	Alexandria Higher Institute of Engineering & Technology (AIET)		
	Mechatronic Department		3^{rd} Year
	EME312	Fluid Mechanics	Final, May, 20, 2015
	Examiners:	Dr. Rola Afify and committee	Time: 3 hours

Answer the following questions:

Question one (12 marks)

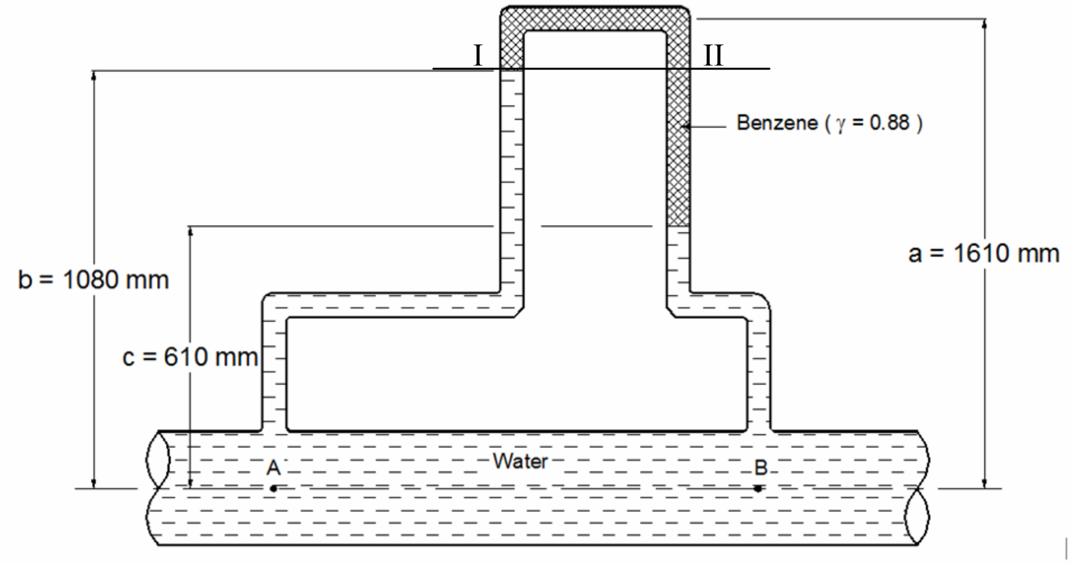
a) The pressure of a liquid, k = 2 x 10^9 N/m^2, increases from 1 bar to 100 bars at constant temperature. Find the corresponding change in fluid volume to its initial volume.

$$k = \frac{-\Delta P}{\left(\frac{\Delta V}{V_1}\right)} = \frac{-(P_2 - P_1)}{\left(\frac{\Delta V}{V_1}\right)}$$

$$2x10^9 = \frac{-(100-1)x10^5}{\left(\frac{\Delta V}{V_1}\right)}$$

$$\frac{\Delta V}{V_1} = \frac{-(100-1)x10^5}{2x10^9} = \frac{-99}{2000} = 4.95x10^{-3}$$

b) Consider a manometer connected as shown in Figure. Calculate the pressure difference between A and B.



$$P_I = P_{II}$$

$$P_A - \rho_w gc - \rho_w g(b-c) = P_B - \rho_w gc - \rho_B g(b-c)$$

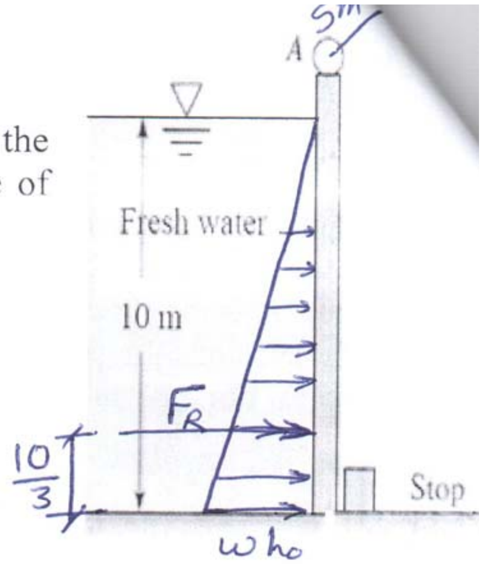
$$P_A - P_B = \rho_w gc + \rho_w g(b-c) - \rho_w gc - \rho_B g(b-c)$$

$$P_A - P_B = \rho_w g(b-c) - \rho_B g(b-c)$$

$$P_A - P_B = [\rho_w - \rho_B]g(b-c)$$

$$P_A - P_B = [1000-880]x9.8x(1080-610)x10^{-3} = 552.72Pa$$

c) Gate AB is 5 m wide into the paper. Determine the hydrostatic force acting on the gate and its line of action, using neat sketches.

