



Hydraulics Laboratory

EXP.1: Center of pressure on a plan surface

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Section: 1

Date: 16/6/2019

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FLUIDS AND HYDRAULICS LABORATORY

EXP.1: Center of Pressure

1.1. Data and Calculations

Notes:-

All unit in hydraulic lab convert it to large unit for example (g TO kg) and so on.

$$(\gamma) = \rho * g = 9810 \text{ N per m}^3$$

b	d	R1	R2	R3	in mm
75	100	100	200	200	

1.1.1. Totally Immersed

Table 1: Determination of the calculated and experimental center of pressure on a plan surface totally immersed with water

Mass (g)	Water depth y (mm)	$\bar{y}$ (m)	$F_{theo.}$ (N)	$F_{exp.}$ (N)	$Y_{c.p.}$ calculated (m)	$Y_{c.p.}$ experimental (m)
400	116	0.066	4.86	5.71	0.075	0.077
500	130	0.080	5.9	7.41	0.09	0.096
600	150	0.1	7.36	8.77	0.108	0.11
		/	/		/	/

• Sample of Calculations:

$$* \bar{y} = 116 - \frac{100}{2} = 66$$

$$* F_{tho} = \rho g * \bar{y} * \sin \alpha * Area$$

$$= 9810 * 0.066 * 0.1 * 0.075 = 4.86 \text{ N}$$

$$* F_{exp} = 9.81 * 0.4 * 0.2 = 5.71 \text{ N}$$

$$\left[0.2 - \left[\frac{(0.116 * \frac{0.1}{2}) - (0.1^2 / 6)}{0.116 - (\frac{0.1}{2})} \right] \right]$$

$$* y_{cp} = 66 + \frac{75 * 100^3 / 12}{66 * 100 * 75} = 0.075 \text{ m}$$

$$* y_{cp \text{ exp}} = \frac{2 * 0.4 * 0.2}{1000 * \left(2 * 0.116 * 0.075 * 0.1 - 0.075 * 0.1^2 \right)}$$

$$= 0.077 \text{ m}$$

$$0.2 + 0.116$$

1.2. Partially Immersed

Table 2: Determination of the calculated and experimental center of pressure on a plan surface partially immersed with water

Mass (g)	Water depth y (mm)	$\bar{y}$ (m)	$F_{theo.}$ (N)	$F_{exp.}$ (N)	$Y_{c.p. theo.}$ (m)	$Y_{c.p. experimental}$ (m)
100	50	0.025	0.92	1.07	0.033	0.063
200	80	0.04	2.35	2.26	0.053	0.047
300	95	0.0475	3.32	3.5	0.063	0.072

• Sample of Calculations:

$$*\bar{y} = \frac{50}{2} = \frac{25}{1000} = 0.025$$

$$*F_{theo} = 9810 * 0.1 * 0.025 * 0.075 = 0.92 \text{ N}$$

$$*F_{exp} = \left[\frac{0.1 * 9.81 * 0.2}{(0.2 - \frac{0.05}{3})} \right] = 1.07 \text{ N}$$

$$*Y_{c.p. theo} = \frac{2}{3} * 0.05 = 0.33$$

$$*Y_{c.p. exp} = \left(\frac{2 * 0.1 * 0.2}{1000 * 0.095 * 0.05^2} \right) - 0.2 + 0.05 = 0.063 \text{ m}$$

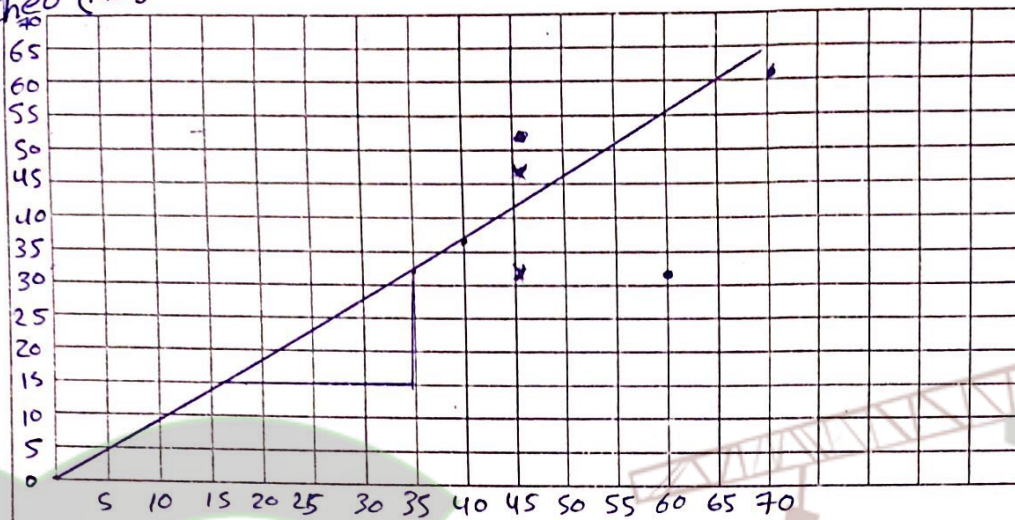
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1.2. Drawing:

1.2.1. Draw $Y_{c,p}$ Theo. Vs. $Y_{c,p}$ experimental (partially) on the same figure, find the angle.

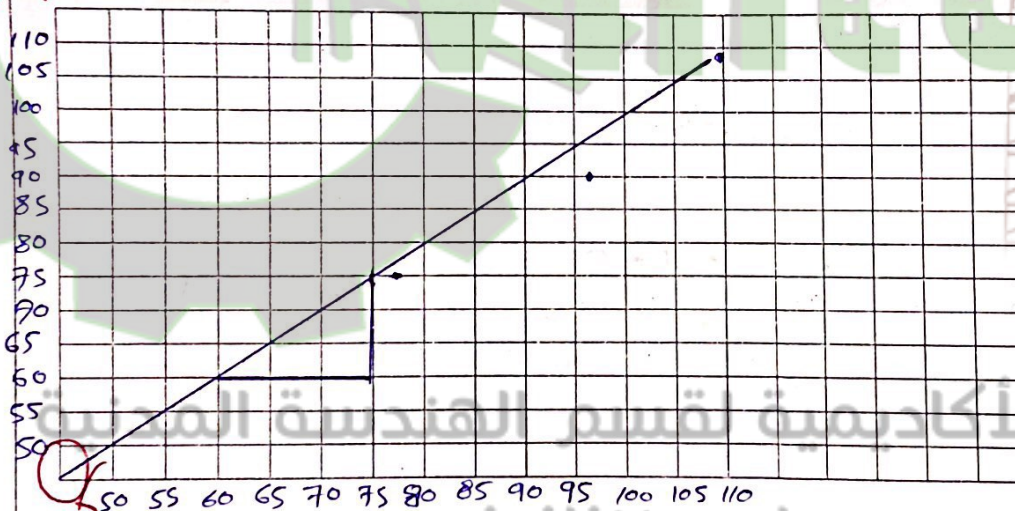
theo (mm)



ex (mm)

$$\phi = \tan^{-1} \left(\frac{33-15}{35-17} \right) = 45$$

1.2.2. Draw F_{theo} Vs. F_{exp} . (Totally) on the same figure, find the angle.



$$\phi = \tan^{-1} \left(\frac{75-60}{75-60} \right) = 45$$

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Fluid & hydraulics Lab.

Exp.Title: Bernoulli's Theorem & Venture Meter.

Exp.No.03

7.5

3.1. Data and Calculations

$D_1 = 25\text{mm}$, $D_5 = 10\text{mm}$, $D_8 = 25\text{mm}$ (Total head).

