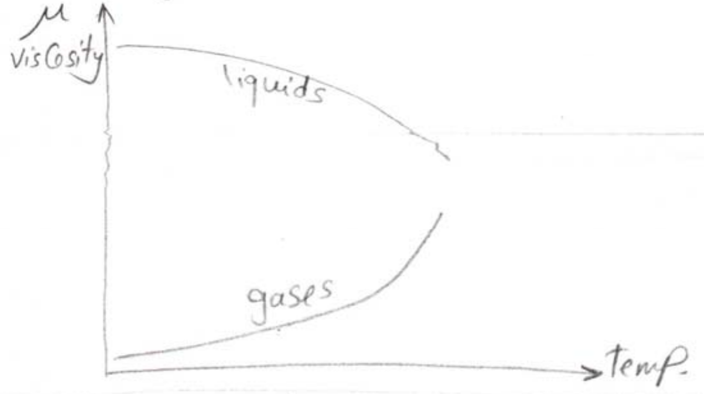
Alexandria Higher Institute of Engineering & Technology (AIET)		
Mechatronic Department		3rd Year
EME312	Fluid Mechanics	Final, June, 14, 2014
Examiners:	Dr. Rola Afify and Dr. Mohamed Zena	Time: 3 hours

Answer the following questions:

Question one (12 marks)

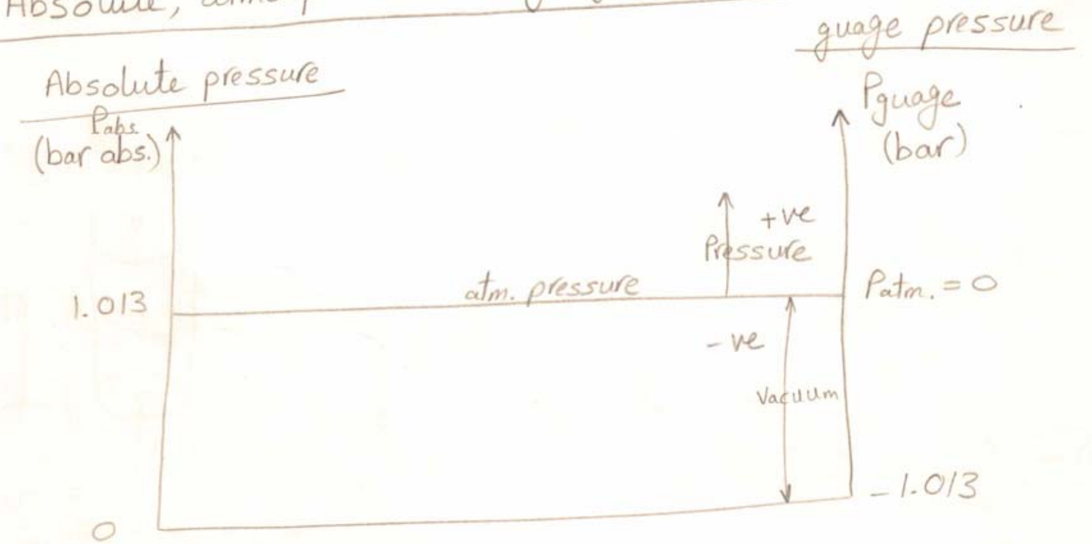
a) Discuss the relation between:
- Viscosity and Temperature for a certain fluid.

* Relation between visCosity and temperature for a certain fluid.



- Absolute, Atmospheric and gauge pressure.