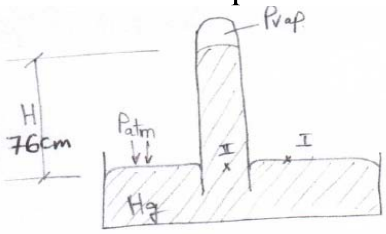


$$F_R = w h_o * \frac{h_o}{2} \times B$$
$$= 9800 * \frac{10^2}{2} * 5$$
$$= 2.45 * 10^6 \text{ Newton}$$

$F_R \perp$ gate and acts at $\frac{10}{3}$ from the bottom.

<u>Question two (12 marks)</u>

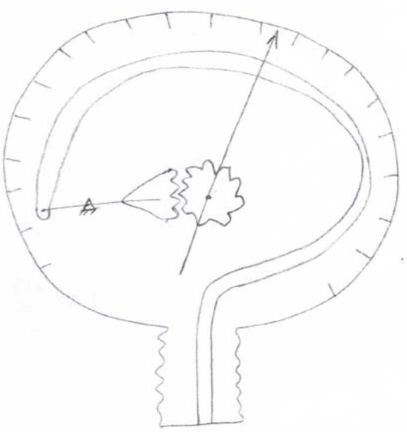
a) Compare between:
- Barometric pressure and Bourdon tube guage.



$$P_{vap\,Hg} = 1.7 * 10^{-5} \text{ bar}$$
$$= 1.7 \ \frac{N}{m^2} = 0$$
neglected

$$P_I = P_{II}$$
$$P_{atm} = P_{vap\,Hg} + \rho_m g H$$
$$= 13600 * 9.8 * 0.76$$
$$= 1.013 * 10^5 \ N/m^2$$
$$= 1.013 \text{ bar}$$

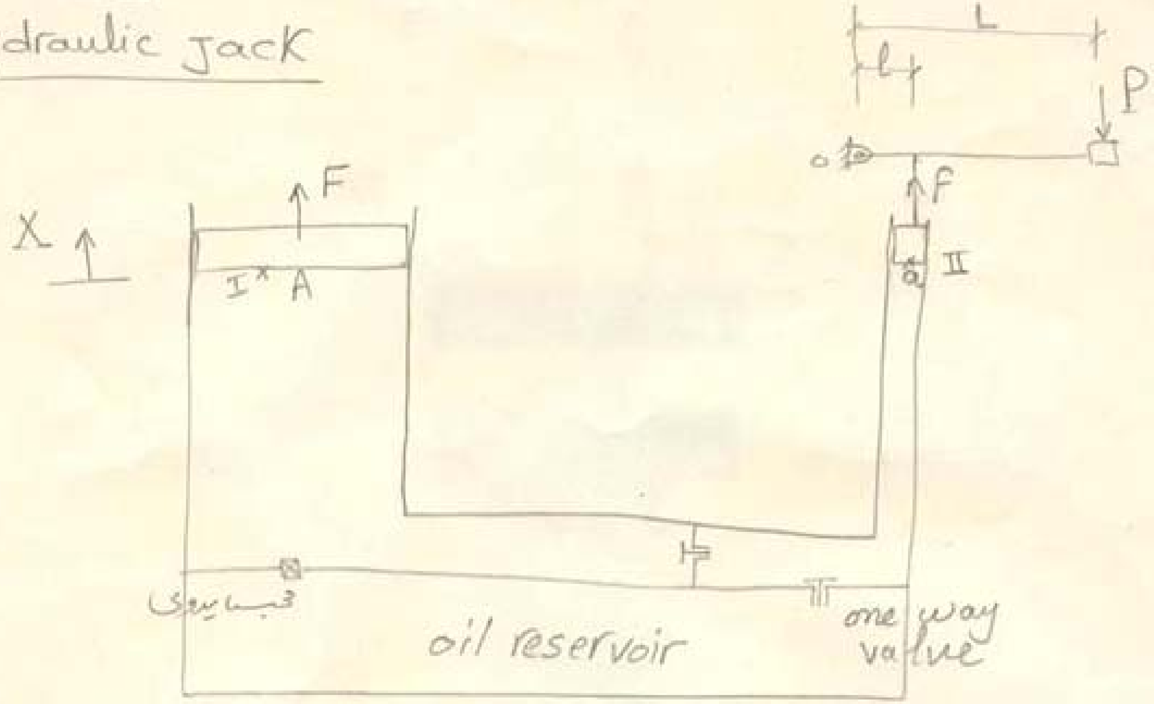
* Bourdon tube gauge



* For measuring pressur in almost all ranges except minutely small press
* Dis advantages
1- Needs calibration on dead weight tester.
2- acuracy is less tha liquid columns.

