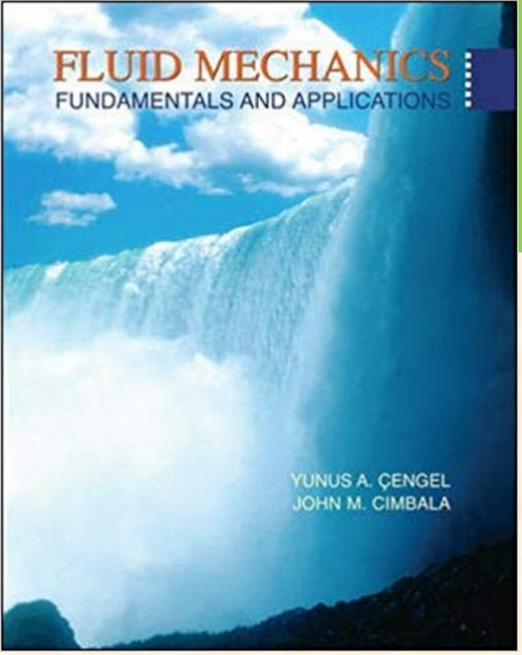

YUNUS A. ÇENGEL and JOHN M. CIMBALA, "Fluid Mechanics: Fundamentals and Applications",1st ed., McGraw-Hill,2006.

Course name

Incompressible Fluid Mechanics

Sheet-01& 06- Chapter-03

Fluid flow concept and Basic equations

Lecture slides by

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University of Tikrit

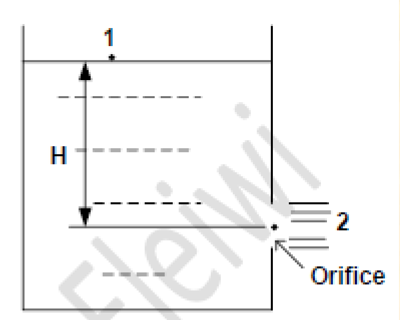
Outline

- ***Examples:* Sheet No. 1**
- ***Examples:* Sheet No. 6**
- ***Homeworks:***

General Equation

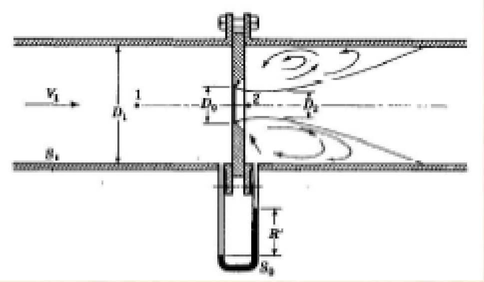
- **Orifice meter**

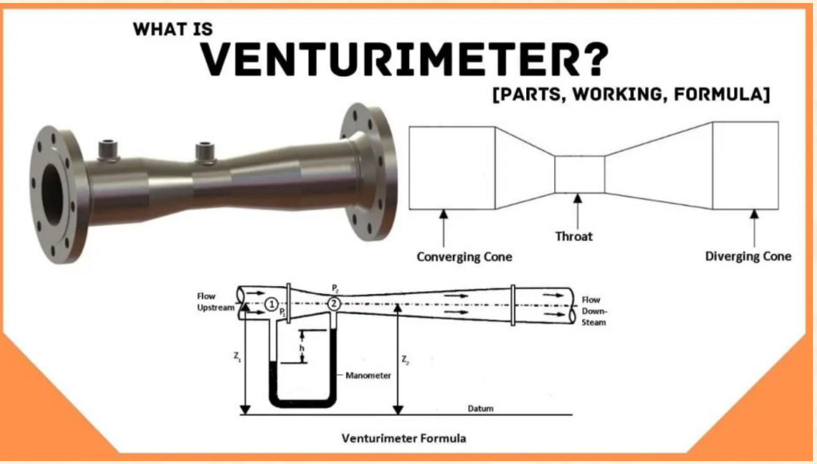
$$V_2 = \sqrt{2gH}.$$



$$V_1 = C_C \left(\frac{D_o}{D_1}\right)^2 V_2$$

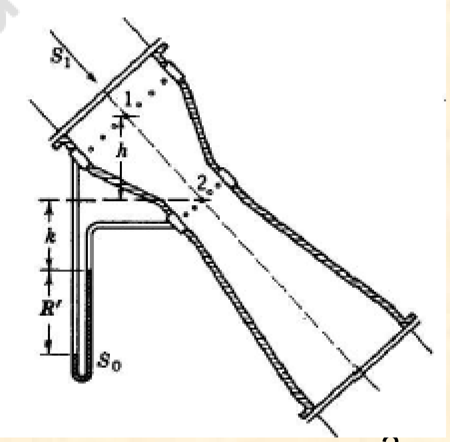
$$V_2 = \sqrt{\frac{2gR\left(\frac{\gamma_s}{\gamma}-1\right)}{1-C_c^2\left(\frac{D_o}{D_1}\right)^4}}$$





