Fluid Mechanics I

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Name :- Afrasiyab

ID No :- 7899

Sec :- A

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QNo 1 (part-a)

Ans:- Total Energy Head :-

The sum pressure head (P/γ), Elevation head (z) and velocity head ($\frac{V^2}{2g}$) is called total Head Energy.

pressure head + Elevation head + Velocity head = Total Head

$$P/\gamma + z + \frac{V^2}{2g} = H$$

Energy Head: Energy per unit weight is called head.

Forms of Energy Head:

There are three main types of Energy head which are given below.

1) Kinetic Head.
2) Potential Head.
3) Pressure Head.

1) Kinetic Head :-

Kinetic Energy per unit weight.

It represented kinetic energy of fluid.

$$\text{Kinetic head} = \frac{KE}{\text{Weight}} = \frac{\frac{1}{2}mV^2}{mg} = \frac{V^2}{2g}$$

$$(W = mg)$$

2) Potential Head:-

"potential energy per unit weight".

It represent the potential energy of fluid.

$$\text{Potential Head} = \frac{PE}{Weight} = \frac{mgZ}{mg} = Z$$

3) Pressure Head:

"pressure energy per unit weight"

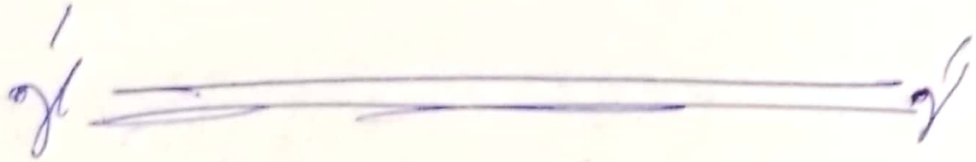
It is height of liquid column that corresponds to a particular pressure exerted by liquid column that corresponds a particular pressure exerted by liquid column on the base of container.

$$\text{Pressur Head} = \frac{PrE}{weight} = P/\gamma$$

P-T-O

Total Head ⇒ Kinetic Head + potential Head + pressure Head.

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



QNo1 (part - b)

Ans:- Hydraulic Grade line:- (HGL)

Hydraulic grade line refers to the profile of water streaming in an open channel or a pipe streaming in a part full. When a pipe is under pressure, the pressure driven review line is the level to which the water would ascend to in a little, vertical tube associated with a pipe.

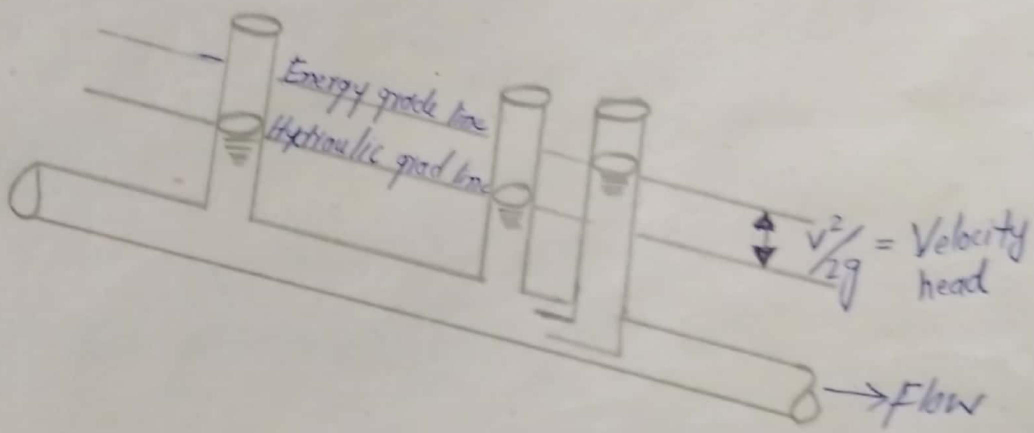
It is denoted as (HGL).

