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Fluid Mechanics

Circular Disk under water :

1| Find the resultant force on one side of a 25 mm diameter vertical circular plate standing at the bottom of 3m pool water? Density of water = 1000 Kg/m^3, $g = 9.8\ m/s^2$.

[SGDL-2017]

2| 25mm diameter circular disk is on the base of a swimming pool of depth 2.5 m, width 3m. Find the force on the circular disk, $g = 9.8\ m/s^2$.

[BHP-2017]

Flow through Pipe :

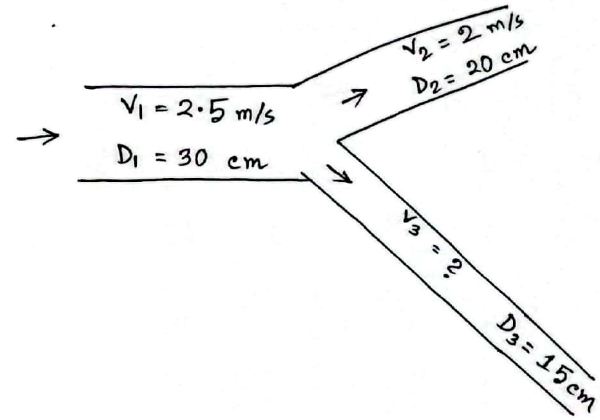
7| Water is flowing in a pipe of a diameter 12 cm at a velocity of 2 m/s. Find out the discharge. [DPDC-2014]

8| Calculate the diameter of a circular pipe that has discharges 2.5 cusec water with a velocity of 6 fps ?

[PGCL-2014, PGCB-2015, BIFPCL-2015]

6| Water velocity 6 ft/sec, Quantity of water is 11.0304 ft^3/min. What is the pipe diameter ?

9|



What is the value of $V_3 = ?$

9.2| A circular pipe with 10 cm diameter having a flow with an average velocity of 10 m/s, calculate the discharge in liter/sec. Also calculate the velocity of another end if the diameter of the pipe is gradually increased to 20 cm. [BPDB-2021]

Solution

Fluid Mechanics

Circular Disk under water:

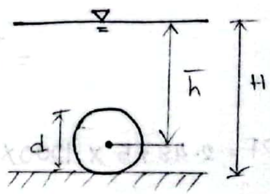
Q1

Solution: Force on circular plate,

$F = P \times A$

$F = \bar{h} \rho g \times A$

$= \bar{h} \rho g \times \left(\frac{\pi}{4} d^2\right)$



$H = 3m$

dia, $d = 25mm = 0.025\ m$

$\therefore r = \frac{25mm}{2} = 12.5mm$

$= 0.0125$

$\therefore \bar{h} = 3 - 0.0125$

$= 2.9875m$

$\rho_w = 1000\ Kg/m^3$

$g = 9.8\ m/s^2$

$\Rightarrow F = 2.9875 \times 1000 \times 9.8 \times \left(\frac{\pi}{4} \times 0.025^2\right)$

$= 14.37\ N$

(Ans.)

(Hints)

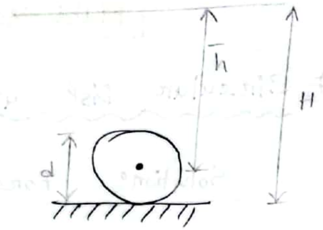
$F = \bar{h} \rho g\ A$

$= \left(m \times \frac{Kg}{m^3} \times \frac{m}{s^2} \times m^2\right)$

$= Kg \times \frac{m}{s^2}$

$= N$ $[\because F = ma]$

2| Solution: Force on circular disk,



$d = 25\,mm = 0.025\,m$

$H = 2.5\,m$

$W = 3\,m$

$F = ?$

$g = 9.8\,m/s^2$

radius, $r = \frac{0.025}{2}\,m$

$= 0.0125\,m$

$\bar{h} = H - r$

$= 2.4875\,m$

$\rho_w = 1000\,kg/m^3$

$F = P \times A$

$\Rightarrow F = \bar{h}\rho g \times A$

$= \bar{h}\rho g \times \left(\frac{\pi}{4}d^2\right)$

$\Rightarrow F = 2.4875 \times 1000 \times 9.8 \times \left(\frac{\pi}{4} \times 0.025^2\right)$

$\therefore F = 11.966\ N$

(Ans.)

Flow through Pipe:

6| Solution:

$d = 12\,cm = 0.12\,m$

$V = 2\,m/s$

$Q = ?$

Discharge, $Q = AV$

$= \left(\frac{\pi}{4}d^2\right) \times V$

$= \left(\frac{\pi}{4} \times 0.12^2\right) \times 2$

$= 0.023\ m^3/s$ (Ans.)

8| Solution:

$d = ?$

$Q = 2.5$ cusec

$= 2.5\ ft^3/s$

$V = 6$ fps

$Q = AV$

$\Rightarrow Q = \left(\frac{\pi}{4} \times d^2\right) \times V$

$\Rightarrow 2.5 = \left(\frac{\pi}{4} \times d^2\right) \times 6$

$\therefore d = 0.728\ ft$

$= 8.74$ inch (Ans.)

6) Water velocity 6 ft/sec, Quantity of water is 11.0304 ft^3/min. What is the pipe diameter?

Solution:

$Q = AV$

$\Rightarrow Q = \left(\frac{\pi}{4}d^2\right) \times V$

$\Rightarrow 0.1838 = \left(\frac{\pi}{4} \times d^2\right) \times 6$

$\therefore d = 0.1975$ ft

$= 2.37$ inch (Ans.)

