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ملخص

مختبر موائع وهيدروليكا

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((Final

Lab Hydraulics Summary))

* Experiments:

(1) Pipe friction losses & Fittings

(2) Uniform flow & roughness coefficient.

(3) Flow over weir

(4) Hydraulic Jump

(5) pumps

} open channel exp.

Wish you the Best

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The loss in any pipe is h_L, which is the differance in the head losses experimentaly

$$h_L = \frac{P_1}{\gamma} - \frac{P_2}{\gamma}$$ → pressure head readings from manometer

- Type of pipes used in lab:-

① pvc — احتكاك أقل

② P.B → (احتكاك أكثر) نزولات أكثر

* head loss theoritically:-

→ $Re = \frac{\rho v D}{\mu}$ → < 2000 laminar نادر الحدوث ; → > 4000 turbulent ✓

- μ: 10^{-6}, D: diameter, v: velocity.

→ $h_L = f \frac{L}{D} \frac{v^2}{2g}$

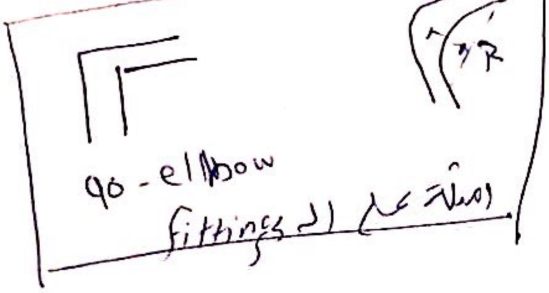
to find "f" you need Re (نحسبه), $\frac{K_s}{D}$ ← بعطيني إياه

f → Laminar f: $\frac{64}{Re}$ → استخدام هذا القانون نادر جداً

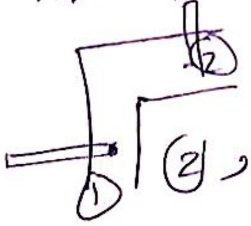
f → Turbulent f: $\frac{0.316}{R^{0.25}}$ ✓

× Note:- $\frac{h_L}{L} \propto v^2$ only in turbulent flow.

② fitting loss :- Any change of direction or shape in the pipe



- h_L exper. in fittings $h_L = \frac{P_1}{\gamma} - \frac{P_2}{\gamma}$ — ①



يقيس باستخدام المانوميتر

الـ Pressure head عند ① و ②

$h_L = K * \frac{v^2}{2g}$ ← من القانون ① — لإيجاد (K)

وهو معامل الاحتكاك حسب شكل الـ fitting.

$v = \frac{Q}{A}$

Q:- ✓ معطى

A: $\frac{\pi}{4} D^2$

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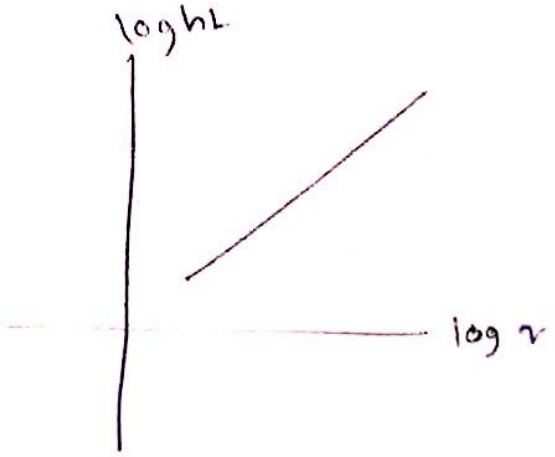
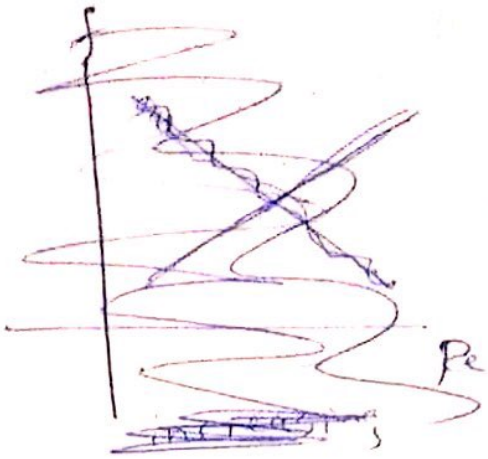
K is theoritically [illegible]