Table 3.1.1. Collected Data (Pressure Head (H_p), Total Head (H_t), and Discharge (V , t))

Volume (L)	Time (Sec)	Readings (cm)	Point 1	Point 5
5	34	H_p	285	70
		H_t	320	320
5	41	H_p	183	15
		H_t	210	205

$A_1(\text{m}^2)$	4.91×10^{-4}
$A_5(\text{m}^2)$	7.85×10^{-5}

$$A_1 = \frac{\pi}{4} d^2 = \frac{\pi}{4} (25 \times 10^{-3})^2$$

Table 3.1.2.: Results (Q_{act} , Q_{theo} , C_d , & Re):

Volume (m^3)	Time (Sec)	Q_{act} (m^3/s)	$h_1 - h_5$ (m)	Q_{theo} (m^3/s)	C_d	V_5 (m/s)	Re At point 5	$(h_1 - h_5)^{0.5}$
5×10^{-3}	34	1.47×10^{-4}	0.215	1.63×10^{-4}	0.9	2.21	22100	0.464
5×10^{-3}	41	1.22×10^{-4}	0.168	1.44×10^{-4}	0.85	1.93	19300	0.41

• Sample of Calculations:

$$Q_{act} = \frac{Vol}{Time} = \frac{5 \times 10^{-3}}{34} = 1.47 \times 10^{-4} \text{ m}^3/\text{s}$$

$$Q_{theo} = A_5 \times \sqrt{\frac{2 \times g \times (h_1 - h_5)}{1 - (A_5 - A_1)^2}} = 7.85 \times 10^{-5} \times \sqrt{\frac{2 \times 9.81 \times 0.215}{1 - \left(\frac{7.85 \times 10^{-5}}{4.91 \times 10^{-4}}\right)^2}} = 1.63 \times 10^{-4}$$

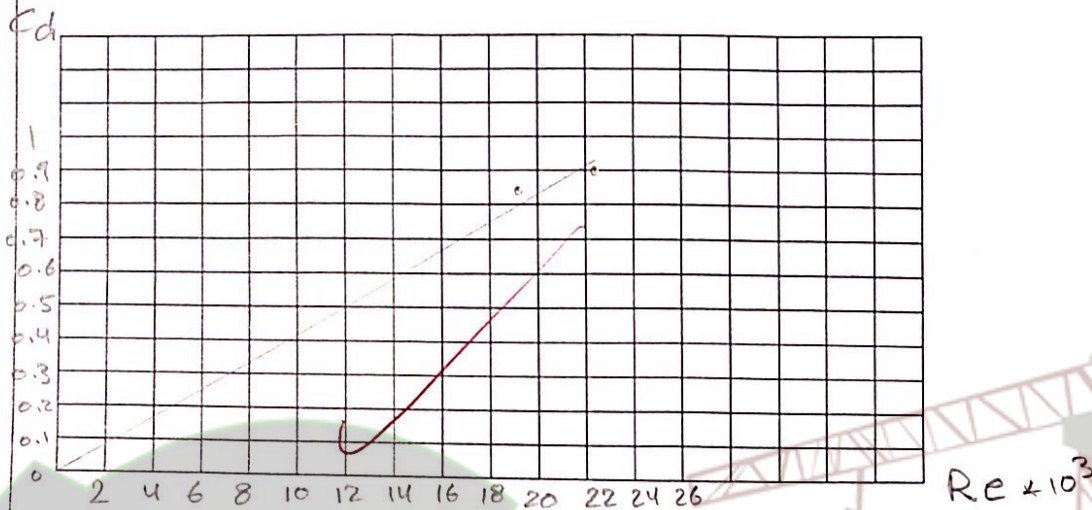
$$C_d = \frac{Q_{act}}{Q_{theo}} = \frac{1.47 \times 10^{-4}}{1.63 \times 10^{-4}} = 0.9$$

$$H_t - H_p = \frac{V^2}{2g} \Rightarrow V = 2.21 \text{ m/s}$$

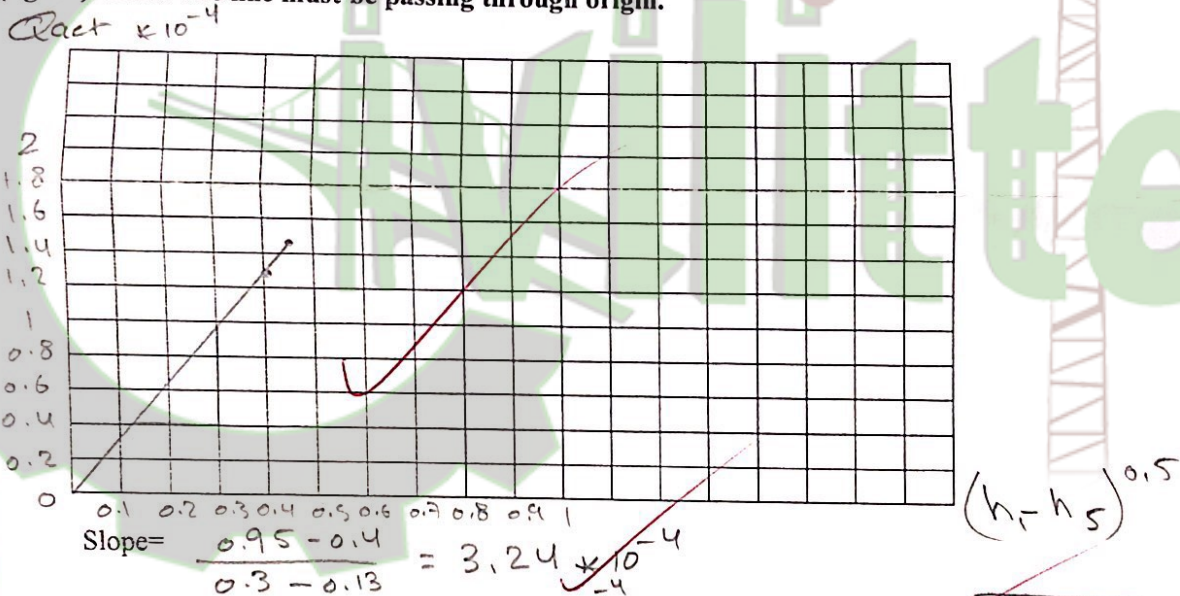
$$Re = \frac{V_5 \times d_5}{10^{-6}} = 22100$$

3.2 Results Plot

3.2.1 Plot C_d versus Re (fig.3.1).



3.2.2 Plot Q_{act} (m^3/s) versus $(h_1 - h_5)^{0.5}$. Use the slope of this plot to calculate the discharge coefficient C_d (fig.3.2). Hint: The line must be passing through origin.



$$C_d = \Rightarrow \text{slope} = 3.24 \times 10^{-4} = C_d \times 7.88 \times 10^{-5} \times \sqrt{\frac{2 \times 9.81}{1 - \left(\frac{7.85 \times 10^{-5}}{4.91 \times 10^{-4}} \right)^2}}$$

$$\Rightarrow C_d = 0.854 \quad C_d = 0.919$$

3.2. Discussion:

• True or false (correct the false):

1. The relation between (RE) & (C_d) is direct. ~~X~~ not direct
2. $C_d < 1$, $Q_{act} > Q_{theo}$ because head loss occurs due to friction and area contraction. ~~TX~~
3. Venturi meter used to measure actual flow velocity. ~~TX~~
4. Total head probe used to read velocity head directly. ~~TX~~
5. Pressure head = P , velocity head = $V^2/2g$ ~~TX~~
6. Velocity head (Kinetic) = total head probe reading + pressure head reading (static) ~~TX~~

-2.5

FLUIDS AND HYDRAULICS LABORATORY

Name: Eng. Alaa **EXP.4:** Impact of water jet
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4.1. Data and Calculations

Table 4.1.: Flat Plate Target ($\theta = 90^\circ$)

Mass (g)	Volume (L)	Time (s)	Q (m ³ /s)	V _{nozzel} (m/s)	V _{o nozzle} (m/s)	Moment m' * V _o	F _{measured} (N)	F _{calculated} (N)
150	5	19	2.63×10^{-4}	5.23	5.17	1.36	1.47	1.36
300	5	11	4.55×10^{-4}	9.05	9.02	4.10	2.94	4.10
450	5	9	5.56×10^{-4}	11.05	11.02	6.13	4.41	6.13

