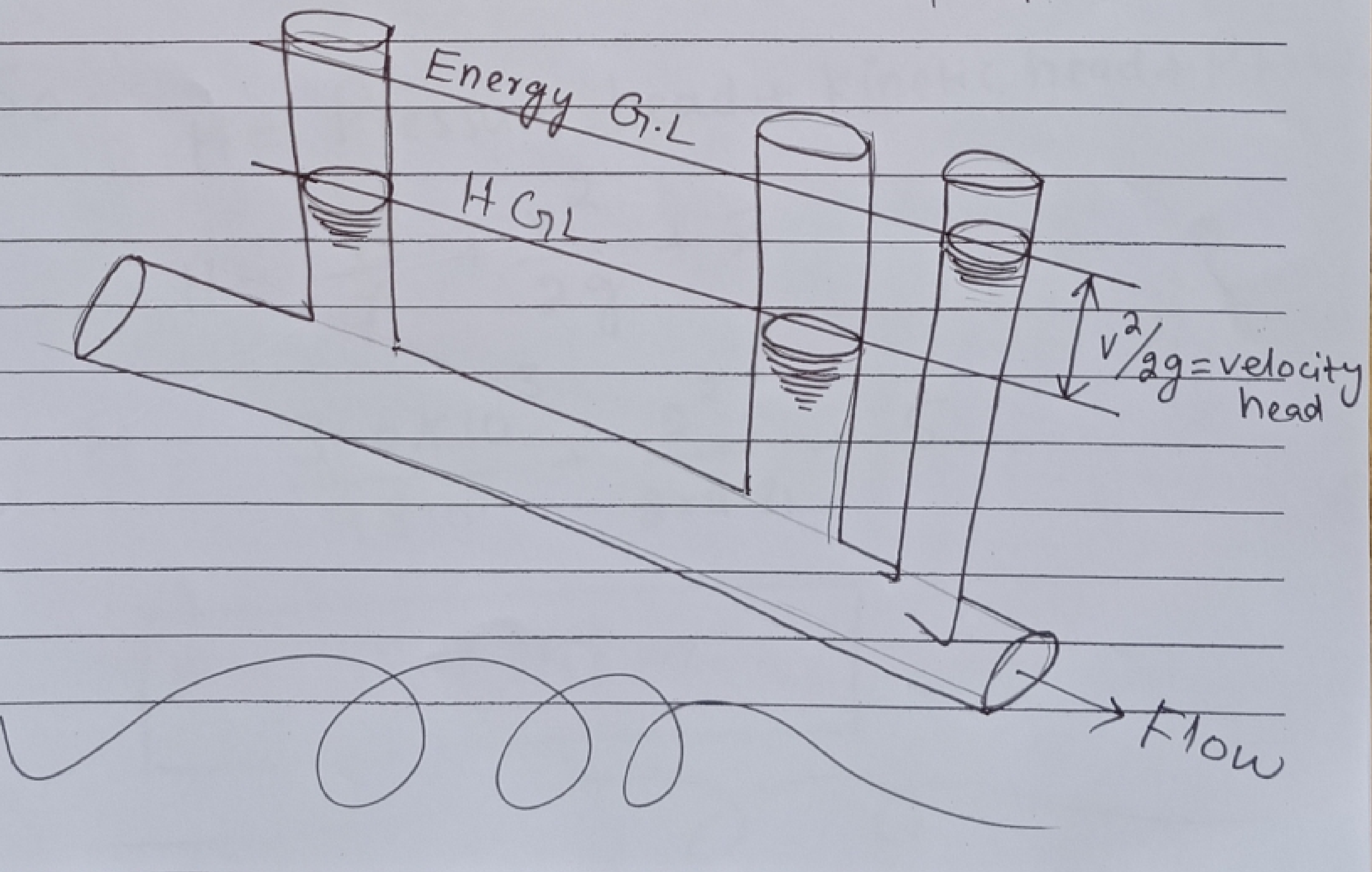
Hydraulic Radius :→ Hydraulic radius is the area of the water prism in a pipe or channel divided by the wetted perimeter. Thus for a round conduit flowing full or half full, The hydraulic radius is $d/4$. Hydraulic radius measures the flows efficiency of a pipe. In trenchless technology it is a function of the shape of the pipe in which the liquid is flowing. It does not indicate half of the diameter as the same name suggests. Another term sometime used for this quantity is hydraulic mean depth. In the designing of sewer, The following parameter should be calculated. Sewer diameter and slope, The Roughness

Coefficient of the pipe, The Runoff flow rate water, and the flow velocity of water. The equation used to derive the hydraulic Radius for a circuler sewer is flowing full is.

$$R = A/P_W \quad \text{or} \quad R = \frac{(\pi D^2/4)}{\pi D} = D/4$$

Where

R = hydraulic Radius
A = cross-sectional Area
PW = wetted periemeter
D = Diameter of pipe



QNO #02 part (a)

→ calculate the total Energy per unit weight of water if it is flowing with a mean velocity of 2 m/s under a pressure of 300 KPa. The height above the datum is 5 m.