- Hydraulic jack and Hydraulic press.

① Hydraulic jack



$$P_{I} = P_{II}$$

$$\frac{F}{A} = \frac{f}{a} \qquad \therefore F = f\,\frac{A}{a} \longrightarrow ①$$

$$\Sigma M_o = 0$$

$$f\ell = PL \qquad \therefore f = \frac{PL}{\ell} \longrightarrow ②$$

from ① & ② $\boxed{F = P * \frac{L}{\ell} * \frac{A}{a}}$

n: no. of strockes to lift the load distance X

$$n = \frac{\text{total volume of oil}}{\text{volume / stroke}}$$

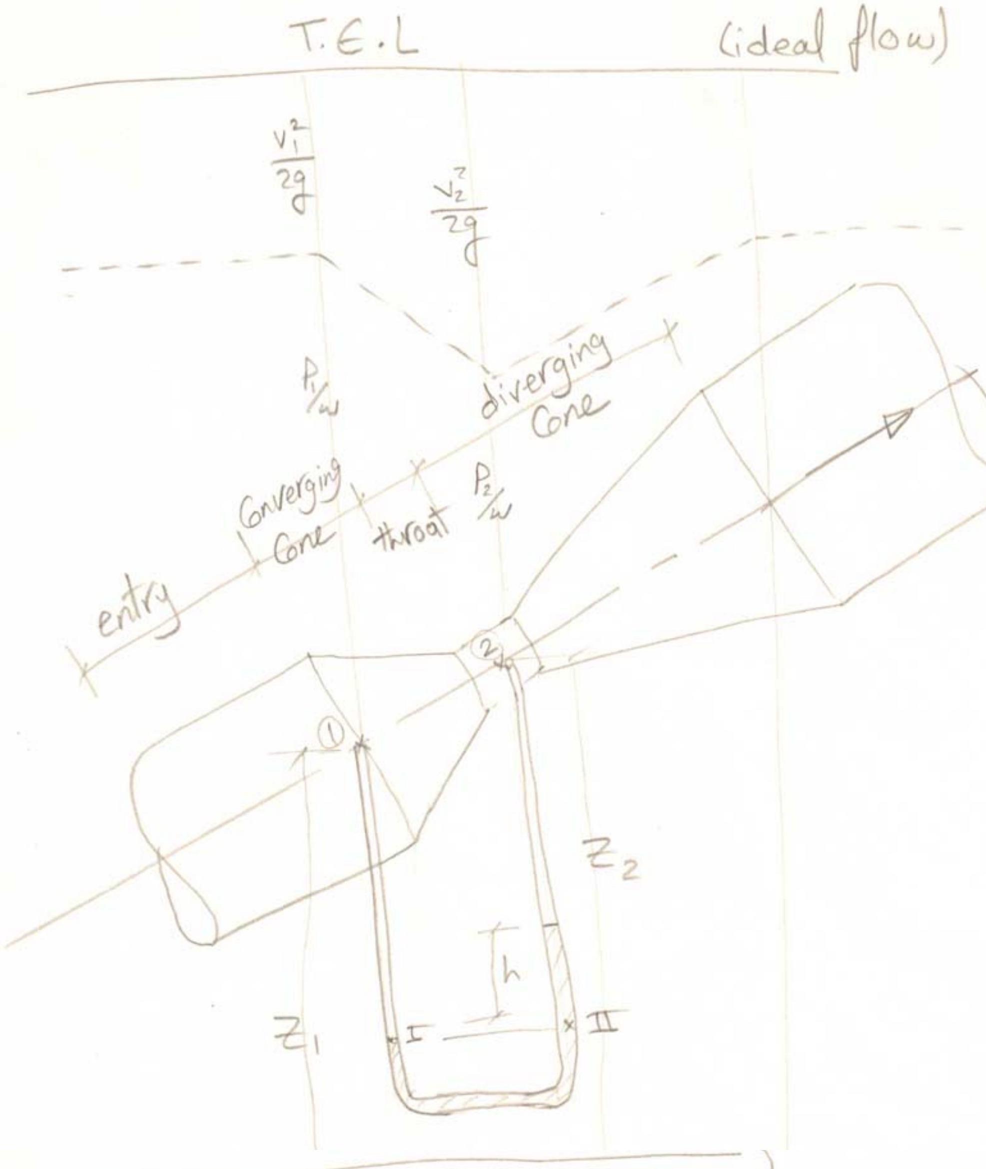
② Hydraulic press

$$\eta = \frac{o/p}{i/p} < 1 \qquad o/p = \frac{F * X}{t} \quad \text{watt}$$

$$i/p = \frac{o/p}{\eta} = \frac{F\ X}{t \cdot \eta}$$

- Venturi and Orifice meters.

