Hydraulics Laboratory

EXP.1: Center of pressure on a plan surface

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ID#: 1632493

9

Section: 1

Date: 16/6/2019

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.
$(\gamma) = \rho * g = 9810$ N per m^3

b	d	R1	R2	R3
75	100	100	200	200

in mm

1.1.1. Totally Immersed

0.2

Table 1: Determination of the calculated and experimental center of pressure on a plan surface totally immerged 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	8.57	0.108	0.11

- **Sample of Calculations:**

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

$$* f_{th.} = \rho g * \bar{y} * \sin\alpha * Area$$

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

$$* F_{exp} = \frac{9.81 * 0.4 * 0.2}{\left[0.2 - \left[\frac{(0.116 * \frac{0.1}{2}) - (0.1^2/6)}{0.116 - (\frac{0.1}{2})}\right]\right]} = 5.71 \text{ N}$$

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

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

$$= 0.077 \text{ m}$$

1.2. Partially Immersed

Table 2: Determination of the calculated and experimental center of pressure on a plan surface partially immerged 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:**

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

$$*f_{tho} = 9810 * 0.05 * 0.025 * 0.075 = 0.92 \text{ N}$$

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

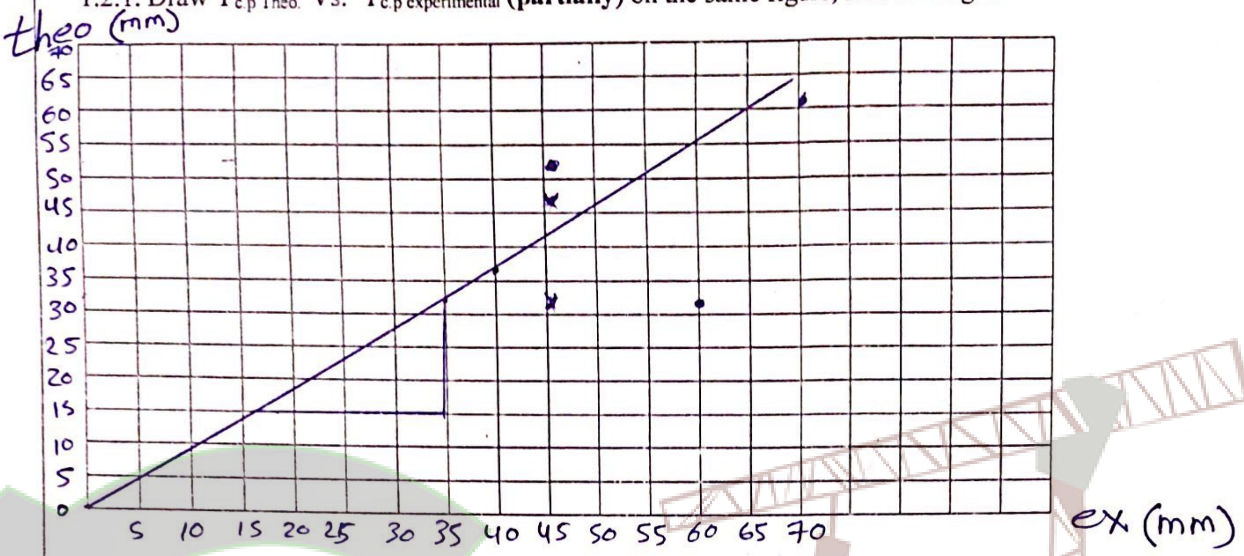
$$* y_{c.p\ theo} = \frac{2}{3} * 0.05 = 0.33$$

$$* y_{c\ exp} = \left(\frac{2 * 0.1 * 0.2}{1000 * 0.075 * 0.05^2} \right) - 0.2 + 0.05$$