⇒ plots:-





*Notes :-

hL is effected by :-

1- v ↑ ⇒ hL ↑

2- D ↑ ∝ 1/hL ↓

3- L ↑ ∝ hL ↑

4- ks

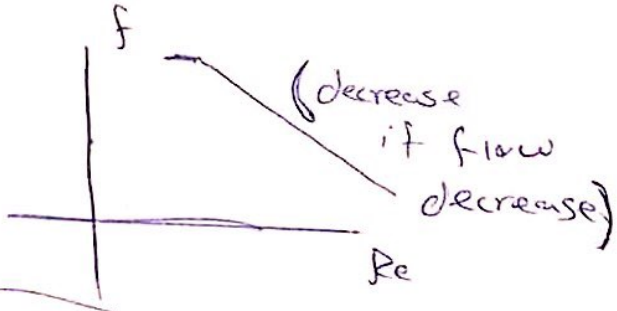
5- Type of flow

6- hL ↑ ∝ f ↑

Each Spin → 1 liter → 10^{-3} m3

تستخدم في التجارب وحدة:

1 Spin ⇒ 10 liter → 10^{-2} m3



ملاحظات قوانين التجربة Friction & fittings

$h_{L_{exp}} = \frac{P_1}{\gamma} - \frac{P_2}{\gamma}$

$Re = \frac{v \times D \rho}{\mu}$

$f_{exp} = \frac{2 g D h_{L exp}}{L v^2}$

$f_{theo} = \frac{0.316}{Re^{0.25}}$ ~~Turbulent~~ Turbulent.

- fittings:-

$h_{L_{exp}} = \frac{v^2}{2g} \times K_{exp}$

$= \frac{P_1 - P_2}{\gamma} = \frac{v^2}{2g} \times K_{exp}$

$v = \frac{Q}{A}$

K_{theo} → tables.

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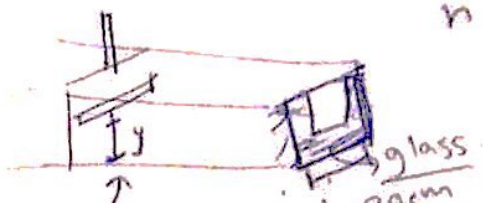
- manning equation to compute n

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

$$R = \frac{A}{P} = \frac{b \times h}{2b + h}$$

S :- Slope

n :- manning Coeffient.



يتم قراءة الارتفاع h بعد تصغير الجهاز على قاعدة القناة channel bed.

- Chezzy equation to compute C

$$V = C \times R^{1/2} S^{1/2}$$

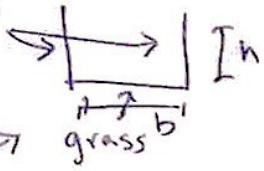
C :- Chezzy Coeffient.

⇒ Note :- يتم حساب n_{avg} وهو العمق المتوسط عند التغير في الخواص (عمق ، نوع قاعدة القناة ، الميل) بينما العرض ثابت دائماً بغض النظر عن المسألة

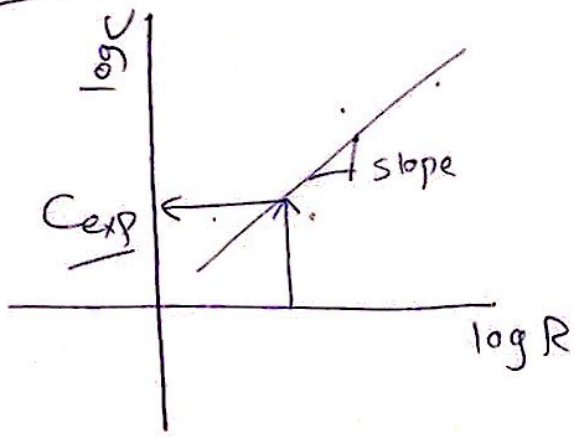
* Relation between C & h

$$C = \frac{1}{n} R^{1/6}$$

$$n_{avg} = \frac{\sum P_i \times n_i}{P_{total}} = \frac{h \times n_{glass} + h\, n_{glass} + b\, n_{grass}}{b + 2h}$$