principle of venturi meter

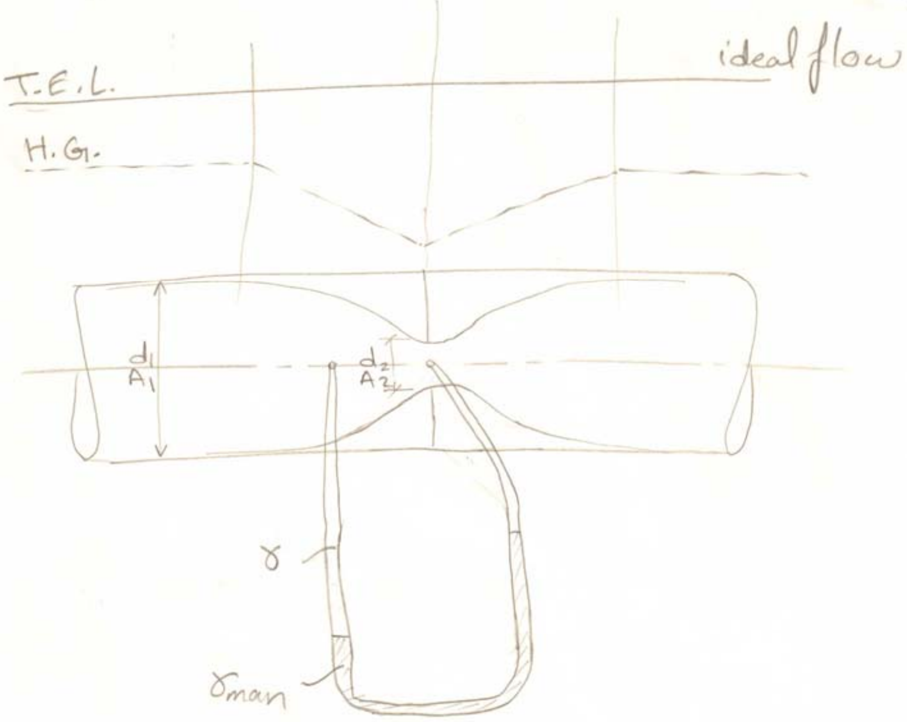


$$Q = A_1 V_1 = A_1 \sqrt{\frac{2gH}{m^2 - 1}}$$ theoretical discharge

$$Q_{actual} = C_d \, Q_{th} \qquad C_{dv} = 0.97$$

$$Q_{act} = C_d \, A_1 \sqrt{\frac{2gh\left(\frac{\rho_{man}}{\rho} - 1\right)}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$