* Absolute, atmospheric and guage pressure



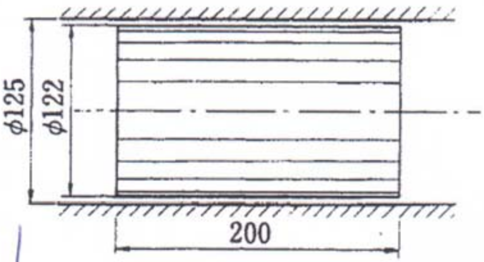
Absolute pressure = true pressure

$$\boxed{P_{abs.} = P_{guage} + P_{atm.}}$$

d L

F=??

b) A cylinder of diameter 122 mm and length 200 mm, shown in figure, is placed D inside a concentric long pipe of diameter 125 mm. An oil film is introduced in the gab between the pipe and the cylinder. What force is necessary to move the cylinder at a velocity of 1 u m/s? Assume that the dynamic viscosity of oil is 0.728 μ Pa.s and the specific gravity is 0.9.γ



$$F = \mu A \frac{du}{dy}$$

$$= 0.728 * 0.0767 * \frac{1}{0.0015}$$

$$= 37.07 \text{ Newton}$$

$$A = \pi d L$$

$$= \pi * 0.122 * 0.2$$

$$= 0.0767 \, m^2$$

$$\boxed{\begin{aligned} \gamma &= \frac{\rho}{\rho_w} \\ \rho &= \gamma \rho_w \end{aligned}}$$

$$y = \frac{D-d}{2}$$

$$= \frac{0.125 - 0.122}{2}$$

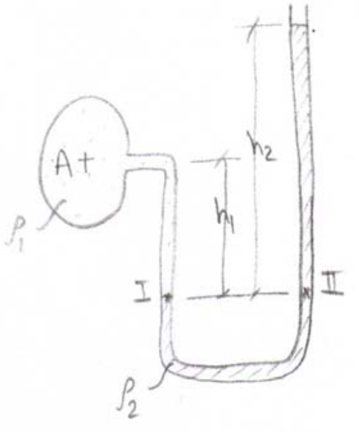
$$= 0.0015 \, m$$

Question two (12 marks)

a) Differentiate between:-

1. U-tube and Inverted U-tube manometers.

* U- tube manometer



* to make pressure equivalence

① still liquid

② Continued liquid

③ same liquid

$$P_I = P_{II}$$

$$P_A + \rho_1 g h_1 = \rho_2 g h_2$$

*B

2. Piezometer tube and U-tube with one leg enlarged.

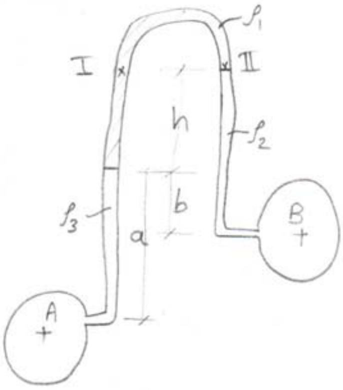
*Inverted U-tube

$$P_I = P_{II}$$

$$P_A - \rho_3 g a - \rho_1 g h = P_B - \rho_2 g (h+b)$$

$$P_A - P_B = \rho_3 g a + \rho_1 g h - \rho_2 g (h+b)$$

$\Delta P =$



b) 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.

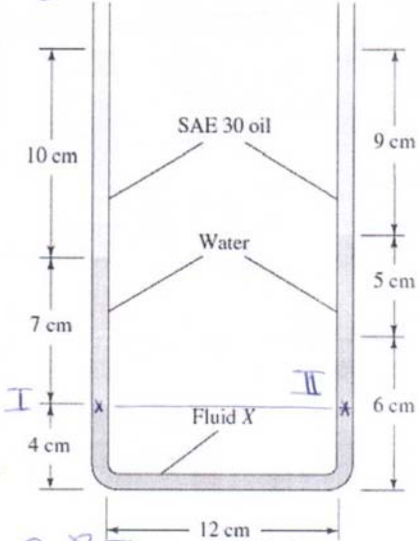
sea water is 1.02.

$$P = wh = \gamma \rho g h$$

$$= 1.02 * 1000 * 9.8 * 18 = 179928 \ Pa = 1.8 \ bar$$

$$P_{abs} = P + P_{atm} = 1.8 + 1.013 = 2.813 \ bar \ abs$$

c) In Figure, both ends of the manometer are open to the atmosphere. If the specific gravity of SAE 30 oil is 0.85 estimate the specific gravity of fluid X.