- **Venturi Meter**

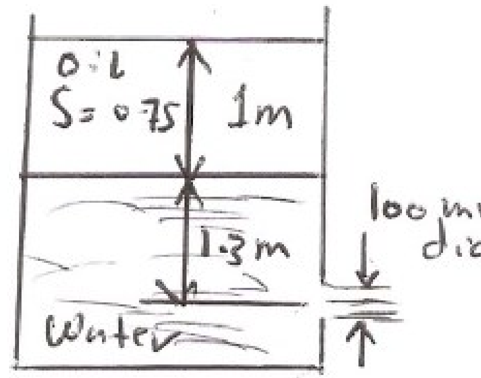
$$V_2 = \sqrt{\frac{2gR\left(\frac{\gamma_s}{\gamma}-1\right)}{1-\left(\frac{D_2}{D_1}\right)^4}}$$



Example 1 :

Sol.1:

Neglecting losses, determine the discharge in Fig



Sol:-

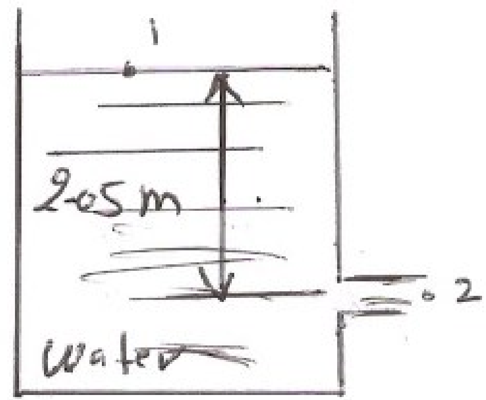
$(\gamma h)_{oil} = (\gamma h)_{water}$

$9.81 * 0.75 * 1 = 9.81 * h \Rightarrow h = 0.75\,m$

Total level of water $= 1.3 + 0.75 = 2.05\,m$

B.E between 1 and 2

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



$$2.05 = \frac{V_2^2}{2*9.81} \Rightarrow V_2 = 6.343\ m/s$$

$$Q = AV \Rightarrow Q = \frac{\pi}{4}(0.1)^2 * 6.343$$

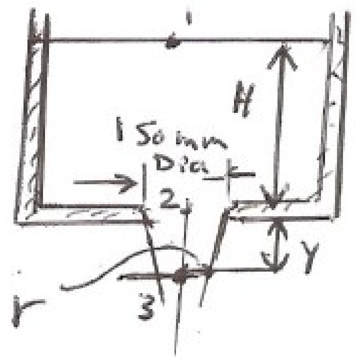
$$\boxed{Q = 0.049\ m^3/s}$$

Examples : Sheet No. 1

Example $_2$:

Sol.$_2$:

Neglecting losses and surface tension effects - derive an equation for the water surface r of the jet of Fig in terms of y/H.



Sol:-

B-E between 1 & 2

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

$$H = \frac{V_2^2}{2g} \Rightarrow V_2 = \sqrt{2gH}$$

B-E between 1 & 3 $\Rightarrow$

$$V_3 = \sqrt{2g(H+y)}$$

$$Q_2 = Q_3 \Rightarrow A_2V_2 = A_3V_3$$

$$\left(\frac{\pi}{4}(0.15)^2\sqrt{2gH}\right)^2 = \left(\pi r^2 \times \sqrt{2g(H+y)}\right)^2 \Rightarrow$$

$$r = \frac{1}{0.075\left(1+\frac{y}{H}\right)^{0.25}}$$

Example 3 :

Sol.3:

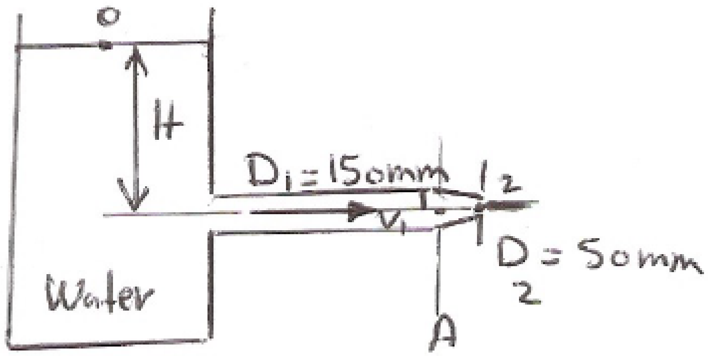
in Fig. The losses up to section A are $5V_1^2/2g$ and the nozzle losses are $0.05\,V_2^2/2g$. Determine the discharge and the pressure at A. H = 8 m

Sol:-

losses at $A = 5\dfrac{V_1^2}{2g}$

losses at nozzle (point 2) $= 0.05\dfrac{V_2^2}{2g}$

$H = 8\,m$ & $(Q, P)_A$?