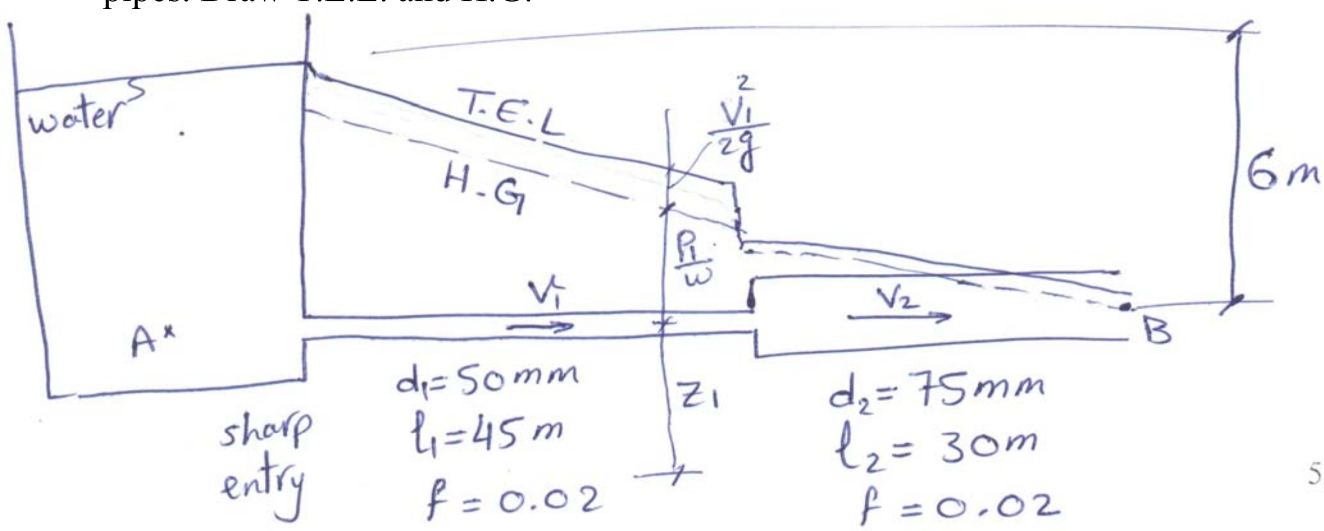
③ pipe orifices



$$Q_{act.} = C_d \, A_1 \sqrt{\frac{2gh\left(\frac{\gamma_{man}}{\gamma} - 1\right)}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$

$C_{d_o} = 0.65$

b) Water discharged from a large tank into atmosphere through a pipe of 50 mm diameter and 45 m long which is sharp at entry, after which there is a sudden enlargement to a pipe of 75 mm diameter, 30 m long. The point of delivery is 6 m below the surface water in the tank. Determine the discharge in m^3/sec. Assume that 'f' = 0.02 for both pipes. Draw T.E.L. and H.G.



$Q = ??\ m^3/sec$

$$Q = A_1 V_1 = A_2 V_2 \quad \therefore V_1 = \frac{A_2}{A_1} V_2 = \left(\frac{d_2}{d_1}\right)^2 V_2 = \frac{9}{4} V_2 \longrightarrow (1)$$

$$\frac{P_A}{w} + Z_A + \frac{V_A^2}{2g} = \frac{P_B}{w} + Z_B + \frac{V_B^2}{2g} + h_{loss\ A\to B}$$

$V_A \to 0$ vel. in tank; $P_B \to = 0$ atm

same horizontal level

$V_2 = V_B$

$$6 - h_{loss\ A\to B} = \frac{V_B^2}{2g} \longrightarrow (2)$$

$$h_{loss\ A\to B} = 0.5 \frac{V_1^2}{2g} + f \frac{l_1}{d_1} \frac{V_1^2}{2g} + 1 \frac{(V_1 - V_2)^2}{2g} + f \frac{l_2}{d_2} \frac{V_2^2}{2g}$$

$$= 0.5 \frac{\left(\frac{9}{4}\right)^2 V_2^2}{2g} + 0.02 * \frac{45}{50*10^{-3}} * \frac{\left(\frac{9}{4}\right)^2 V_2^2}{2g} +$$

$$\frac{\left(\frac{9}{4} V_2 - V_2\right)^2}{2g} + 0.02 * \frac{30}{75*10^{-3}} * \frac{V_2^2}{2g}$$

$$= \frac{V_2^2}{2g} \left[\frac{81}{2*16} + \frac{0.02*45*81}{50*10^{-3}*16} + \frac{81}{16} + \frac{25}{16} + \frac{0.02*30}{75*10^{-3}} \right]$$

$$= \frac{V_2^2}{2g} * 108.28$$

sub. in (2)

$$\frac{V_2^2}{2g} + \frac{V_2^2}{2g} * 108.28 = 6$$

$$\therefore V_2 = 1.037 \ m/sec$$

$$Q = A_2 V_2 = \frac{\pi}{4} d_2^2 V_2$$

$$= \frac{\pi}{4} (75*10^{-3})^2 * 1.037 = 4.583*10^{-3} \ m^3/se$$

$$= 4.583 \ lit/sec$$

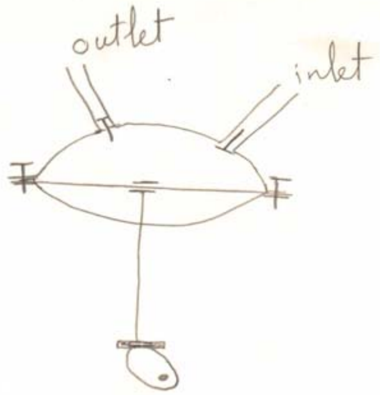
Question Three (12 marks)

a) Compare between Diaphram and Gear pumps.