$V = 6$ ft/s

$Q = 11.0304$ ft^3/min

$= \frac{11.0304}{60}$ ft^3/s

$= 0.1838$ ft^3/s

6) Determine discharge if velocity 2.5 m/s and dia of pipe 15mm, water flow through pipe. (L/sec Unit)

Solution:

$Q = A V$

$\Rightarrow Q = \left(\frac{\pi}{4}d^2\right) \times V$

$= \left(\frac{3.1416}{4} \times 0.015^2\right) \times 2.5$

$= 4.418 \times 10^{-4}$ m^3/s

$= 0.442$ Litre/sec (Ans.)

$Q = ?$

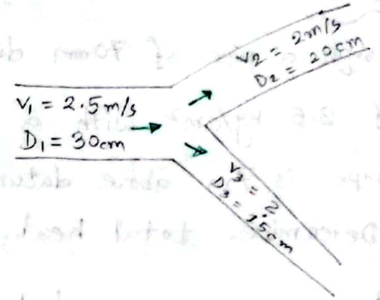
$V = 2.5$ m/s

$d = 15$ mm

$= 0.015$ m

$1\ m^3 = 1000$ L

9)



Solution:

$Q_1 = Q_2 + Q_3$

$\Rightarrow$ $\boxed{A_1V_1 = A_2V_2 + A_3V_3}$

$\Rightarrow \left(\frac{\pi}{4}D_1^2\right) \times V_1 = \left(\frac{\pi}{4}D_2^2\right) \times V_2 + \left(\frac{\pi}{4}D_3^2\right) \times V_3$

$\Rightarrow \left(\frac{\pi}{4} \times 0.3^2\right) \times 2.5 = \left(\frac{\pi}{4} \times 0.2^2\right) \times 2 + \left(\frac{\pi}{4} \times 0.15^2\right) \times V_3$

$\therefore V_3 = 6.44$ m/s (Ans.)

$D_1 = 30cm = 0.3m$

$D_2 = 20cm = 0.2m$

$D_3 = 15cm = 0.15m$

9.2)

$\boxed{Q_1 = A_1 \times V_1}$

$Q_1 = \left(\frac{\pi}{4}d_1^2\right) \times V_1$

$= 0.0785$ m^3/s

$= 78.54$ L/s

Continuity Equation

$\boxed{A_1V_1 = A_2V_2}$

$\Rightarrow 0.0785 = \left(\frac{\pi}{4}0.2^2\right) \times V_2$

$\therefore V_2 = 2.499$ m/s (Ans.)

$d_1 = 10$ cm $= 0.1$m

$V_1 = 10$ m/s

$Q = ?$

$d_2 = 20$ cm $= 0.2$m

$V_2 = ?$

$Q_1 = Q_2 = Q$

Water Head :

b) Water flowing through a pipe of 70mm dia under a gauge pressure of 3.5 Kg/cm² with a mean velocity of 1.5 m/s. The pipe is 7m above datum Line. Neglecting ~~Negative~~ Friction. Determine total head of water.

Solution: Total Head,

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

$$= \frac{3.5 \times 100^2}{1000} + \frac{(1.5)^2}{2 \times 9.81} + 7$$

$$= 42.115 \text{ m} \quad \text{(Ans)}$$

d = 70mm

P = 3.5 Kg/cm²

= 3.5×100^2 Kg/m²

v = 1.5 m/s

Z = 7m

γ_w = 1000 Kg/m³

Neglecting Friction.

So, No Head Loss.

a) Calculate the total head for $Z_1 = 7m$, $V = 25$ m/s, $P = 25$ KN/m², Neglect friction.

Solution: Total Head,

$$H = \frac{P_1}{\gamma} + \frac{v^2}{2g} + Z_1$$

$$= \frac{25}{9.81} + \frac{25^2}{2 \times 9.81} + 7$$

$$= 41.40 \text{ m} \quad \text{(Ans.)}$$

γ_w = 9.81 KN/m³

g = 9.81 m/s²

Z_1 = Elevation

Bernoulli's Equation :

20) Solution:

No energy loss, $h_f = 0$

$$V_A = \frac{Q}{A_A} = 16.81 \text{ ft/s}$$

$$V_B = \frac{Q}{A_B} = 4.202 \text{ ft/s}$$

d_A = 12 in = $\frac{12}{12}$ ft

$\therefore A_A = \frac{\pi}{4} d_A^2 = 0.7854$ ft²

d_B = 24 in = 2 ft

$A_B = \frac{\pi}{4} d_B^2 = 3.1416$ ft²

$Q = Q_A = Q_B$ = 13.2 cfs

$\frac{P_A}{\gamma}$ = 22.1 ft

$\frac{P_B}{\gamma}$ = ? = Pressure head

Z_A = 10 ft, Z_B = 25 ft

From Bernoulli's Equation,

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B$$

$$\Rightarrow 22.1 + \frac{16.81^2}{2 \times 32.2} + 10 = \frac{P_B}{\gamma} + \frac{4.202^2}{2 \times 32.2} + 25$$

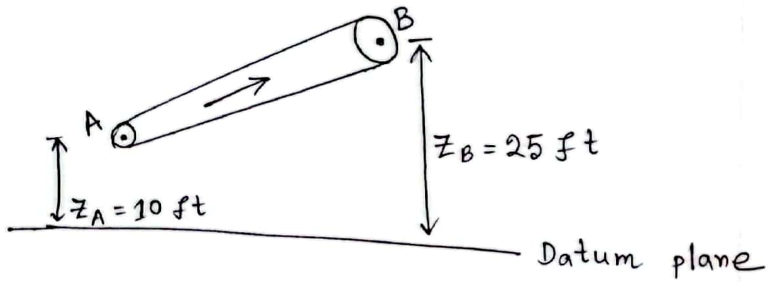
$\therefore$ Pressure head, $\frac{P_B}{\gamma} = 11.21$ ft (Ans.)

