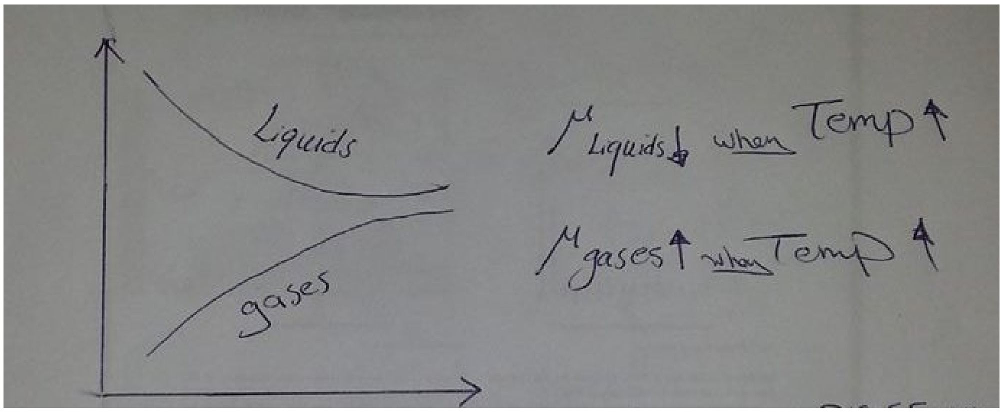
Alexandria Higher Institute of Engineering & Technology (AIET)			
Industrial Department		2nd Year	
ME251	Fluid Mechanics	Final, End-of-Semester-3 Exam, Aug., 17, 2013	
Examiners:	Dr. Rola Afify and committee		Time: 3 hours

Answer the following questions:

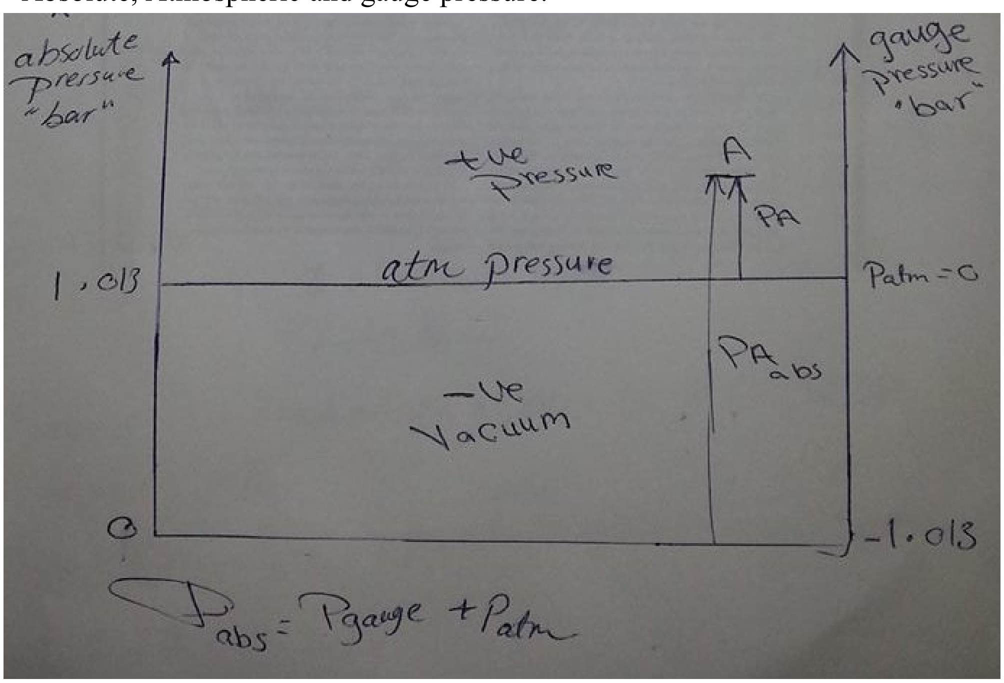
Question one (12 marks)

a) Discuss the relation between:

- Viscosity and Temperature for a certain fluid.



