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اللجنة الأكاديمية للهندسة المدنية

تقارير لاب الهيدرو

حازم دراوشة

Experiment 6

Center of Pressure

ID: 1834046	Name: حازم عمر خليفه دراوشه	SEC.1

1. Data and Calculations:

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

γ (N/m³) = ρ*g	b(mm)	d(mm)	R1(mm)	R2(mm)	R3(mm)
9810	75	100	100	200	200

1.1 Totally Immersed

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)	ȳ (mm)	$F_{theo.}$ (N)	$F_{exp.}$ (N)	$Y_{c.p\ calculated}$ (mm)	$Y_{c.p\ experimental}$ (mm)
400	122	72	5.3	5.67	84	70
500	155	105	7.73	6.91	112.9	81.9

Show sample of calculation on each computation of mass 400g

ȳ (mm)	$F_{theo.}$ (N)	$F_{exp.}$ (N)	$Y_{c.p\ calculated}$ (mm)	$Y_{c.p\ experimental}$ (mm)
$\bar{y} = y - \frac{d}{2}$ $= 122 - \frac{100}{2}$ $= 72\,mm$	$F_{theo} = \rho g \bar{y} b d$ $= 9810 * 0.072 * 0.075 * 0.1$ $= 5.3\ N$	$F_{exp} = \frac{m g R_3}{R_2 - \left(\frac{\frac{yd}{2} - \frac{d^2}{6}}{y - \frac{d}{2}}\right)}$ $= \frac{0.4 * 9.81 * 0.2}{0.2 - \left(\frac{\frac{0.122 * 0.1}{2} - \frac{0.1^2}{6}}{0.122 - \frac{0.1}{2}}\right)}$ $= \cancel{0.85}\,N$ $5.67\,N$	$y_{cp\,theo} = \bar{y} + \frac{I}{\bar{y} A}$ $= 0.072 + \frac{\frac{1}{12} * 0.075 * 0.1^3}{0.072 * 0.075 * 0.1}$ $= 0.084\ m$ $= 84\ mm$	$y_{cp\,exp} = \frac{2 m R_3}{\rho(2ybd - bd^2)} - R_2 + y$ $= \frac{2(0.4) * 0.2}{1000(2(0.122 * 0.075 * 0.1) - 0.075 * 0.1^2)} - 0.2 + 0.122$ $= 0.07\ m$ $= 70\,mm$

1.3 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)	ȳ (mm)	$F_{theo.}$ (N)	$F_{exp.}$ (N)	$Y_{c.p\ theo.}$ (mm)	$Y_{c.p\ experimental}$ (mm)
100	54	27	1.073	1.078	36mm	36.9
200	78	39	2.24	2.255	52mm	53.3

Show sample of calculation on each computation of mass 100g

ȳ (mm)	$F_{theo.}$ (N)	$F_{exp.}$ (N)	$Y_{c.p\ calculated}$ (mm)	$Y_{c.p\ experimental}$ (mm)
$\bar{y} = \frac{y}{2} = \frac{54}{2}$ $= 27\,mm$	$F_{theo.} = \rho g \bar{y} A$ $= 9810 * 0.027 * 0.075 * 0.054$ $= 1.073\ N$	$F_{exp.} = \frac{m g R_3}{R_2 - \frac{y}{3}}$ $= \frac{0.1 * 9.81 * 0.2}{0.2 - \frac{0.054}{3}}$ $= 1.078\,N$	$y_{cp\,theo} = \bar{y} + \frac{I}{\bar{y} A}$ $= 0.027 + \frac{\frac{1}{12} * 0.075 * 0.054^3}{0.027 * 0.075 * 0.054}$ $= 0.036\,m$ $= 36\,mm$	$y_{cp\,exp.} = \left(\frac{2 m R_3}{\rho b y^2}\right) - R_2 + y$ $= \frac{2(0.1) * 0.2}{1000 * 0.075 * 0.054^2} - 0.2 + 0.054$ $= 0.0369\ m$ $= 36.9\,mm$