$\frac{P_A}{\gamma}$, $\frac{P_B}{\gamma}$ = Pressure Head

g = 32.2 ft/s²

Bernoulli's Energy Equation:

20| Water flows from A, where the diameter is 12 in, to B, where the diameter is 24 in, at the rate of 13.2 cfs. The pressure head at A is 22.1 ft. Considering no loss of energy from A to B, find the pressure head at B.



21| In a horizontal pipe of 30 cm diameter, water flows with a velocity 2 m/s and the pressure is 52 KN/m^2. If the diameter of pipe is 60cm in the other end, what is the pressure?

[BWDB - 2019]

22| Water flows through a pipe from A to B at 80 l/sec, cross sectional area of the pipe at A and B is 20 cm^2 and 80 cm^2 respectively. The height of point B from A is 0.5m and head loss is 0.05 m. If the pressure at point A is 50 Pa, find out the pressure at point B.

[PGCB - 2021]

※ 221 Horizontal pipe, $Z_1 = Z_2$

$d_1 = 30\,cm = 0.3\,m$

$v_1 = 2\,m/s$

$P_1 = 52\,KN/m^2$

$d_2 = 60\,cm = 0.6\,m$

$P_2 = ?$

$\rho_w g = \gamma_w = 9.81\,KN/m^3$

$A_1 = \frac{\pi}{4} d_1^2 = 0.071\ m^2$

$A_2 = \frac{\pi}{4} d_2^2 = 0.283\ m^2$

Now, $A_1 V_1 = A_2 V_2$

$\Rightarrow 0.071 \times 2 = 0.283 \times V_2$

$\therefore V_2 = 0.5\ m/s$

$$\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + Z_2$$

$\Rightarrow \frac{P_1}{\gamma} + \frac{v_1^2}{2g} = \frac{P_2}{\gamma} + \frac{v_2^2}{2g}$ [∵ Horizontal Pipe]

$\Rightarrow \frac{52}{9.81} + \frac{2^2}{2\times 9.81} = \frac{P_2}{9.81} + \frac{0.5^2}{2\times 9.81}$

$\therefore P_2 = 53.875\ KN/m^2$

(Ans.)

\# 221 Solution:

Flow From A to B.

$Q = 80\ L/s = \frac{80}{1000}\ m^3/s$

$= Q_A = Q_B$

$A_A = 20\,cm^2 = 0.002\,m^2$

$A_B = 80\,cm^2 = 0.008\,m^2$

$Z_B = 0.5\,m$, $Z_A = 0\,m$

$h_L = 0.05\,m$

$P_A = 50\,Pa = 50\,N/m^2$

$P_B = ?$

$\gamma_w = 9.81 \times 10^3\ N/m^3$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B + h_L$$

Now, $V_A = \frac{Q}{A_A} = 40\ m/s$

$V_B = \frac{Q}{A_B} = 10\ m/s$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B + h_L$$

$\Rightarrow \frac{50}{9.81\times 10^3} + \frac{40^2}{2\times 9.81} + 0 = \frac{P_B}{9.81\times 10^3} + \frac{10^2}{2\times 9.81} + 0.5 + 0.05$

$\therefore P_B = 744654.5\ Pa$

$= 744654.5\ N/m^2$

$= 744.65\ KN/m^2$

$KN/m^2 = K.Pa$

(Ans.)

২৩। A pipe discharge 40 m^3/s, Head loss is 10% of the difference of velocity head. Find out the pressure at point Q.

	Point P	Point Q
Elevation	1011 m	1050 m
Pipe Dia	50 cm	100 cm
Pressure	50 Kpa	???

[BWDB-2018]

২৪। The value of pressure, elevation and diameter of a pipe in a point P are 12 N/m^2, 5m and 25 cm. Another point Q whose elevation and diameter are 3m and 17 cm. What will be the pressure at Q? Given discharge P to Q is 2 m^3/s and head loss 1 m.

[BWDB-2016, WASA-2017]

২৬ Solution:

Given:

$Q = 40\ m^3/s$

$h_L = 10\%\ \text{of} \left(\frac{V_P^2}{2g} - \frac{V_Q^2}{2g}\right)$

$P_Q = ?$

$P_P = 50\ KPa = 50\ KN/m^2$

$d_P = 50\ cm = 0.5\ m$

$d_Q = 100\ cm = 1\ m$

$\gamma_w = 9.81\ KN/m^3$

$A_P = \frac{\pi}{4} \times d_P^2 = 0.196\ m^2$

$A_Q = \frac{\pi}{4} \times d_Q^2 = 0.785\ m^2$

$V_P = \frac{Q}{A_P} = 204.08\ m/s$

$V_Q = \frac{Q}{A_Q} = 50.96\ m/s$

$\therefore h_L = 10\%\ \text{of} \left(\frac{V_P^2}{2g} - \frac{V_Q^2}{2g}\right)$

$= \frac{10}{100} \times \left(\frac{204.08^2}{2 \times 9.81} - \frac{50.96^2}{2 \times 9.81}\right)$

$= 199.04\ m$

$$\frac{P_P}{\gamma} + \frac{V_P^2}{2g} + Z_P = \frac{P_Q}{\gamma} + \frac{V_Q^2}{2g} + Z_Q + h_L$$