$$= 0.063 \text{ m}$$

1.2. Drawing:

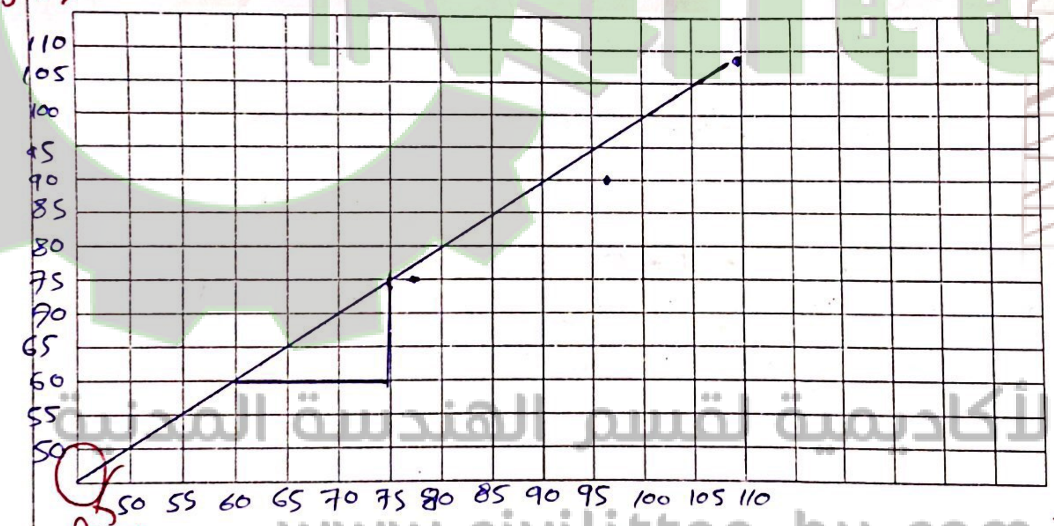
1.2.1. Draw $Y_{c.p\ Theo.}$ Vs. $Y_{c.p\ experimental}$ **(partially)** on the same figure, find the angle.



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

-0.25

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



-0.25

-0.25

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

Name : محمد خير صالح	Fluid & hydraulics Lab.	Exp.Title: Bernoulli's Theorem & Venture Meter.
ID No: 1632493		Exp.No.03

7.5

3.1. Data and Calculations

D_1= 25mm, D5=10mm, D8=25mm (Total head).

Table3.1.1. 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

$A1(m^2)$	$4.91 * 10^{-4}$	m^2
$A5(m^2)$	$7.85 * 10^{-5}$	m^2

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

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:

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

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

$$= 1.63*10^{-4}$$

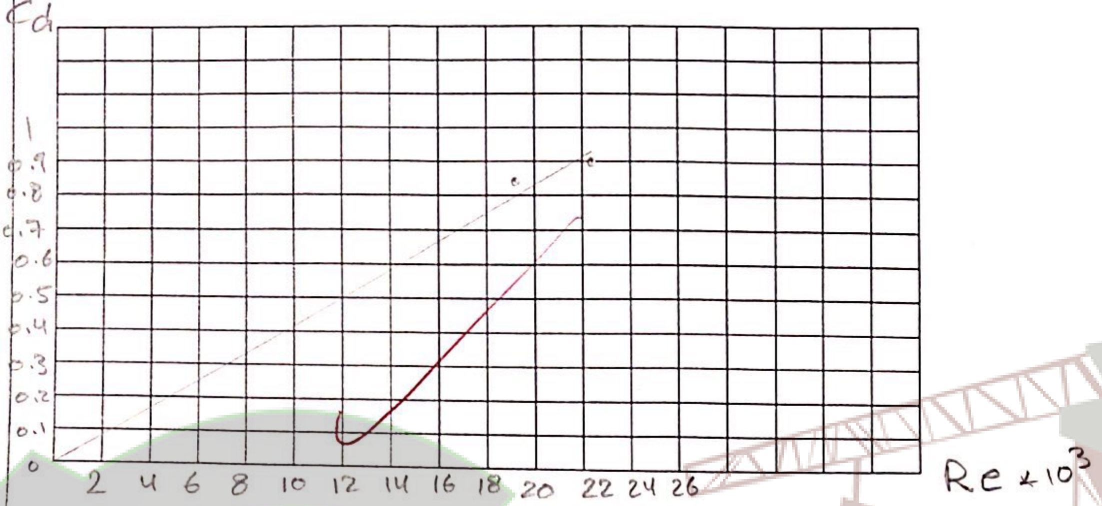
$$C_d = \frac{Q_{act}}{Q_{theo}} = \frac{1.47*10^{-4}}{1.63*10^{-4}} = 0.9$$