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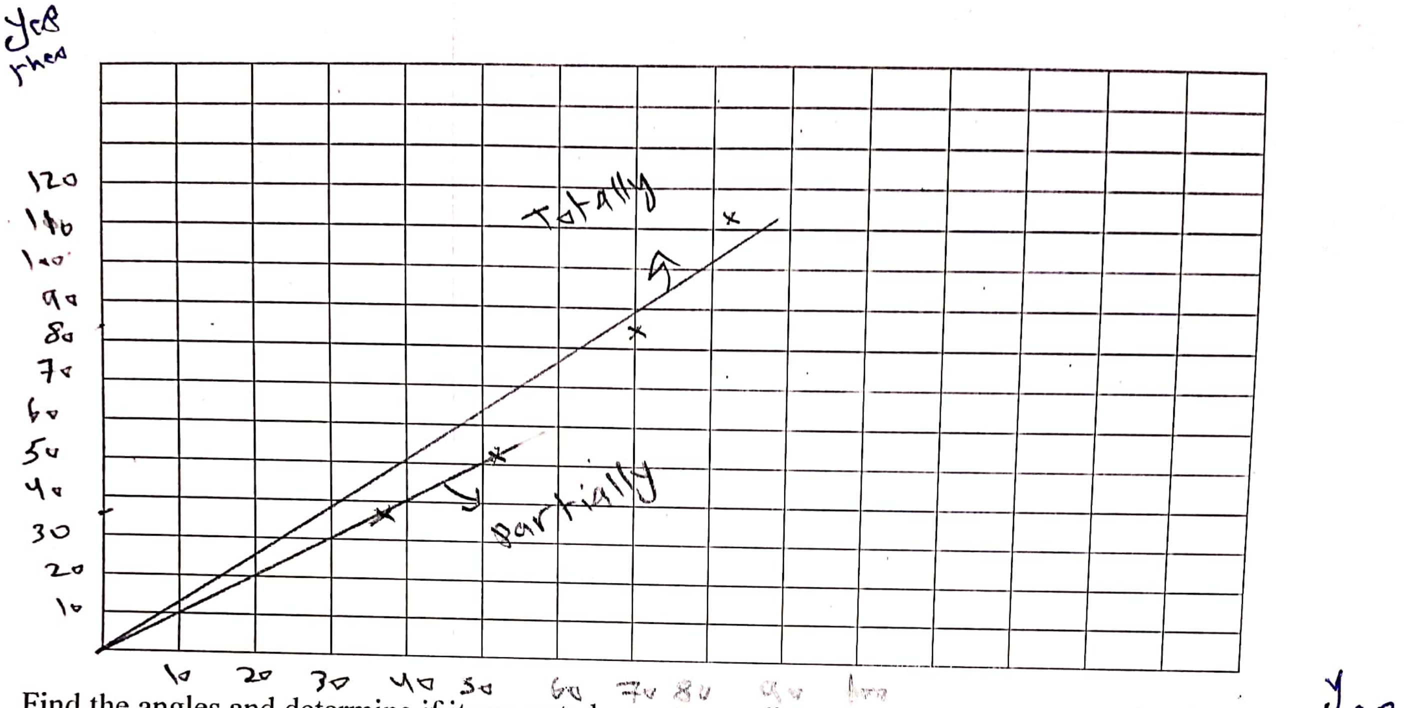
2. Plot the results:

Draw $Y_{c.p\ Theo.}$ vs. $Y_{c.p\ experimental}$ for **Totally** and **Partially** immersed in the same figure.

***Hint: the plot must start from origin**



Find the angles and determine if its accepted or not according to the angles values. (40^0-50^0).

