INU - FINAL TERM EXAMINATION

B.Sc Civil

SUBJECT ⇒ FLUID MECHANICS I

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Section ⇒ B

QUESTION No. 1

Part (a)

(a) Define total energy head and various forms of energy head with mathematical equations.

ANSWER:

TOTAL ENERGY HEAD

From Bernoulli's Principle, the total energy at a given point in a fluid is the energy associated with the movement of the fluid, plus energy from static pressure in fluid, plus energy from height of the fluid relative to arbitrary datum.

OR

The sum of pressure head (psi), velocity head ($v^2/2g$) and elevation head z is constant along a stream line. This constant is called total height H.

$$h = z + \psi$$

∴ h = total energy head
z = elavation head
ψ = pressure head

FORMS OF ENERGY

There are various forms of energy head which are as follows

1. Potential head
2. Kinetic head
3. Pressure head

1. Potential head

It is the potential energy per unit weight.

⇒ It is due to the position above some suitable datum line.

⇒ It is denoted by h or z.

Mathematical Representation

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

2. Kinetic Head

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

⇒ It is due to velocity of flowing liquid.

⇒ It is also known as velocity head.

Mathematical Representation

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

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

UNIT:

Its unit is meters (m).

3. PRESSURE HEAD

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

OR

Level of fluid due to pressure exerted by fluid.

⇒ It is due to pressure of liquid.

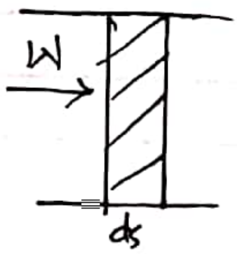
Mathematical representation:

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

OR

$$\Rightarrow \frac{F.ds}{W}$$

$$= \frac{P.A.ds}{W} \Rightarrow \frac{P.V}{\omega} \Rightarrow \frac{P}{\gamma}$$



Total head, H = Potential head + Kinetic head + Pressure head

Part (b)

(b) Define Hydraulic grade line, Energy line and hydraulic Radius.

ANSWER:

HYDRAULIC GRADE LINE

The surface or profile of water flowing in an open channel or a 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.

⇒ It is represented by HGL.

equation:

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

where, z is height above datum level and distance is P/γ.

ENERGY GRADE LINE

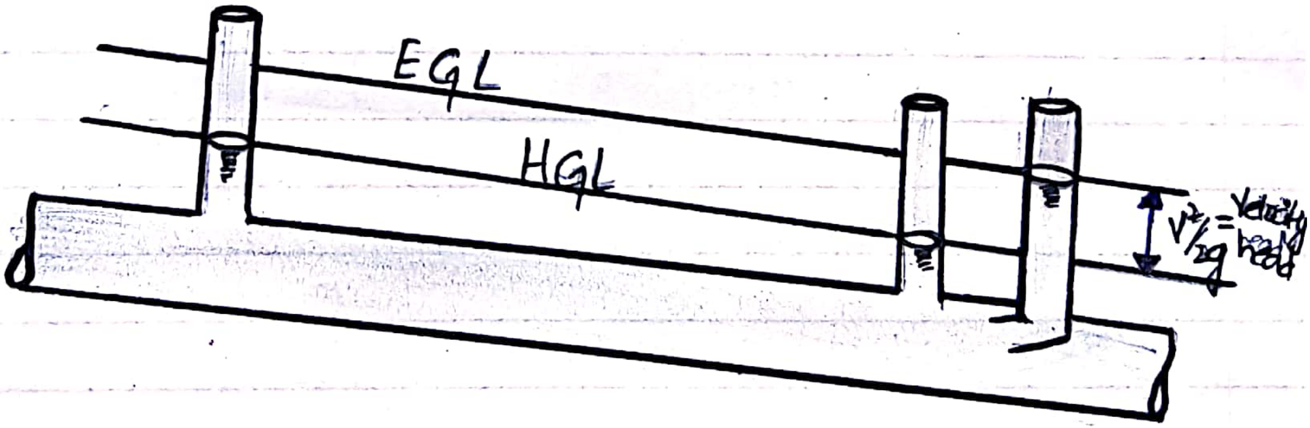
Energy grade line refers to a line that represents to the height of energy head of water streaming in a pipe, course or channel.

Mathematical Representation

$$EGL = H = P/\gamma + V^2/2g + z$$

where

EGL = Energy Grade line



HYDRAULIC RADIUS

Definition:

It is defined as,

"The cross sectional area of flow divided by the wetted perimeter, so the calculation of rectangle and trapezoid area

and triangle area will be included along with (6)
the perimeter for each."