$\Rightarrow \frac{50}{9.81} + \frac{204.08^2}{2 \times 9.81} + 1011 = \frac{P_Q}{9.81} + \frac{50.96^2}{2 \times 9.81} + 1050 + 199.04$

$\Rightarrow P_Q = 17240.69\ KPa$

$= 17240.69\ KN/m^2$ (Ans)

Hints:

For Pipe of Uniform diameter,

$\frac{V_1^2}{2g} = \frac{V_2^2}{2g}$

২৮ Solution:

$P \Rightarrow$

$P_P = 12\ N/m^2$

$Z_P = 5m$

$d_P = 25cm = 0.25m$

$Q \Rightarrow$

$Z_Q = 3m$

$d_Q = 17\ cm = 0.17\ m$

$P_Q = ?$

$Q = Q_P = Q_Q = 2\ m^3/s$

$h_L = 1m$

$\gamma_w = 9.81 \times 10^3\ N/m^3$

$A_P = \frac{\pi}{4} \times d_P^2 = 0.05\ m^2$

$A_Q = \frac{\pi}{4} \times d_Q^2 = 0.023\ m^2$

$V_P = \frac{Q}{A_P} = 40\ m/s$

$V_Q = \frac{Q}{A_Q} = 86.96\ m/s$

From Bernoulli's Equation,

$$\frac{P_P}{\gamma} + \frac{V_P^2}{2g} + Z_P = \frac{P_Q}{\gamma} + \frac{V_Q^2}{2g} + Z_Q + h_L$$

$\Rightarrow \frac{12}{9.81 \times 10^3} + \frac{40^2}{2 \times 9.81} + 5 = \frac{P_Q}{9.81 \times 10^3} + \frac{86.96^2}{2 \times 9.81} + 3 + 1$

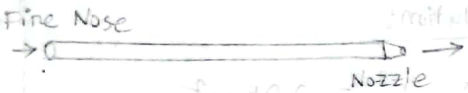
$\Rightarrow P_Q = -2971198.8\ N/m^2$

$= -2971.2\ KN/m^2$ (Ans)

(Pressure Negative হতে পারে)

২৫| Water is flowing in a Fire nose with velocity of 1 m/s with pressure 200 KPa. At the Nozzle, the pressure decreases to atmosphere pressure 101.3 KPa and there is no change in height. Calculate the velocity of water exiting at the nozzle. [NESCO-2021]

Solution:



No change in height.

$\therefore z_1 = z_2$ #

$$\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + z_2$$

$$\Rightarrow \frac{P_1}{\gamma} + \frac{v_1^2}{2g} = \frac{P_2}{\gamma} + \frac{v_2^2}{2g}$$

[∵ No change in ht.]

$$\Rightarrow \frac{200}{9.81} + \frac{1^2}{2\times9.81} = \frac{101.3}{9.81} + \frac{V_2^2}{2\times9.81}$$

$\therefore V_2 = 14.085$ m/s (Am.)

$V_1 = 1$ m/s

$P_1 = 200$ KPa

$= 200$ KN/m²

$P_2 = 101.3$ KPa

$= 101.3$ KN/m²

$V_2 = ?$

$\gamma_w = 9.81$ KN/m³

Head Loss; Reynold's Number:

২৬| Water at 40°c flow in a 75mm pipe @ Reynold's number 80000. If the pipe contains a uniform sand roughness of grain size 0.12 mm dia, how much head loss is to be expected in 300m of the pipe?

Solution:

$$f = 1.76\sqrt{d_{mm}}$$

$= 1.76 \times \sqrt{0.12}$

$= 0.61 = f'$

Reynold's number,

$$Re = \frac{VD}{\nu}$$

$$\Rightarrow 80000 = \frac{V \times 0.075}{0.66\times10^{-6}}$$

$\therefore V = 0.704$ m/s

Head Loss, $$h_L = \frac{f' L V^2}{2gd}$$

$$= \frac{0.61 \times 300 \times 0.704^2}{2 \times 9.81 \times 0.075}$$

$= 61.64$ m (Am.)

$D = 75$ mm $= 0.075$ m

$Re = 80000$

$d_{mm} = 0.12$ mm

$h_L = ?$

$L = 300$ m

Water at 40°c,

$\nu = 0.66\times10^{-6}$ m²/s

D = dia = d

d_{mm} = grain size

Head Loss ; Reynold's Number :

২৭| For axial flow through a circular tube, the Reynolds number for transition to turbulence is approximately 2300, based upon the diameter and average velocity. If $d = 5$ cm and the fluid is Kerosene at 20°C, find the volume flow rate in m^3/s which causes transition.

For Kerosene at 20°C, take

$\rho = 804 \ Kg/m^3$ and $\mu = 0.00192 \ Kg/m.s$.

Hints : (২৮ ও ২৯ নং এর জন্য)
$f = 0.005, 0.009, 0.0003$ etc
$f' = 0.1, 0.8, 0.9$ etc

২৮| A fluid flows through a pipe having diameter 0.5 m, length 100 m and discharge 0.4 m^3/s. If frictional coefficient is 0.005, find the head loss due to friction.

[51 BMA]

২৯| Calculate the discharge through a pipe of diameter 200 mm when the difference of pressure head between the two ends of a pipe 500 m apart is 4 m of water. Take the value of coefficient of friction as 0.009.