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

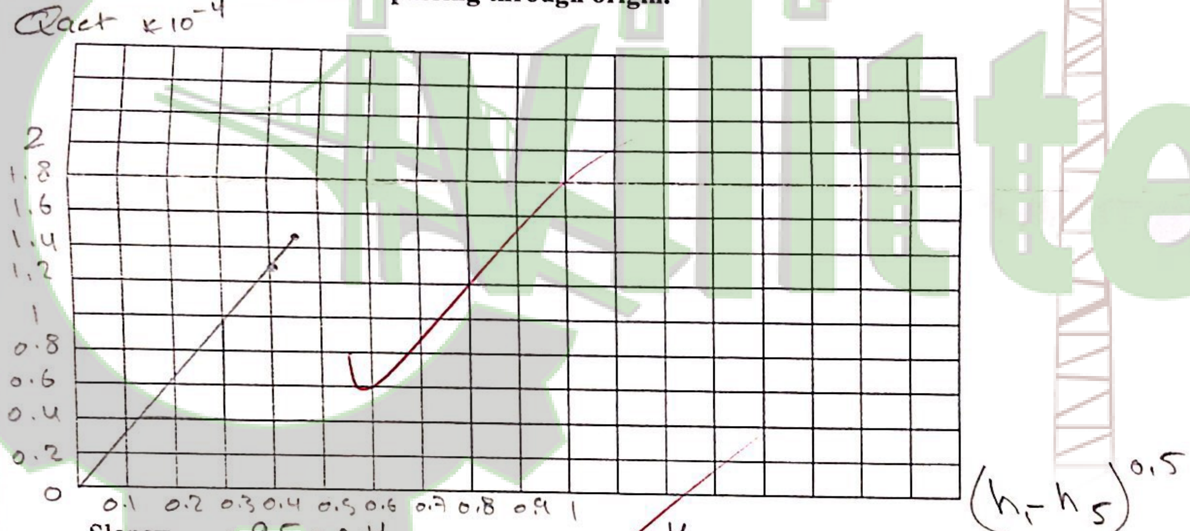
$$H_t - H_p = \frac{V^2}{2g} \Rightarrow V = 2.21\ m/s$$

3.2 Results Plot

3.2.1 Plot Cd versus Re (fig.3.1).



3.2.2 Plot Qact (m^3/s) versus $(h1\text{-}h5)^{0.5}$. Use the slope of this plot <u>to calculate the discharge coefficient Cd</u> (fig.3.2). Hint: The line must be passing through origin.



Slope= $\dfrac{0.95-0.4}{0.3-0.13} = 3.24 \times 10^{-4}$

Cd= $\Rightarrow$ slope $= 3.24 \times 10^{-4} = Cd \times 7.85 \times 10^{-5} \times \sqrt{\dfrac{2 \times 9.81}{1-\left(\dfrac{7.85\times10^{-5}}{4.91\times10^{-4}}\right)^2}}$

$\Rightarrow$ $\boxed{\cancel{Cd = 0.854}}$ $\boxed{Cd = 0.919}$

3.2. Discussion:

- **True or false (correct the false):**

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

-2.5

FLUIDS AND HYDRAULICS LABORATORY

Name: محمد نمر صلاح **EXP.4:** Impact of water jet

ID#: 1632493

4.1. Data and Calculations

9.4 / 10

Table 4.1.: Flat Plate Target ($\theta = 90^0$)

Mass (g)	Volume (L)	Time (s)	Q (m^3/s)	V_{nozzel} (m/s)	V_o nozzle (m/s)	Moment $m^\cdot * V_o$	$F_{measured}$ (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 ($\theta = 180^0$)*

Mass (g)	Volume (L)	Time (s)	Q (m^3/s)	V_{nozzel} (m/s)	V_o nozzle (m/s)	Moment $m^\cdot * V_o$	$F_{measured}$ (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:

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

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

$$V_{nozzel} = \frac{Q}{A} = \cancel{8.68}\ 5.23 \ m/s$$

$$V_{o\,nozzel} = \sqrt{V_n^2 - 2gS} = \sqrt{(5.23)^2 - 2 * 9.81 * 3 * 10^{-2}} = 5.17 \ m/s$$

