FLUID MECHANICS FINAL TERM

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SECTION: "A"

SEMESTER: 4th

SUBMITTED TO: ABDUL WAHEED

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QUESTION #1

Part "a"

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

ANSWER:

TOTAL ENERGY HEAD:

According to Bernoulli's equation

The total energy at a given point in a fluid is the energy associated with movement of fluid, and energy from static pressure in the fluid energy from height of fluid relative to an orbitary datum height.

OR

The sum of pressure head, velocity head and elevation head is constant along a stream line.

The constant is called total head.

FORMS OF ENERGY HEAD:

There are three forms of energy head.

i) KINETIC HEAD:

It represents kinetic energy per unit weight of fluid.
It is the height in feet that flowing fluid will rise in column.

ii) POTENTIAL HEAD:

It is the potential energy per unit weight.
It is due to position above same datum.
As Total Head = Pressure head + velocity head + Potential head.

Potential Head = Total head − pressure head + velocity head.

iii) PRESSURE HEAD:

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

QUESTION #1

PART "B"

Define Hydraulic grade line, Energy line and hydraulic radius?

ANSWER:

HYDRAULIC GRADE LINE:-

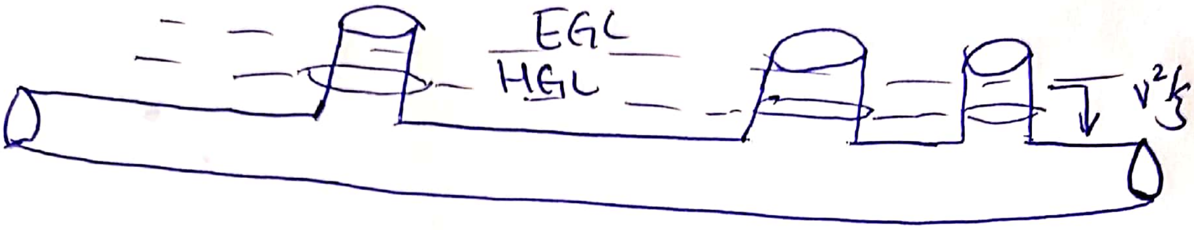
The level of water that would rise to in a small vertical tube to connected to the pipe and the pipe is under pressure is called hydraulic grade line.

It is denoted by "HGL".

This represents the total head available to the fluid minus the velocity head. Hydraulic grade line lies one velocity head below

The energy line

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



ENERGY GRADE LINE (EGL):

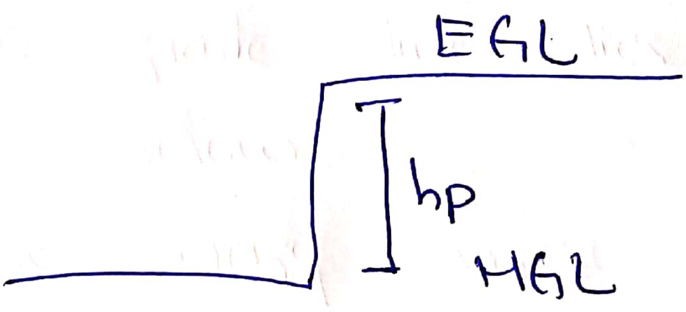
It represents the elevation of energy head of water flowing in a pipe.

It is above the hydraulic grade line. The separation between EGL and HGL is known a velocity head ($V^2/2g$).

MATHEMATICALLY:

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

along a stream line. while rise in EGL is equal to hp.



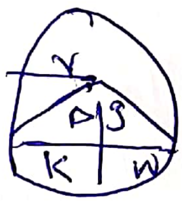
HYDRAULIC RADIUS:

It is defined as the cross-sectional area of flow divided by wetted perimeter.

So calculation of rectangle trapozoidal, and triangular area will be include along perimeter of each.

It measures the efficieney of pipe.

It shows the function of shape in which the liquid is following



QUESTION #2

PART "A"

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

GIVEN DATA:

$V = 2 m/sec$

$P = 300 kPa$

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

$Z = 5m$

REQUIRED ~~THE~~

Head loss = ?

SOLUTION:

From Bernouli's equation

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

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

Putting values

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

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

QUESTION #2

PART "B"

A tapering pipe is having diameter 300mm at bottom end and 200mm at top end. The intensity of pressure at bottom end and top end are 300 kpa and 120 kpa respectively. Determine the difference in datum head between top and bottom if water flow rate through pipe is 40 liters per second. Assume that head loss is negligible.

GIVEN DATA:

Pressure = $P_1 = 300\ kpa$

$\Rightarrow P_1 = 300 \times 10^3\ Pa$

$P_2 = 120\ kpa$

$= 120 \times 10^3\ Pa$

Diameter

$d_1 = 300\ mm$

$d_2 = 200\ mm$

REQUIRED:

Datum = $Z = ?$

SOLUTION:

We know that

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

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

$$d_1 = 0.3m$$
$$d_2 = 0.2m$$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{3.14(0.3)^2}{4}$$

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

$$A_2 = \frac{\pi d_2^2}{4} = \frac{3.14(0.2)^2}{4}$$

$$\boxed{A_2 = 0.0314 m^2}$$

As $Q = V_1 A_1$

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

$$\boxed{V_1 = 0.566}$$

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

$$\boxed{V_2 = 1.27}$$

Now

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

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

$$\Rightarrow \frac{300 \times 10^3}{9810} + \frac{(0.566)^2}{2(9.81)} + 0 = \frac{120 \times 10^3}{9810} + \frac{(1.27)^2}{2(9.8)} + Z_2$$

$$\Rightarrow 30.597 = 12.314 + Z_2$$

$$Z_2 = 30.597 - 12.314$$

$$Z_2 = 18.2834$$

$$\boxed{\text{Datum} = Z_2 = 18.2834}$$

QUESTION #3

A 500 m long 0.2m diameter pipe transport an oil of specific gravity 0.9 and viscosity 6×10^{-6} N.s/m² at rate of 0.06 m³/s. Find pressure loss due friction. Darcy friction coefficient as $f = [0.0022 + (0.221 / R^{0.237})]$ where R is reynold's number.

GIVEN DATA:

Length of pipe = l = 500m

diameter = d = 0.2m

Specific gravity of oil = 0.9

flow rate = Q = 0.06 m³/s

viscosity = $\mu = 6\times10^{-5}$ N.s/m²

REQUIRED:

Pressure loss = Δp = ?

SOLUTION:

As we know that

$$f = \left(0.0032 + \left(\frac{0.221}{R^{0.237}}\right)\right) \rightarrow (i)$$

where R = Reynold no. and is given as

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

and

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

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

and

$$V = \frac{Q}{A} \quad : - \quad A = \frac{\pi}{4}D^2$$

$$A = 0.031$$

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

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

$$R = \frac{1.9356 \times 0.2}{6.67\times10^{-5}}$$

$$\boxed{R = 5.8\times10^{3}}$$

Hence

eq (i)

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

$$\boxed{f = 0.0664}$$

According to Bernoulis equation

Head loss = $h_L = \frac{f l v^2}{2gD}$ → (i)

Putting value

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

$$\boxed{h_L = 31.786}$$

To find Pressure loss

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

$$\Delta P = h_L \times \rho g$$

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

$$\Delta P = 280638 \text{ Pa}$$

$$\boxed{\Delta P = 280.638 \text{ KPa}}$$

THE END