২৭। Solution:

Given: $Re = 2300$; $D = d = 5cm = 0.05\,m$; $Q = ?\ (m^3/s)$; $\rho = 804\ Kg/m^3$; $\mu = 0.00192\ Kg/m.s$

$$Re = \frac{VD}{\nu}$$

$$\Rightarrow Re = \frac{VD}{\left(\frac{\mu}{\rho}\right)} \quad \left[\nu = \frac{\mu}{\rho}\right]$$

$$\therefore \boxed{Re = \frac{VD\rho}{\mu}}$$

$$\Rightarrow 2300 = \frac{V \times 0.05 \times 804}{0.00192}$$

$$\therefore V = 0.11 \ m/s$$

$$\therefore \boxed{Q = AV}$$

$$= \left(\frac{\pi}{4} d^2\right) \times V$$

$$= 2.16 \times 10^{-4} \ m^3/s \quad \text{(Ans.)}$$

২৮। Solution: Head Loss,

Given: dia, $d = 0.5m$; $L = 100\ m$; $Q = 0.4\ m^3/s$; $f = 0.005$ (ধরি); $h_L = ?$

$$V = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4}d^2} = 2.037 \ m/s$$

$$\boxed{h_L = \frac{(4f)LV^2}{2gd}}$$

$$= \frac{(4 \times 0.005) \times 100 \times 2.037^2}{2 \times 9.81 \times 0.5}$$

$$= 0.846 \ m \quad \text{(Ans.)}$$

২৯। Solution:

Given: $d = 200\ mm = 0.2\ m$; $A = \frac{\pi}{4}d^2 = 0.031\ m^2$; $L = 500\ m$; $f = 0.009$; $Q = ?$

Difference of pressure head, $h_L = 4m$

Now, $$\boxed{h_L = \frac{(4f)LV^2}{2gd}}$$

$$\Rightarrow 4 = \frac{(4 \times 0.009) \times 500 \times V^2}{2 \times 9.81 \times 0.2}$$

$$\therefore V = 0.934 \ m/s$$

Discharge, $$\boxed{Q = AV}$$

$$= 0.031 \times 0.934$$

$$= 0.029 \ m^3/s \quad \text{(Ans.)}$$

CamScanner

Shear Stress ; Critical Shear ; Critical Shear velocity :

২২। A plate separated by 0.5 mm from a fixed plate moves at 0.50 m/s under a force per unit area of 4 N/m^2. Determine the viscosity of the fluid between the plates.

২২। If co-efficient of dynamic viscosity, $\mu = 1 \frac{N\text{-sec}}{m^2}$ and velocity distribution, $V = 0.9 - y^2$, Determine the shear stress if $y = 0.45$, [BWDB-2016]

২৬। Find the Kinematic viscosity of an oil having density 981 Kg/m^2. The shear stress at a point in oil is 0.2452 N/m^2 and velocity gradient at that point is 0.2 per second.

২৮। The dimensionless effective stress is 0.045 $\frac{N}{m^2}$. Find (i) effective velocity (ii) incipient depth of a wide river channel with the bed sediment size of 0.2 mm with longitudinal river bed slope of 0.0001, specific gravity is 2.65, [BWDB-2016]

29। A rectangular channel of 4 m depth and 6 m width has a side slope of 0.0001, calculate the shear velocity. [BUET M.Sc - 2018]

Shear Stress ; Critical Shear; Critical Shear Velocity:

20| If the co-efficient of dynamic viscosity is $\mu = 1 \ \frac{N \cdot s}{m^2}$ and velocity distribution is 0.9 m/s, Determine shear stress at $y = 0.45$ m. [GTCL-2016]

Solution: Shear stress, $\tau = \mu \frac{V}{y}$

$$\Rightarrow \tau = 1 \times \frac{0.9}{0.45} \quad \left(\frac{N \cdot s}{m^2} \times \frac{m}{s} \times \frac{1}{m}\right)$$

$$\Rightarrow \tau = 2 \ N/m^2$$

$$= 2 \ Pa \quad \text{(Ans.)}$$

Hints:

ν = Kinematic viscosity $\Rightarrow \nu = \frac{\mu}{\rho}$ $\left(\frac{cm^2}{s}, \text{stoke}\right)$

τ = Shear stress $\left(\frac{N}{m^2}, Pa\right)$

μ = Coefficient of Dynamic Viscosity $\left(\frac{N \cdot s}{m^2}, Pa \cdot s, \text{poise}\right)$

V = Velocity distribution (m/s)

y = Separated distance (m)

$\frac{V}{y}$ = Velocity Gradient (/s)

μ = Viscosity (Pa.s, poise)

1 Poise $= \frac{1}{10} \frac{N \cdot s}{m^2}$

$1 \ \frac{cm^2}{s} = 1$ stoke

22|

$y = 0.5$ mm $= 0.5 \times 10^{-3}$ m

$V = 0.50$ m/s

$\tau = 4 \ N/m^2$

$\mu = ?$

Solution: $\tau = \mu \frac{V}{y}$

$$\Rightarrow 4 = \mu \times \frac{0.50}{0.5 \times 10^{-3}}$$

$$\Rightarrow \mu = 4 \times 10^{-3} \ \frac{N \cdot s}{m^2}$$

$$\therefore \mu = 4 \times 10^{-3} \ Pa \cdot s \quad \text{(Ans.)}$$

22|

$\mu = 1 \ \frac{N\text{-sec}}{m^2}$

$V = 0.9 - y^2$

$\tau = ?$ $\quad y = 0.45$

Solution: $\tau = \mu \frac{V}{y}$

$$\Rightarrow \tau = 1 \times \frac{0.9 - y^2}{0.45}$$

$$= 1 \times \frac{0.9 - 0.45^2}{0.45}$$

$$\therefore \tau = 1.55 \ \frac{N}{m^2} \quad \text{(Ans.)}$$

※ ২৬। $\nu = ?$ $\rho = 981\ kg/m^3$

$\tau = 0.2452\ N/m^2$

$\frac{V}{y} = 0.2\ /sec$

Solution:

$$\tau = \mu \frac{V}{y}$$

$$\mu = \rho \nu$$

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

$1\ \frac{cm^2}{s} = 1$ stoke

$\Rightarrow \tau = (\rho \nu) \frac{V}{y}$

$\Rightarrow 0.2452 = (981 \times \nu) \times 0.2$

$\Rightarrow \nu = 1.25 \times 10^{-3}\ m^2/s$

$\Rightarrow \nu = 1.25 \times 10^{-3} \times 100^2\ cm^2/s$

$\therefore \nu = 12.5$ stoke (Ans.)