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

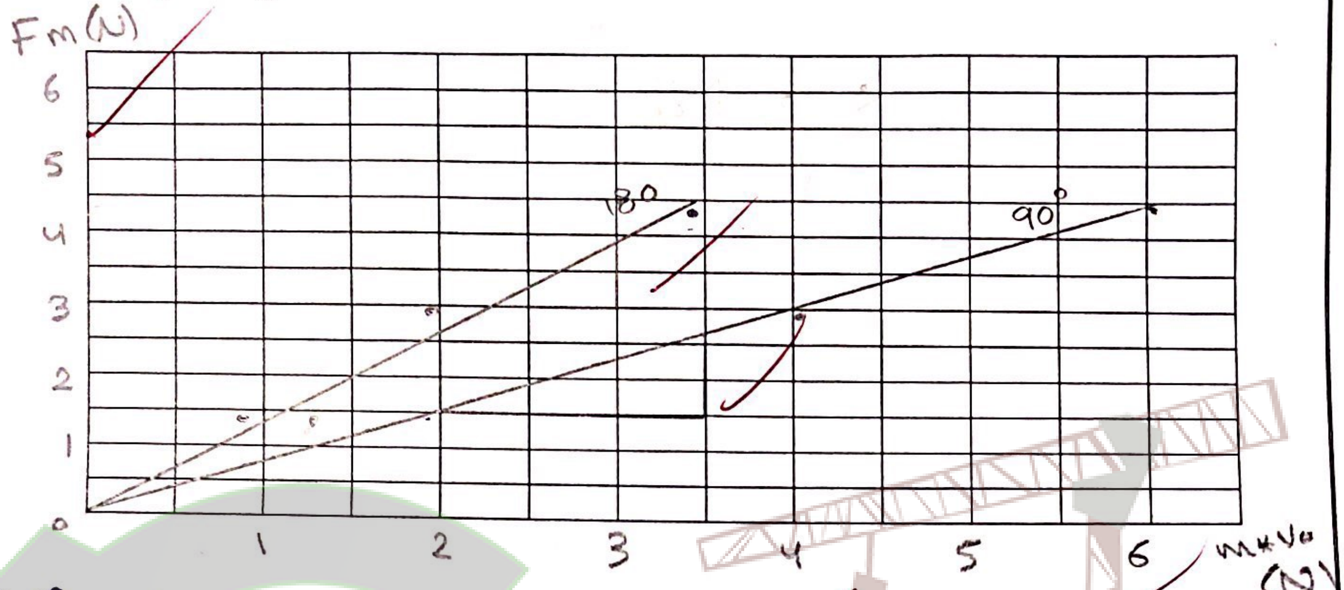
$$F_m = mg = \frac{150}{1000} * 9.81 = 1.47 \ N$$

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

$180^\circ (-0.25)$

4.3. Plot:

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



180 → Slope = $\frac{3.9-2.5}{3-2}$ 1.9 = 1.27

(−0.1)

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

4.4. Discussion

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

$\mu g = \rho Q V_o$ → 90° → slope = 0.69 ≤ 1 → ok

$\mu g = \rho Q V_o$ → 180° → slope = 2 ≤ 2 → ok

4.4.2 – true or false (correct the false):

(−0.25)

- When the internal angle =40°, the impact equation= 1.86 $\dot{m}$ * Vo F
- When the impact angle increases the flow rate ~~increase~~. F decrease
- mg = $\dot{m}$ * Vo for flat plate. T