$Q_1 = Q_2$

$A_1V_1 = A_2V_2$

$\frac{\pi}{4}(0.15)^2 V_1 = \frac{\pi}{4}(0.05)^2 V_2 \Rightarrow V_1 = 0.111\,V_2$ --- ①

B-E between o & 2

$$\frac{P_o}{\gamma} + \frac{V_o^2}{2g} + Z_o = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + losses_{0-2}$$

Example 3 :

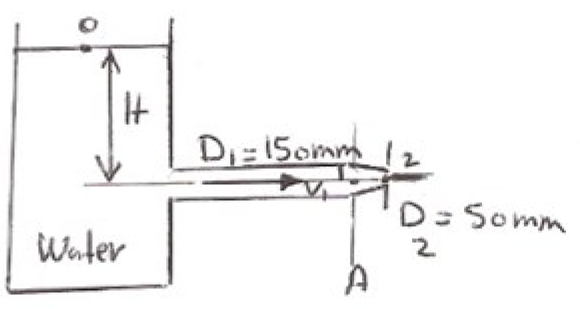
Sol.3:

$$H = \frac{V_2^2}{2g} + 5 * \frac{V_1^2}{2g} + 0.005 \frac{V_2^2}{2g} \quad --- (2)$$

Sub (1) in (2)

$$8 = \frac{V_2^2}{2*9.81} + \frac{5(0.111 V_2)^2}{2*9.81} + \frac{0.005 V_2^2}{2*9.81} \Longrightarrow V_2 = 12.1 \text{ m/s}$$

$$\therefore V_1 = 0.111 * 12.1 \Longrightarrow \boxed{V_1 = 1.343 \text{ m/s}}$$



B-E between 0 & 1

$$\frac{P_0}{\gamma} + \frac{V_0^2}{2g} + Z_0 = \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 + \text{losses}_{0\to 1}$$

$$8 = \frac{P_1}{9.81} + \frac{(1.343)^2}{2*9.81} + \frac{5*(1.343)^2}{2*9.81} \Longrightarrow \boxed{P_1 = 73 \text{ Kp}}$$

Examples : Sheet No. 1

Example $_4$:

$$P_1-\gamma_w(a+0.2)+\gamma a\,(0.2)+\gamma_w\,(a+h)=P_2$$

Sol.$_4$:

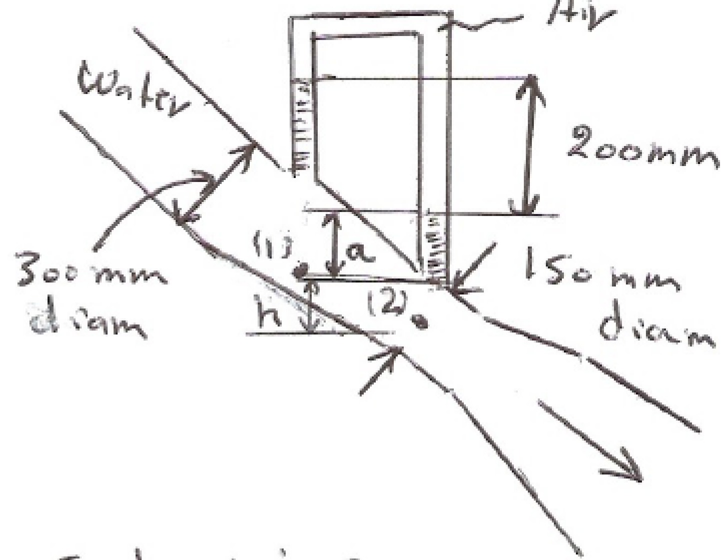
Neglecting losses find the discharge through the venturi meter ?