→ The Hydraulic grade line is a line representing the total head avaliable to the fluid - minus velocity head and can be expressed as

$$HGL = \frac{P}{\gamma} + h$$

Where HGL = Hydraulic Grade line

The Hydraulic Grade line lies on velocity head below the Energy line.



* Energy Line :- (EGL)

Energy Grade line refer to a line that represents to the Height of energy head of water streaming in a pipe, Course, or channel. The line is drawn over the pressure Hydraulic grade line (inclination).

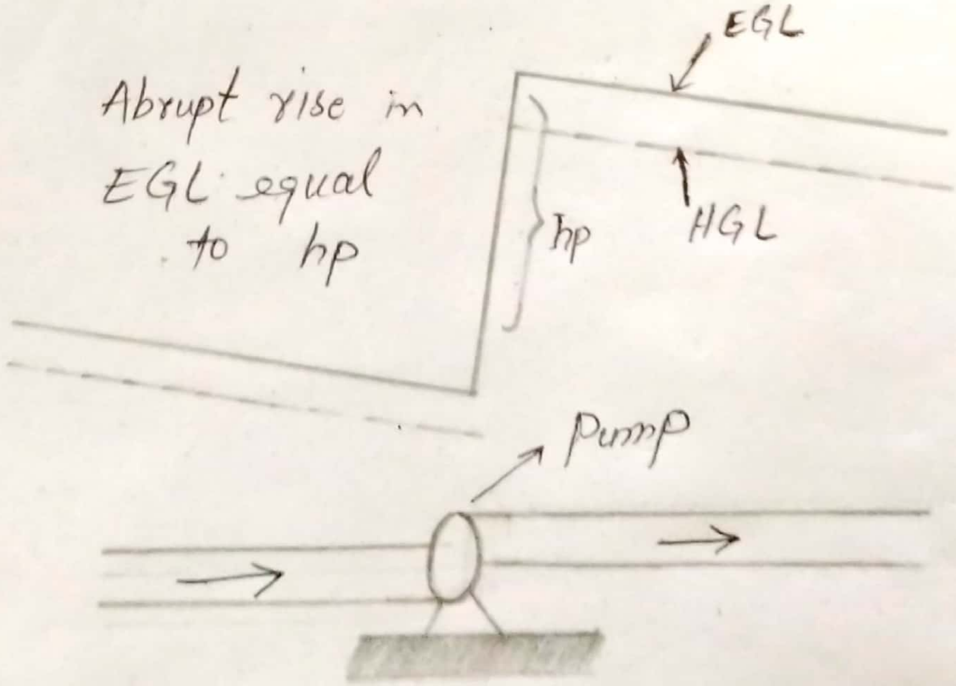
The separation equalont to speed head $(V^2/2g)$ of the water streaming at every area or a point along the pipe or channel.

→ The Energy line is a line that represent the total head avaliable the fluid can be expressed as..

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

along a streamline.

EL = Energy line



* Hydraulic Radius:-

Hydraulic Radius is the area of 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 $d/4$.

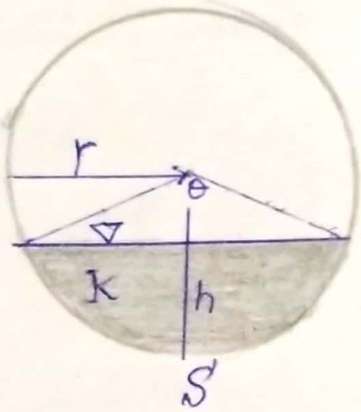
→ Hydraulic radius measures the flow efficiency of a pipe.

→ 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 name suggests.

P-T-O

→ Another term sometimes used for this quantity is hydraulic mean depth.



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Q NO2

(part – a).

Ans :-

Given data

$V = 2\ m/sec$

$P = 300\ kps$

$P = 300 \times 10^3\ N/m^2$ $[k = 10^3]$

Required data :-

Total Head "H" ?