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8.8/10

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= 3/4in A= 0.000285m²

	Volume (m^3)	Time (sec)	h_L (m)	Q (m^3/sec)	V (m/sec)	K
90⁰ Elbow						

5.2. Sample of Calculations:

$Q = \frac{V}{t} = 2.273*10^{-4}$ -0.1

$V = \frac{Q}{A} = 1.794$ -0.1

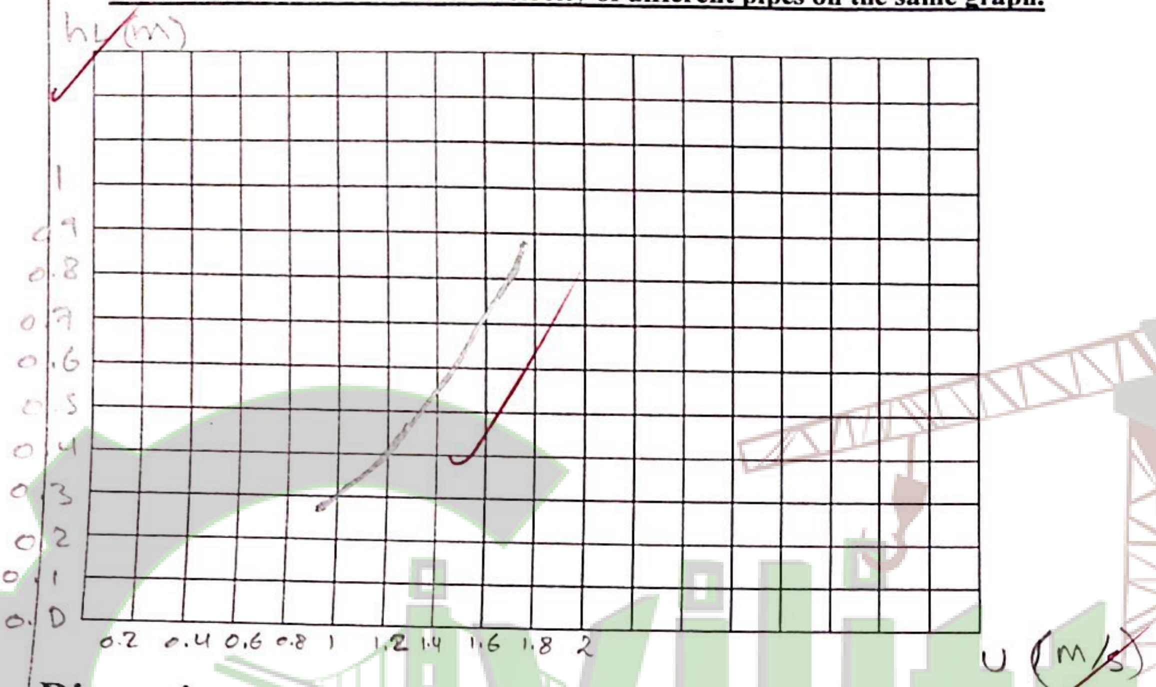
$Re = \frac{UD}{1*10^{-6}} = \frac{1.794*0.0127}{*10^{-6}}$

$f = \frac{h_L*D*2*g}{LV^2} = 0.069$

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):

- $h_L \ \alpha \ V^2$ for turbulent flow while $h_L \ \alpha \ V$ for laminar flow . T
- $f \ \alpha \ 1/Re$. 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 less → smooth material less than rough material
- If v=2v then hl α 4v² in laminar flow. F 2V² -0.25
- hL α lengthe of pipe and α 1/d² in laminar flow. T

Write the **type of flow (turbulent or laminar)**:

From the figure 5.3.1, the flow is (turbulent), because (Re > 4000). -0.5

The Darcy friction factor *f* is function of Re# only (laminar).

hL effected by the type of material (turbulent).

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Specific Energy: slow and fast flow

ID#: 1632493

5

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

Q(L/min)= 50.7 Q(m³/s)= 8.45×10^{-4} h_c= 0.023 V_c= 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= $h * b = 0.175 * 75 \times 10^{-3} = 0.013\ m^2$