Totally:

$$\text{angle} = \tan^{-1}(\text{slope}) = \tan^{-1}\left(\frac{90-50}{70-40}\right) = \tan^{-1}\left(\frac{40}{30}\right) = 53.13^\circ$$

not accepted

Partially:

$$\tan^{-1}(\text{slope}) = \tan^{-1}\left(\frac{40-20}{40-20}\right) = 45^\circ$$

accepted

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1) it is a linear relation

2) pressure of water increase by depth

	Experiment 6 Orifice and Jet Flow	
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1. Data and Calculations: Hint: Diameter of orifice is 6mm

Trial #	H (cm)	V (Lt)	Time (sec)	H (m)	Qact (m3/s)	$H^{0.5}$
1	30	5	135	0.3	3.7×10^{-5}	0.55
2	40	5	111	0.4	4.5×10^{-5}	0.63

1.2. According to the second trial find:

A. Theoretical flow rate (m^3/s)

$$Q_{theo} = \frac{\pi}{4} D^2 \sqrt{2gH}$$

$$= \frac{\pi}{4}(0.006)^2 \sqrt{2 \times 9.81 \times 0.4}$$

$$= 7.92 \times 10^{-5} \ m^3/s$$

$$Q_{act} = \frac{V}{t}$$

$$= \frac{0.005}{111} = 4.5 \times 10^{-5} \ m^3/s$$

B. Coefficient of discharge (Cd).

$$Cd = \frac{Q_{act}}{Q_{theo}} = \frac{4.5 \times 10^{-5}}{7.92 \times 10^{-5}} = 0.568$$

C. coefficient of velocity (Cv) if the flow jet is traveling horizontal distance (X) 350mm while falling vertical distance (Y) 83mm. Is it valid or not? Why?

$$C_v = \frac{X}{2\sqrt{Y \times H}} = \frac{0.35}{2\sqrt{0.083 \times 0.4}} = 0.96 < 1$$