$$P_I = P_{II}$$

$$\cancel{\rho_w g} * 0.07 + 0.85 \cancel{\rho_w g} * 0.1 =$$

$$X \cancel{\rho_w g} * 0.02 + \cancel{\rho_w g} * 0.05 + 0.85 * \cancel{\rho_w g} * 0.09$$

$$0.07 + 0.085 = 0.02 X + 0.05 + 0.85 * 0.09$$

$$0.155 = 0.02 X + 0.1265$$

$$0.0285 = 0.02 X$$

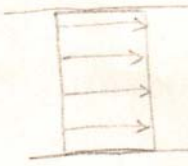
$$\therefore X = 1.425$$

Question three (12 marks)

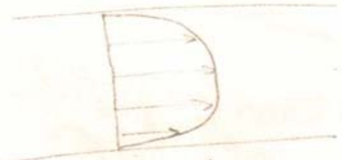
a) Differentiate between:-

i. Ideal and Real flow.

① Ideal and real flow



Ideal flow



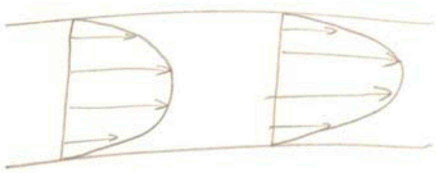
Real flow

* Ideal flow: means frictionless flow, no energy is lost, the viscosity is Considered zero.

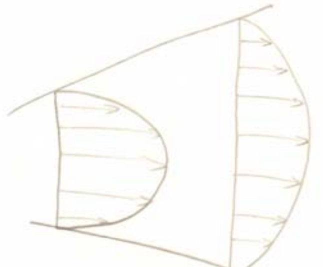
* Real flow: viscosity Can't be neglected, there is friction. Friction Causes some of the mechanical energy to be Converted into heat energy & Can't be restored.

ii. Uniform flow and Non-Uniform flow

③ uniform and non-uniform flow [from point to point]



