FINAL EXAM SPRING 2020

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DEPARTMENT : BE (Civil)

SECTION : "B"

PAPER : FLUID MECHANICS

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QUESTION NO.1 (a)

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

ANSWER:

TOTAL ENERGY HEAD

DEFINITION:

The sum of all the energy heads at a point in a fluid is called as total Energy head.

FORMS OF ENERGY HEAD:

There are three forms of energy head which are following.

a) Kinetic head
b) Potential head
c) Pressure head.

a) KINETIC HEAD

DEFINITION:

The kinetic energy of the fluid divided by weight of fluid is called

Kinetic head.

MATHIMATICAL:

$$\text{Kinetic head} = \frac{\text{Kinetic energy}}{\text{Fluid weight}}$$

$$\Rightarrow K.H = \frac{K.E}{W}$$

$$\Rightarrow K.H = \frac{\frac{1}{2}mv^2}{mg}$$

$$\Rightarrow K.H = \frac{1}{2} v^2/g$$

$$\Rightarrow \boxed{K.H = \frac{v^2}{2g}}$$

This is the mathematical form of kinetic head.

Its unit is meter (m)

b) POTENTIAL HEAD:

DEFINITION:

The potential energy of the fluid divided by weight of fluid is called potential head.

MATHIMATICAL FORM:

$$\text{Potential head} = \frac{\text{Potential Energy}}{\text{Fluid weight}}$$

$$\Rightarrow P.H = \frac{P.E}{W}$$

$$\Rightarrow P.H = \frac{\cancel{mg}h}{\cancel{mg}}$$

$$\Rightarrow \boxed{P.H = h}$$

In other words the height of fluid is called the Potential head.

Its unit is meter (m)

c) PRESSURE HEAD:

DEFINITION:

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

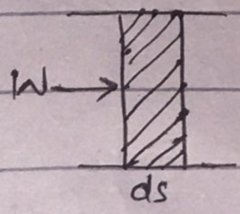
(OR)

The level of fluid due to pressure exerted by fluid is called Pressure head.

MATHIMATICAL FORM:

As

$$\frac{Work}{W} = \frac{F \cdot ds}{W}$$



$$= \frac{P \cdot A ds}{W}$$

$$= \frac{P \cdot V}{W}$$

$\Rightarrow$ **Pressure head $= \frac{P}{\gamma}$**

$\because \gamma = \frac{W}{V} \Rightarrow \frac{1}{\gamma} = \frac{V}{W}$

This equation is known as Pressure head.

Its unit is meter (m)

QUESTION No. 2(b)

Define Hydraulic grade line, Energy line and hydraulic radius.

ANSWER:

HYDROLIC GRADE LINE:

DEFINITION:

Hydrolic grade line refers to the profile of water streaming in an open channel or a pipe streaming in part full.

When a pipe is under pressure, the ~~volume~~ pressure driven review line is the level to which the water would ascend to in a little, vertical tube associated with the pipe.

MATHIMATICAL FORM:

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

where z is the height above the datum line and P/γ is distance.

ENERGY GRADE LINE:

DEFINITION:

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

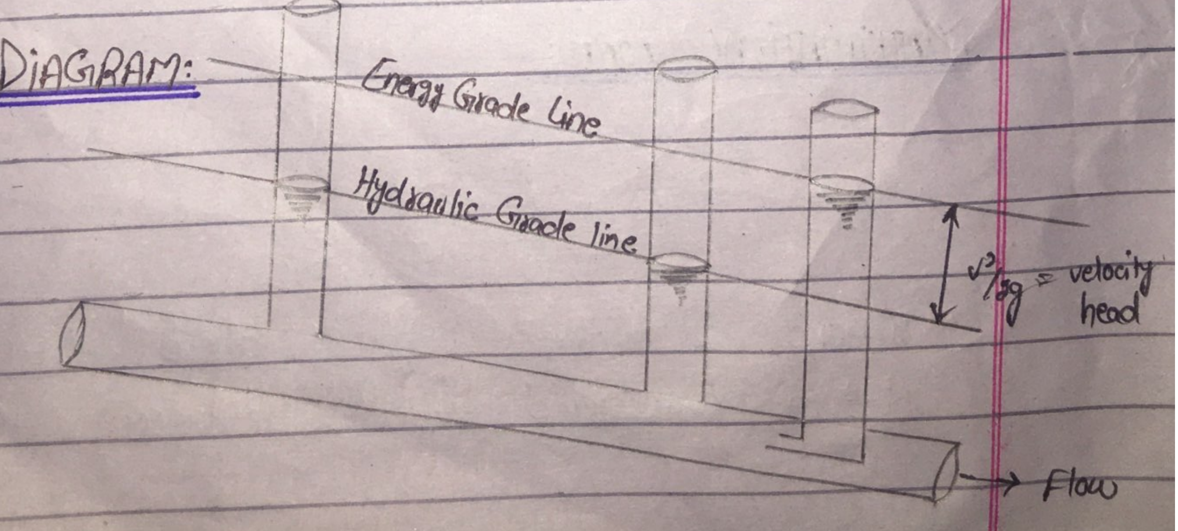
The line is drawn over the pressure hydraulic grade line (inclination) a separation equivalent to the speed head ($V^2/2g$) of the water streaming at every area or point along the pipe or channel.