* Plots :-



$$\log C = \left(\frac{1}{6}\right) \log R - \log n$$

use n_{avg}

the slope must be close to 0.167

Cexp is more acurate on the line fit method than the avarge method

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* الهدف من التجربة معرفة تأثير الـ weir على خصائص الـ flow ...

* We have two types of weir → Rec, V-notch — each one has its own equations / formulas.

* Rectangular weir :- L : 15cm (given)

$Q_{theo} = \frac{2}{3}\sqrt{2g}\, L\, H^{3/2}$, while $\frac{Q_{act}}{Q_{theo}} = Cd$; $Cd < 1$

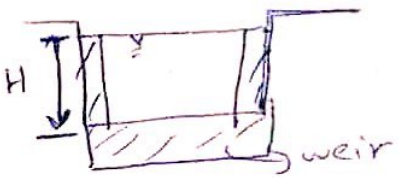
$Q_{act} = Cd * Q_{theo}$

* $Q_{act} = Cd \times \frac{2}{3}\sqrt{2g}\, L\, H^{3/2}$

$\Rightarrow Q_{act} = \underline{K}\, H^{3/2}$

$\log Q_{act} = \underline{\log K} + \frac{3}{2}\log H$ ← plot 1 Cd_{exp} نستخرج لإيجاد

↳ slope ≈ 1.5 تقريباً



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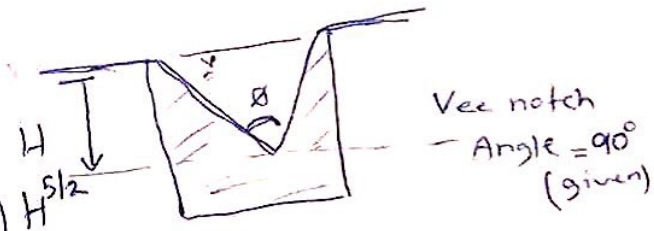
* Vee-notch weir:-

$Q = Cd\ Q_{theo}$

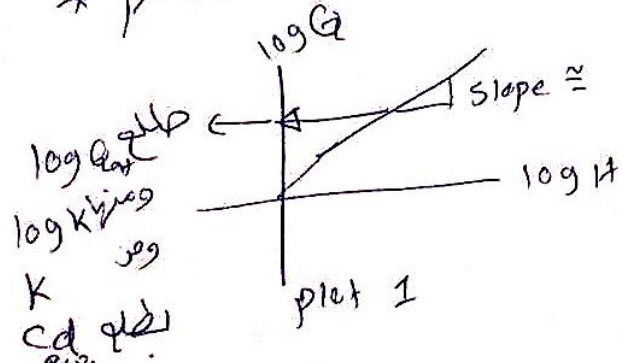
$Q_{act} = Cd * \frac{8}{15}\sqrt{2g}\, \tan\left(\frac{\phi}{2}\right) H^{5/2}$