- Absolute, Atmospheric and gauge pressure.



b) The pressure of 1 m^3 of a fluid is increased 10 to 20 bar at a constant temperature, calculate the final volume of the fluid in the following cases:-

a. The fluid is an ideal gas.

b. The fluid is water ($k = 2 \times 10^9$ N/m^2).

Use the results to explain the main difference between liquids and gases.

b) $V_1 = 1 m^3$; $P_1 = 10$ bar ; $P_2 = 20$ bar ; $T \rightarrow$ Constant

Req: V_2 = ?!

—Soln—

i) Ideal gas

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$\because$ T is constant $\Rightarrow$ $P_1 V_1 = P_2 V_2$

$$V_2 = \frac{P_1 V_1}{P_2} = \frac{10 * 1}{20} = \frac{1}{2} m^3.$$

ii) water, $K = 2 * 10^9 \ N/m^2$

$$K = -\frac{P_2 - P_1}{\left(\frac{V_2 - V_1}{V_1}\right)} = -\frac{(20-10) * 10^5}{\left(\frac{V_2 - 1}{1}\right)}$$

$$V_2 - 1 = \frac{-10 * 10^5}{2 * 10^9} = -5 * 10^{-4}$$

$$V_2 = 1 - 5 * 10^{-4} = 0.9995 m^3$$

From Results:→ * Water is an Incompressible fluid

* Ideal gas is a Compressible fluid

Question two (12 marks)

a) A diver is working at a depth of 18 m under sea water surface; calculate the pressure at this depth in gauge and absolute values if the specific gravity of sea water is 1.02.

* $P_{gauge} = wh = \gamma_w h = 1.02 * 9800 * 18 = 179928 Pa$

$P_{gauge} \doteqdot 1.8$ bar

* $P_{abs} = P_{gauge} + P_{atm} = 1.8 * 10^5 + 1.013 * 10^5 = 281228 Pa$

$\cong 2.8$ bar abs.

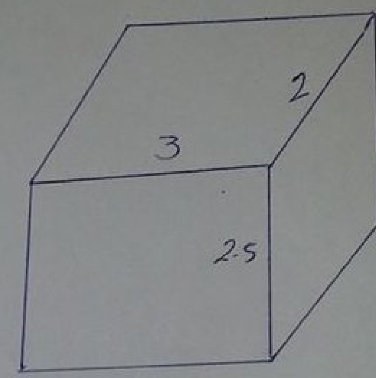
b) A rectangular tank (3 m long, 2 m wide, and 2.5 m high) contains oil of specific gravity $\gamma = 0.9$. Calculate the magnitude, direction, and line of action of the pressure force on the following:

a. The sides of the tank.

b. The tank's bottom.

Req :- $F_{sides} = ?!$ $F_{bottom} = ?!$

Soln

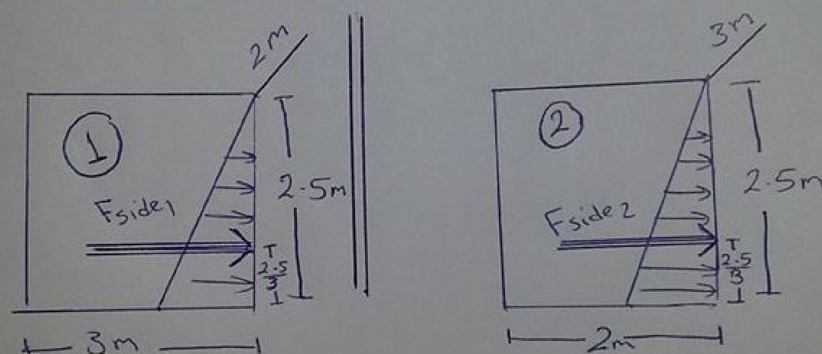


$W_{oil} = \gamma_{oil} * W_{\omega}$

$W_{oil} = 0.9 * 9800$

$W_{oil} = 8820\ N/m^3$

* To get F_{sides}



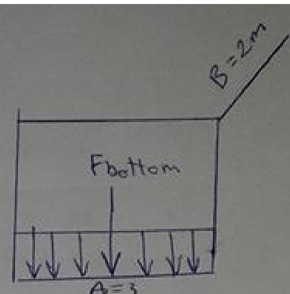
$F_{side} = W_{oil} h * \frac{h}{2} * B$