Sol:-

$$Q_1 = Q_2$$

$$\frac{\pi}{4}(0.3)^2 \times V_1 = \frac{\pi}{4}(0.15)^2\, V_2$$

$$\Rightarrow V_1 = 0.25\, V_2 \quad \text{----} \ (1)$$



B.E between 1 & 2

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

$$\frac{P_2 - P_1}{\gamma} = h + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} \quad \text{---} \ (2)$$ sub 1 in 2

$$\frac{P_2 - P_1}{\gamma} = h + (-0.047 V_2^2) \quad \text{——} \ (3)$$

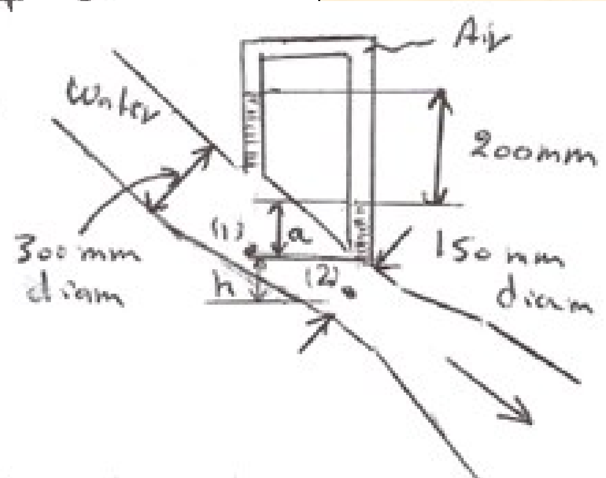
Examples : Sheet No. 1

Example $_4$: **Sol.$_4$:**

Manometer equation between 1 & 2

$$P_2 - \gamma h - \gamma a = P_1 - \gamma a - \gamma * 0.2$$

$$\frac{P_2 - P_1}{\gamma} = h - 0.2 \quad \text{———} \quad (4)$$



sub 4 in 3

$$h - 0.2 = h - 0.047 V_2^2 \Rightarrow V_2 = 2.06 \text{ m/s}$$

$$Q = \frac{\pi}{4}(0.15)^2 * 2.062$$

$$\boxed{Q = 0.0364 \text{ m}^3/\text{s}}$$

$$P_1 - \gamma_w(a + 0.2) + \gamma_a(0.2) + \gamma_w(a + h) = P_2$$

$$P_1 - a\gamma_w - 0.2\gamma_w + 0.2\gamma_a + a\gamma_w + h\gamma_w = P_2$$

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$$P_1 + \gamma_w(h - 0.2) = P_2$$

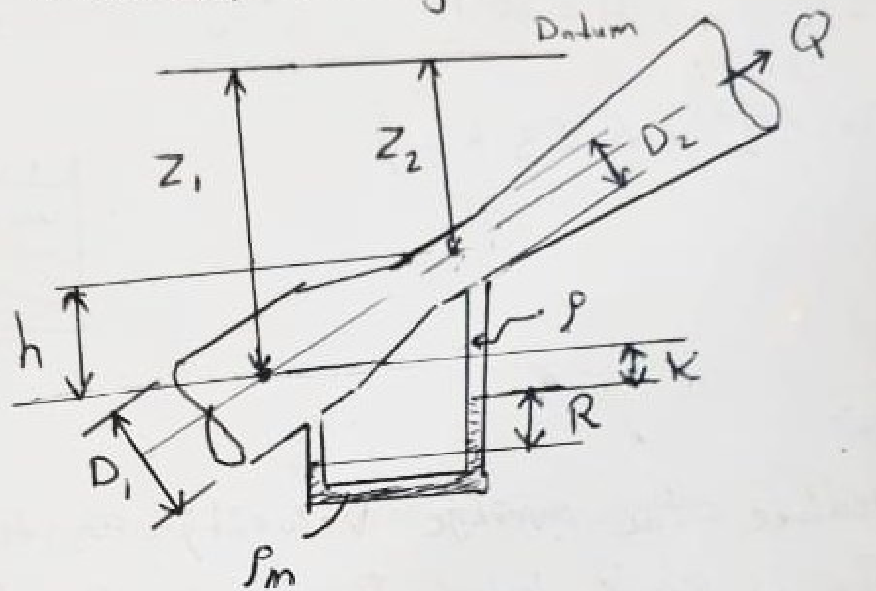
$$\therefore \frac{P_2 - P_1}{\gamma_w} = h - 0.2$$

Examples: Sheet No. 6

Example $_1$:

Sheet No. 6

Q1:- For the venturi meter and manometer installation shown in Fig, derive an express relating the volume rate of flow rate with The manometer reading.