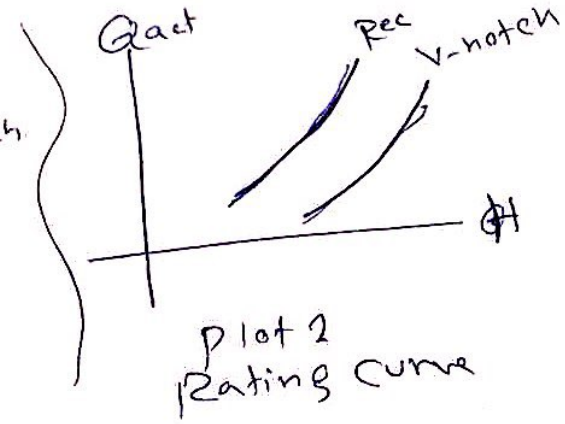


$\log Q_{act} = \log K + \frac{5}{2}\log H$

↳ Slope ≈ 2.5 تقريباً

* plots





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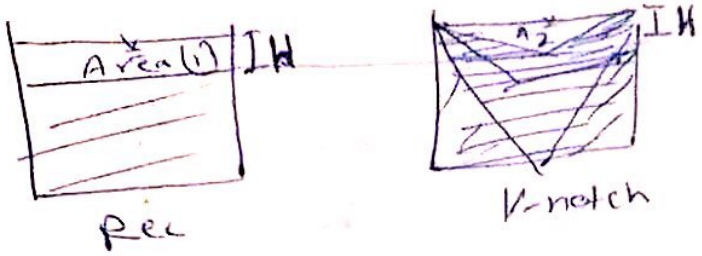
Actual

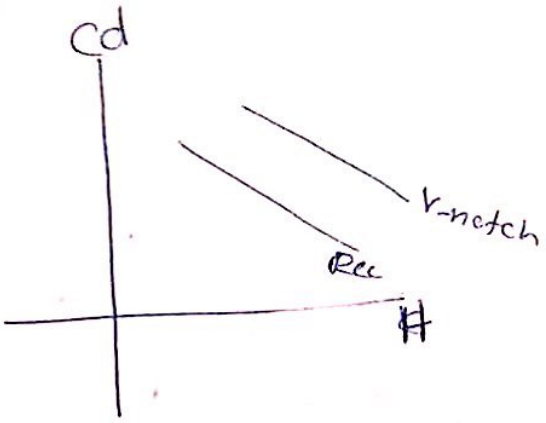
* The V-notch weir is better than the Rec when you want a high flow, Explain?

The V-notch at Angle 90°, has less over all area at the Same depth in rectangular; while in rect the area is much bigger



$$\uparrow Q_{act} = \frac{V}{A\downarrow} = Cd\uparrow$$

$Cd\downarrow \propto Q_{act}\uparrow$



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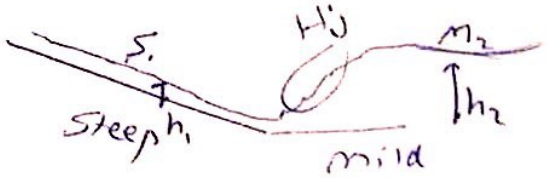
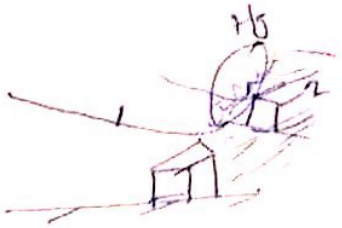
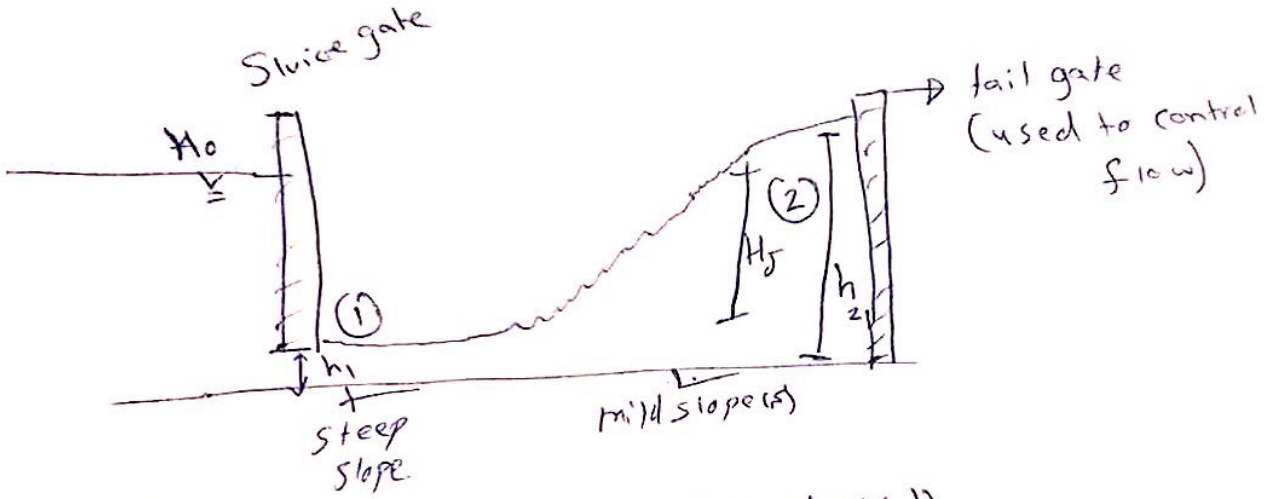
* hydraulic jump occurs when the flow transfers from fast flow to slow flow
or super critical to sub critical
or ~~mild~~ steep slope to mild slope

