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Section : B

Subject : Fluid Mechanics I

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Question No : 1 : part A :-

Energy Head :-

It is the sum of all energy heads at a point in a fluid.

Form of Energy Head :-

There are various forms of energy head which are as follow.

① Kinetic Head
② Potential Head
③ Pressure Head

① Kinetic Head :-

It is the kinetic energy per unit weight of the fluid.

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Mathematical Form:-

$$\frac{K.E}{w} = \frac{\frac{1}{2} mv^2}{mg}$$

$$K.E = \frac{1}{2} \frac{v^2}{g}$$

This is also know as velocity head.

Unit:-

Its unit is meter (m).

(2) Potential Head:-

It is the potential energy per unit weight of the fluid.

Mathematical Form:-

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

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## (3) Pressure Head:-

The vertical height of the free surface above any point in a liquid at rest is called pressure head.

OR

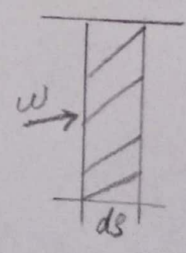
Level of fluid due to pressure exerted by fluid.

### Mathematical Form:-

$$\text{Pressure Head} = \frac{P.E}{\text{weight}} = P/\gamma$$

OR

$$\text{Pressure Head} = \frac{F \cdot ds}{w}$$




$$\text{Pressure Head} = \frac{P \cdot A \cdot ds}{w}$$

$$\text{Pressure Head} = \frac{P \cdot V}{w} = P/\gamma$$

Pressure Head = $P/\gamma$ is Pressure

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# Question No:1 :- Part B

## Hydraulic Grade Line:-

It is the line showing the pressure head and the potential head at a point in a fluid.

OR

The surface or profile of water flowing in an open channel or pipe flowing partially full. If a pipe is under pressure.

the hydraulic grade line is that level water would rise to in a small vertical tube connected to the pipe.

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## Energy Grade Line:-

A line that represents the elevation of energy head (in feet or meter) of water flowing in a pipe or channel.

The line is drawn above the hydraulic grade line a distance equal to the velocity head ($V^2/2g$) of the water flowing at each section or channel.

OR

It is the line joining the total heads along a pipe line.

## Represented By:-

It is represented by E.G.L.

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Question No:2 : Part A

Given Data

$V_m = 2\, m/s$

$P = 300\, KPa = 300 \times 10^3\, Pa$

P.E head = $z = 5$

$\gamma = 9.81\, KN/m^3$

Required :-

Total Energy per unit weight of water = Total head = ?

Sol :-

Total head = $K.E_{head} + P.E_{head} + Pressure_{head}$ → (1)

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pressure head = $P/\gamma$

$= \frac{300}{9.81}$

pressure head = 30.6 m

Kinetic head = $V^2/2g$

$= \frac{(2)^2}{2 \times 9.81}$

Kinetic head = 0.2 m

As given

Potential head = 2 = 5m

Putting values in eq (1)

Total head = 0.2 + 30.6 + 5

T.E per unit weight = 35.8 m

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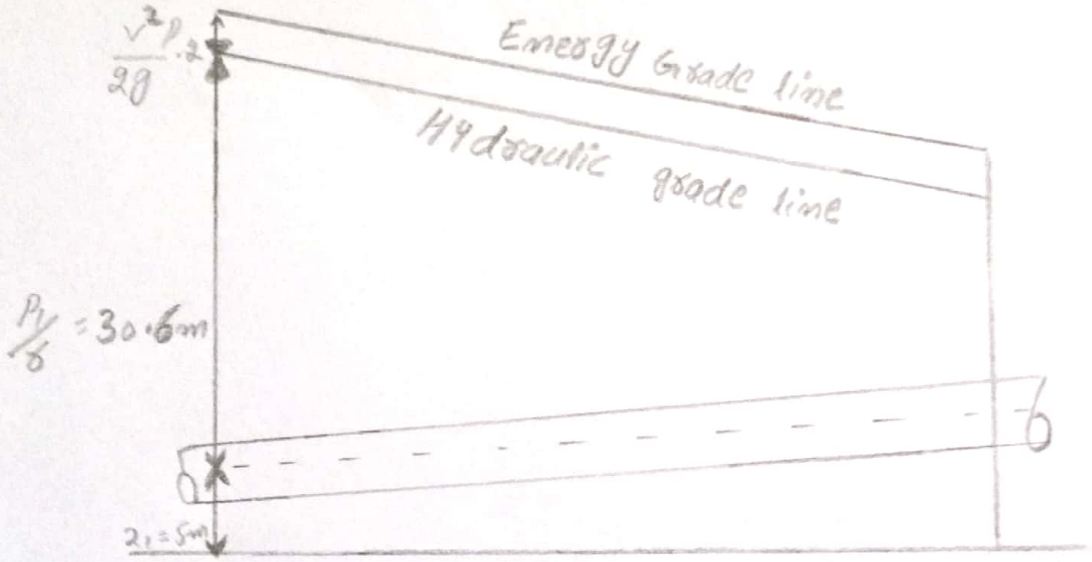