ii) Diaphram pump

disadvantages

- very low pressure
- low discharge



b) Rotary pumps

i) Gear pump

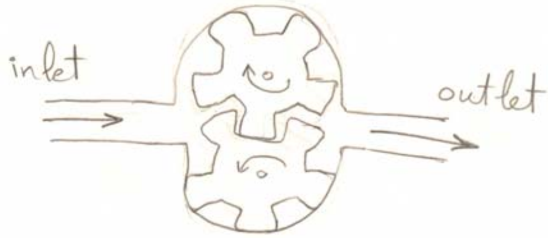
$Q = \eta_{vol} * 2n(a*l)\frac{N}{60}$

n = no. of teeth

l = gear length

a = area between two teeth

N = rpm



* This pump is only used for oil.
* One of the cheapest pumps.
* High pressure but low discharge.

b) A gear pump of volumetric and mechanical efficiencies are 95% and 80%, respectively, rotates at 1200 rpm. The gear is 6 cm diameter and 4 cm thick. The pump is working against head 22 m of water, area between teeth equals 1.655 cm^2 and each gear has five teeth. Calculate the power of the electric motor.

$\eta_{vol} = 0.95$

$\eta_m = 0.8$

$N = 1200$ rpm $\quad d = 6$ cm, $l = 4$ cm $\quad h_{st} = 22$ m

$a = 1.655$ cm^2 $\quad n = 5$ teeth $\quad$ power = ??

Soln

$$\text{shaft power} = \frac{\omega Q_{act} h}{\eta_m}$$

$$= \frac{9800 * Q_{act} * 22}{0.8} \longrightarrow (1)$$

$$Q_{act} = \eta_{vol} * z n a l * \frac{N}{60}$$

$$= 0.95 * 2 * 5 * 1.655 * 10^{-4} * 4 * 10^{-2} * \frac{1200}{60}$$

$$= 1.2578 * 10^{-3} \; m^3/sec$$

sub. in ①

sh. power = 338.9771 watt

<u>Question Four (12 marks)</u>

a) Explain how to discover cavitation in the installed pumps.

* إذا وصل ضغط السائل داخل المضخة أو قبلها (في ماسورة السحب).
إلى ضغط البخار يتحول جزء من السائل إلى بخار

* يبدء ضغط السائل في الارتفاع داخل المضخة إلى ضغط أكبر من ضغط
البخار الذي يتكثف على الجدران و يندفع السائل حول الفقاعات ليصطدم
بالأجزاء الداخلية بالمضخة مسببا ما يلي :-

① صوت طرقات متتالية
② اهتزازات ميكانيكية
③ انخفاض في كفاءة عمل المضخة والتصرف والضغط
④ يتحول السائل الخارج من المضخة إلى لون جيري (milky Glor)

* تكرار هذه الظاهرة تحدث تآكل في المضخة بما يشبه تسوس الأسنان

b) A centrifugal pump, running at 2140 rpm with water at 20°C, produces the following performance data:

Q, m3/s	0.00	0.05	0.10	0.15	0.20	0.25	0.30
H, m	105	104	102	100	95	85	67
Power, kW	#####	115	135	171	202	228	249

i. Determine the best efficiency point.
ii. Determine the mechanical losses.
iii. Determine the maximum discharge obtained when this pump is used in a 2 in. pipe 100 m long having 2 bends k = 0.8), static head = 20 m and f = 0.01.

and f = 0.01.

$$sh.\ power = \frac{wQH}{\eta} \qquad \therefore \eta = \frac{wQH}{sh.\ power}$$

From the next table

ⓘ $\eta_{m_{max}} = 92\%$ at $Q = 0.2 \; m^3/se$

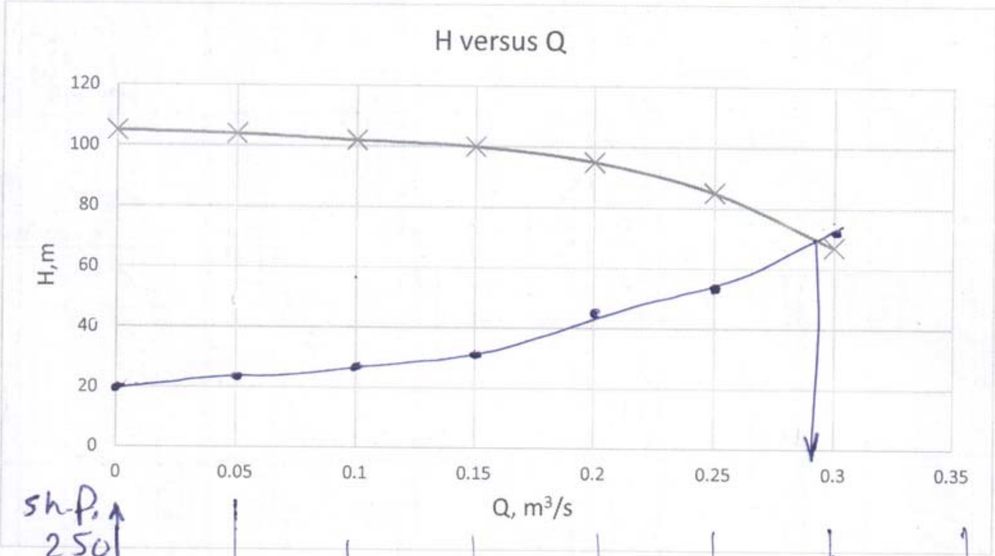
(ii) from sh. power graph
mechanical losses = 100 KW