uniform flow



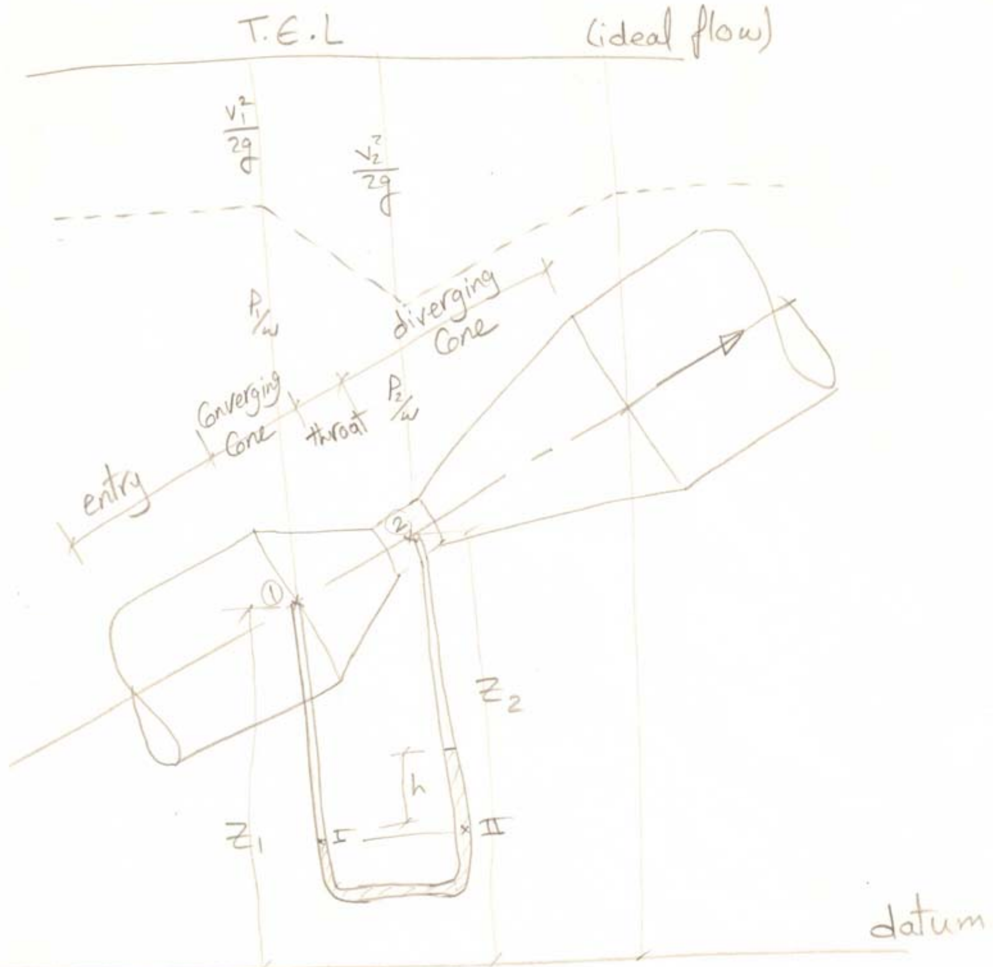
non-uniform flow

* uniform flow: The velocity at a given instant is the same in magnitude and direction at every point in the fluid.

* non-uniform flow: The velocity at a given instant changes from point to point.

iii. Venturi and Orifice meters.

② principle of venturi meter



$$V_1 = \sqrt{\frac{2g\left[(Z_1 - Z_2) + \frac{P_1 - P_2}{w}\right]}{\left(\frac{A_1}{A_2}\right)^2 - 1}} = \sqrt{\frac{2gH}{m^2 - 1}}$$

$$\boxed{\begin{array}{l} Q = A_1 V_1 = A_1 \sqrt{\frac{2gH}{m^2-1}} \\ Q_{actual} = C_d \, Q_{th} \qquad C_{dv} = 0.97 \end{array}}$$

theoretical discharge

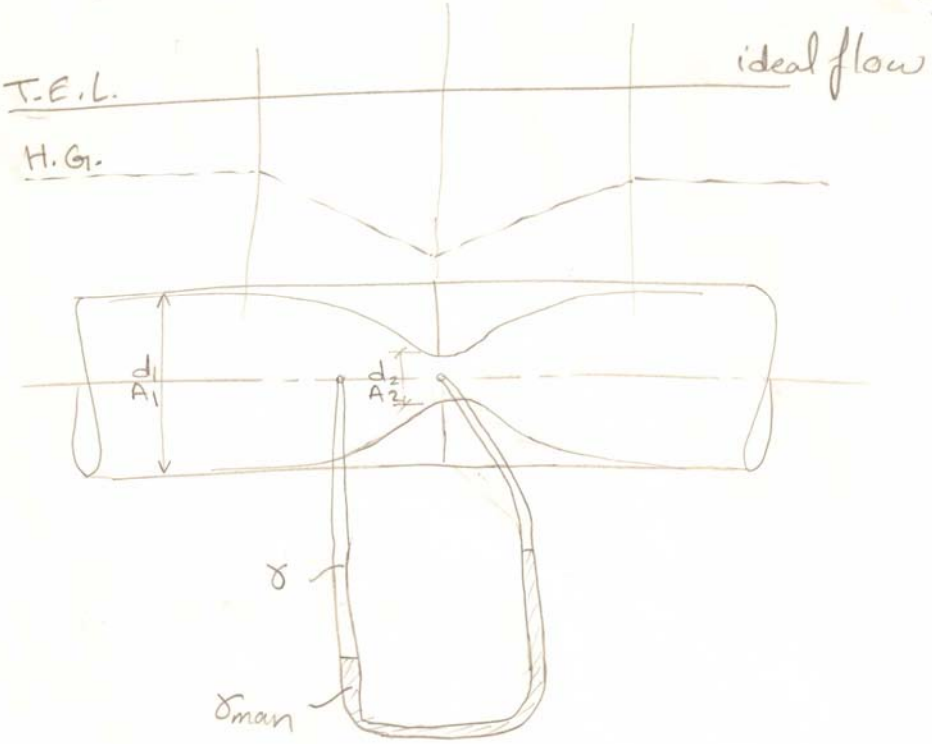
C_d : Coefficient of discharge < 1

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

A_1 : Area of pipe

A_2 : Area of throat

③ pipe orifices



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

$C_{d_o} = 0.65$

iv. Friction and Eddy Losses.