Solution:- As we know that

H = pressure Head + K. Head + P. Head

$$H \Rightarrow \frac{P}{\gamma} + \frac{V^2}{2g} + Z$$

$$= \frac{300 \times 10^3}{9810} + \frac{2^2}{2 \times 9.8} + 5m$$

$$\boxed{H = 35.783m}$$ Ans

Q No 2 (part - b).

Ans:-

Given data :-

Diammeter $= d_1 = 300mm$

Diameter $= d_2 = 200mm$

Pressure $= P_1 = 300\,kpa = 300 \times 10^3\,N/m^2$

$P_2 = 120\,kpa = 120 \times 10^3\,N/m^2$

Required data

Datum $= Z = ?$

Solution:-

$$Q = \frac{40}{1000}\,m^3/sec = \boxed{0.04}$$

$d_1 = 300mm = 0.3m$

$d_2 = 200mm = 0.2m$

$$A_1 = \frac{\pi d^2}{4}$$

$$= \frac{(3.14)(0.3)^2}{4}$$

$$\boxed{A_1 = 0.0706\,m^2}$$

$$A_2 = \frac{\pi d^2}{4} \Rightarrow \frac{(3.14)(0.2)^2}{4}$$

$$\boxed{A_2 = 0.0314}$$

We know that

$$Q = V_1 A_1$$

$$V_1 = \frac{Q}{A_1} \Rightarrow \frac{0.04}{0.0706}$$

$$\boxed{V_1 = 0.566}$$

$$V_2 = \frac{Q}{A_2} \Rightarrow \frac{0.04}{0.0314}$$

$$\boxed{V_2 = 1.27}$$

Now

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

Put

$$Z_1 = 0$$

$$\gamma = 9810$$

$$\frac{300 \times 10^3}{9810} + \frac{(0.566)^2}{2(9.81)} + 0 = \frac{120 \times 10^3}{9810} + \frac{(1.27)^2}{2(9.81)} + Z_2$$

$$30.597 = 12.314 + Z_2$$

$$\boxed{Z_2 = 18.283}$$

Now Datum = $\boxed{Z = 18.283}$

Ans.

Q.No 03

Ans:: **Given data**

Length of pipe = $L = 500m$

diameter = $D = 0.2m$

Specific gravity = $S = 0.9$

flow rate = $Q = 0.06\ m^3/s$

Viscosity = $\mu = 6\times10^{-5}\ N\text{-}s/m^2$

Required data:

pressure loss = $\Delta P = ?$

We know that

$$f = \left[0.0032 + \frac{0.221}{R^{0.237}}\right] \quad \text{—— (1)}$$

Here R = Reynold's number

$$R = \frac{V\times d}{\nu}$$

and $\nu = \frac{\mu}{\rho} = \frac{6\times10^{-5}}{900}$

$\nu = 6.67\times10^{-8}\ m^2/s$

and

$V = \frac{Q}{A}$ $\therefore A = \pi r^2 = \frac{\pi d^2}{4}$

$V = \frac{0.06}{0.031}$

$$\boxed{V = 1.9356\ m/s}$$

$R = \frac{1.9356\times0.2}{6.67\times10^{-5}} \Rightarrow 5.8\times10^{3}$

Hence

eq (1) $f = 0.0032 + \frac{0.221}{(5.8\times10^{3})^{0.237}}$

$$\boxed{f = 0.0664}$$

According to Bernoulli's Equation

Head loss $= h_L = \frac{fLV^2}{2gD}$ —— (2)

putting value in eq (2)

$$h_L = \frac{(0.0664)(500)(1.9356)^2}{2(9.81)(0.2)}$$

$$\boxed{h_L = 31.786}$$

To find pressure loss

$$h_L = \frac{\Delta P}{\rho g} \Rightarrow \Delta P = h_L \times \rho g$$

putting values

$$\Delta P = 31.786 \times 900 \times 9.81$$

$$\Delta P = 280638 \, Pa$$

$$\boxed{\Delta P = 280.638 \, kPa}$$