Examples: Sheet No. 6

$Q_1 = Q_2$

$A_1 V_1 = A_2 V_2$

$\frac{\pi}{4}(D_1)^2 V_1 = \frac{\pi}{4}(D_2)^2 V_2$

$\therefore V_1 = \left(\frac{D_2}{D_1}\right)^2 V_2$ --- (1)

B-E between (1) & (2)

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

$h = Z_1 - Z_2$

$\therefore \frac{P_1 - P_2}{\gamma} - h = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$ --- (2)

Sub 1 in 2

$\frac{P_1 - P_2}{\gamma} - h = \frac{V_2^2}{2g} - \left(\frac{D_2}{D_1}\right)^4 \frac{V_2^2}{2g}$

$\therefore \frac{P_1 - P_2}{\gamma} - h = \frac{V_2^2 - \left(\frac{D_2}{D_1}\right)^4 V_2^2}{2g}$ --- (3)

Manometer equation between 1 & 2

$P_1 + \rho g(K+R) = P_2 + \rho g h + g\rho K + \rho_m g R$

$P_1 + \rho g K + \rho g R = P_2 + \rho g h + \rho g K + \rho_m g R$

$P_1 - P_2 = \rho g h + gR(\rho_m - \rho)$ --- (4) sub in (3)

$\frac{\rho g h + gR(\rho_m - \rho)}{\gamma} - h = \frac{V_2^2 - \left(\frac{D_2}{D_1}\right)^4 V_2^2}{2g}$ $* \gamma$

$\rho g h + gR(\rho_m - \rho) - \rho g h = \frac{\left(V_2^2 - \left(\frac{D_2}{D_1}\right)^4 V_2^2\right)\rho}{2}$

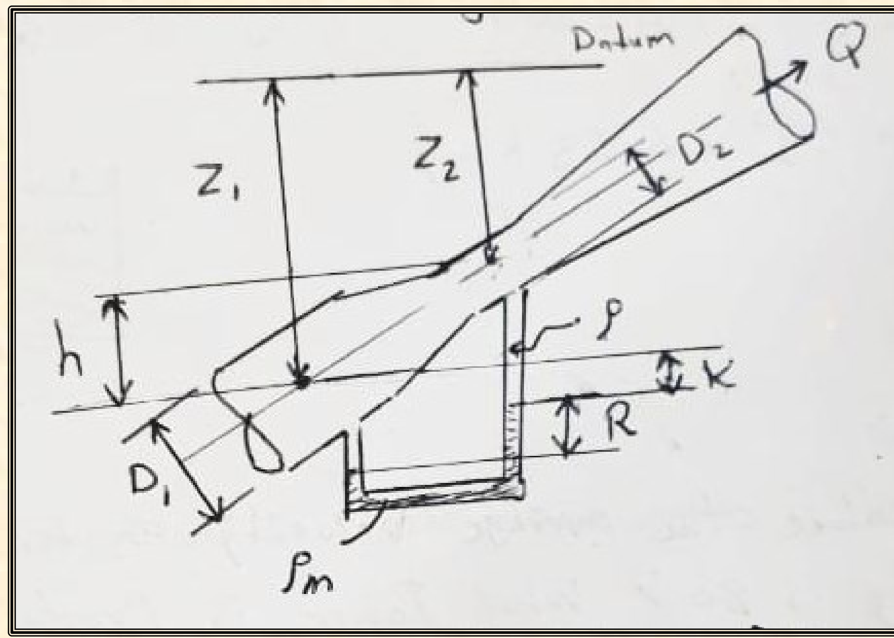
Sol.$_1$:

$V_2 = \sqrt{\frac{2gR\left(\frac{\rho_m}{\rho} - 1\right)}{1 - \left(\frac{D_2}{D_1}\right)^4}}$