$F_{side_1} = 8820 * 2.5 * \frac{2.5}{2} * 2 = 55,125$ Newton

$F_{side_2} = 8820 * 2.5 * \frac{2.5}{2} * 3 = 82,687.5$ Newton

Both of Fside1 & Fside 2 acting ⊥ to the surface and at $\frac{2.5m}{3}$ From the Bottom.

* To get F_{bottom} :



$F_{bottom} = w h * A * B$

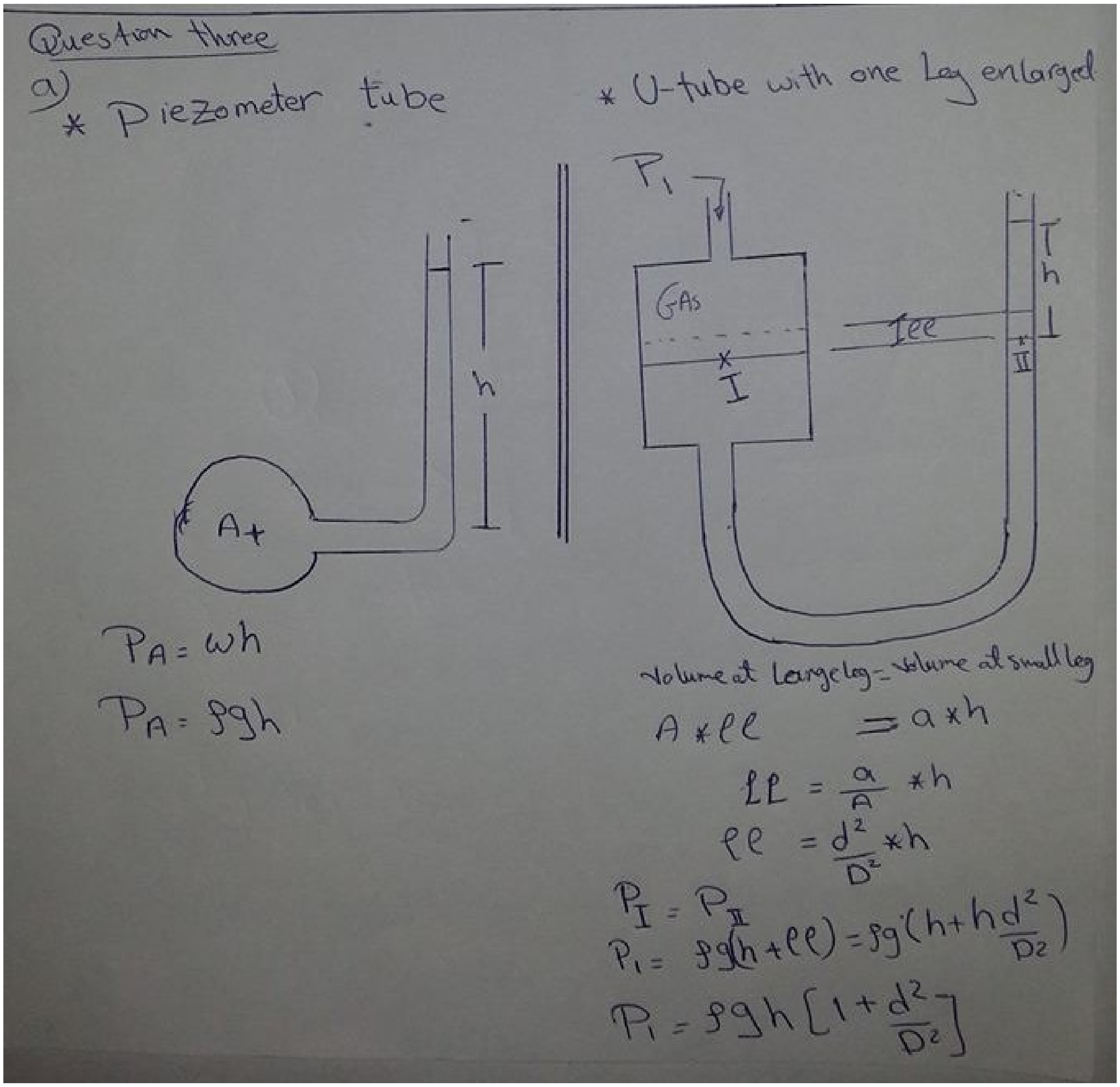
$= 8820 * 2.5 * 2 * 3$

$= 132,300$ Newton

F_{bottom} acts at the center of the surface and ⊥ on it.

Question three (12 marks)

a) Compare between Piezometer tube and U-tube with one leg enlarged.



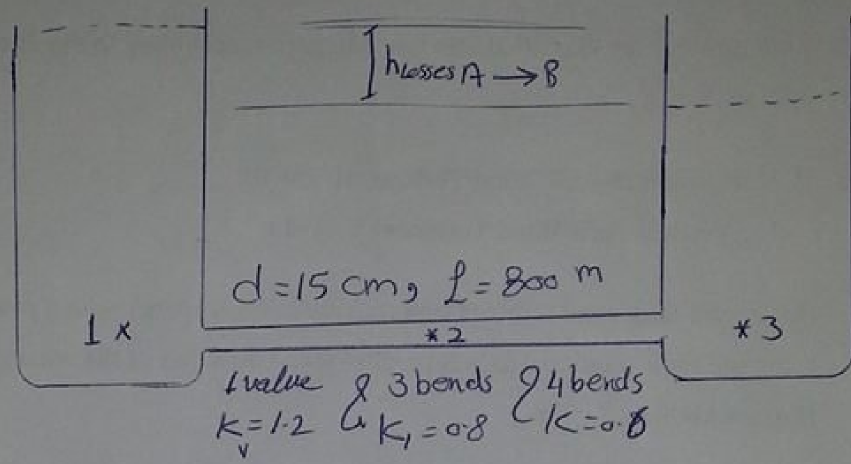
b) Two water tanks A and B are connected with a cast iron pipe (ε = 0.25 mm) 15 cm diameter and 800 m long has a coefficient of friction (f = 0.025). Along the pipe, there are a fully opened gate valve (k = 1.2), three 45^{o} bends (k for each= 0.8) and four 45^{o} bends (k for each= 0.6).

For sudden contraction k = 0.5 and enlargement k = 1.0.

i. Find the difference in levels between water surfaces in two tanks, so that a discharge of 60 lit/s flows from tank A to tank B.

ii. If the valve is partially closed to reduce the discharge to 60% of its initial value, keeping the same difference in levels, what will be the head lost in the value.

b)



I) $Q = 60$ Litre/sec $= 60$ m³/sec

$$Q = A_2 V_2 = 60 * 10^{-3}$$

$$\frac{\pi}{4} * (0.15)^2 V_2 = 60 * 10^{-3}$$

$$V_2 = 3.4 \text{ m/sec}$$

$$h_{\text{losses } A \to B} = h_{\text{sudden Contraction}} + h_{\text{friction}} + h_{\text{valve}} + 3 h_{\text{bend}①} + 4 h_{\text{bend}} + h_{\text{sudden Enlargement}}$$

$$= 0.5 \frac{v_2^2}{2g} + f \frac{L}{d} \frac{v_2^2}{2g} + K_v \frac{v_2^2}{2g}$$

$$+ 3 K_{bend_1} \frac{v_2^2}{2g} + 4 K_{bend_2} \frac{v^2}{2g} + 1 * \frac{v_2^2}{2g}$$