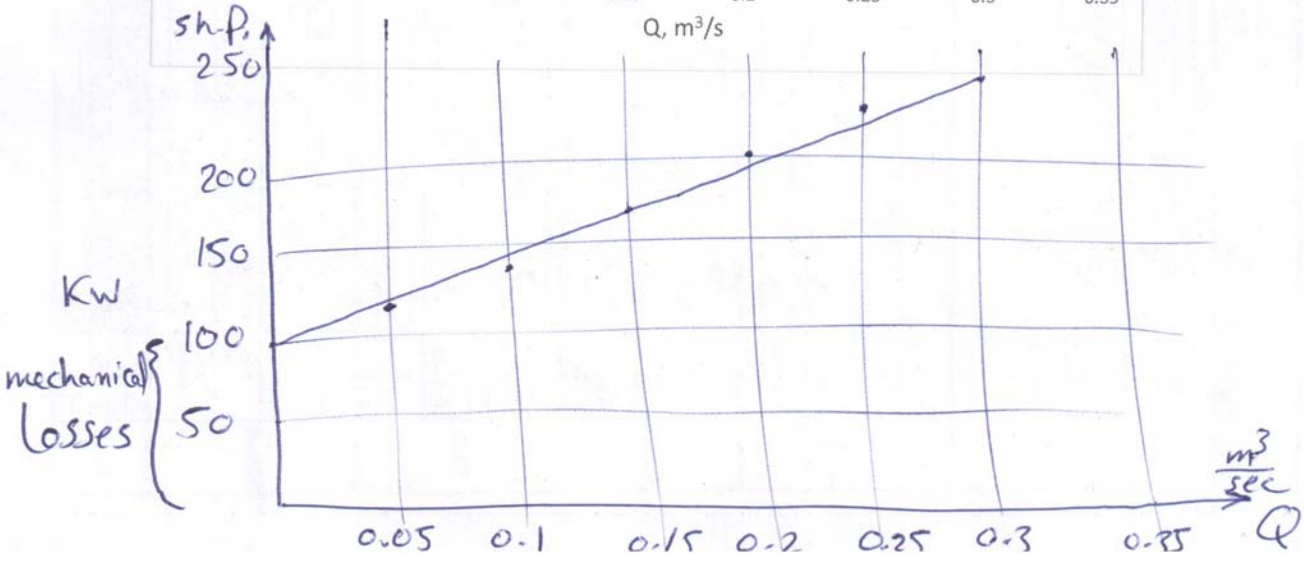
(iii) $Q_{max} = ??$ $d = 2'' * \frac{2.54}{100} = 0.05\ m$ $l = 100\ m$

2 bends $K = 0.8$ $h_{st} = 20\,m$ $f = 0.01$

$$h_{piping} = h_{st} + h_{loss\ total} + \frac{V^2}{2g}$$

Q, m^3/s	0.0	0.05	0.10	0.15	0.20	0.25	0.30
H, m	105	104	102	100	95	85	67
P, kW		115	135	171	202	228	249
η (%)	0	44	74	86	***92***	91	79
h piping	20	49.36	25.87	33.2	43.49	56.7	72.85





$$h_{piping} = 20 + f\frac{l}{d}\frac{V^2}{2g} + 2K\frac{V^2}{2g} + \frac{V^2}{2g}$$

$$= 20 + \frac{Q^2}{2*9.8} * \frac{1}{\left[\frac{\pi}{4}(0.05)^2\right]^2}\left[0.01 * \frac{100}{0.05} + 2*0.8 + 1\right]$$

$$\boxed{h_{piping} = 20 + 587.25\,Q^2}$$

max. discharge

من الرسم

$Q_{max} = 0.29 \; m^3/sec$

Question Five (12 marks)

a) Write the functions of:-

i. Oil.

1. transmit power
2. lubricate moving parts
3. seal clearances between mating parts.
4. dissipate heat
5. prevent Corrosion

ii. Valves.

1. protect the Components of the circuit
2. Control oil direction.
3. Control pressure
4. Control discharge.

iii. Actuators.