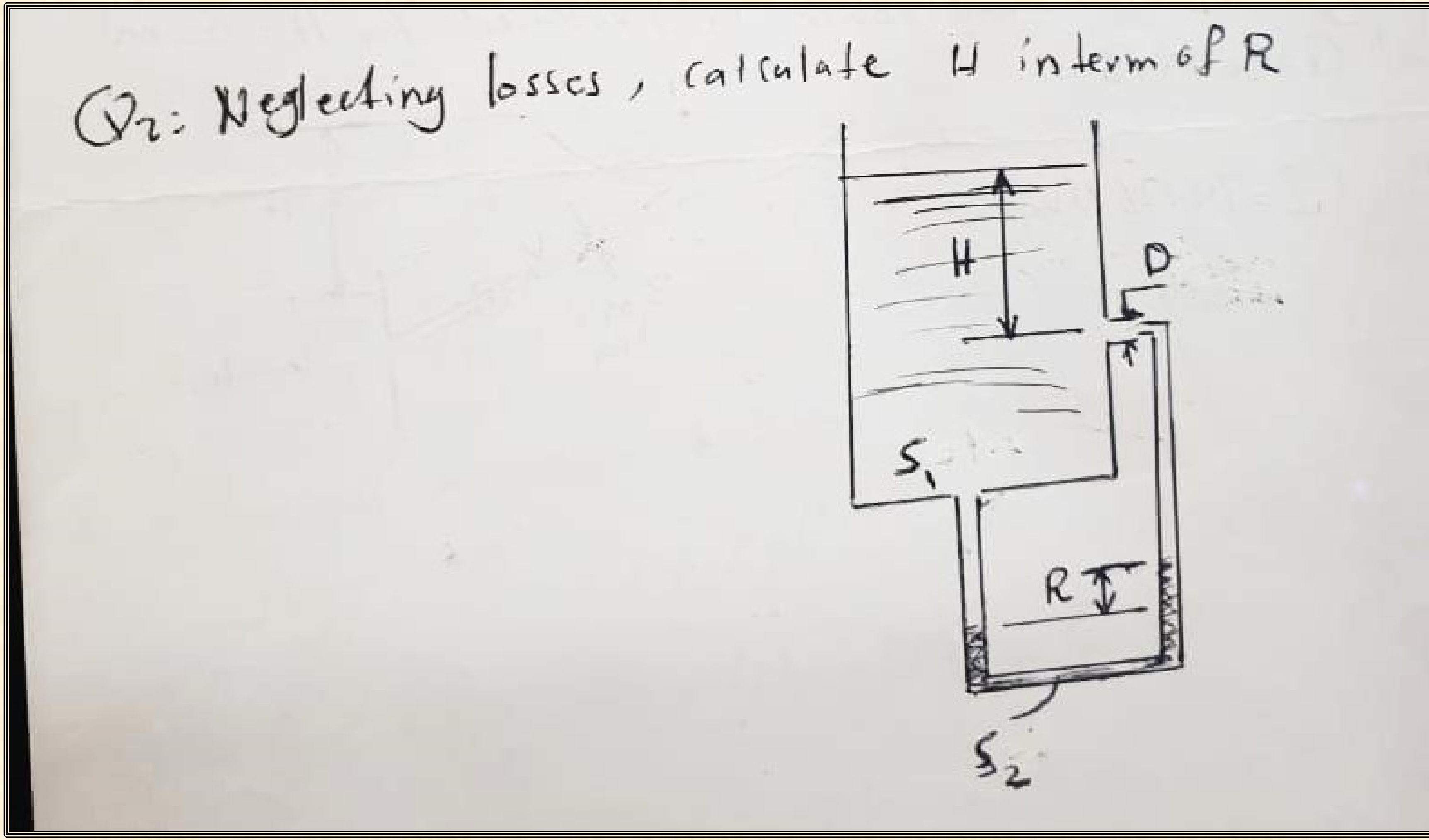
$\therefore Q = A_2 V_2$

$Q = A_2 \sqrt{\frac{2gR\left(\frac{\rho_m}{\rho} - 1\right)}{1 - \left(\frac{D_2}{D_1}\right)^4}}$

$P_1 + \rho g(K + R) - \rho_m g R - \rho g K - \rho g h = P_2$



Example 2:



Examples: Sheet No. 6

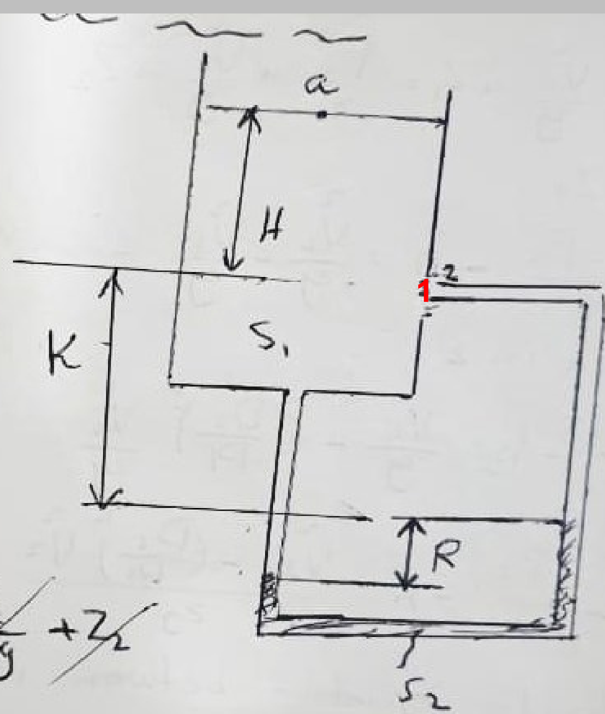
Sol. 2

Q2:-

B.E between 1 & a

$$\frac{P_a}{\gamma} + \frac{V_a^2}{2g} + Z_a = \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1$$