* Cases of Hydraulic jump





* Lab case:-



- h_0 & h_1 are called ((Alternative depths))
- h_1 & h_2 are called ((Conjugate depths))

* The hydraulic JUMP in Rectangular channel.

-Energy between 1 & 2 (bernoulis)

$$z_1 + h_1 + \frac{v_1^2}{2g} = z_2 + h_2 + \frac{v_2^2}{2g} + h_L$$

$$E_1 = E_2 + h_L$$ ← You must use Force momentum to find depths first,

* Force momentum between 1 & 2 gives this eqation:-

$$h_L = \frac{(h_2 - h_1)^3}{4 h_1 h_2}$$

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$$h_2 = \frac{h_1}{2}\left(-1 + \sqrt{1 + 8Fr_1^2}\right)$$

لايجاد العمق عند 2 يجب معرفة عمق (1) و Fr_1

$$Fr_1 = \frac{v_1}{\sqrt{g h_1}} \qquad v_1 = \frac{q}{h_1} \quad \left(\frac{Q}{b}\right)$$

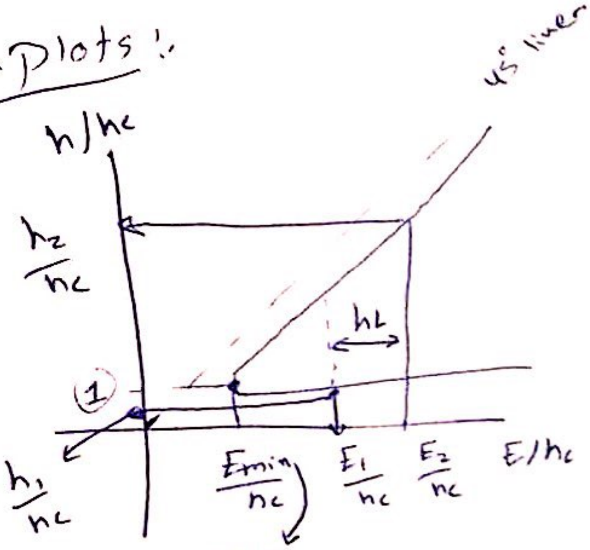
b: width of channel (30 cm) (given)