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

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

Fr= $\frac{V}{\sqrt{g\,hm}}$

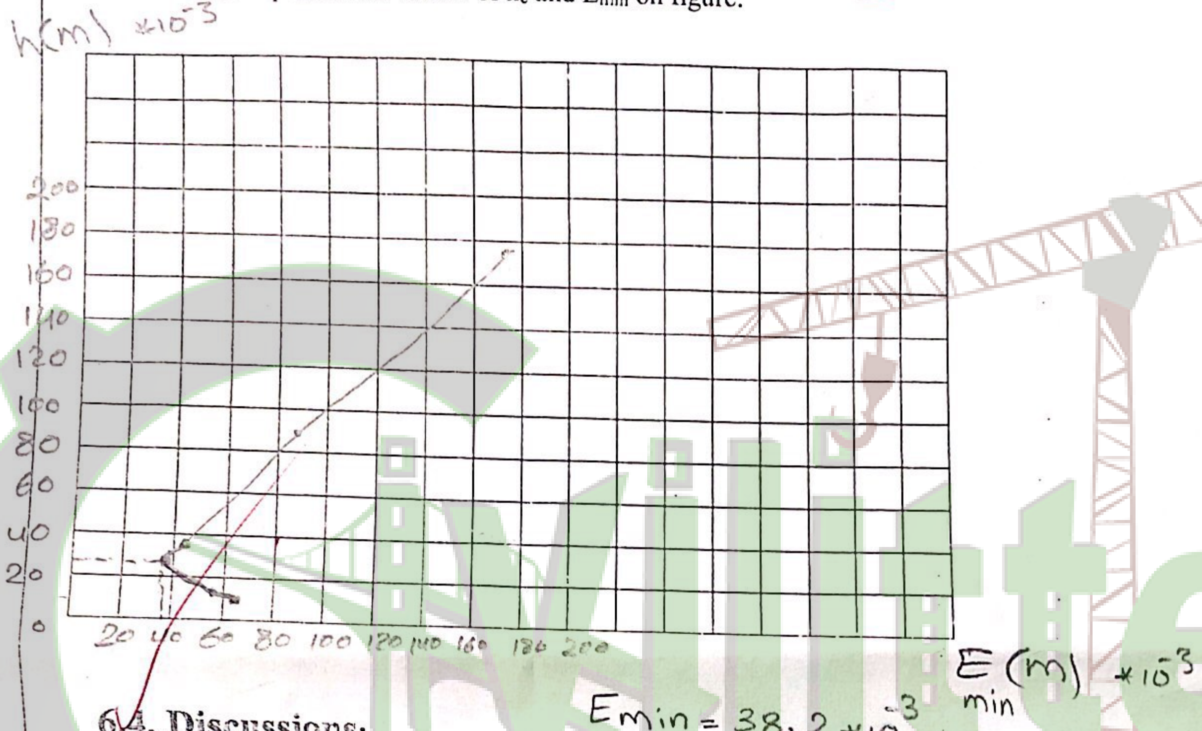
Flow type

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

Emin.(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.



$E_{min} = 38.2 * 10^{-3}$ m

$h_{min} = 31$ m

6.4. Discussions:

Write the type of flow:

h< hc (Super critical).

V< Vc (Subcritical).

Fr=1 (critical flow).

Hydraulic Jump

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$\frac{4.8}{5}$

7.1. Data collected from experiment:

Flow Rate (L/min.)	Flow Rate (m^3/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

-0.2

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)	hj(m)	hl exp. (m)	hl theo. (m)
0.891	2.84	Super	0.035	0.198	0.298	Sub	0.0[illegible]3	0.035	0.0[illegible]	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).

$E_1 = 0.05$ $E_1 =$

$E_2 = 0.04$ $E_2 =$

Name: محمد نصر صلاح The Flow Beneath aSluice gate
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$\frac{9.25}{10}$

8.1. Data and Calculations

Data:

h_g=15mm

Table 1: variations of h_0 with Q

Q (L/min)	h_0 (mm)

h_g=20mm

Table 2: variations of h_0 with Q

Q (L/min)	h_0 (mm)
78.6	130
67.6	100
56.6	70

Calculations:

h_g=15mm

Table 3: variations of Cd and with h_0.

h_0 (m)	$Q_{act.}$ (m^3/sec)	$Q_{theo.}$ (m^3/sec)	Cd Calc.	h_0^.5

Cd avg=

h_g=20mm

Table 4: variations of Cd with h_0

h_0 (m)	$Q_{act.}$ (m^3/sec)	$Q_{theo.}$ (m^3/sec)	Cd Calc.	h_0^.5
0.13	1.31×10^{-3}	2.396×10^{-3}	0.55	0.36
0.1	1.13×10^{-3}	2.1×10^{-3}	0.54	0.32
0.07	9.43×10^{-4}	1.758×10^{-3}	0.54	0.26