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



B.E between 1 & 2

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

$$\therefore \frac{P_2}{\gamma} = \frac{V_1^2}{2g} \quad \text{---- } 2$$

$$\Rightarrow \frac{P_2}{\gamma} = H \quad \text{---- } 3$$

Manometer reading between (a) and (2)

$$P_a + \gamma H + \gamma s_1 K + \gamma s_1 R = P_2 + \gamma s_1 K + \gamma s_2 R$$

$$\gamma H + \gamma s_1 R = \gamma H + \gamma s_2 R$$

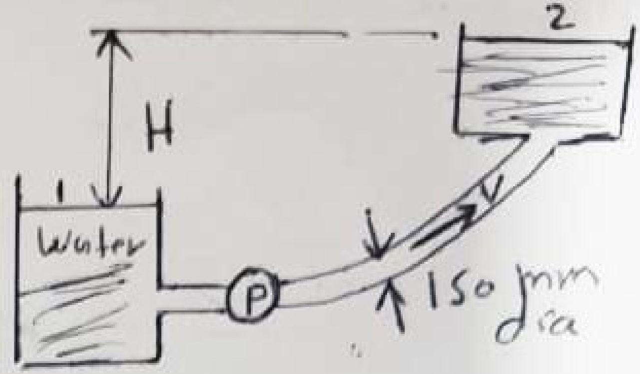
$$S_1 R = S_2 R \quad \because S_1 \neq S_2 \Rightarrow R = 0$$

$\therefore R = 0$ for all H

Example $_3$:

Q3:- Determine the Shaft Power for an 80% efficient Pump to discharge 30 L/s through the syst of fig. The system losses exclusive of pump losses are $12 \frac{V^2}{2g}$ and H = 16 m

Ans (P = 6.53 kw)



Examples: Sheet No. 6

Sol. 3

$Q = \frac{30}{1000} = 0.03\ m^3/s$

$Q = V \cdot A \Rightarrow V = \frac{0.03}{\frac{\pi}{4} \cdot (0.15)^2} \Rightarrow V = 1.698\ m/s$

$losses = \frac{12 \times (1.698)^2}{2 \times 9.81} = 1.763\ m$

B-E between 1 & 2

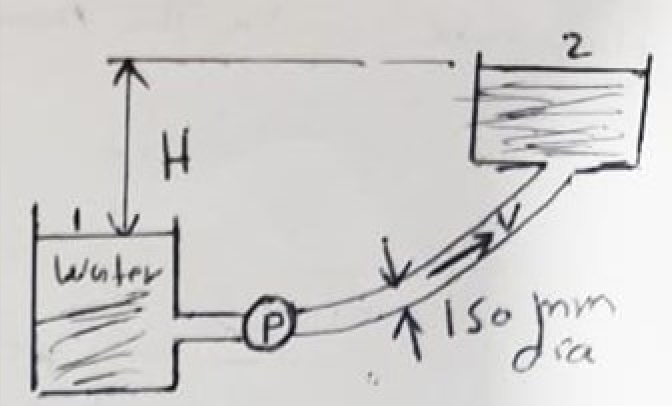
$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + losses$

$h_p = 16 + 1.763 \Rightarrow h_p = 17.763\ m$

$P = \gamma Q h_p$

$P_o = 9.81 \times 0.03 \times 17.763 \Rightarrow P_o = 5.227\ kW$

$\eta = \frac{P_o}{P_{in}} \Rightarrow 0.8 = \frac{5.227}{P_{in}} \Rightarrow P_{in} = 6.53\ kW$



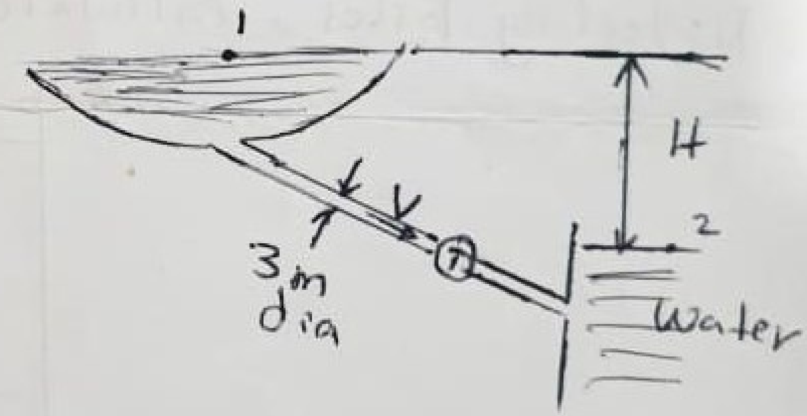
Examples: Sheet No. 6

Example 4:

Q4:-

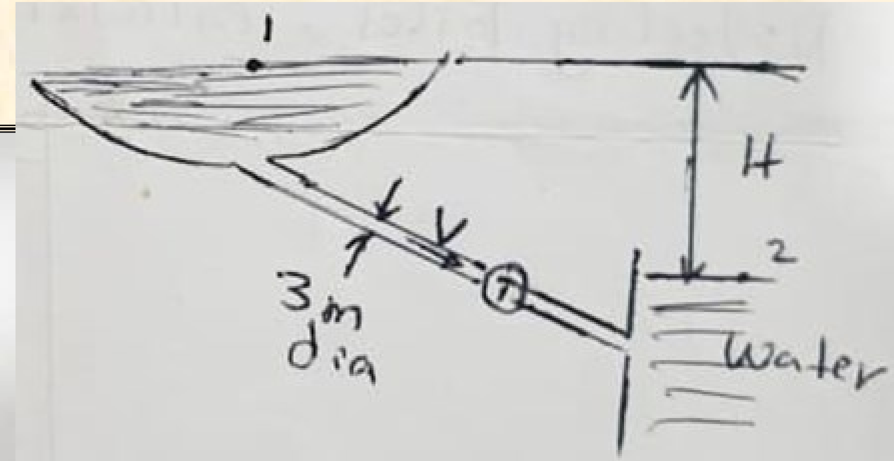
If the overall efficiency of the system and turbine in Fig is 80% what Power is Produced for $H = 60\ m$ and $Q = 30\ m^3/s$

Ans ($P = 14.126\ MW$)



Examples: Sheet No. 6

Sol. 4



Q4:-

$\eta_T = 80\%$

$P_{in} = ?$ $H = 60\,m$, $Q = 30\,\frac{m^3}{sec}$

B-E between 1 & 2

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

$h_T = 60\,m$

$P_{in} = \gamma Q h_T \Rightarrow P_{in} = 9.81 \times 30 \times 60 \Rightarrow P_{in} = 17.658\,MW$

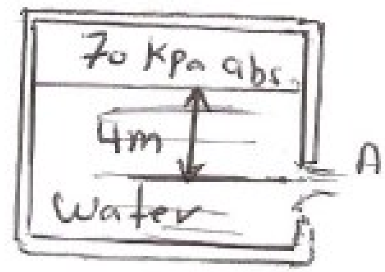
$\eta_T = \frac{P_{out}}{P_{in}} \Rightarrow P_{out} = 17.658 \times 0.8 \Rightarrow P_{out} = 14.126\,MW$

Homeworks:

H.w 1

For losses of 0.1 m.N/N. Find the velocity at A in Fig. Barometer reading is 750 mm Hg

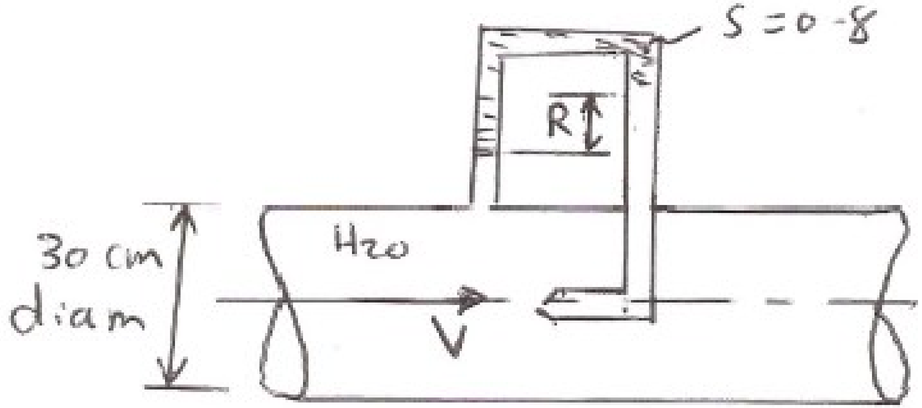
Ans (V_A = 4.064 m/s)



H.w 2

in Fig. determine V for R=22 cm

Ans (V = 0.92 m/s)



- Note: Solve all **two** Homeworks and sending me the answering next week on Monday 21 February 2024.

- I hope everything is clear for all students

- Good luck