(P. T. O.)

28| Dimensionless critical shear = 0.45, slope = 0.001, sedimentation size 0.20 mm. Find out the Critical shear stress of incipient depth. Channel is a wide channel. Assume necessary data. Determine the incipient depth. [PGCB-2017]

Solution:

$\tau_{DC} = 0.45$

$S = 0.001$

$d_{mm} = 0.20 \text{ mm}$

$\therefore d_m = 2\times10^{-4}$ m

Wide channel → $A = y_0$, $R = y_0$

Let, $G_s = 2.5$

$\gamma_w = 9.81$ KN/m³

| $\tau_c \rightarrow \gamma_w$

(i) Critical shear stress,

$\tau_c = \tau_{DC}(\gamma - \gamma_w)\, d_m$

$= \tau_{DC}(G_s \gamma_w - \gamma_w)\, d_m$

$= 0.45 \times (2.5\times9.81 - 9.81) \times (2\times10^{-4})$

$= 1.32\times10^{-3}$ KN/m²

(ii) $\tau_c = \gamma_w R S$

$\Rightarrow \tau_c = \gamma_w y_0 S$ [wide channel, $R = y_0$]

$\Rightarrow (1.32\times10^{-3}) = 9.81 \times y_0 \times 0.001$

$\therefore y_0 = 0.135$ m (Ans.)

29| $\tau_{DC} = 0.045$ N/m²

$V = ?$ $y_0 = ?$

$S = 0.0001$

$G_s = 2.65$

| $d_{mm} = 0.2$ mm
| $\therefore d_m = 2\times10^{-4}$ m
| $\gamma_w = 9.81$ KN/m³

Solution: (ii) $\boxed{\tau_c = \tau_{DC}(\gamma - \gamma_w)\, d_m}$

$= \tau_{DC}(G_s \cdot \gamma_w - \gamma_w)\, d_m$

$= 0.045 \times (2.65\times9.81 - 9.81) \times (2\times10^{-4})$

$= 1.46\times10^{-4}$ KN/m²

$\boxed{\tau_c = \gamma_w R S}$

$\Rightarrow \tau_c = \gamma_w \times y_0 \times S$ [wide River channel]

$\Rightarrow 1.46\times10^{-4} = 9.81 \times y_0 \times 0.0001$

$\therefore y_0 = 0.149$ m (Ans.)

(P.T.O.)

(i) Effective velocity,

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Let, $n = 0.02$

$$\Rightarrow V = \frac{1}{n}(y_0)^{2/3} S^{1/2}$$

[wide River channel, $A = y_0$, $R = y_0$]

$$\Rightarrow V = \frac{1}{0.02} \times (0.149)^{2/3} \times (0.0001)^{1/2}$$

$\therefore V = 0.141$ m/s (Ans.)

#26) If depth is 5m and slope is 1:2, Then find critical shear velocity. Wide channel.

Solution: Critical shear velocity,

$$V_c = \sqrt{gRS}$$

$y = 5m$

$S = 1:2 = 1/2$

$$\Rightarrow V_c = \sqrt{gyS} \quad [\text{Wide Channel}]$$

$$= \sqrt{9.81 \times 5 \times \frac{1}{2}}$$

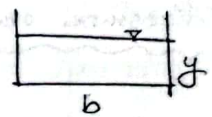
$\therefore V_c = 4.95$ m/s

29) $y = 4m$

$b = 6m$

$S = 0.0001$

$V_c = ?$



Solution: $R = \frac{A}{P} = \frac{by}{b+2y}$

$$\Rightarrow R = \frac{6 \times 4}{6 + 2 \times 4} = 1.71 \text{ m}$$

Shear velocity, $V_c = \sqrt{gRS}$

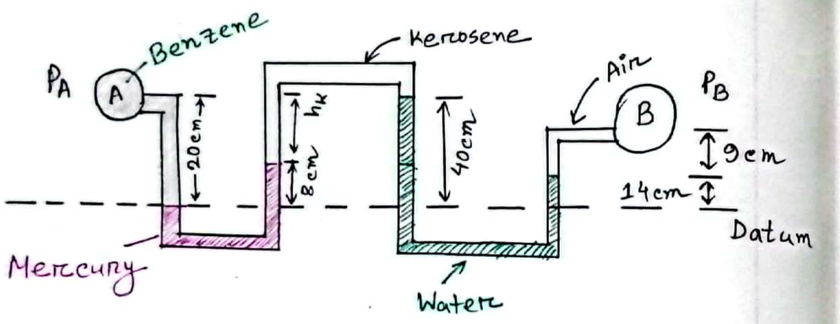
$$= \sqrt{9.81 \times 1.71 \times 0.0001}$$

$= 0.041$ m/s (Ans.)