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Q2: Part B:-

Given Data

$D_1 = 300\,mm = 0.3\,m$

$D_2 = 200\,mm = 0.2\,m$

$P_1 = 300\,KPa = 300 \times 10^3\,Pa$

$P_2 = 120\,KPa = 120 \times 10^3\,Pa$

$Q = 40\,liters/s = 0.04\,m^3/s$

$h_2 = 0$

Required:-

$z_2 - z_1 = ?$

Sol:- According to Bernoullis theorem.

$$H_1 = z_1 + \frac{V_1^2}{2g} + P_1/\gamma$$

$$H_2 = z_2 + \frac{V_2^2}{2g} + \frac{P_2}{\gamma}$$

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As given that head loss is negligible.

$$H_1 = H_2.$$

Now,

$$z_1 + \frac{V_1^2}{2g} + \frac{P_1}{\gamma} = z_2 + \frac{V_2^2}{2g} + \frac{P_2}{\gamma} \rightarrow (1)$$

$$A_1 = \frac{\pi}{4} d_1^2$$

$$A_1 = \pi/4 \times (0.3)^2 = 0.0675 m^2$$

$$\boxed{A_1 = 0.0675 m^2}$$

$$A_2 = \frac{\pi}{4} d_2^2$$

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

$$\boxed{A_2 = 0.03 m^2}$$

Now As we know that

$$Q = AV$$

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Now

$$Q_1 = A_1 V_1 = A_2 V_2$$

So,

$$V_1 = \frac{Q_1}{A_1}$$

$$V_1 = \frac{0.04}{0.0675}$$

$$\boxed{V_1 = 0.6 \, m/s}$$

$$V_2 = Q/A_2$$

$$V_2 = \frac{0.04}{0.03}$$

$$\boxed{V_2 = 1.34 \, m/s}$$

Putting the values in eq ①

$$z_1 + \frac{0.6^2}{2 \times 9.81} + \frac{300}{9.81} = z_2 + \frac{1.34^2}{2 \times 9.81} + \frac{120}{9.81}$$

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$$z_1 + 30.6 = z_2 + 12.32$$

$$z_2 - z_1 = 30.6 - 12.32$$

$$\boxed{z_2 - z_1 = 18.28\,m}$$

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Question No - 03

Given Data:-

$l = 500m$ $\rho_{water} = 1000 kg/m^3$

$D = 0.2$

$(\gamma)_{oil} = 0.9$

Dynamic viscocity $= \mu = 6 \times 10^{-5} \frac{N-s}{m^2}$

$Q = 0.06 \, m^3/s$

$f = \left[0.0032 + \frac{0.221}{0.237}\right]$

Where R is reynold numbers.

Required :-

$\Delta P$ = Pressure loss due to friction

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Sol:-

$\gamma \cdot \rho$

$$\gamma = \frac{\rho_{oil}}{\rho_{water}}$$

$\rho_{oil}$ (Density of oil)

$$\rho_{oil} = \gamma \times \rho_{water}$$

$$\rho_{oil} = 0.9 \times 1000$$

$$\rho_{oil} = 900 \ kg/m^3$$

As we know that

$$Q = AV$$

$$V = Q/A$$

$$V = \frac{0.06}{(\pi/4 \times (0.2)^2)}$$

$$\boxed{V = 1.91 \ m/s}$$

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As we know that

Reynold's number is given by,

$$Re = \rho_{oil} VD/\mu$$

$$Re = \frac{900 \times 1.91 \times 0.2}{6 \times 10^{-3}}$$

$$\boxed{Re = 5730000}$$ flow is turbulent.

Now

$$Cf = \left[0.0032 + \frac{0.221}{(5730000)^{0.237}}\right]$$

$$\boxed{Cf = 8.72 \times 10^{-3}}$$

$$f = 4Cf = 4 \times 8.72 \times 10^{-3}$$

$$\boxed{f = 0.03488}$$

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Now,

$$\Delta P = \frac{f L V^2}{2D} \rho_{oil}$$

$$\Delta P = \frac{(0.03488) \times 500 \times 1.91^2}{2 \times 0.2} \times 900$$

$$\boxed{\Delta P = 143151.44 \ N/m^2}$$

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