SOLUTION: →

Given data:

Velocity = v = 2 m/s

Pressure = P = 300 KPa

datum = Z = 5 m

So

H = Pressure head + kinetic head + P. head.

$$H = \frac{P}{\gamma} + \frac{v^2}{2g} + Z$$

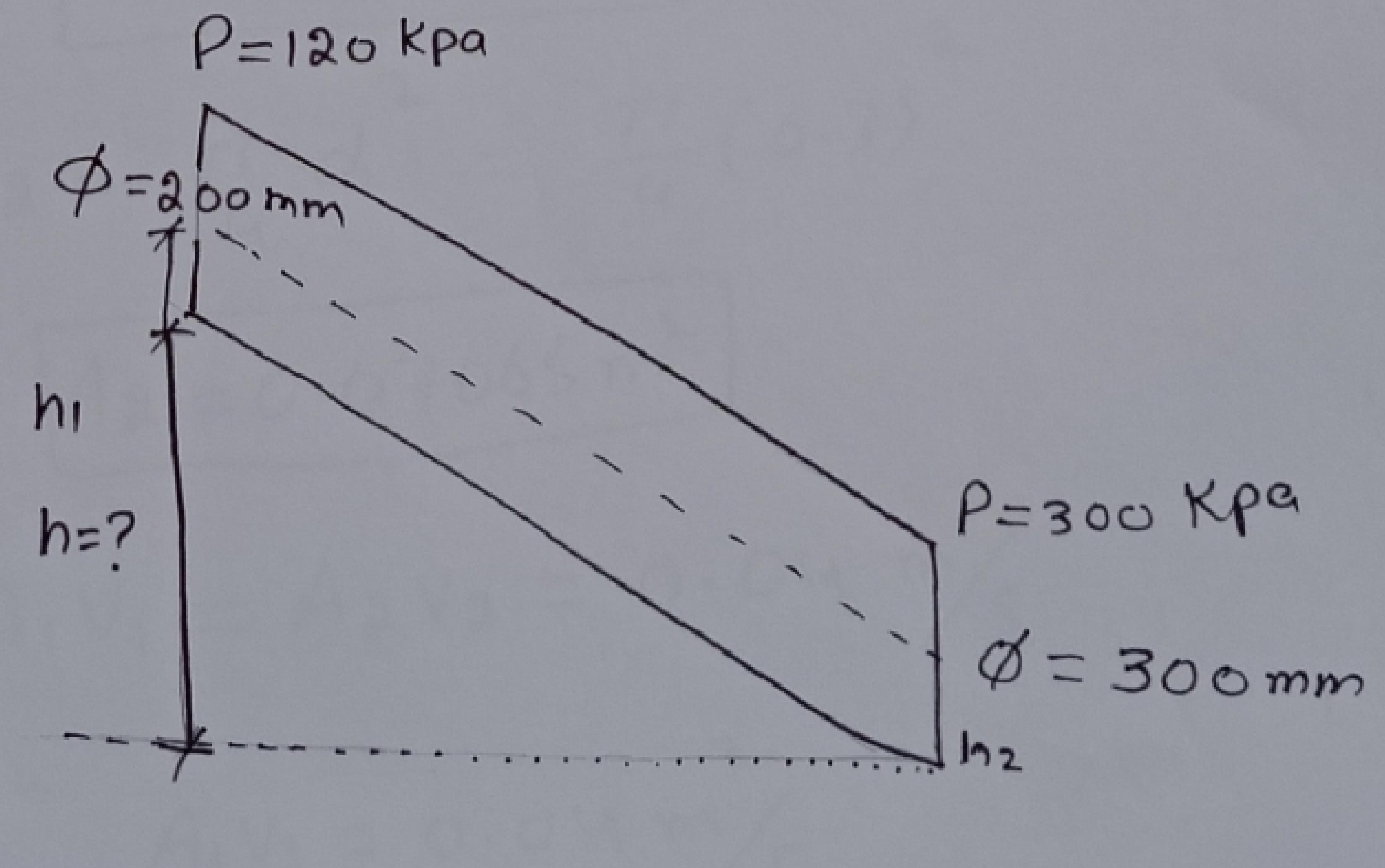
$$H = \frac{300 \times 10^3}{9810} + \frac{2^2}{2 \times 9.81} + 5$$

$$\boxed{H = 35.7849\ m}$$

QNO# 02 Part (b)

→ A tapering pipe is having diameter 300mm at bottom and and 200 mm at top end. The intensity of Pressure at bottom end and top end are 300 KPa and 120 KPa Respectivly. Determine the difference in datum head between TOP and bottom if water flow Rate throug pipe is 40 Liter per second. Assume that head Loss is Negligible.