Cd avg= -0.25

8.2. Sample of calculation

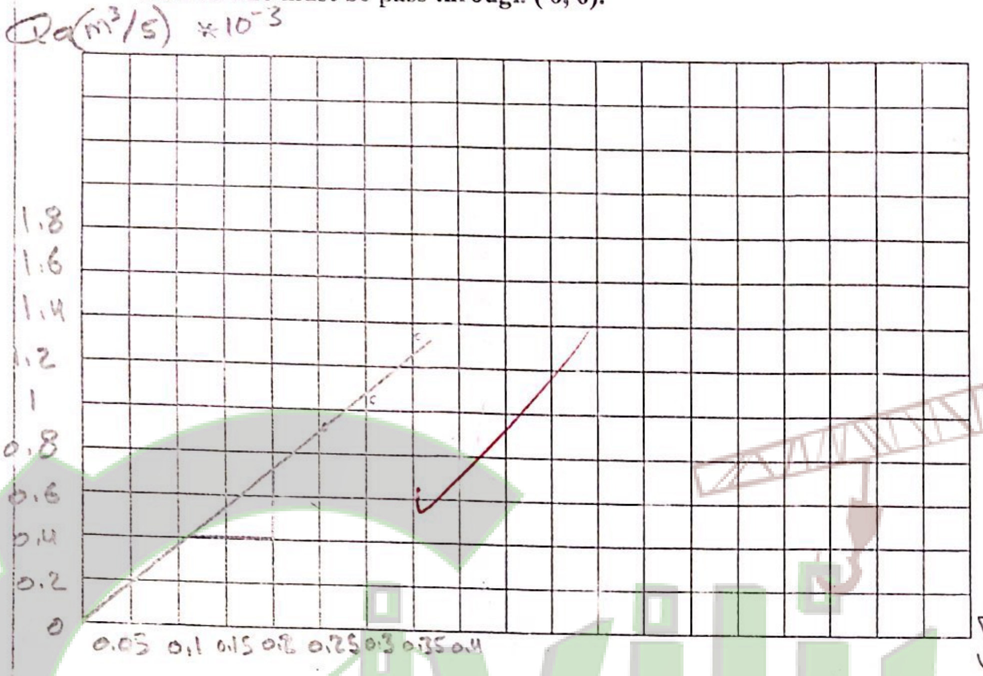
$$Q_A = \frac{Q(L/min)}{60000} = 1.31 \times 10^{-3}\ m^3/s$$

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

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

8.3. Plots:

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



slope = $\frac{0.7-0.4}{0.2-0.11}$

$= 3.33 * 10^{-3}$

$\Rightarrow$ Slope = $C_d * b * h_g \sqrt{2g}$

$C_d = 0.501$

Plot C_d (from table) versus h_g.

8.4. Discussion

-0.5

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

accepted because Cd < 1

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Rectangular Weir

9.1. Data and Calculations

Data:

b= 75mm $h_w = 0.075$ m

Table 1: variations of H with Q for rectangular weir

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

9.25 / 10

Calculations:

Table 3: variations of Cd with H for Rectangular weir

H (m)	Qact. (m³/sec)	Qtheo. (m³/sec)	Cd	Log H	Log Qact	$H^{3/2}$
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

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

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

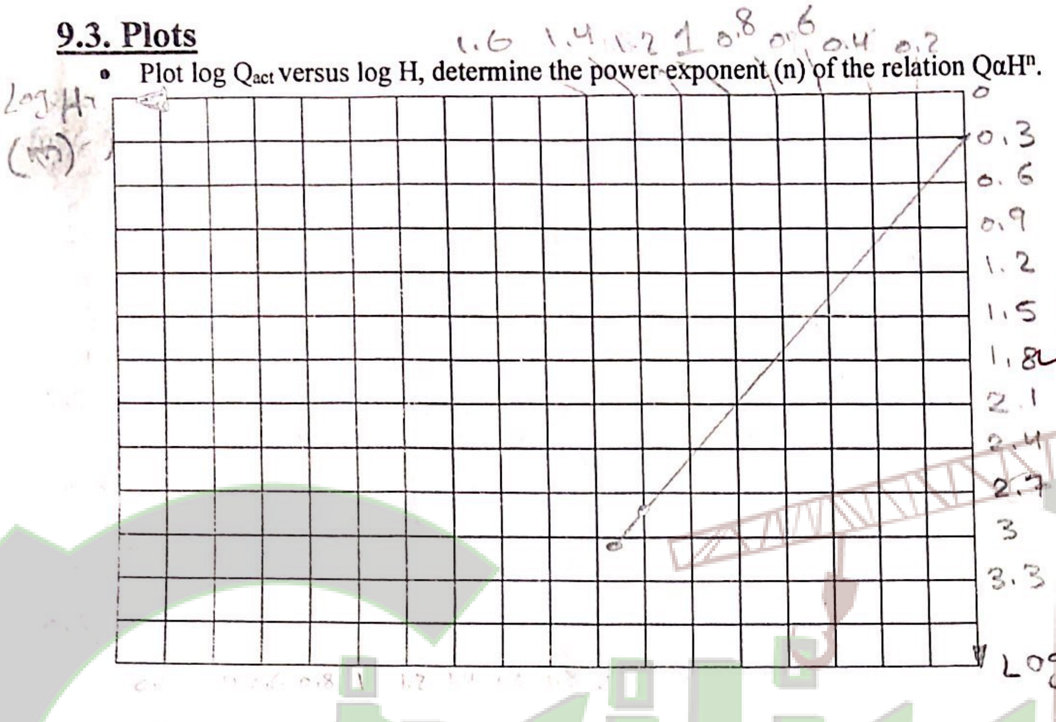
$$Cd = \frac{Q_{act}}{Q_{theo}} = \frac{1.29*10^{-3}}{1.77*10^{-3}} = 0.73$$