it's valid because it's less than 1

D. Coefficient of contract area (Cc). (Cd=Cc*CV). Is it valid or not? Why?

$$C_c = \frac{C_d}{C_v} = \frac{0.568}{0.96} = 0.592 < 1$$

it's valid because it's less than 1

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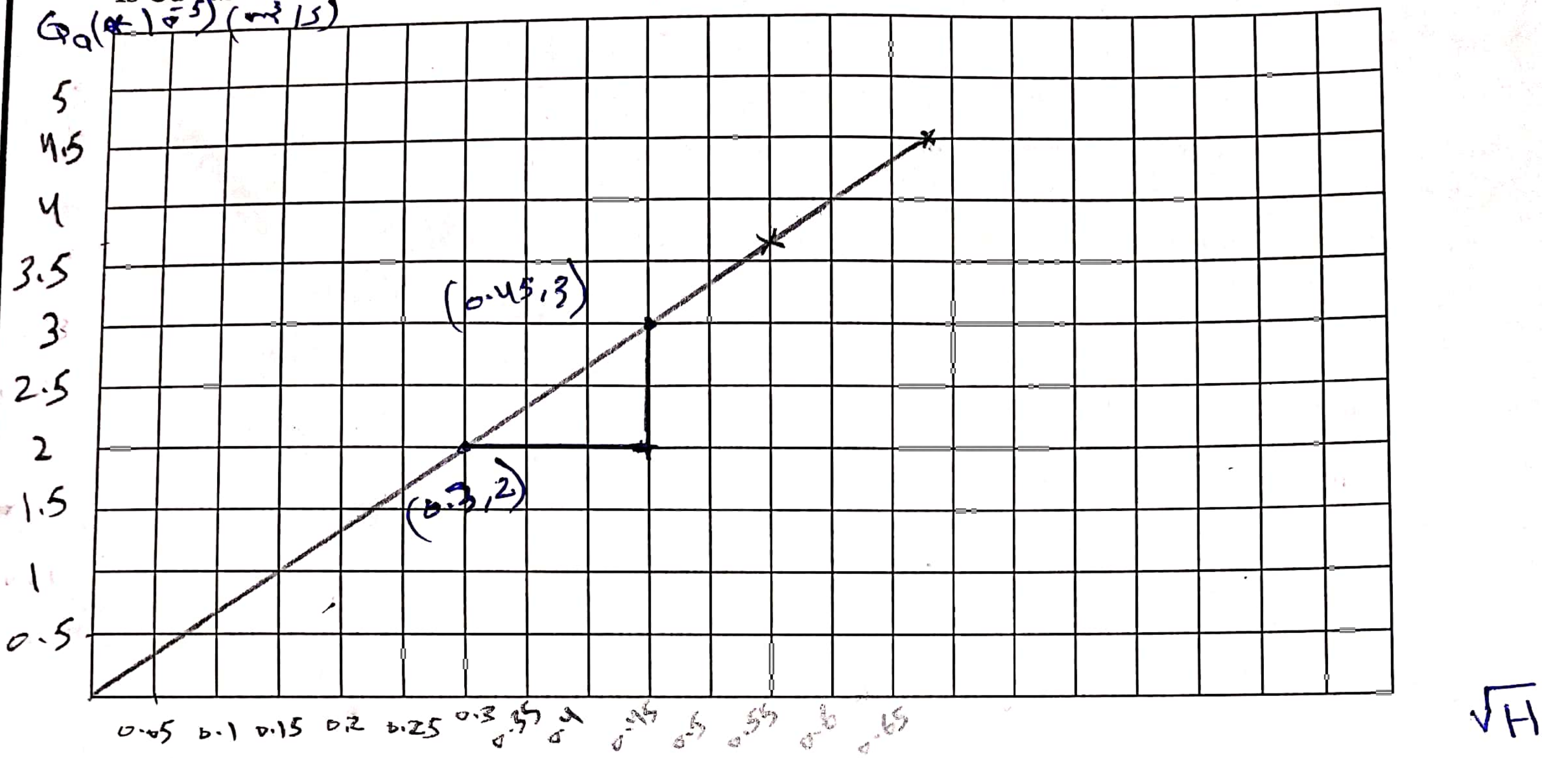
2. Plots:

- Plot Qa versus ($H^{0.5}$) and from the plot compute Cd. (The plot must passes through origin).
- Is Cd value valid or not, why?



Hint: Slope=$\Delta Qa/\Delta H^{0.5}$=A*Cd*(2g) $^{0.5}$

$$slope = \frac{(3-2)\times 10^{-5}}{(0.45-0.3)} = 6.67\times 10^{-5} = \frac{\Delta Q_a}{\Delta \sqrt{H}}$$

$$Cd = \frac{slope}{A\sqrt{2g}} = \frac{6.67\times 10^{-5}}{\frac{\pi}{4}(0.006^2)\times\sqrt{2\times 9.81}}$$

$Cd = 0.533 < 1$ it's valid because it's less than 1

3)

1. True
2. ~~False~~ True
3. True

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	Experiment 6 Bernoulli's Theorem	
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1. Data

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

Trial #	Volume (Lt.)	Time (sec)	reading (cm)	Point 1	Point 5
1	5	41	Hp	46.9	28.9
			Ht	47.3	44.8
2	5	44	Hp	27.9	13.3
			Ht	24.1	28.4

2. Calculations

$A_1= \frac{\pi}{4}(0.025)^2 = 4.91*10^{-4} m^2$

$A_5= \frac{\pi}{4}(0.01)^2 = 7.85*10^{-5} m^2$

Trial #	$Q_{act.}$ (m^3/s)	$Q_{theo.}$ (m^3/s)	Cd	V_5	Re_5	$(h_1-h_5)^{0.5}$
1	$1.22*10^{-4}$	$1.5*10^{-4}$	0.813	1.55	15500	0.42
2	$1.14*10^{-4}$	$1.35*10^{-4}$	0.84	1.45	14500	0.38