Solution



So Given:

$P_1 = 120$ Kpa

$d_1 = 200$ mm $= 0.2$ m

$P_2 = 300$ KPa

$d_2 = 300$ mm $= 0.3$ m

$Q = 40$ liter/s $\quad \therefore 1$ l/s $= 0.001$ m^3/s

$$Q = 0.04\ m^3/sec$$

Now $A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(0.2)^2$

$$A_1 = 0.0314 m^2$$

$\Rightarrow A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(0.3)^2$

$\Rightarrow$ $$A_2 = 0.07065 m^2$$

Now $A_1 V_1 = A_2 V_2 = 0.04$ m^3/s

Hance $A_1 V_1 = 0.04$ m^3/s

$$V_1 = \frac{0.04}{A_1} \Rightarrow \frac{0.04}{0.0314} = 1.274 \ m/s$$

$$\boxed{V_1 = 1.274 \ m/s}$$

$$A_2 V_2 = 0.04 \ m^3/s$$

$$V_2 = \frac{0.04}{A_2} = \frac{0.04}{0.07065} = 0.56 \ m/s$$

$$\boxed{V_2 = 0.56 \ m/s}$$

By using Bernoulli's Theorm:

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

$$\frac{120 \times 10^3}{9810} + \frac{(1.274)^2}{2(9.81)} + Z_1 = \frac{300 \times 10^3}{9810} + \frac{(0.56)^2}{2(9.81)} + Z_2$$

$$12.23 + 0.082 + Z_1 = 30.58 + 0.016 + Z_2$$

$$12.312 + Z_1 = 30.596 + Z_2$$

$$\& \quad Z_2 - Z_1 = 18.28 m$$

OR $\boxed{h_2 - h_1 = 18.28 m}$

Q NO #03

A 50m long 0.2m diameter pipe transport an oil of specific gravity 0.9 and viscosity $6\times10^{-5}\ N.s/m^2$ at the Rate of $0.06\ m^3/s$. Find pressure loss due to friction. Use Darcy friction coefficient as $f = [0.0032 + (0.221/R^{0.237})$ where R is Reynold's number.

Solution:→

Given data :

Length = L = 500m

Diameter = D = 0.2m

Specific gravity = 0.9

Flow Rate of discharge = $0.06\ m^3/s$

$$C_f = [0.0032 + (0.221/R_e^{0.237})$$

Required pressure loss due to Friction.

Now we find the velocity.

So Flow rate of discharge

$$Q = A * velocity$$

$$0.06 = \frac{\pi}{4}(0.2)^2 * velocity$$

$$0.06 = 0.0314 \times veloiity$$

$$Velocity = \frac{0.06}{0.0314}$$

hance $V = 1.91 \; m/s$ ✓

In The given Question viscocity is given which is dynamic viscosity. So we Convert into Kinametic viscosity.

$$\nu = \frac{\mu}{\rho}$$

Where ν = Kinametic viscosity

μ = is The dynamic viscosity
& ρ = density of that fluid.
Now it is Necessary to find the Density of fluid.
So we have formula.

$$S.Gravity = \frac{\rho_{Fluid}}{\rho_{water}}$$

$$\rho_{Fluid} = \text{Specific gravity} * \rho_{water}$$

$$\rho_{Fluid} = 0.9 * 1000$$

$$\boxed{\rho_{Fluid} = 900}$$

Now $\nu = \frac{\mu}{\rho} = \frac{6 \times 10^{-5}}{900}$

$$\boxed{\nu = 6.67 \times 10^{-8}}$$

So $Re = \frac{VD}{\nu} = \frac{(1.19)(0.2)}{6.67 \times 10^{-8}}$

$Re = 3568215.892$

$$C_f = 0.0032 + \left(0.221 / Re^{0.237}\right)$$

$$C_f = 0.0032 + \left(0.221 / (3568215.892)^{0.237}\right)$$

$$C_f = 9.386 \times 10^{-3}$$

$h_f = \frac{fLv^2}{2gD}$ where $f = 4c_f$

$$h_f = \frac{4c_f L v^2}{2gD} = \frac{4(9.386 \times 10^{-3})(500)(1.19)^2}{2(9.81)(0.2)}$$

$$\boxed{h_f = 6.7\,m}$$

Hance head losses in pipe Refers to the Pressure drop (due to friction) as a fluid flows through a pipe. Head losses Represents how much Pressure will be lost due to the orientation of the Pipe system.

Now to find the pressure loss due to friction.

Pressure head formula is used.

$$h_L = \frac{\Delta P}{\gamma}$$

So $S = \frac{\gamma_F}{\gamma_w} = 0.9 = \frac{\gamma_F}{9810}$

$\gamma_F = 8829$

Now $h_L = \frac{\Delta P}{\gamma}$

$\Delta P = h_L * \gamma$

$\Delta P = 6.7 * 8829$

$\Delta P = 59154.3$ pa

$\boxed{\Delta P = 59.154 \text{ KPa}}$

→ pressure loss