Table 2: Hemispherical Target ($\theta = 180^\circ$)

Mass (g)	Volume (L)	Time (s)	Q (m ³ /s)	V _{nozzel} (m/s)	V _{o nozzle} (m/s)	Moment m' * V _o	F _{measured} (N)	F _{calculated} (N)
150	5	24	2.08×10^{-4}	4.14	4.07	0.85	1.47	1.69
300	5	16	3.125×10^{-4}	6.21	6.16	1.925	2.94	3.85
450	5	12	4.17×10^{-4}	8.29	8.25	3.44	4.41	6.88

4.2. Sample of Calculations:

$$Q = \frac{V}{t} = \frac{5 \times 10^{-3}}{19} = 2.63 \times 10^{-4} \text{ m}^3/\text{s}$$

$$A = \frac{\pi}{4} \times (8 \times 10^{-3})^2 = 5.03 \times 10^{-5} \text{ m}^2$$

$$V_{\text{nozzel}} = \frac{Q}{A} = \frac{2.63 \times 10^{-4}}{5.03 \times 10^{-5}} = 5.23 \text{ m/s}$$

$$V_{\text{nozzel}} = \sqrt{V_n^2 - 2gH} = \sqrt{(5.23)^2 - 2 \times 9.81 \times 3 \times 10^{-2}} = 5.17 \text{ m/s}$$

$$\text{moment} = m \times V_o = \rho Q V_o = 1.36 \text{ N}$$

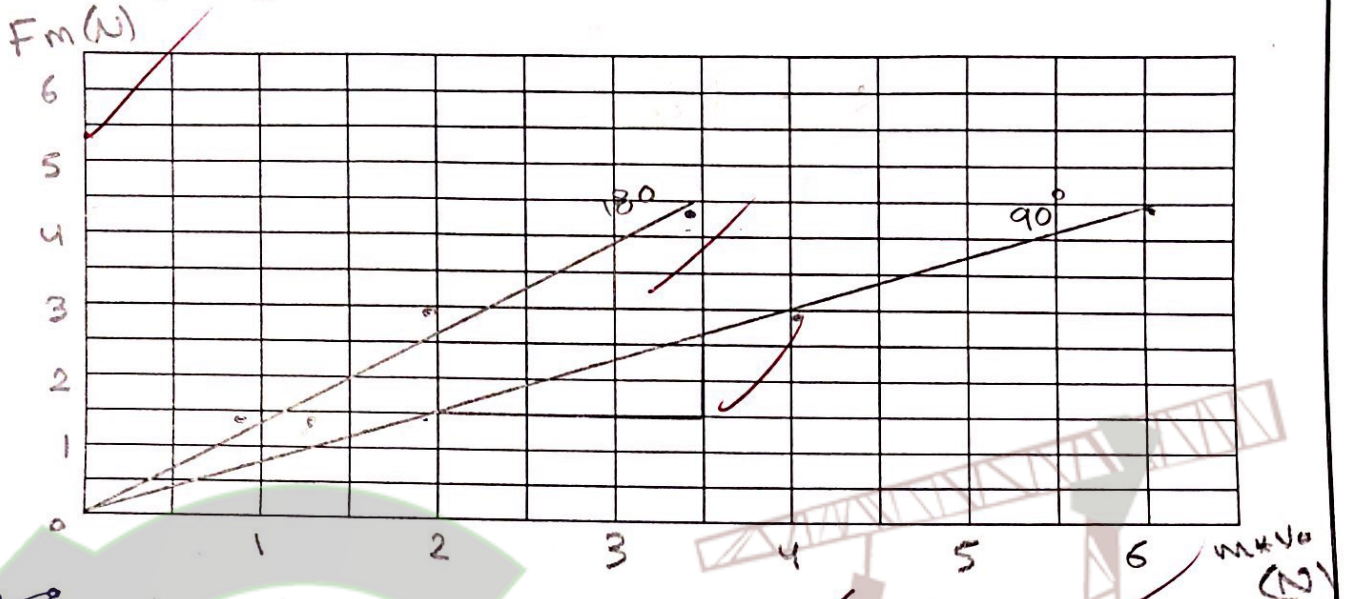
$$F_m = mg = \frac{150}{1000} \times 9.81 = 1.47 \text{ N}$$

$$F_{\text{calc}} = \rho Q V_o = 1.36 \text{ N}$$

180° (-0.25)

4.3. Plot:

- Plot F_{measured} on the target (for all targets on the same figure) versus the rate of momentum ($m \cdot V_0$)



180° $\Rightarrow$ Slope = $\frac{3.9 - 2.5}{3 - 2.5} = 1.27$

90° $\Rightarrow$ Slope = $\frac{2.53 - 1.5}{3.5 - 2} = 0.69$

(-0.1)

4.4. Discussion

4.4.1-Compare the slopes calculated from this figure with the expected from the theoretical equations.

$\mu g = \sin \alpha V_0 \rightarrow 90^\circ \rightarrow \text{slope} = 0.69 \leq 1 \rightarrow \text{OK}$

$\mu g = \sin \alpha V_0 \rightarrow 180^\circ \rightarrow \text{slope} = 2 \leq 2 \rightarrow \text{OK}$

4.4.2 – true or false (correct the false):

- When the internal angle = 40°, the impact equation = 1.86 $m \cdot V_0$ $\checkmark$
- When the impact angle increases the flow rate increase. $\checkmark$
- $mg = m \cdot V_0$ for flat plate. $\checkmark$

decrease $\checkmark$

5.1 Losses due to Friction**A) PVC Pipe:**

D = 3/4 in = 0.01905m

L = 1.00m

A = 0.000285m²

Volume (m ³)	Time (sec)	h _L (m)	Q (m ³ /sec)	V (m/sec)	Re	Flow Type	f

B) PVC Pipe

D = 1/2 in = 0.0127m

L = 1.00m

A = 0.000126676m²

Volume (m ³)	Time (sec)	h _L (m)	Q (m ³ /sec)	V (m/sec)	Re	Flow Type	f
5 × 10 ⁻³	22	0.885	2.273 × 10 ⁻⁴	1.794	22783.8	Turb	0.069
5 × 10 ⁻³	31	0.48	1.613 × 10 ⁻⁴	1.273	16167.1	Turb	0.074
5 × 10 ⁻³	42	0.285	1.19 × 10 ⁻⁴	0.939	11925.3	Turb	0.08

C) PB Pipe:

D = 3/4 in = 0.01905m

L = 1.00m

A = 0.000285m²

Volume (m ³)	Time (sec)	h _L (m)	Q (m ³ /sec)	V (m/sec)	Re	Flow Type	f

2. Losses due to Fittings and Valves

D = 3/4 in

A = 0.000285m²

	Volume (m ³)	Time (sec)	h _L (m)	Q (m ³ /sec)	V (m/sec)	K
90° Elbow						

5.2. Sample of Calculations:

$$Q = \frac{V}{t} = 2.273 \times 10^{-4} \text{ m}^3/\text{sec}$$

$$V = \frac{Q}{A} = 1.794 \text{ m/sec}$$

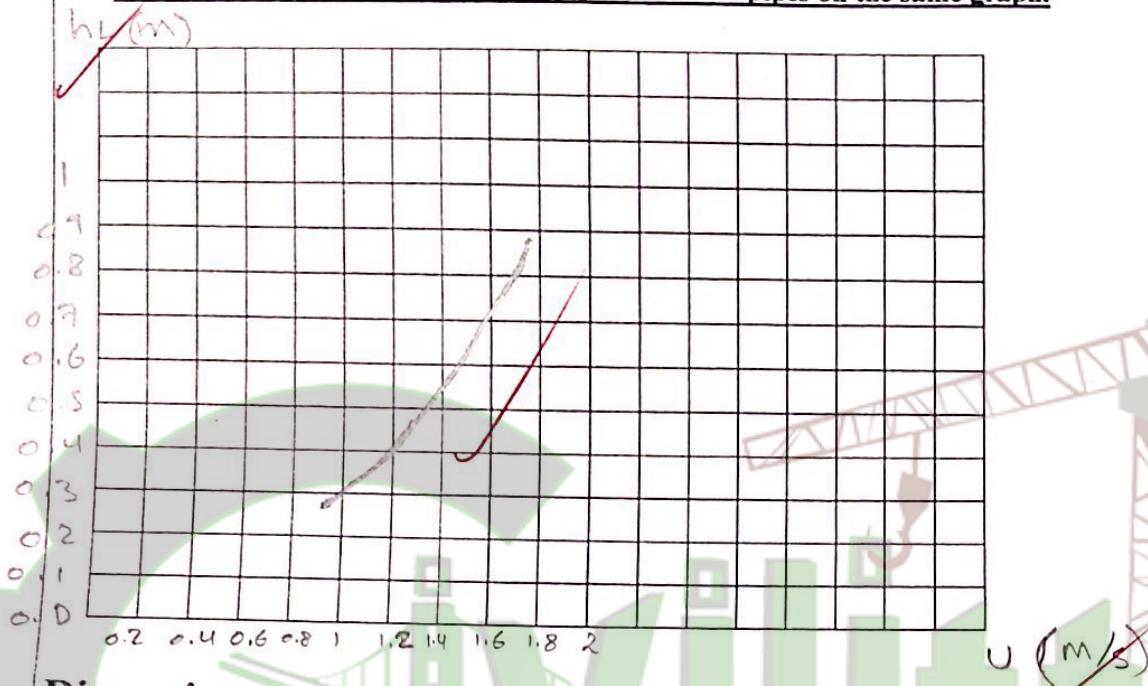
$$Re = \frac{VD}{\nu} = \frac{1.794 \times 0.0127}{1 \times 10^{-6}} = 2.273 \times 10^4$$

$$f = \frac{h_L \cdot D \cdot 2 \cdot g}{L V^2} = 0.069$$

flow type (-0.25)

5.3 Drawing

5.3.1. Draw head losses versus velocity of different pipes on the same graph.



Discussion:

Write true or false (correct the false statement):