$$h_{Losses\,A\to B} = \frac{V^2}{2g}\left[0.5 + \frac{0.025*800}{0.15} + 1.2 + 3*0.8 + 4*0.6 + 1\right]$$

$$h_{Losses\,A\to B} = \frac{(3.4)^2}{2*9.8} * 140.3$$

$$h_{Losses\,A\to B} \cong 83 \text{ m}$$

So the difference in level betw water surface In two tanks is 83 m

(ii) $Q_{new} = 0.6\,Q \Rightarrow A\,V_{new} = 0.6\,A\,V$

$V_{new} = 0.6 * 3.4 = 2.04 \text{ m/sec}$

Req: $h_{Loss\,Value} = ?!$

$$83 = h_{Losses\,A\to B} = \frac{0.5\,V_{new}^2}{2g} + \frac{fL}{d}\frac{V_{new}^2}{2g} + h_{Loss\,Value} + 3*0.8\frac{V_{new}^2}{2g} + 4*0.6*\frac{V_{new}^2}{2g} + 1*\frac{V_{new}^2}{2g}$$

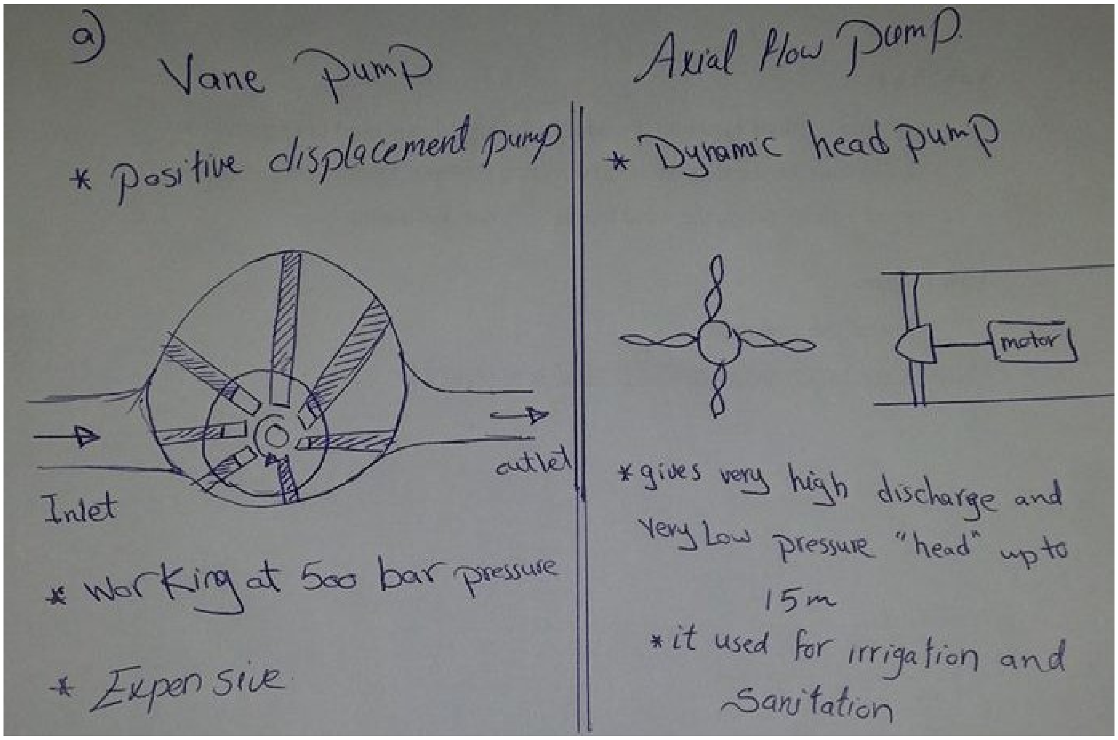
$$h_{Loss\,Value} = 83 - \frac{(2.04)^2}{2g}\left[0.5 + \frac{0.025*800}{0.15} + 3*0.8 + 4*0.6 + 1\right]$$