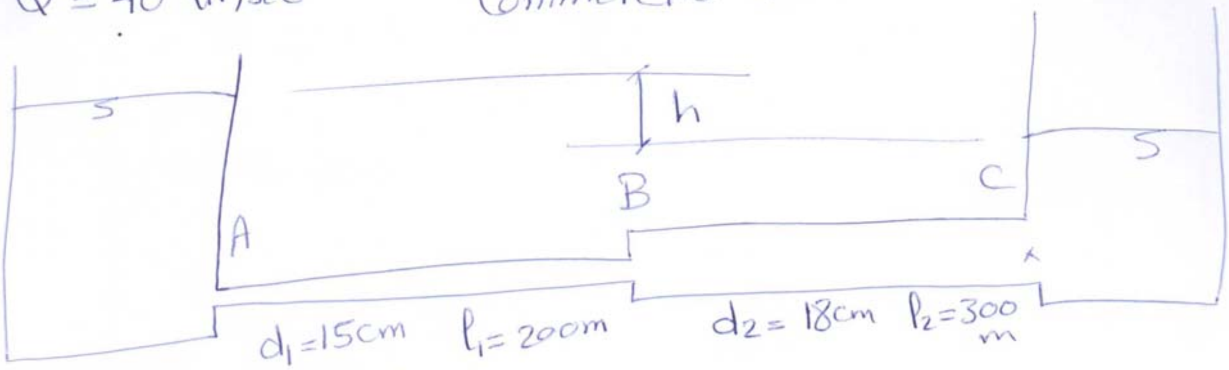
① Friction losses : This type of losses exists for any flow as a result of fluid viscosity and velocity difference between fluid layers. As a result of friction, part of the fluid's mechanical energy is Converted into heat energy (decipated into atmosphere) and is Considered as an energy loss.

② Eddy losses: occurs due to any change in the velocity vector (magnitude or direction). This change causes some of energy to be transfered from main flow to the eddies formed at corners. This part of energy is considered as energy losses.

b) A horizontal water pipeline ABC transmits 40 lit/s between two tanks. The pipe material is commercial steel, the part AB is 15 cm diameter and 200 m long and the part BC is 18 cm diameter and 300 m long. Calculate the difference in water levels between the two tanks. All changes in pipe diameter are sudden. Take $\mu = 0.001$ N.s/m^2.

من الجدول

$Q = 40$ lit/sec   Commercial steel $\epsilon = 0.046$ mm



$Q = A_1 V_1 = A_2 V_2$

$40 * 10^{-3} = \frac{\pi}{4}(0.15)^2 V_1 = \frac{\pi}{4}(0.18)^2 V_2$

$V_1 = 2.26$ m/sec

$V_2 = 1.572$ m/sec

$\frac{\epsilon}{d} = \frac{0.046}{150} = 0.00031$

$Re = \frac{\rho V d}{\mu} = \frac{1000 * 2.26 * 0.15}{0.001}$

$= 339000$

$f_1 = 0.017$

$\frac{\epsilon}{d} = \frac{0.046}{180} = 0.00026$

$Re = \frac{\rho V d}{\mu} = \frac{1000 * 1.572 * 0.18}{0.001}$

$= 282960$

$\underline{\text{Moody chart}}$ $f_2 = 0.0.166$

$$h = h_{loss} = \overset{0.5}{\cancel{K}}_{\text{max Cont.}} \frac{V_1^2}{2g} + f_1 \frac{l_1}{d_1}\frac{V_1^2}{2g} + \overset{1}{\cancel{K}}_{\text{max. enl.}} \frac{(V_1 - V_2)^2}{2g} + f_2 \frac{l_2}{d_2}\frac{V_2^2}{2g} + \overset{0.5}{\cancel{K}}_{\text{Con}} \frac{V_2^2}{2g}$$