Pressure on U-shape Manometer:

$\gamma = \rho g$

২৮| Determine ΔP between points A and B. All fluids are at 20°C. Take the specific weights of Benzene 8640 N/m^3, Mercury 133100 N/m^3, Kerosene 7885 N/m^3, water 9790 N/m^3 and Air 12 N/m^3.



২৯| For the manometer of figure, all fluids are at 20°C, If $P_B - P_A = 97$ KPa, Determine the height H in centimeters. Take the specific weights of mercury 133100 N/m^3 and water 9790 N/m^3,

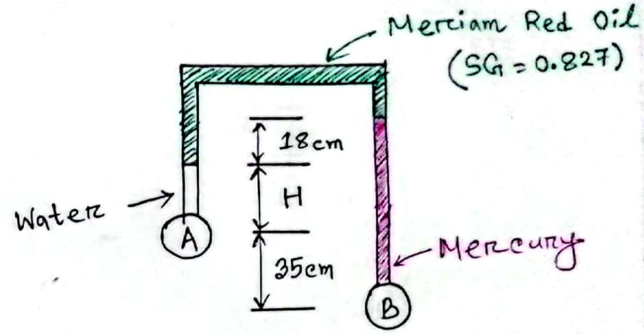
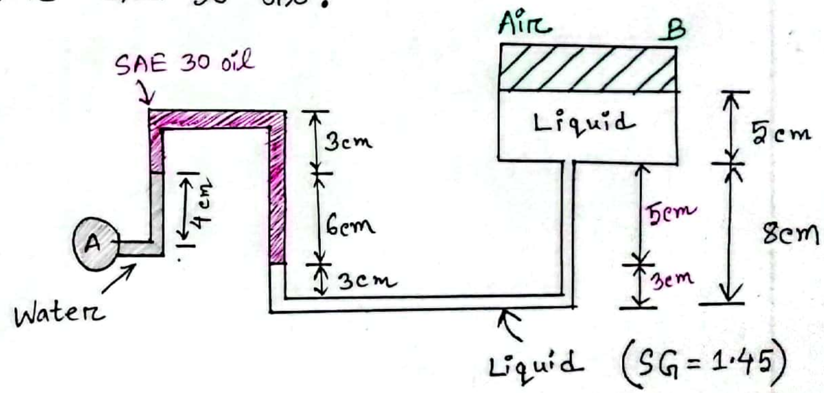


Fig: Inverted Manometer.

৩০| In figure the pressure at point A is 25 psi. All fluids are at 20°C. What is the air pressure in the closed chamber B? $\gamma = 9810$ N/m^3 for water, 8720 N/m^3 for SAE 30 oil.



Pressure on U-Shape Manometer:

Concept
$P = h\gamma$
$= h\rho g$
$= h \times (G_s \gamma_w)$

※ ২৮ Solution:

$P_A + h_B\gamma_B - h_m\gamma_m - h_K\gamma_K + h_w\gamma_w = P_B + h_a\gamma_a$

$\Rightarrow P_A + 0.2 \times 8640 - 0.08 \times 133100 - 0.32 \times 7885 + 0.26 \times 9790$
$= P_B + 0.09 \times 12$

$\Rightarrow P_A - P_B = 8839 \; N/m^2$ (Ans.)

※ ২৯ Solution:

Given, $P_B - P_A = 97 \; kPa$
$H = ?$

For inverted manometer,

$P_A - h_w\gamma_w - h_{mno}\gamma_{mno} = P_B - h_m\gamma_m$

$\Rightarrow P_B - P_A = \gamma_m h_m - H \times \gamma_w - h_{mno}\gamma_{mno}$

$\Rightarrow 97 \times 10^3 = 133100 \times (0.18 + H + 0.35) - H \times 9790 - 0.18 \times (9790 \times 0.827)$

$\Rightarrow H = 0.2264 \; m$

$\therefore H = 22.64 \; cm$ (Ans.)

※ ৩০ $P_A = 25 \; psi = 172414 \; N/m^2$
$P_{air} = ?$

$1 \; MPa = 145 \; psi$
$\Rightarrow 1 \times 10^6 \; \frac{N}{m^2} = 145 \; psi$
$\therefore 1 \; psi = \frac{10^6}{145} \; \frac{N}{m^2}$

Solution:

$P_A - h_w\gamma_w + h_{SAE}\gamma_{SAE} = h_L\gamma_L + P_{air}$

$\Rightarrow 172414 - 0.04 \times 9810 + 0.06 \times 8720 = (0.05 + 0.05) \times (9810 \times 1.45) + P_{air}$

$\therefore P_{air} = 171122 \; \frac{N}{m^2}$ (Ans.)

৩১ ※ Solution: $P_A + h_1\gamma_1 + h_2\gamma_2 = P_B + h_3\gamma_3$

~~৩২ Solution:~~

$G_S = 13.6$
$P_a = ?$
$\gamma_w = 9.81 \; kN/m^3$

~~$P_a + h_1\gamma_1 = h_2\gamma_2$~~

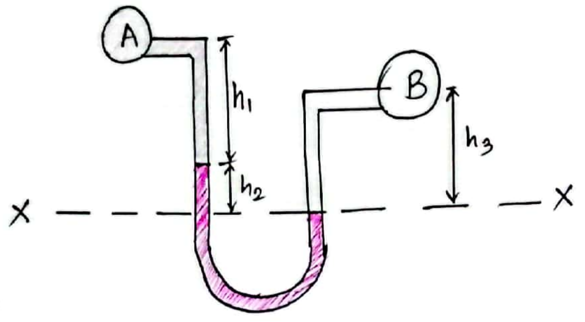
~~$\Rightarrow P_a + 0.05 \times 9.81 = 0.15 \times (9.81 \times 13.6)$~~

~~$\therefore P_a = 19.522 \; kN/m^2$~~

~~$= 19522 \; N/m^2$~~ (Ans.)