MATHIMATIMAL FORM:

$$EGL = h_0 = \frac{P}{\gamma} + \frac{V^2}{2g} + z$$

The equation of energy grade line shows the total Bernoulli constant height.

DIAGRAM:



HYDRAULIC RADIUS:

DEFINITION:

The ratio of the cross-sectional area of a channel or pipe in which a fluid is flowing to the welted perimeter of the conduct is called Hydraulic Radius.

MATHIMATICAL FORM:

$$\text{Hydraulic Radius} = \frac{\text{Cross-sectional area}}{\text{Welted Perimeter}}$$

QUESTION No.2(a)

Calculate the total energy ---------- the datum is 5m.

GIVEN DATA:

velocity, $v = 2 m/s$
Pressure, $P = 300 kPa$
$z = 5m$
$g = 9.8 ms^{-2}$
$\gamma = \rho g = 1000 \times 9.81$
$= 9810 \, N/m^3$

REQUIRED DATA:

Total Energy Per Unit Weight, $H = ?$

SOLUTION:

As we know that

$$H = Z + \frac{1}{2}\frac{V^2}{g} + \frac{P}{\gamma}$$

Putting values.

$$\Rightarrow H = 5 + \frac{1}{2} \times \frac{(2)^2}{9.81} + \frac{300 \times 10^3}{9810}$$

$$\Rightarrow \boxed{H = 35.784\ Nm/N} \text{ or Joule}/N$$

RESULT:

Hence $H = 35.784\ Nm/N$ or J/N

QUESTION No. 2(b)

A tapering pipe is having -----
--- head loss is negligible.

GIVEN DATA:

Diameter, d_1 = 300 mm = 0.3 m

Diameter, d_2 = 200 mm = 0.2 m

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

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

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

REQUIRED DATA:

Datum, $z = ?$

SOLUTION:

As we know that

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

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

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

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

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

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

Now as we know that

$$Q = V_1 A_1$$

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

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

$$\Rightarrow V_1 = 0.5661 ms^{-1}$$

Now

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

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

$$\Rightarrow V_2 = 1.2738 \, m/s$$

Now

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma_2} + \frac{V_2^2}{2g} + z_2$$

where $z_1 = 0$

$\gamma = 9810$

Putting values.

$$\Rightarrow \frac{300 \times 10^3}{9810} + \frac{(0.566)^2}{2(9.81)} + 0 = \frac{120 \times 10^3}{9810} + \frac{(1.27)^2}{2(9.81)} + z_2$$

$$\Rightarrow 30.597 = 12.314 + z_2$$

$$\Rightarrow z_2 = 30.597 - 12.314$$

$$\Rightarrow \boxed{z_2 = 18.282 \, m}$$

RESULT:

Hence $z_2 = 18.282 \, m$

QUESTION No.3

A 500m long 0.2m diameter pipe - - - - -
- - - - R is reynold's number.

GIVEN DATA:

Length of pipe, $l = 500m$
Diameter, $d = 0.2m$
Specific gravity of oil $= 0.9$
Flow rate, $Q = 0.06\ m^3/s$
Viscosity, $\mu = 6 \times 10^{-5}\ Ns/m^2$
Density, $\rho = 0.9 \times 1000 = 900\ kg/m^3$

REQUIRED DATA:
Pressure loss, $\Delta P = ?$

SOLUTION:

As we know that

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

$$\Rightarrow \nu = \frac{6 \times 10^{-5}}{900}$$

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

Now we have to find "V"

$$V = \frac{Q}{A} \quad \text{—①}$$

Now for circular pipe

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

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

$$\Rightarrow A = 0.0314 m^2$$

Put values in equ ①

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

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

Now we know that

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

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

$$\Rightarrow \boxed{R = 5.72 \times 10^{+6}}$$

Now

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

$$\Rightarrow f = 0.0032 + (5.5320 \times 10^{-3})$$

$$\Rightarrow \boxed{f = 8.7309 \times 10^{-3}}$$

Now from the Bernouli's Equation

Head Loss, $H_f = \frac{fLv^2}{2gD}$

Putting values

$\Rightarrow H_f = \frac{(8.73209\times10^{-3})(500)(1.91)^2}{2\times9.81\times0.2}$

$\Rightarrow \boxed{H_f = 4.0590}$

Now we know by Pressure loss and head loss relation

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

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

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

$\Rightarrow \Delta P = 4.0590\times900\times9.81$

$\Rightarrow \Delta P = 35837.47$

$\Rightarrow \boxed{\Delta P = 35.837 \text{ KPa}}$

RESULT:

Hence Pressure loss, $\Delta P = 35.837$ kPa