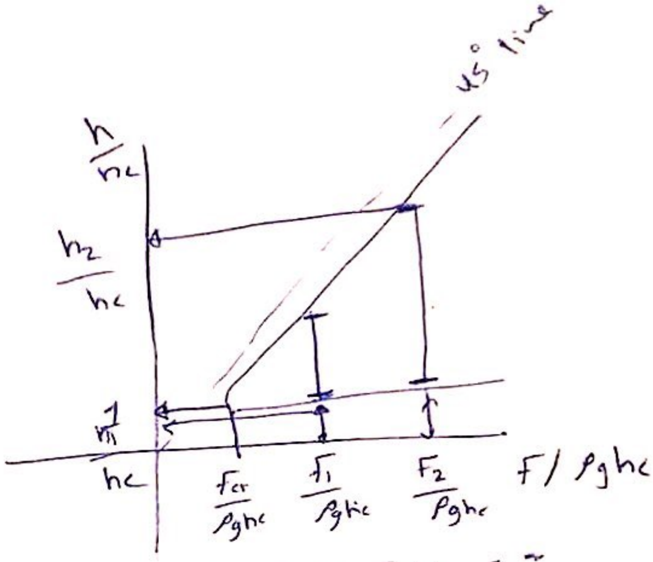
$$Fr_1 = \frac{q}{h_1\left(\sqrt{g h_1}\right)} \quad \text{only rect.}$$

$$Fr_{critical} = 1 \quad \ldots \quad \boxed{h_c = \left(\frac{q^2}{g}\right)^{1/3}} \quad h_1 < h_c < h_2$$

$$\boxed{E_{min} = \frac{2}{3} h_c}$$

* Plots :-





h_c لانها عند E_{min} تكون

يعتبر الفرق ثابت بين أي نقطة والأخرى

$\boxed{hL}$ الفرق يتغير بتغير

---

* Relations:-

$v\uparrow \propto hL\uparrow \propto HJ\uparrow \propto \frac{1}{h_1\downarrow} \propto h_2\uparrow \propto slope\uparrow \propto Q \text{ or } q\uparrow$

Sluice gate hieght $y\uparrow \propto \downarrow v$ ابنيها على العلاقة بالأعلى.

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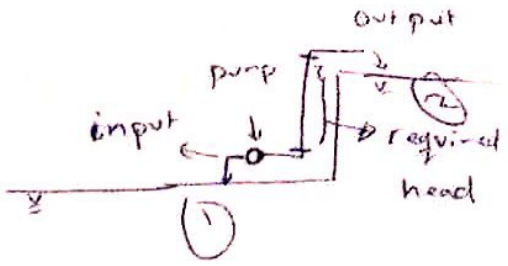
* Pumps: are electrical machines used to give Flow & elevation head

* In this lab we will take one type of pumps (centerfugal pumps)



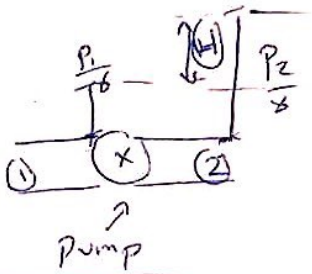
* Cfugal pumps are used when we want
(1) High Flow rate.
(2) low Pressure head.

* Net total head produced by the pump is measured by bars

$1\ bar = 10^5 \frac{N}{m^2} = 10^5\ Pa$

$1\ bar = 10\ m$ if $g = 10\ m/s^2$ } حسب السؤال
$1\ bar = 10.193\ m$ if $g = 9.81\ m/s^2$ }

$H_{exp} = \left(\frac{P_2}{\gamma} - \frac{P_1}{\gamma}\right) * 10^5$ ← In bars



— IH produced by pump

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* Power out put ((watt)) الطاقة التي تخرج من المضخة

$P = \rho g Q H_{avg}$ in meters

P in watt

* Power Input الطاقة قبل ان تدخل المضخة.