OR

"The ratio of the cross sectional area of a channel or pipe in which a fluid is flowing to the wetted perimeter of the conduit."

Mathematically

$$R = A/P$$

where R = Hydraulic Radius

A = Cross Section Area

P = Wetted Perimeter

QUESTION NO. 2

PART (a)

Given data

Velocity, $V = 2 m/s$

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

datum, $z = 5m$, $\gamma = 9810$

Required

Total energy, $H = ?$

SOLUTION

As we know that

H = Pressure head + K.E + P.E

$$H = \frac{P}{\gamma} + \frac{V^2}{2g} + z \quad \text{—(1)}$$

putting values in eq (1)

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

$$H = 30.58 + 0.201 + 5$$

$$\boxed{H = 35.785 Nm/N}$$

PART (b)

Given data

Diameter, d_1 = 300mm = 0.3m

Diameter, d_2 = 200mm = 0.2m

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

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

Flow Rate, $\phi = \frac{40}{1000} \, m^2/s = 0.04 \, m^2/s$

Required data

Datum, **Z** = ?

Solution

As we know that

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

$$A_1 = \frac{3.14}{4} \times (0.3)^2$$

$$A_1 = 0.07065 \, m^2$$

$$A_2 = \pi d_2^2/4$$

$$A_2 = \frac{3.14 \times (0.2)^2}{4}$$

$$A_2 = 0.0314 \, m^2$$

Now, we know that

$$Q = V_1 A_1$$

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

$$V_1 = \frac{0.04}{0.0706}$$

$$V_1 = 0.5661 \text{ m/s}$$

And

$$V_2 = \frac{Q}{A_2}$$

$$V_2 = \frac{0.04}{0.0314}$$

$$V_2 = 1.2738 \text{ m/s}$$

Now

$$\Rightarrow \frac{P_1}{V} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_n.$$

Where

$$Z_1 = 0 \quad , \gamma = 9810$$

Putting values

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

$$\Rightarrow 30.597 \Rightarrow 12.314 + Z_2$$

$$\Rightarrow Z_2 = 30.597 - 12.314$$

$\Rightarrow Z_2 = 18.282\,m$

$\Rightarrow \boxed{Z_2 = 18.282\,m}$ ⇒ Required Answer

QUESTION No-3

Given data

Length of pipe $= l = 500m$

dia $= d = 0.2m$

Specific gravity of oil $= 0.9$

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

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

Density, $\rho = 0.9\times1000 = 900\,kg/m^3$

Required data

pressure Loss $= \Delta P = ?$

As we know that

$$f = \left[0.0032 + \left(\frac{0.221}{R^{0.2}}\right)\right] \Rightarrow \text{Find}$$

Solution:

As we know that

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

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

$\nu = 6.67 \times 10^{-8}\ m^2/s$

Now find $V = ?$

$$V = \frac{\Phi}{A} \quad \text{—} (A)$$

For Circular pipe

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

$$A = \frac{3.14(0.2)^2}{4}$$

$$A = 0.0314\ m^2$$

Putting values in eq (A)

$$V = \frac{0.06}{0.0314} = 1.91\ m/s$$

$$V = 1.91\ m/s$$

We know that

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

$$R = \frac{1.91 \times 0.2}{6.67 \times 10^{-8}} \Rightarrow \boxed{R = 5.72 \times 10^{-6}}$$

Now,

$$f = 0.0032 + \frac{0.221}{(5.72 \times 10^{6})^{0.237}}$$

$$f = 0.0032 + 5.532 \times 10^{-3} \Rightarrow \boxed{f = 8.73209 \times 10^{-3}}$$

FROM BERNOULLI'S EQUATION

Head loss, $H_f = \frac{fLV^2}{2gD}$

Putting all the values we get,

$$H_f = \frac{(8.73209 \times 10^{-3})(500)(1.91)^2}{2 \times (9.81)(0.2)}$$

$$H_f = 4.0590$$

$$\Rightarrow h_f = \frac{\Delta P}{\gamma}$$

$$h_f = \frac{\Delta P}{\rho g}$$

$$\Delta P = h_f \rho g$$

$$\Delta P = 4.0590 \times 900 \times 9.81$$

$$\Delta P = 35837.47 \text{ pa}$$

$$\Delta P = 35.837 \text{ kpa}$$

Hence,

Pressure Loss, $\Delta P = 35.837$ Kpa