7/12

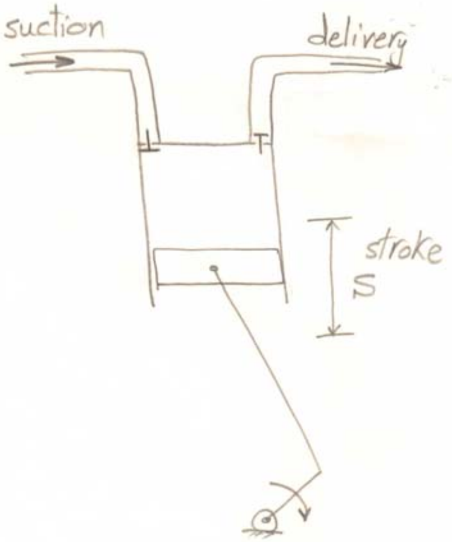
Question Four (12 marks)

a) Compare between Piston and Diaphram pumps.

* Positive displacement pumps

a- Reciprocating pumps

i) piston pump



$$\boxed{Q_{ideal} = \frac{\pi}{4} D^2 * S * \frac{N}{60}}$$

N : rpm of motor

S : stroke

$Q_{act} < Q_{ideal}$ due to leakage

$$\boxed{Q_{act} = \eta_{vol} \, Q_{ideal}}$$

η_{vol} : volumetric efficiency $\simeq 97\%$

* This pump is a type of positive pumps which gives the max. discharge.

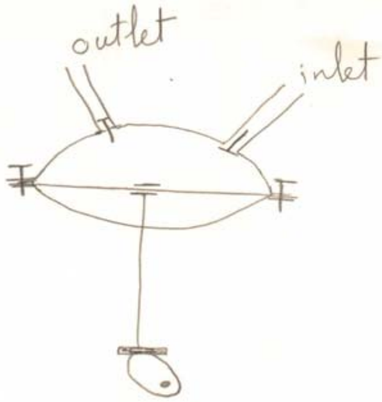
* If the delivery valve is closed, the motor or the pump can be destroyed.

* when this pump rotates at constant speed, it should give constant discharge.

ii) Diaphram pump

disadvantages

- very low pressure
- low discharge



b) Calculate the volumetric and mechanical efficiencies of gear pump rotating at 1200 rpm and discharging 1.27 lit/sec using 0.7 hp electric motor. The gear is 6 cm diameter and 4 cm thick. The pump is working against head 21.41 m of water, area between teeth equals 1.655 cm^2 and each gear has five teeth.

$$Q_{th} = 2 n a L \frac{N}{60}$$

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

$$= 1.324 * 10^{-3} \ m^3/sec = 1.324 \ lit/sec.$$

$$\eta_{vol} = \frac{Q_{act.}}{Q_{th}} = \frac{1.27 * 10^{-3}}{1.324 * 10^{-3}} = 0.959$$

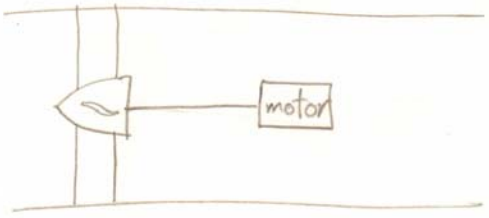
$$\eta_m = \frac{w Q_{act} h}{sh.P} = \frac{9800 * 1.27 \times 10^{-3} * 21.41}{0.7 * 738}$$

$$= 0.5158$$

Question Five (12 marks)

a) Describe, with neat sketches, Axial flow Pump.