$\gamma W = Fr \frac{2\pi N}{60}$ ← هذا القانون ما بتشرحه المهندسة

T: tork(N)
W = angle velocity
F: Force (N)
N: pump speed(rpm)
r = 0.178 m

η efficiency $= \frac{\text{Power output}}{\text{" input}} * 100\%$

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* Connection of pumps

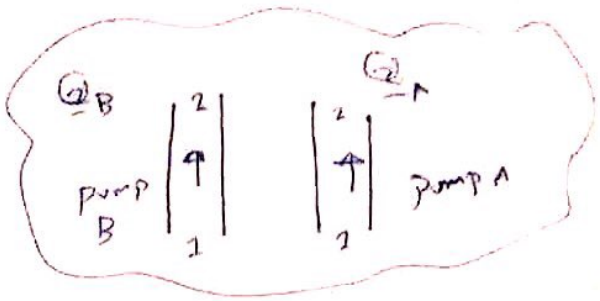
(1) parrallel توازي

(2) Seires توالي

*(1) On parrallel

$$h_A = \frac{P_{A2} - P_{A1}}{9.81 \times 1000} \times 10^5 = \_\_ (m)$$

$$h_B = \frac{P_{B2} - P_{B1}}{9.81 \times 1000} \times 10^5 = \cdots (m)$$



$$Q_{total} = Q_A + Q_B$$

$$h_{avg} = \frac{h_A + h_B}{2}$$

$$Power_{total} = \rho Q_{tot} g h_{avg} \quad (\text{watt})$$

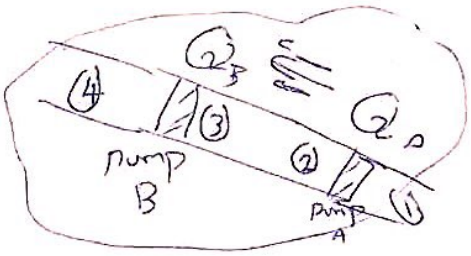
$$P_A = \rho Q_A g h_A \quad (\text{same thing for B})$$

(2) on Seires :-

$$h_A = \frac{P_{A2} - P_{A1}}{9.81 \times 1000} \times 10^5 = \cdots m$$

$$Q_{total} = Q_A = Q_B \quad \text{in } m^3/s$$

m^3/hr اذا كانت
تقسم على 3600



$$h_{avg} = h_A + h_B$$

$$P_{total} = \rho g Q_t h_{avg} \text{ in watt}$$

* Relations :-

Q ↑ ∝ P ↓ ∝ h ↓ ∝ Power ↓

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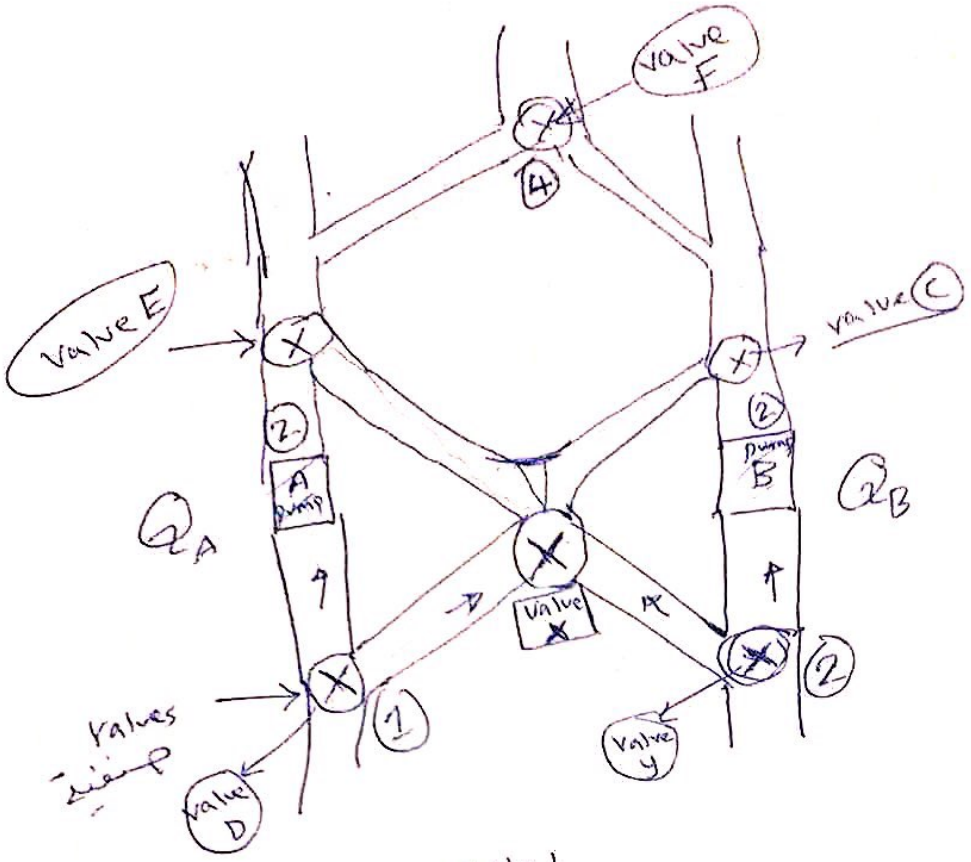
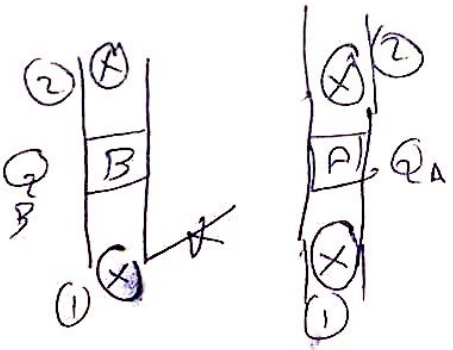
Pumps connections in lab :-