- $h_L \propto V^2$ for turbulent flow while $h_L \propto V$ for laminar flow. ☒ T
- $f \propto 1/Re$. ☒ T
- If the pipe internal surface is rough and the flow has high velocity then the flow is said to be turbulent flow. ☒ T
- The value of head losses in smooth material more than rough material. ☒ F
- If $v=2v$ then $h_L \propto 4v^2$ in laminar flow. ☒ F
 $2 \times 2^2 = 4$
 $h_L \propto 4v^2$
 $h_L \propto 4 \times 2^2 = 16$
 $h_L \propto 16v^2$
 $h_L \propto 16 \times 2^2 = 64$
 $h_L \propto 64v^2$
 $h_L \propto 64 \times 2^2 = 256$
 $h_L \propto 256v^2$
 $h_L \propto 256 \times 2^2 = 1024$
 $h_L \propto 1024v^2$
 $h_L \propto 1024 \times 2^2 = 4096$
 $h_L \propto 4096v^2$
 $h_L \propto 4096 \times 2^2 = 16384$
 $h_L \propto 16384v^2$
 $h_L \propto 16384 \times 2^2 = 65536$
 $h_L \propto 65536v^2$
 $h_L \propto 65536 \times 2^2 = 262144$
 $h_L \propto 262144v^2$
 $h_L \propto 262144 \times 2^2 = 1048576$
 $h_L \propto 1048576v^2$
 $h_L \propto 1048576 \times 2^2 = 4194304$
 $h_L \propto 4194304v^2$
 $h_L \propto 4194304 \times 2^2 = 16777216$
 $h_L \propto 16777216v^2$
 $h_L \propto 16777216 \times 2^2 = 67108864$
 $h_L \propto 67108864v^2$
 $h_L \propto 67108864 \times 2^2 = 268435456$
 $h_L \propto 268435456v^2$
 $h_L \propto 268435456 \times 2^2 = 1073741824$
 $h_L \propto 1073741824v^2$
 $h_L \propto 1073741824 \times 2^2 = 4294967296$
 $h_L \propto 4294967296v^2$
 $h_L \propto 4294967296 \times 2^2 = 17179869184$
 $h_L \propto 17179869184v^2$
 $h_L \propto 17179869184 \times 2^2 = 68719476736$
 $h_L \propto 68719476736v^2$
 $h_L \propto 68719476736 \times 2^2 = 274877906944$
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 $h_L \propto 17592186044416v^2$
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 $h_L \propto 4503599627370496v^2$
 $h_L \propto 4503599627370496 \times 2^2 = 18014398509481984$
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 $h_L \propto 1152921504606846976v^2$
 $h_L \propto 1152921504606846976 \times 2^2 = 4611686018427387904$
 $h_L \propto 4611686018427387904v^2$
 $h_L \propto 4611686018427387904 \times 2^2 = 18446744073709551616$
 $h_L \propto 18446744073709551616v^2$
 $h_L \propto 18446744073709551616 \times 2^2 = 73786976294838206464$
 $h_L \propto 73786976294838206464v^2$
 $h_L \propto 73786976294838206464 \times 2^2 = 295147905179352825856$
 $h_L \propto 295147905179352825856v^2$
 $h_L \propto 295147905179352825856 \times 2^2 = 1180591620717411303424$
 $h_L \propto 1180591620717411303424v^2$
 $h_L \propto 1180591620717411303424 \times 2^2 = 4722366482869645213696$
 $h_L \propto 4722366482869645213696v^2$
 $h_L \propto 4722366482869645213696 \times 2^2 = 18889465931478580854784$
 $h_L \propto 18889465931478580854784v^2$
 $h_L \propto 18889465931478580854784 \times 2^2 = 75557863725914323419136$
 $h_L \propto 75557863725914323419136v^2$
 $h_L \propto 75557863725914323419136 \times 2^2 = 302231454903657293676544$
 $h_L \propto 302231454903657293676544v^2$
 $h_L \propto 302231454903657293676544 \times 2^2 = 1208925819614629174706176$
 $h_L \propto 1208925819614629174706176v^2$
 $h_L \propto 1208925819614629174706176 \times 2^2 = 4835703278458516698824704$
 $h_L \propto 4835703278458516698824704v^2$
 $h_L \propto 4835703278458516698824704 \times 2^2 = 19342813113834066795298816$
 $h_L \propto 19342813113834066795298816v^2$
 $h_L \propto 19342813113834066795298816 \times 2^2 = 77371252455336267181195264$
 $h_L \propto 77371252455336267181195264v^2$
 $h_L \propto 77371252455336267181195264 \times 2^2 = 309485009821345068724781056$
 $h_L \propto 309485009821345068724781056v^2$
 $h_L \propto 309485009821345068724781056 \times 2^2 = 1237940039285380274899124224$
 $h_L \propto 1237940039285380274899124224v^2$
 $h_L \propto 1237940039285380274899124224 \times 2^2 = 4951760157141521099596496896$
 $h_L \propto 4951760157141521099596496896v^2$
 $h_L \propto 4951760157141521099596496896 \times 2^2 = 19807040628566084398385987584$
 $h_L \propto 19807040628566084398385987584v^2$
 $h_L \propto 19807040628566084398385987584 \times 2^2 = 79228162514264337593543950336$
 $h_L \propto 79228162514264337593543950336v^2$
 $h_L \propto 79228162514264337593543950336 \times 2^2 = 316912650057057350374175801344$
 $h_L \propto 316912650057057350374175801344v^2$
 $h_L \propto 316912650057057350374175801344 \times 2^2 = 1267650600228229401496703205376$
 $h_L \propto 1267650600228229401496703205376v^2$
 $h_L \propto 1267650600228229401496703205376 \times 2^2 = 5070602400912917605986812821504$
 $h_L \propto 5070602400912917605986812821504v^2$
 $h_L \propto 5070602400912917605986812821504 \times 2^2 = 20282409603651670423947251286016$
 $h_L \propto 20282409603651670423947251286016v^2$
 $h_L \propto 20282409603651670423947251286016 \times 2^2 = 81129638414606681695789005144064$
 $h_L \propto 81129638414606681695789005144064v^2$
 $h_L \propto 81129638414606681695789005144064 \times 2^2 = 324518553658426726783156020576256$
 $h_L \propto 324518553658426726783156020576256v^2$
 $h_L \propto 324518553658426726783156020576256 \times 2^2 = 1298074214633706907132624082305024$
 $h_L \propto 1298074214633706907132624082305024v^2$
 $h_L \propto 1298074214633706907132624082305024 \times 2^2 = 5192296858534827628530496329220096$
 $h_L \propto 5192296858534827628530496329220096v^2$
 $h_L \propto 5192296858534827628530496329220096 \times 2^2 = 20769187434139310514121985316880384$
 $h_L \propto 20769187434139310514121985316880384v^2$
 $h_L \propto 20769187434139310514121985316880384 \times 2^2 = 83076749736557242056487941267521536$
 $h_L \propto 83076749736557242056487941267521536v^2$
 $h_L \propto 83076749736557242056487941267521536 \times 2^2 = 332306998946228968225951765070086144$
 $h_L \propto 332306998946228968225951765070086144v^2$
 $h_L \propto 332306998946228968225951765070086144 \times 2^2 = 1330827995784915872903807060280344576$
 $h_L \propto 1330827995784915872903807060280344576v^2$
 $h_L \propto 1330827995784915872903807060280344576 \times 2^2 = 5323311983139663491615228241121378304$
 $h_L \propto 5323311983139663491615228241121378304v^2$
 $h_L \propto 5323311983139663491615228241121378304 \times 2^2 = 21309247932558653966460912964485513216$
 $h_L \propto 21309247932558653966460912964485513216v^2$
 $h_L \propto 21309247932558653966460912964485513216 \times 2^2 = 85236991730234615865843651857942052864$
 $h_L \propto 85236991730234615865843651857942052864v^2$
 $h_L \propto 85236991730234615865843651857942052864 \times 2^2 = 340947966920938463463374607431768211456$
 $h_L \propto 340947966920938463463374607431768211456v^2$
 $h_L \propto 340947966920938463463374607431768211456 \times 2^2 = 1363791867683753853853498429727072845824$
 $h_L \propto 1363791867683753853853498429727072845824v^2$
 $h_L \propto 1363791867683753853853498429727072845824 \times 2^2 = 5455167470735015415413993718908291383296$
 $h_L \propto 5455167470735015415413993718908291383296v^2$
 $h_L \propto 5455167470735015415413993718908291383296 \times 2^2 = 21820669882940061661655974875633165533184$
 $h_L \propto 21820669882940061661655974875633165533184v^2$
 $h_L \propto 21820669882940061661655974875633165533184 \times 2^2 = 87282679531760246646623899502532662132736$
 $h_L \propto 87282679531760246646623899502532662132736v^2$
 $h_L \propto 87282679531760246646623899502532662132736 \times 2^2 = 349130718127040986586495598010130648530944$
 $h_L \propto 349130718127040986586495598010130648530944v^2$
 $h_L \propto 349130718127040986586495598010130648530944 \times 2^2 = 1396522872508163946345982392040522594123776$
 $h_L \propto 1396522872508163946345982392040522594123776v^2$
 $h_L \propto 1396522872508163946345982392040522594123776 \times 2^2 = 5586091490032655785383929568162090376495040$
 $h_L \propto 5586091490032655785383929568162090376495040v^2$
 $h_L \propto 5586091490032655785383929568162090376495040 \times 2^2 = 22344365960130623141535718272648361505980160$
 $h_L \propto 22344365960130623141535718272648361505980160v^2$
 $h_L \propto 22344365960130623141535718272648361505980160 \times 2^2 = 89377463840522492566142873090593446023920640$
 $h_L \propto 89377463840522492566142873090593446023920640v^2$
 $h_L \propto 89377463840522492566142873090593446023920640 \times 2^2 = 357509855362089970264571492362373784095682560$
 $h_L \propto 357509855362089970264571492362373784095682560v^2$
 $h_L \propto 357509855362089970264571492362373784095682560 \times 2^2 = 1430039421448359881058285969449495136382730240$
 $h_L \propto 1430039421448359881058285969449495136382730240v^2$
 $h_L \propto 1430039421448359881058285969449495136382730240 \times 2^2 = 5720157685793439524233143877797980545530920960$
 $h_L \propto 5720157685793439524233143877797980545530920960v^2$
 $h_L \propto 5720157685793439524233143877797980545530920960 \times 2^2 = 22880630743173758096932575511191922182123683840$
 $h_L \propto 22880630743173758096932575511191922182123683840v^2$
 $h_L \propto 22880630743173758096932575511191922182123683840 \times 2^2 = 91522522972695032387730302044767688728494735360$
 $h_L \propto 91522522972695032387730302044767688728494735360v^2$
 $h_L \propto 91522522972695032387730302044767688728494735360 \times 2^2 = 366090091890780129550921208179070754913978941440$
 $h_L \propto 366090091890780129550921208179070754913978941440v^2$
 $h_L \propto 366090091890780129550921208179070754913978941440 \times 2^2 = 1464360367563120518203684832716283019655915765760$
 $h_L \propto 1464360367563120518203684832716283019655915765760v^2$
 $h_L \propto 1464360367563120518203684832716283019655915765760 \times 2^2 = 5857441470252482072814739330865132078623663063040$
 $h_L \propto 5857441470252482072814739330865132078623663063040v^2$
 $h_L \propto 5857441470252482072814739330865132078623663063040 \times 2^2 = 23429765881009928291258957323460528314494652252160$
 $h_L \propto 23429765881009928291258957323460528314494652252160v^2$
 $h_L \propto 23429765881009928291258957323460528314494652252160 \times 2^2 = 93719063524039713165035829293842113257978609008640$
 $h_L \propto 93719063524039713165035829293842113257978609008640v^2$
 $h_L \propto 93719063524039713165035829293842113257978609008640 \times 2^2 = 374876254096158852660143317175368453031914436034560$
 $h_L \propto 374876254096158852660143317175368453031914436034560v^2$
 $h_L \propto 374876254096158852660143317175368453031914436034560 \times 2^2 = 1499505016384635410640573268701473812127657744138240$
 $h_L \propto 1499505016384635410640573268701473812127657744138240v^2$
 $h_L \propto 1499505016384635410640573268701473812127657744138240 \times 2^2 = 5998020065538541642562293074805895248510630976552960$
 $h_L \propto 5998020065538541642562293074805895248510630976552960v^2$
 $h_L \propto 5998020065538541642562293074805895248510630976552960 \times 2^2 = 23992080262154166570249172299223580994042523906211840$
 $h_L \propto 23992080262154166570249172299223580994042523906211840v^2$
 $h_L \propto 23992080262154166570249172299223580994042523906211840 \times 2^2 = 95968321048616666280996689196894323976170095624847360$
 $h_L \propto 95968321048616666280996689196894323976170095624847360v^2$
 $h_L \propto 95968321048616666280996689196894323976170095624847360 \times 2^2 = 383873284194466665123986756787577295904680382509389440$
 $h_L \propto 383873284194466665123986756787577295904680382509389440v^2$
 $h_L \propto 383873284194466665123986756787577295904680382509389440 \times 2^2 = 1535493136777866660495947027150309183618721530037557760$
 $h_L \propto 1535493136777866660495947027150309183618721530037557760v^2$
 $h_L \propto 1535493136777866660495947027150309183618721530037557760 \times 2^2 = 6141972547111466641983788108601236734474886120150231040$
 $h_L \propto 6141972547111466641983788108601236734474886120150231040v^2$
 $h_L \propto 6141972547111466641983788108601236734474886120150231040 \times 2^2 = 24567890188445866567935152434404946937899544480600924160$
 $h_L \propto 24567890188445866567935152434404946937899544480600924160v^2$
 $h_L \propto 24567890188445866567935152434404946937899544480600924160 \times 2^2 =$