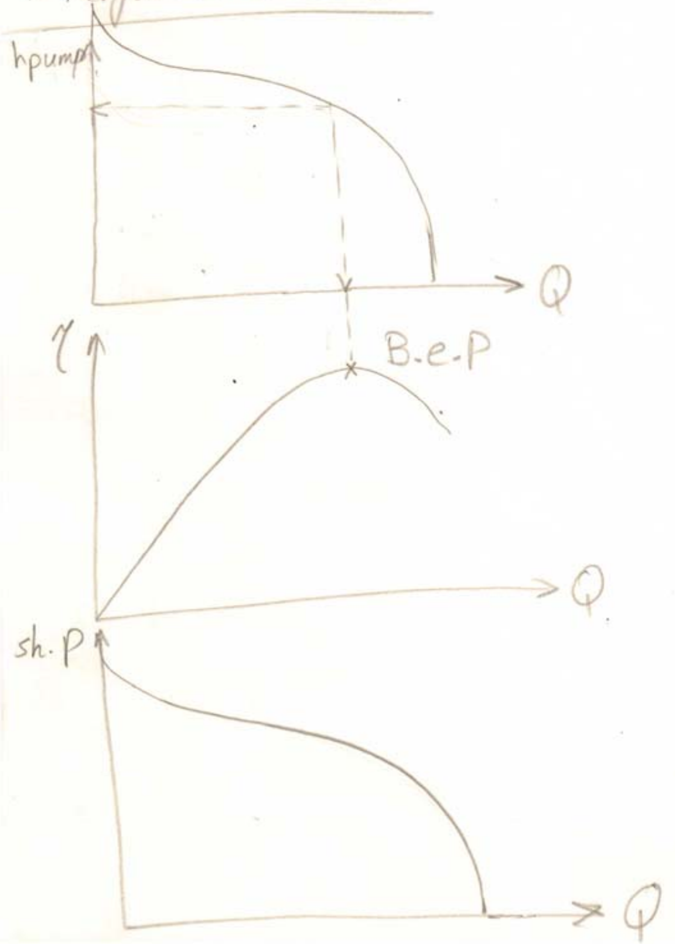
B) Axial flow pump (propeller pump)



* This pump gives very high discharge
& very low pressure (head) up to 15m

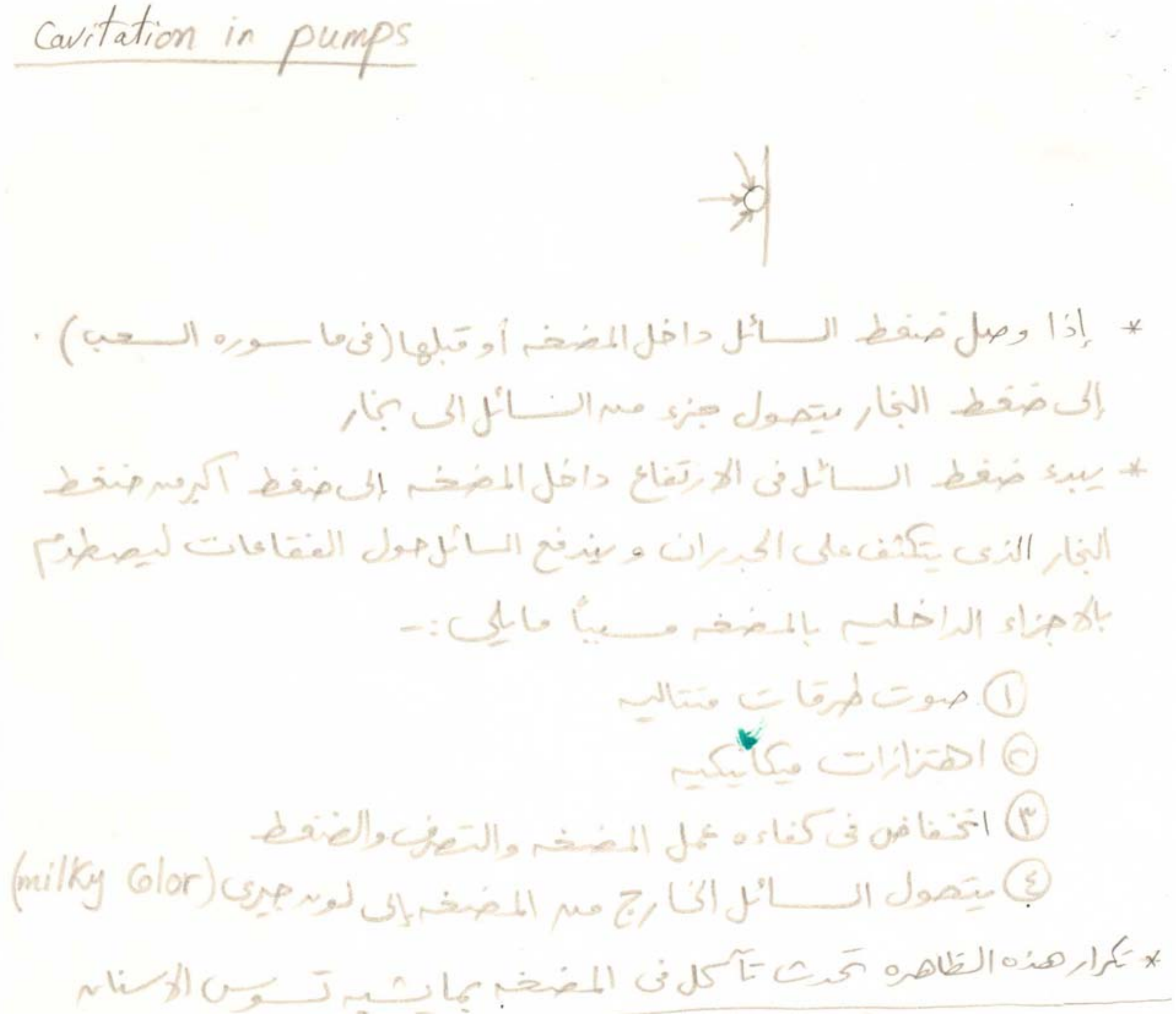
* It used for irrigation, sanitation.