3. Sample: Show sample of calculation on each computation of trial 1.

$Q_{act.}$ (m^3/s)	$Q_{theo.}$ (m^3/s)	Cd
$= \frac{V}{T}$ $= \frac{0.005}{41}$ $= 1.22*10^{-4} m^3/s$	$= A_5 \sqrt{\frac{2g(h_1-h_5)}{1-\left(\frac{A_5}{A_1}\right)^2}}$ $= 7.85*10^{-5}\sqrt{\frac{2(9.81)(0.469-0.289)}{1-\left(\frac{7.85*10^{-5}}{4.91*10^{-4}}\right)^2}}$ $= 1.5*10^{-4} m^3/s$	$= \frac{Q_{act}}{Q_{theo}}$ $= \frac{1.22*10^{-4}}{1.5*10^{-4}}$ $= 0.813$

V_5	Re_5	$(h_1-h_5)^{0.5}$
$= \frac{Q_{act}}{A_5}$ $= \frac{1.22*10^{-4}}{7.85*10^{-5}}$ $= 1.55 m/s$	$= \frac{V_5 D_5}{10^{-6}}$ $= \frac{1.55 * 0.01}{10^{-6}}$ $= 15500$	$= (0.469-0.289)^{0.5}$ $= 0.42$

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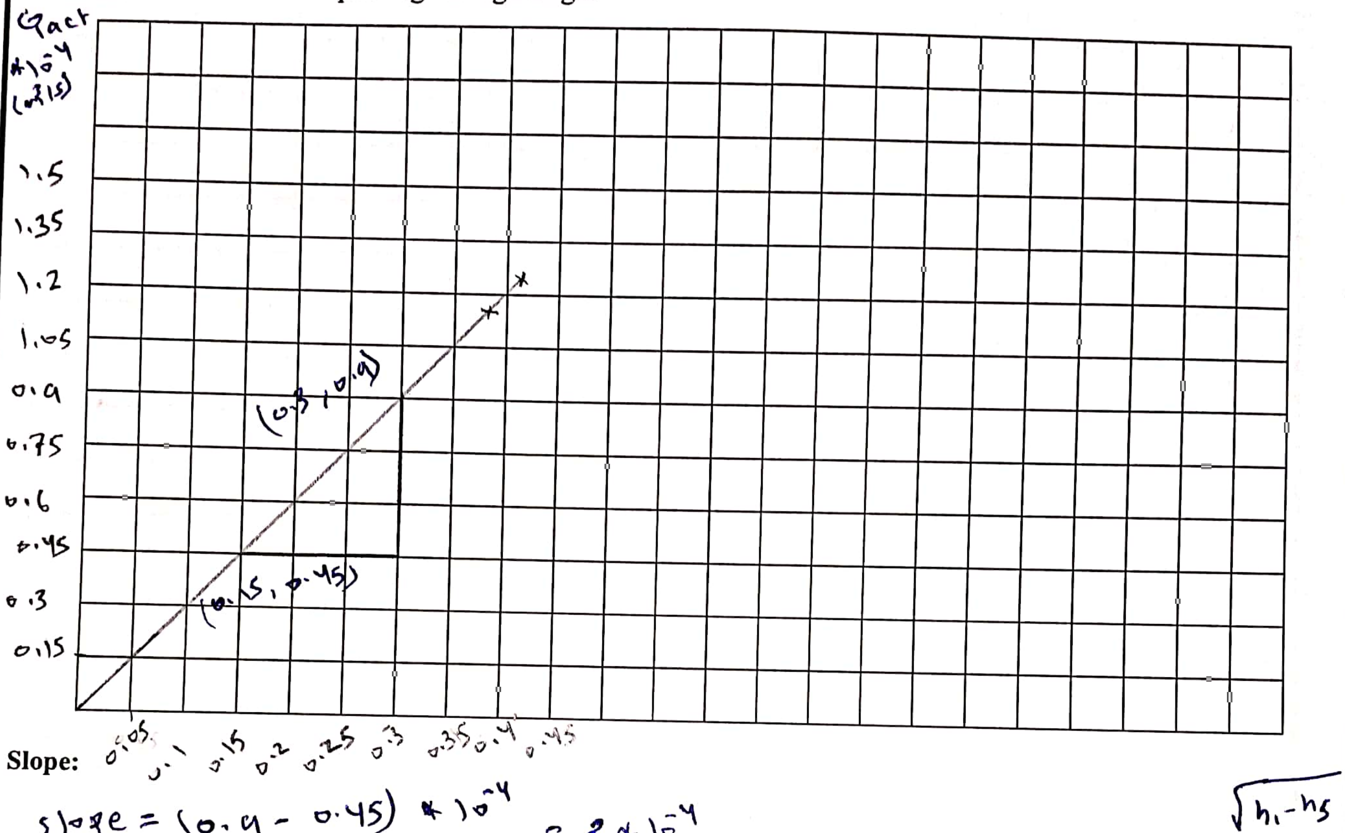
4. Plots:

- Plot Qact (m^3/s) versus $(h_1-h_5)^{0.5}$. Use the slope of this plot to calculate the discharge coefficient Cd.

  Hint: The line must be passing through origin



Slope:

$$slope = \frac{(0.9 - 0.45) * 10^{-4}}{0.3 - 0.15} = 3 * 10^{-4}$$

CD:

$$slope = C_d * A_5 \sqrt{\frac{2g}{1-\left(\frac{A_5}{A_1}\right)^2}} \Rightarrow C_D = \frac{slope}{A_5 \sqrt{\frac{2g}{1-\left(\frac{A_5}{A_1}\right)^2}}}$$

$$C_D = \frac{3*10^{-4}}{7.85*10^{-5}\sqrt{\frac{2*9.81}{1-\left(\frac{7.85*10^{-5}}{4.91*10^{-4}}\right)^2}}} = 0.8517$$

Comment on Cd value:

it's accepted because it's less than 1 (0.8517 < 1)

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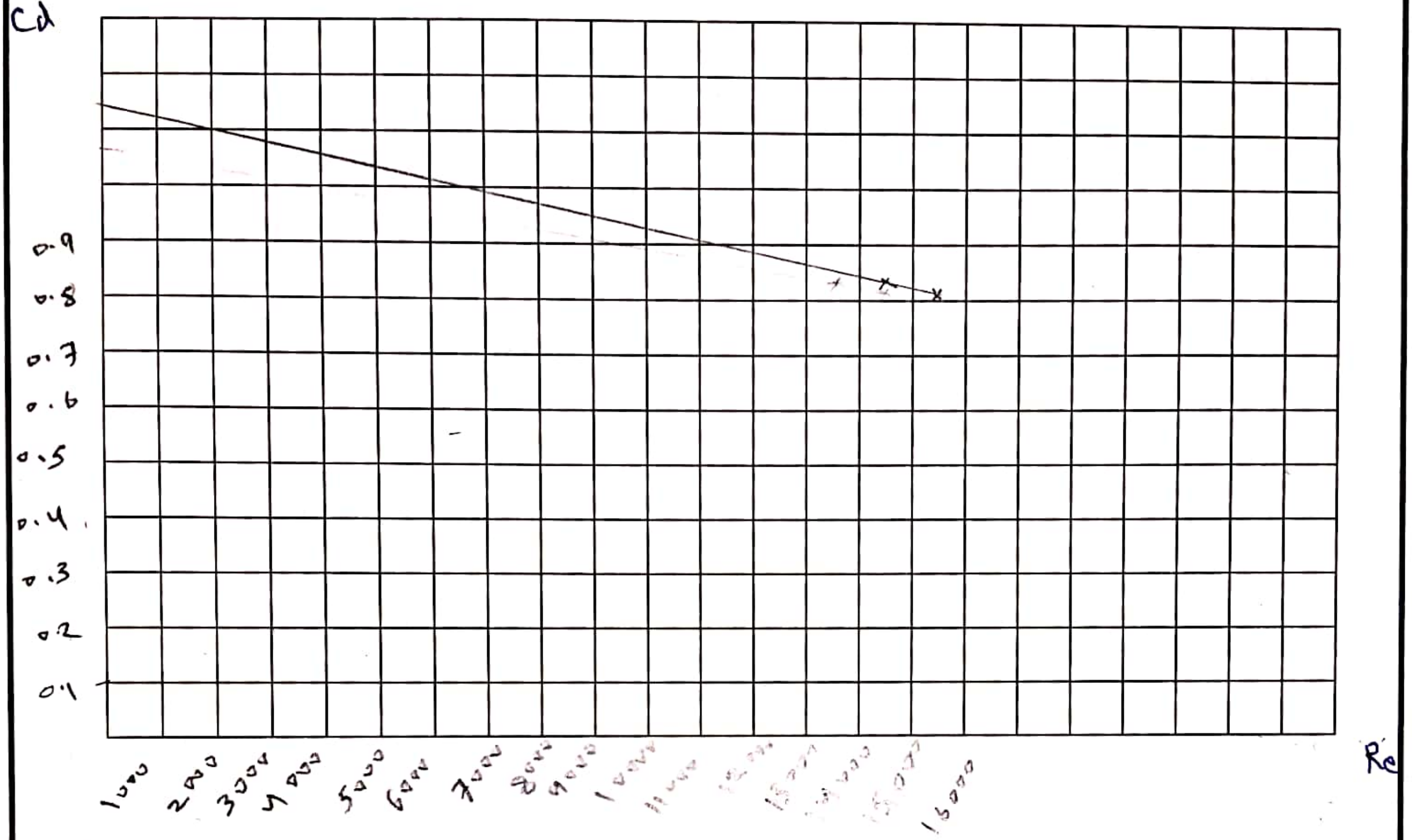
- Plot Cd versus Re