Specific Energy, : slow and fast flow

Table 6.1. Variation of V and E with the height of water.

$$Q(L/min) = 50.7 \quad Q(m^3/s) = 8.45 \times 10^{-4} \quad h_c = 0.023 \quad V_c =$$

ID#: 1632493

$$E_{min.}(theo.) = 0.016$$

H before sluice gate (m)	E before sluice gate (m)	H after sluice gate (m)	E after sluice gate (m)
0.175	0.175	0.011	0.064
0.088	0.089	0.012	0.057
0.037	0.042	0.034	0.039
0.035		0.035	

6.2. Sample of calculations:

$$A = h \times b = 0.175 \times 75 \times 10^{-3} = 0.013 \text{ m}^2$$

$$V = \frac{Q}{A} = 0.065 \text{ m/s}$$

$$E = h + \frac{V^2}{2g} = 0.175 \text{ m}$$

$$Fr = \frac{V}{\sqrt{g h m}}$$

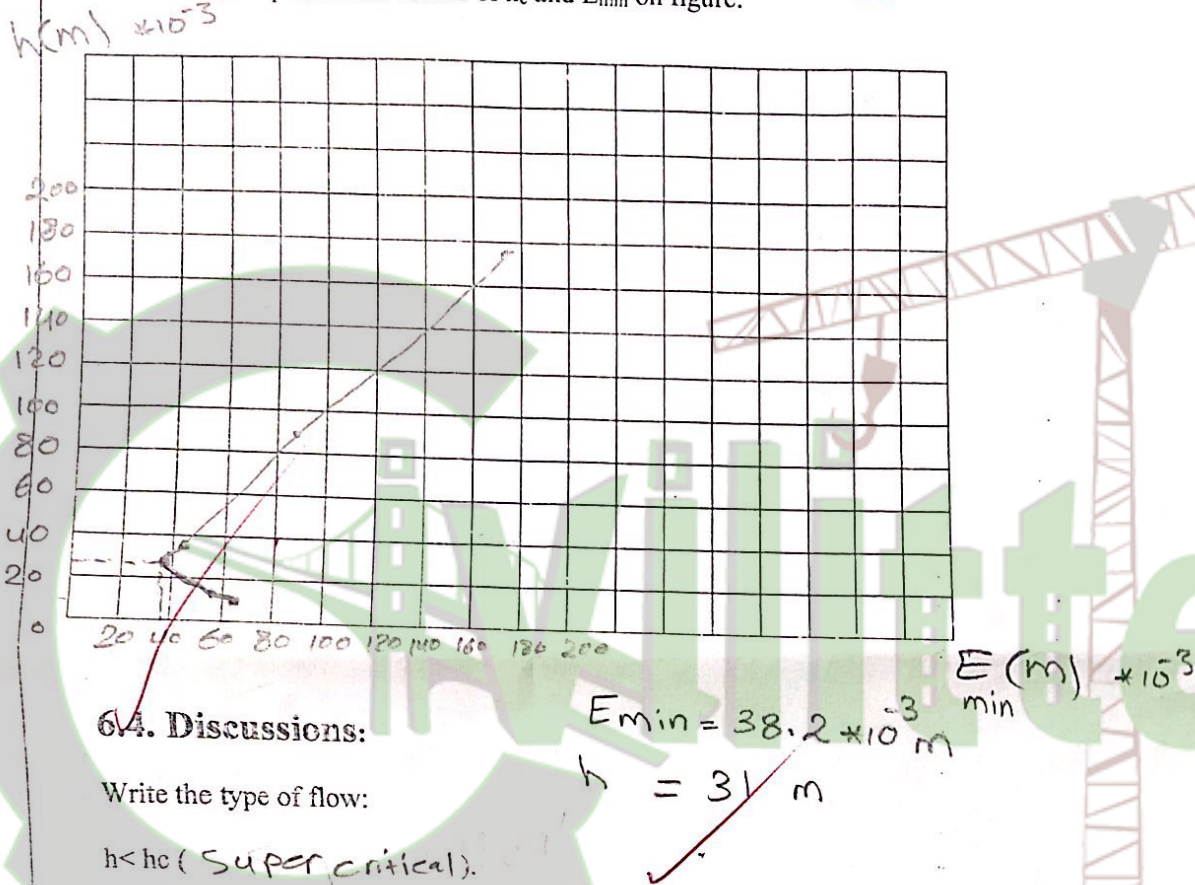
Flow type

$$h_c (theo.) = \left(\frac{q^2}{g} \right)^{1/3} = 0.023 \quad q = \frac{Q}{b} = 0.011$$

$$E_{min.}(theo.) = \frac{2}{3} (h_c) = 0.016$$

6.3. Plot:

- Plot h versus E and show the supercritical and subcritical regions on figure.
- Find the experimental values of h_c and E_{min} on figure.



6.4. Discussions:

Write the type of flow:

$h < h_c$ (Supercritical).

$V < V_c$ (Subcritical).

$Fr = 1$ (critical flow).

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Hydraulic Jump

Name: محمد فرحات

ID#: 1632493

7.1. Data collected from experiment:

Flow Rate (L/min.)	Flow Rate (m³/s)	Initial Depth (h ₁) (mm)	Sequent Depth (h ₂) (mm)
40.1	6.68×10^{-4}	10	45
46.3	7.72×10^{-4}	11	42

7.2. Calculations:

V ₁ (m/s)	Fr ₁	Flow Type	h ₂ ; Theo. (m)	V ₂ (m/s)	Fr ₂	Flow Type	h ₁ ; Theo. (m)	h _j (m)	hl exp. (m)	hl theo. (m)
0.891	2.84	Super	0.035	0.198	0.298	Sub	0.023	0.035	0.023	0.024
0.936	2.85	Super	0.039	0.245	0.382	Sub	0.01	0.031	0.01	0.016

Notes:

- hl exp. (depend on energy).
- hl theo. (depend on depth value).

$$E_1 = 0.05$$

$$E_1 =$$

$$E_2 = 0.04$$

$$E_2 =$$

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Name: محمد عبد الرحمن The Flow Beneath a Sluice gate
ID# 1632493

8.1. Data and Calculations

Data:

$h_g = 15 \text{ mm}$

Table 1: variations of h_o with Q

$Q \text{ (L/min)}$	$h_o \text{ (mm)}$

$h_g = 20 \text{ mm}$

Table 2: variations of h_o with Q

$Q \text{ (L/min)}$	$h_o \text{ (mm)}$
78.6	130
67.6	100
56.6	70

9.25
10

Calculations:

$h_g = 15 \text{ mm}$

Table 3: variations of C_d and with h_o .