$$= 83 - 29.6$$

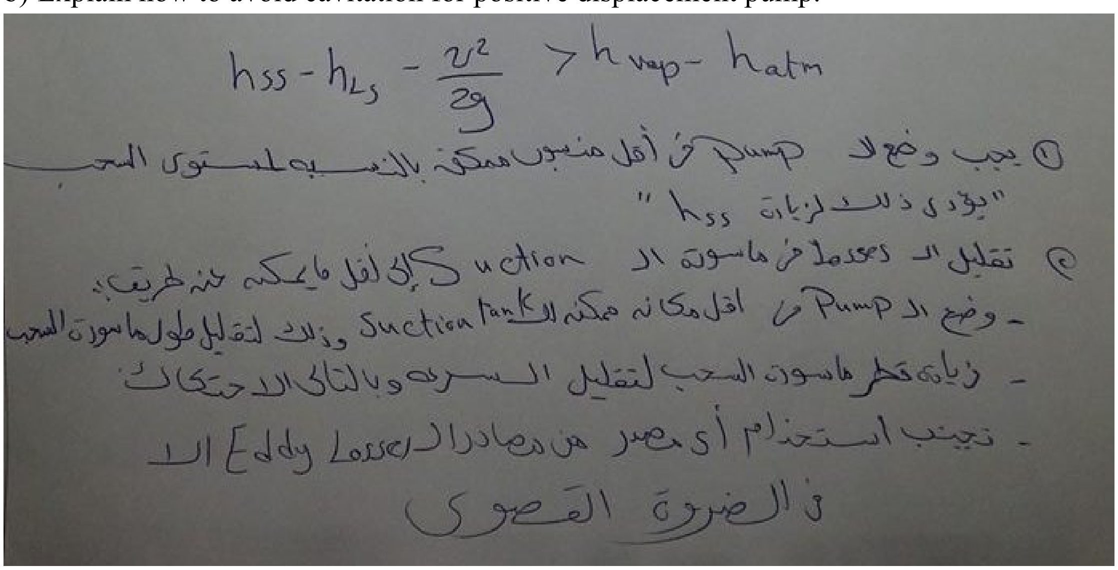
$$h_{Loss\,Value} = 53.4 \text{ m}$$

Question Four (12 marks)