They transfer Hydraulic energy into mechanical energy

They Contains two types.

1. Hydraulic motors

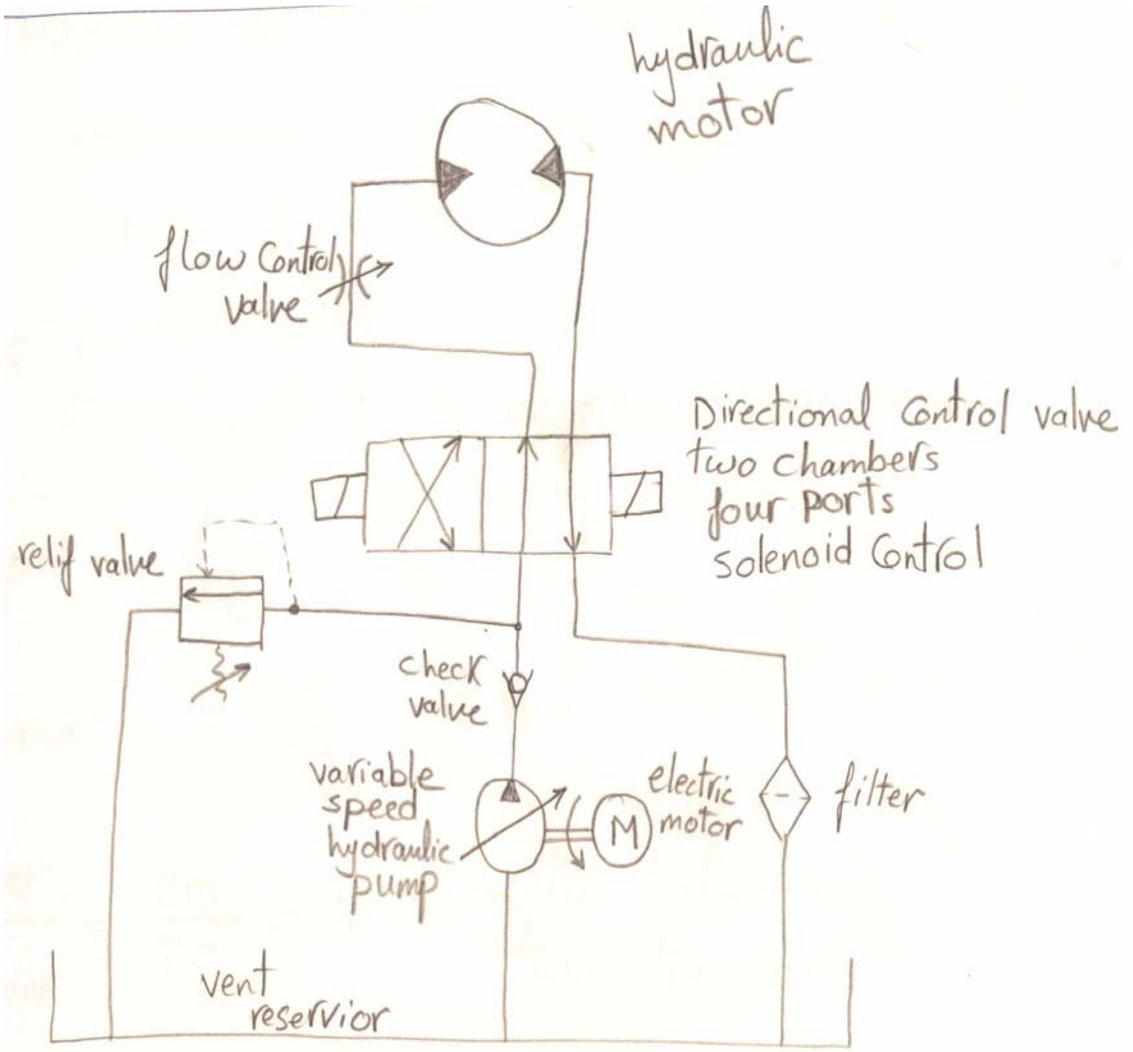
   hydraulic energy ⟶ rotation motion

2. Hydraulic cylinders

   Hydraulic energy ⟶ translation motion

b) Draw a complete hydraulic circuit used to rotate a hydraulic motor with a controllable velocity. This circuit contains:-

i. Vented reservoir. ii. Variable speed Hydraulic pump.
iii. Electric motor. iv. Filter. v. Check valve
vi. Relief valve. vii. Flow control valve. viii. Hydraulic motor.
ix. Directional control valve two chambers four ports using solenoid control.



Dr. Rola Afify