To make it on parallel

* close Valve x ~~and~~ and valve (F)

*~~You~~ get :-



عندي Q_A ، Q_B

ومعي القراءة لـ

P_{A1}

P_{A2}

:

بطبق القوانين فقط :)

To make it on series :-

close ~~pump~~ valve (E), (y) & open valve F)

الشكل آخر صفحة (11)

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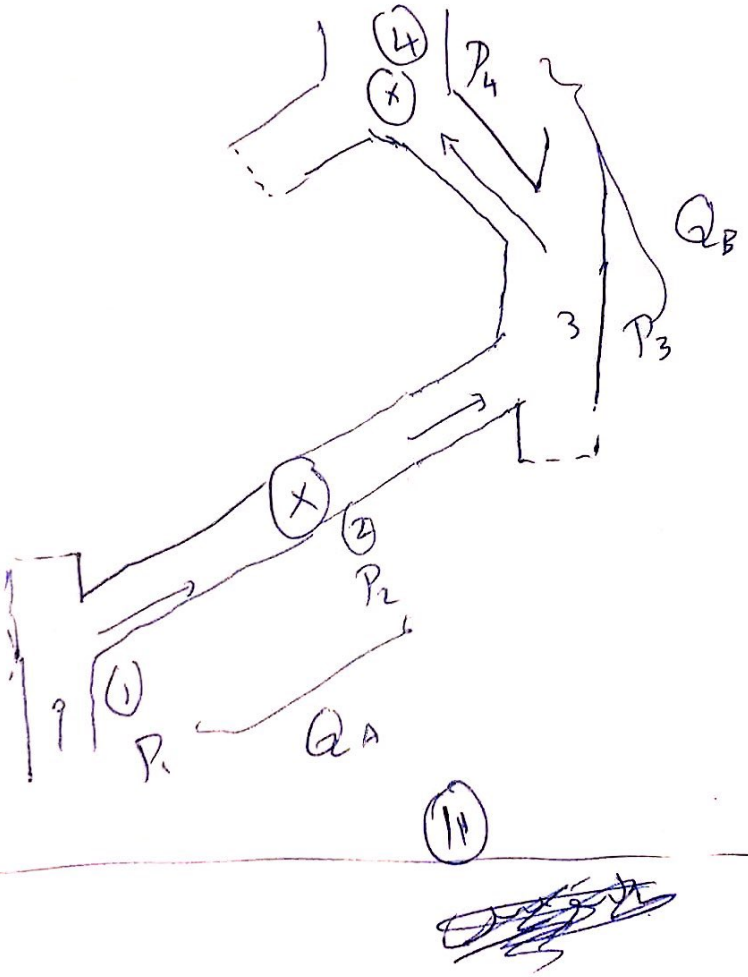
Series connection



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