(P.T.O.)

৬৫।



G_s (A) = 1.5

G_s (B) = 0.9

What is the Pressure Equation ?

Solution :

$$P_A + h_1\gamma_1 + h_2\gamma_2 = P_B + h_3\gamma_3$$

$$\Rightarrow P_A + h_1\rho_1 g + h_2\rho_2 g = P_B + h_3\rho_3 g$$

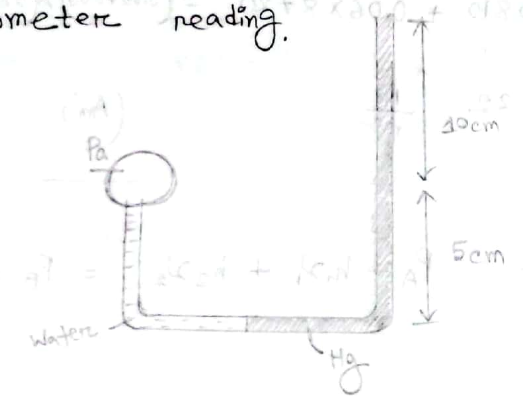
(Ans.)

৬৬। A 15 cm diameter pipe carries 70 L/s of oil (G = 0.75). At a section 15 cm above the datum, the pressure is 2 cm vaccum of mercury. If $\alpha = 1.1$ then calculate the total head in A of the oil section.

[BIWTA – 2019]

 # Q2) A U-type manometer containing Hg ($G_s = 13.6$) has its right limb opened to the atmosphere. The left limb is full of water and is connected to a pipe containing water under pressure. Find the pressure of water in pipe above atmosphere for the manometer reading. [BWDB-2019]

Solution:



$P_a + h_w \gamma_w = h_{Hg} \gamma_{Hg}$ | $\gamma_w = 9.81\ KN/m^3$

$\Rightarrow P_a + h_w \gamma_w = h_{Hg} \times (\gamma_w \times G_s)$

$\Rightarrow P_a + 0.05 \times 9.81 = 0.15 \times (9.81 \times 13.6)$

$\therefore P_a = 19.522\ KN/m^2$ (Ans.)

Extra

 # Q6) Dia, $d = 15\ cm = 0.15 m$

$Q = 70\ L/s = 70 \times 10^{-3}\ m^3/s$

$Z = 15\ cm = 0.15\ m$

$G_s = 0.75$, $\alpha = 1.1$

$P = 2$ cm vaccum of mercury | $G_s(mercury) = 13.6$

Total Head, $H = ?$

Solution:

Area, $A = \frac{\pi}{4} d^2 = 0.0176\ m^2$

Velocity, $v = \frac{Q}{A} = 3.977\ m/s$

Pressure, $P = 2$ cm vaccum of mercury

$$P = h_m \gamma_m$$

$= h_m (\gamma_w \times G_s(mercury))$

$= \frac{2}{100} \times 9.81 \times 13.6$

$= 2.668\ KN/m^2$

$\gamma_{oil} = \gamma_w \times G_s(oil) = 7.36\ KN/m^3$

Total Head, $H = \frac{P}{\gamma} + \alpha \frac{v^2}{2g} + Z$

$= \frac{2.668}{7.36} + 1.1 \times \frac{3.977^2}{2 \times 9.81} + 0.15$

$= 1.4\ m$ (Ans.)

*** 68|** You have planned to irrigate a garden by a hush well using a centrifugal pump at a rate of 10 gpm through 1" pipe. At the lower point of the water level is 50' below the garden level, You will need a 75' long plastic pipe (including horizontal length). According to the chart, the frictional head loss per 100 ft length of 1" plastic pipe is 6.3 ft and the same one 90° below connector is 16.655 ft. Calculate water HP and motor HP for efficiency 0.5, [NPBCL-2019]

Solution: $Q = 10$ gpm

$d = 1$ in (No use)

$h = 50'$

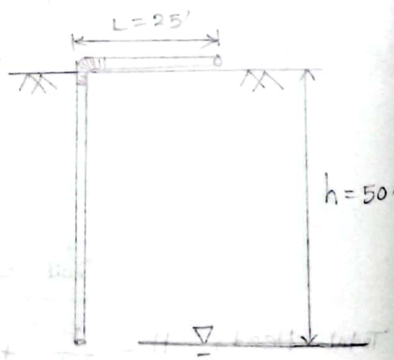
$L = 25'$

$L_{Total} = 50 + 25 = 75'$

$\eta = 0.5$

Water HP = ?

motor HP = ?



Friction head loss = 6.3' per 100' length

Now, Frictional head loss,

$$h_f = \left(\frac{\text{Head loss for}}{\text{Total Length}}\right) + \left(\text{Head Loss below connector}\right)$$

$$= \left(6.3' \times \frac{75}{100}\right) + (16.655')$$

$$= 21.38'$$

Total Head, $H = h + h_f$

$= 50 + 21.38$

$= 71.38$ ft

$$\text{Water HP} = \frac{HQ}{3960}$$

Q → gpm
H → ft

$$= \frac{71.38 \times 10}{3960}$$

$= 0.18$ (WHP)

$$\text{Motor HP} = \frac{WHP}{\eta}$$

$$= \frac{0.18}{0.5}$$

$= 0.36$ (BHP)

(Ans)