$h_o \text{ (m)}$	$Q_{act.} \text{ (m}^3/\text{sec)}$	$Q_{theo.} \text{ (m}^3/\text{sec)}$	$C_d \text{ Calc.}$	$h_o^{1.5}$
	1			

$C_d \text{ avg} =$

$h_g = 20 \text{ mm}$

Table 4: variations of C_d with h_o

$h_o \text{ (m)}$	$Q_{act.} \text{ (m}^3/\text{sec)}$	$Q_{theo.} \text{ (m}^3/\text{sec)}$	$C_d \text{ Calc.}$	$h_o^{1.5}$
0.13	1.31×10^{-3}	2.396×10^{-3}	0.55	0.36
0.1	1.13×10^{-3}	2.11×10^{-3}	0.54	0.32
0.07	9.43×10^{-4}	1.758×10^{-3}	0.54	0.26

$C_d \text{ avg} = 0.55$

8.2. Sample of calculation

$$Q_A = \frac{Q \text{ (L/min)}}{60000} = 1.31 \times 10^{-3} \text{ m}^3/\text{s}$$

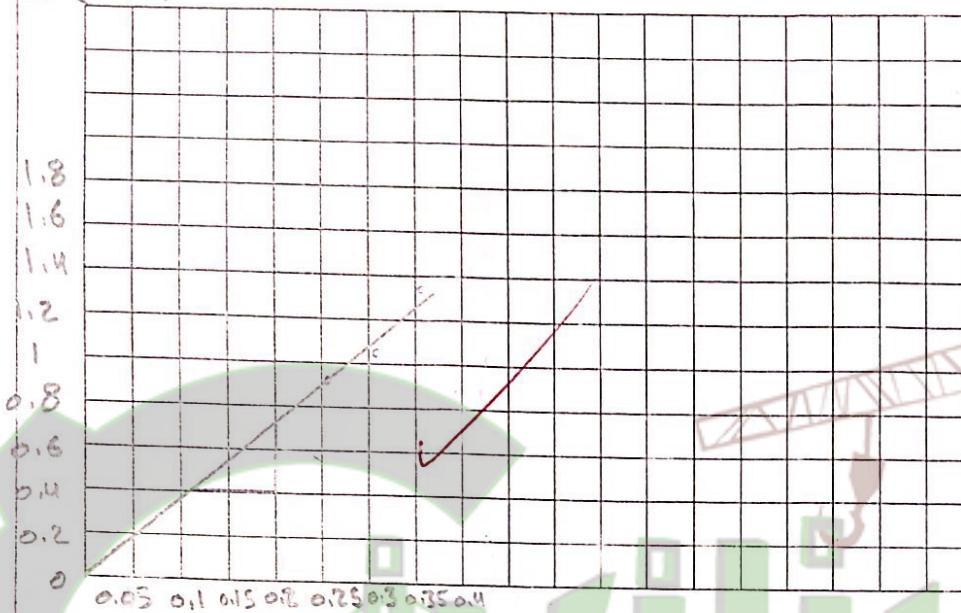
$$Q_{theo} = b h_g \sqrt{2gh_o} = 2.396 \times 10^{-3} \text{ m}^3/\text{s}$$

$$C_d = \frac{Q_a}{Q_{theo}} = 0.55$$

8.3. Plots:

- Plot Q_a versus h_o , from the plot determine C_d .
Best-fit line must be pass through (0, 0).

$Q_a (m^3/s) \times 10^{-3}$

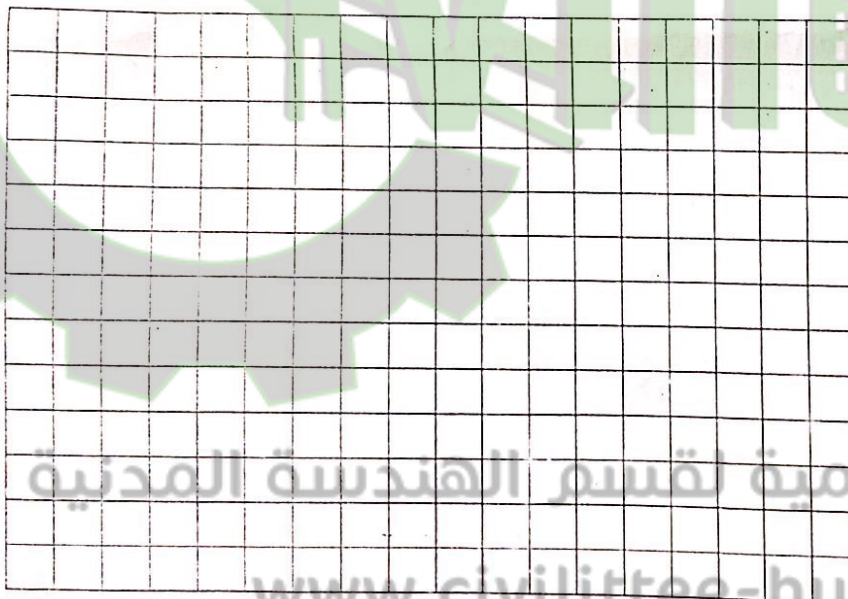


$$\text{slope} = \frac{0.7 - 0.4}{0.2 - 0.11} = 3.33 \times 10^3$$

$$\Rightarrow \text{slope} = C_d \cdot b \cdot h_g \sqrt{2g}$$

$$C_d = 0.501$$

Plot C_d (from table) versus h_g .



8.4. Discussion

- Is the value of C_d from table and figure is accepted or not? Why?

accepted because $C_d < 1$

Name: عبد الرحمن

Rectangular Weir

ID#: 1632493

9.1. Data and Calculations

Data:

b = 75mm

$h_w = 0.075 \text{ m}$

Table 1: variations of H with Q for rectangular weir

Q (L/min.)	H (mm)
77.3	115
52.2	105

$\frac{9.25}{10}$

Calculations:

Table 3: variations of Cd with H for Rectangular weir

H (m)	Q _{act.} (m ³ /sec)	Q _{theo.} (m ³ /sec)	Cd	Log H	Log Q _{act}	H ^{3/2}
0.040	1.29×10^{-3}	1.77×10^{-3}	0.73	-1.4	-2.89	8×10^{-3}
0.03	8.7×10^{-4}	1.15×10^{-3}	0.76	-1.52	-3.06	5.2×10^{-3}

9.2. Sample of calculation

$$Q_{act} = \frac{77.3}{60000} = 1.29 \times 10^{-3} \text{ m}^3/\text{s}$$

$$Q_{theo} = \frac{2}{3} b \sqrt{2g} H^{3/2} = 1.77 \times 10^{-3} \text{ m}^3/\text{s}$$

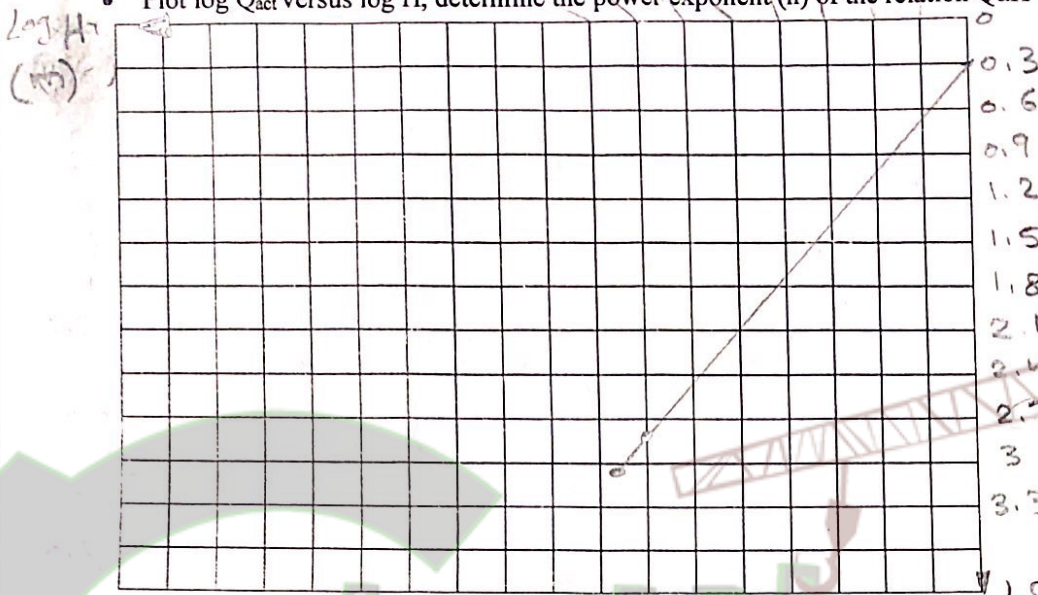
$$C_d = \frac{Q_{act}}{Q_{theo}} = \frac{1.29 \times 10^{-3}}{1.77 \times 10^{-3}} = 0.73$$