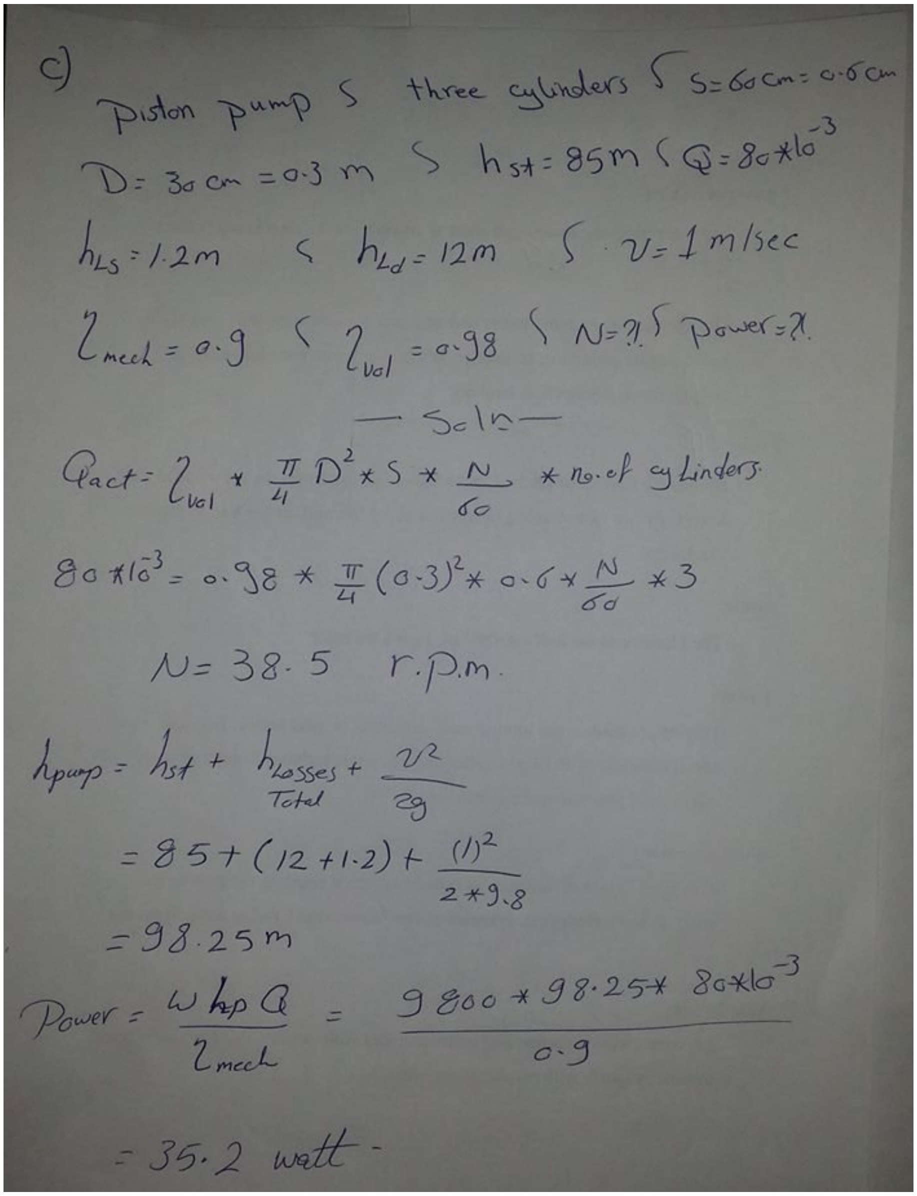
a) Compare between vane pump and axial flow pump.



b) Explain how to avoid cavitation for positive displacement pump.



c) A three cylinders piston pump, having ram 30 cm diameter by 60 cm stroke, is required to lift 80 liter of water per second against a static head of 85 m. The friction loss in the suction pipe is 1.2 m and in delivery pipe is 12 m. The water velocity is 1 m/s. The mechanical efficiency of the pump (η_m) is 90% and the volumetric efficiency (η_{vol}) is 98%. Calculate the speed at which the pump should run and the power required to drive it.



c)

Piston pump ; three cylinders ; $S = 60\ cm = 0.6\ cm$

$D = 30\ cm = 0.3\ m$; $h_{st} = 85\ m$; $Q = 80 * 10^{-3}$

$h_{Ls} = 1.2\ m$; $h_{Ld} = 12\ m$; $v = 1\ m/sec$

$\eta_{mech} = 0.9$; $\eta_{vol} = 0.98$; $N = ??$; $Power = ?$

— Soln —

$$Q_{act} = \eta_{vol} * \frac{\pi}{4} D^2 * S * \frac{N}{60} * \text{no. of cylinders}$$