$$Log_H (0.04) = -1.4 \ m$$

$$Log_Q (1.29*10^{-3}) = -2.89 \ m^3/s$$

9.3. Plots

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



$$\text{Slope} = \frac{3.06-2.89}{1.52-1.4} = 1.42$$

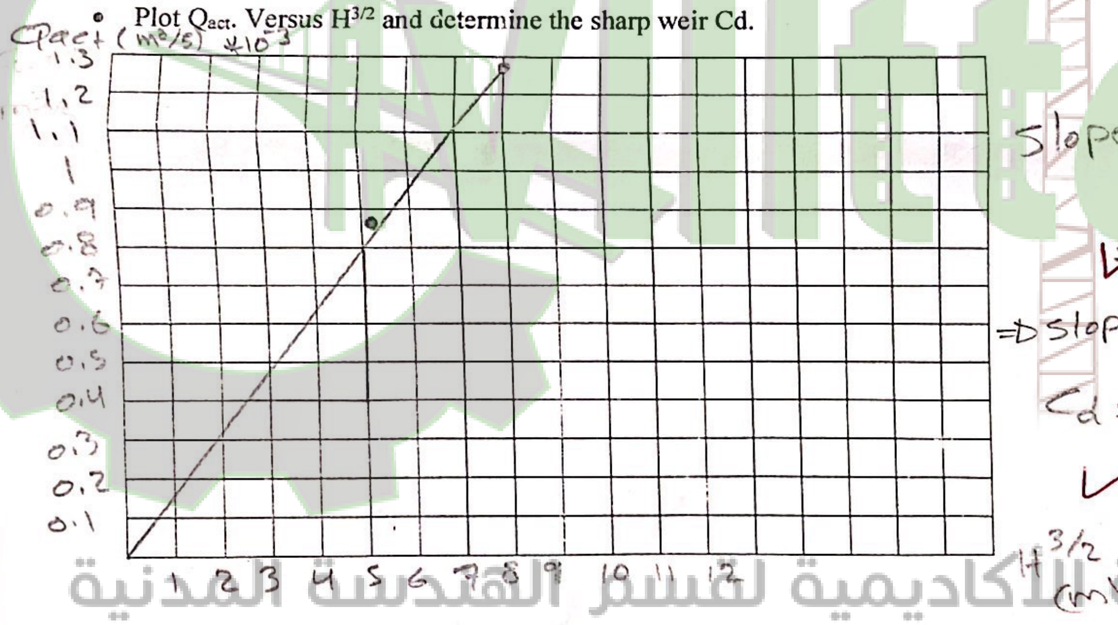
$\boxed{Q \alpha H^{1.42}}$

$0.3 = \log \frac{2}{3} C_d \sqrt{2g}\, b$

$10^{-0.3} = \frac{2}{3} C_d * \sqrt{2g}\, b$

$\Rightarrow C_d = -0.25$

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



$$\text{Slope} = \frac{0.8 - 0.4}{5 - 2.5} \times 10$$

$= 0.16$

$\Rightarrow \text{slope} = C_d \times \frac{2}{3} \times b \times \sqrt{2g}$

$C_d = 0.722$

9.5. Discussion

- Comment on the value of :

Cd the value of the Cd = 0.722 < 1

n → slope = 1.42 < 1.5

-0.5

FLUIDS AND HYDRAULICS LABORATORY

EXP.5: Pumps

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$\frac{9.75}{10}$

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

Table10. 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	0.4	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

Table10. 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	inp . 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:

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

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

$$Q_t = \frac{Q_A + Q_B}{3600} = 1.67\times10^{-3}\ m^3/s$$

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

$$h_t = H_A + H_B$$

Qt

$$\mathcal{E} = \frac{\text{Power out}}{\text{Power input}} = 0.78$$

10.3. Plots:

1-Plot H VS Q for single pump, series and parallel pumps
2-Plot Є vs. Q on the same plot for single pump.