$$\log_H(0.04) = -1.4 \text{ m}$$

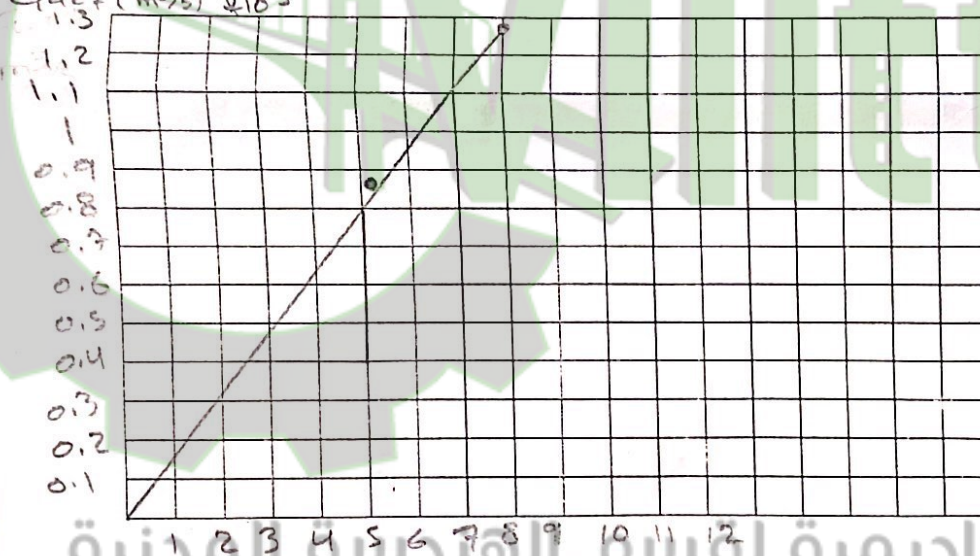
$$\log_Q(1.29 \times 10^{-3}) = -2.89 \text{ m}^3/\text{s}$$

9.3. Plots

- Plot $\log Q_{act}$ versus $\log H$, determine the power-exponent (n) of the relation $Q \propto H^n$.



- Plot Q_{act} Versus $H^{3/2}$ and determine the sharp weir C_d .



9.5. Discussion

- Comment on the value of:

C_d the value of the $C_d = 0.722 < 1$

$n \rightarrow \text{slope} = 1.42 < 1.5$

FLUIDS AND HYDRAULICS LABORATORY

EXP.5: Pumps

Name محمد بن عبد الله
ID# 1632493

Parallel Connection

Table 10.1.1: Data and Calculations for Parallel Connection

Q_A (L/min.)	Q_B (L/min)	P_{A1} (Bar)	P_{A2} (Bar)	P_{B1} (Bar)	P_{B2} (Bar)	h_A (m)	h_B (m)	Q_t (m ³ /s)	h_{avg} (m)
50	50	-0.2	0.75	-0.16	0.71	9.7	8.87	1.67×10^{-3}	9.29
30	30	-0.11	0.9	-0.1	0.9	10.3	10.19	1×10^{-3}	10.245
10	10	-0.09	1	-0.09	1	11.11	11.11	3.33×10^{-4}	11.11

Series Connection

Table 10. 1.2: Data and Calculations for Series Connection

Q (L/min.)	P_{A1} (Bar)	P_{A2} (Bar)	P_{B1} (Bar)	P_{B2} (Bar)	h_A (m)	h_B (m)	Q_t (m ³ /s)	h_t (m)
70	-0.4	0.7	0.7	0.9	11.21	8.15	1.17×10^{-3}	19.35
50	-0.2	0.75	0.8	1.4	9.68	6.11	8.33×10^{-4}	15.79
30	-0.1	0.9	0.8	1.8	10.19	10.19	5×10^{-4}	20.38

Single Pump

Table 10. 1.3: Data and Calculations for single pump

Q (L/min.)	P_{A1} (Bar)	P_{A2} (Bar)	h_A (m)	Q (m ³ /s)	ϵ	imp. P
70	-0.3	0.5	8.16	1.17×10^{-3}	0.78	120.66
50	-0.2	0.7	9.18	8.33×10^{-4}	0.68	111
30	-0.1	0.9	10.19	5×10^{-4}	0.52	95.6

10.2. Sample of calculations:

$$h_A = \frac{\Delta P}{\rho g} \times 10^5 = 9.7 \text{ m}$$

$$h_B = \frac{\Delta P}{\rho g} \times 10^5 = 8.87 \text{ m}$$

$$Q_t = \frac{Q_A + Q_B}{3600} = \frac{50 + 50}{3600} = 1.67 \times 10^{-3} \text{ m}^3/\text{s}$$

$$h_{avg} = \frac{h_1 + h_2}{2} = 9.29 \text{ m}$$

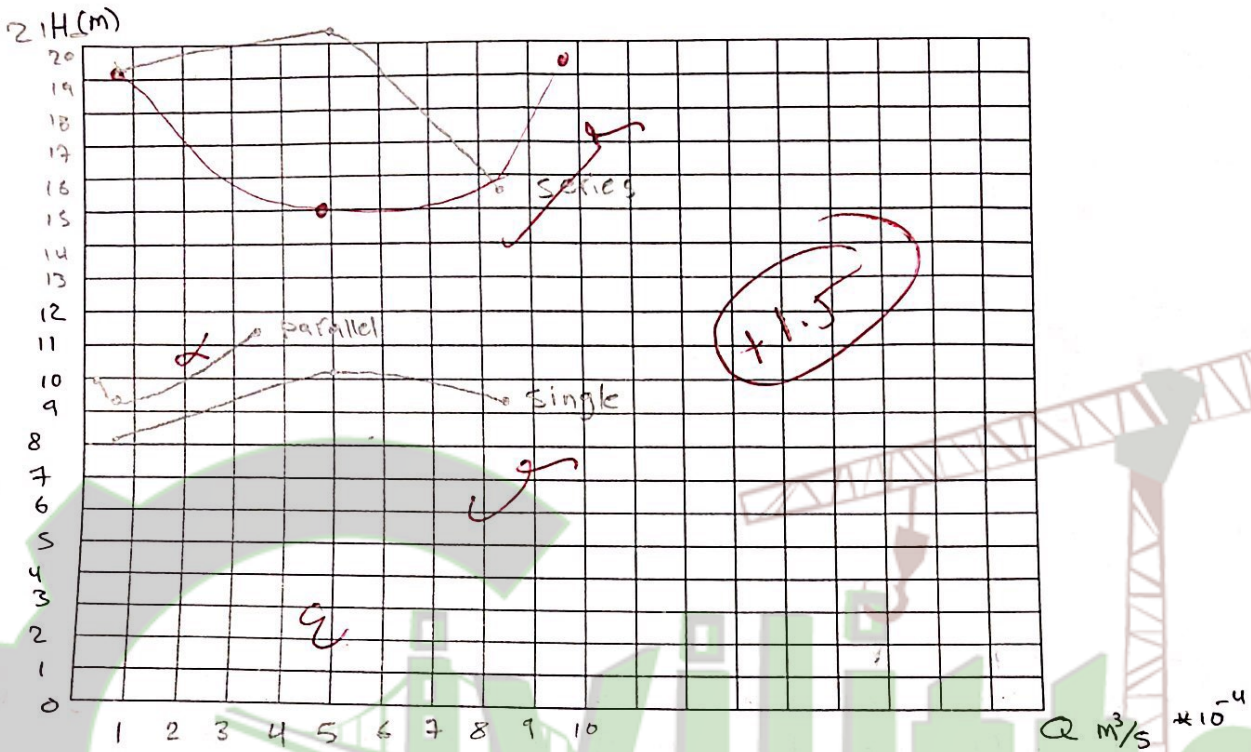
$$h_t = h_A + h_B$$

$$\epsilon = \frac{\text{Power out}}{\text{Power input}} = 0.78$$

10.3. Plots:

1-Plot H VS Q for single pump, series and parallel pumps

2-Plot ϵ vs. Q on the same plot for single pump.



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