$$80 * 10^{-3} = 0.98 * \frac{\pi}{4} (0.3)^2 * 0.6 * \frac{N}{60} * 3$$

$$N = 38.5\ r.p.m.$$

$$h_{pump} = h_{st} + h_{losses\ Total} + \frac{v^2}{2g}$$

$$= 85 + (12 + 1.2) + \frac{(1)^2}{2 * 9.8}$$

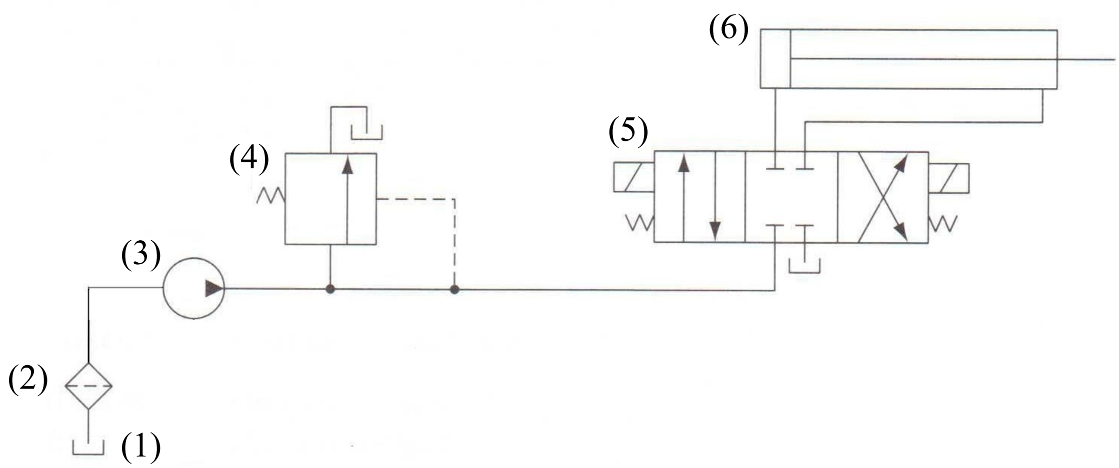
$$= 98.25\ m$$

$$Power = \frac{w\ h_p\ Q}{\eta_{mech}} = \frac{9800 * 98.25 * 80 * 10^{-3}}{0.9}$$

$$= 35.2\ watt$$

Question Five (12 marks)

For the hydraulic circuit shown in figure:-



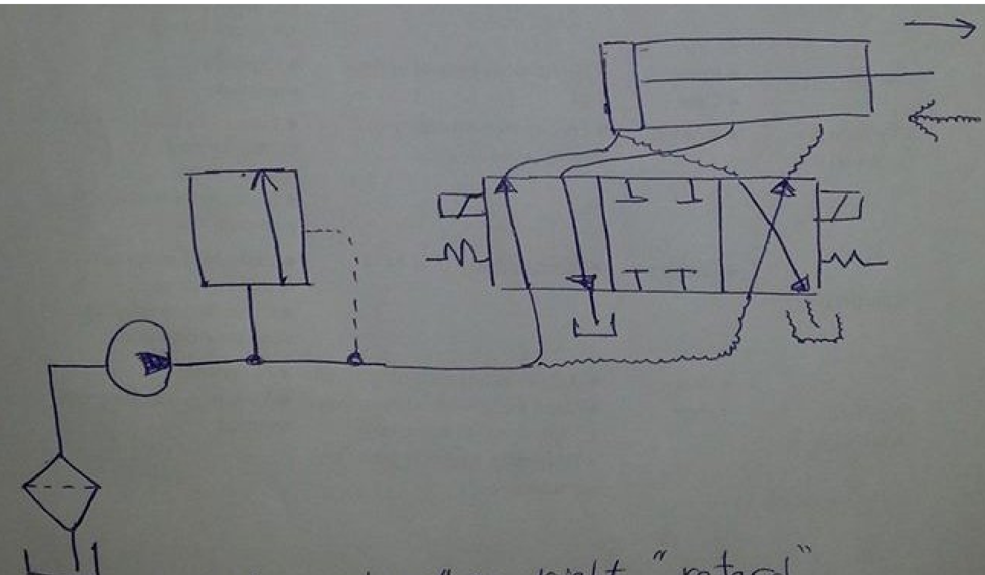
a) Write the name of each component.

[a]
1) Vented tank
2) Filter
3) Single Fixed displacement pump.
4) relief valve
5) directional Control Valve, three positions, Four ports, Solenoid Control, Spring Centered.
6) Double acting - differential Cylinder.

b) What will happen to (6) when:-

i- the left solenoid in (5) is activated (draw the circuit).

ii- the right solenoid in (5) is activated (use different pen in the previous drawing).



i) Cylinder rod will go right "retard"

ii) Cylinder rod will go left "Extend"

Dr. Rola Afify