* Performance curves



* نفس كلام الطلمبه الطارده المركزيه
ينطبق على هذه الطلمبه
ماعدا sh.P عند البدايه

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



Cavitation in pumps

* إذا وصل ضغط السائل داخل المضخة أو قبلها (فى ماسوره السحب).
إلى ضغط البخار يتحول جزء من السائل الى بخار

* يبدء ضغط السائل فى الارتفاع داخل المضخة الى ضغط أكبر من ضغط
البخار الذى يتكثف على الجدران و يندفع السائل حول الفقاعات ليصطدم
بالاجزاء الداخلية بالمضخة مسببا مايلى :-

① صوت طرقات متتالية
② اهتزازات ميكانيكية
③ انخفاض فى كفاءه عمل المضخة والتصرف والضغط
④ يتحول السائل الخارج من المضخة إلى لون جيرى (milky Color)

* تكرار هذه الظاهره تحدث تآكل فى المضخة يشابه تسوس الاسنان

c) A centrifugal pump has the following performance:

Q (m^3/hr)	0	15	30	45	60	75
hm (m)	75	72	65	53	38	19
η (%)	0	43	69	73	65	49

When this pump is used in a system where the difference between delivery and suction levels (h_{st}) is 42 m, it gives a discharge of 47 m^3/hr.
Calculate the discharge and shaft power of the pump when (h_{st}) decreases to 35 m.

Q (m3/hr)	0	15	30	45	60	75
hm (m)	75	72	65	53	38	19
η (%)	0	43	69	73	65	49
h piping	42	42.92	45.67	50.25	56.67	64.92
h pnew	35	35.92	38.67	43.25	49.67	57.92

h piping = Hst + K * Q2

h piping = 42 + K * (47)2 = 51 m from chart

Then K = 0.004

For the same pipelines

K is the same

h piping new = 35 + 0.004 * Q2

from cha^{r}t Qnew = 52 m3/hr

shaft power =

$$= \frac{\omega h Q}{\eta}$$

$$= \frac{9800 * 45.8 * 52}{0.7}$$

$$= 33354048 \frac{N.m}{h}$$