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The relation between Re & Cd is not direct

when Re inc. ↑ , Cd dec. ↓

& when Re dec. ↓ , Cd inc. ↑

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	Experiment 4 Impact of water jet	
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4.1. Data and Calculations

D_{nozzle}= 8mm $S = 0.03$ m

Note: The answers must be to the nearest two decimal places

Table 4.1.: *Flat Plate Target (θ = 90⁰)*

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)
100	5	22	$2.3*10^{-4}$	4.58	4.52	1.04	0.98	0.45
200	5	15	$3.33*10^{-4}$	6.62	6.58	2.19	1.96	1.32

Table 4.2: *120 cone Target (θ = 120⁰)*

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)
100	5	28	$1.79*10^{-4}$	3.56	3.48	0.62	0.98	0.52
200	5	19	$2.63*10^{-4}$	5.23	5.17	1.36	1.96	1.55

4.2. Sample of Calculations @ 100g of flat target (θ = 90⁰)

Q (m^3/s)	V_{nozzel} (m/s)	$V_{o\ nozzle}$ (m/s)
$Q = \frac{\forall}{T}$ $= \frac{0.005}{22} = 2.3*10^{-4}\ m^3/s$	$V_{nozzle} = \frac{Q}{A}$ $= \frac{2.3*10^{-4}}{\frac{\pi}{4}(0.008)^2} = 4.58$ m/s	$V_o = \sqrt{(V_{nozzle})^2 - 2gS}$ $= \sqrt{4.58^2 - 2*9.81*0.03}$ $= 4.52$ m/s

Moment $m^{\cdot} * V_o$	$F_{measured}$ (N)	$F_{calculated}$ (N)
$mV_o = \rho Q V_o$ $= 1000*2.3*10^{-4}*4.52$ $= 1.04$ N	$F_m = mg$ $= 0.1*9.8$ $= 0.98$ N	$F_{cal} = mV_o(1-\cos\theta)$ $= 0.1*4.52(1-\cos 90)$ $= 0.45$ N

4.3. Plot

Plot $F_{measured}$ versus mv_o for each of the tested targets on the same chart and determine the slope.
Hint: start from origin.

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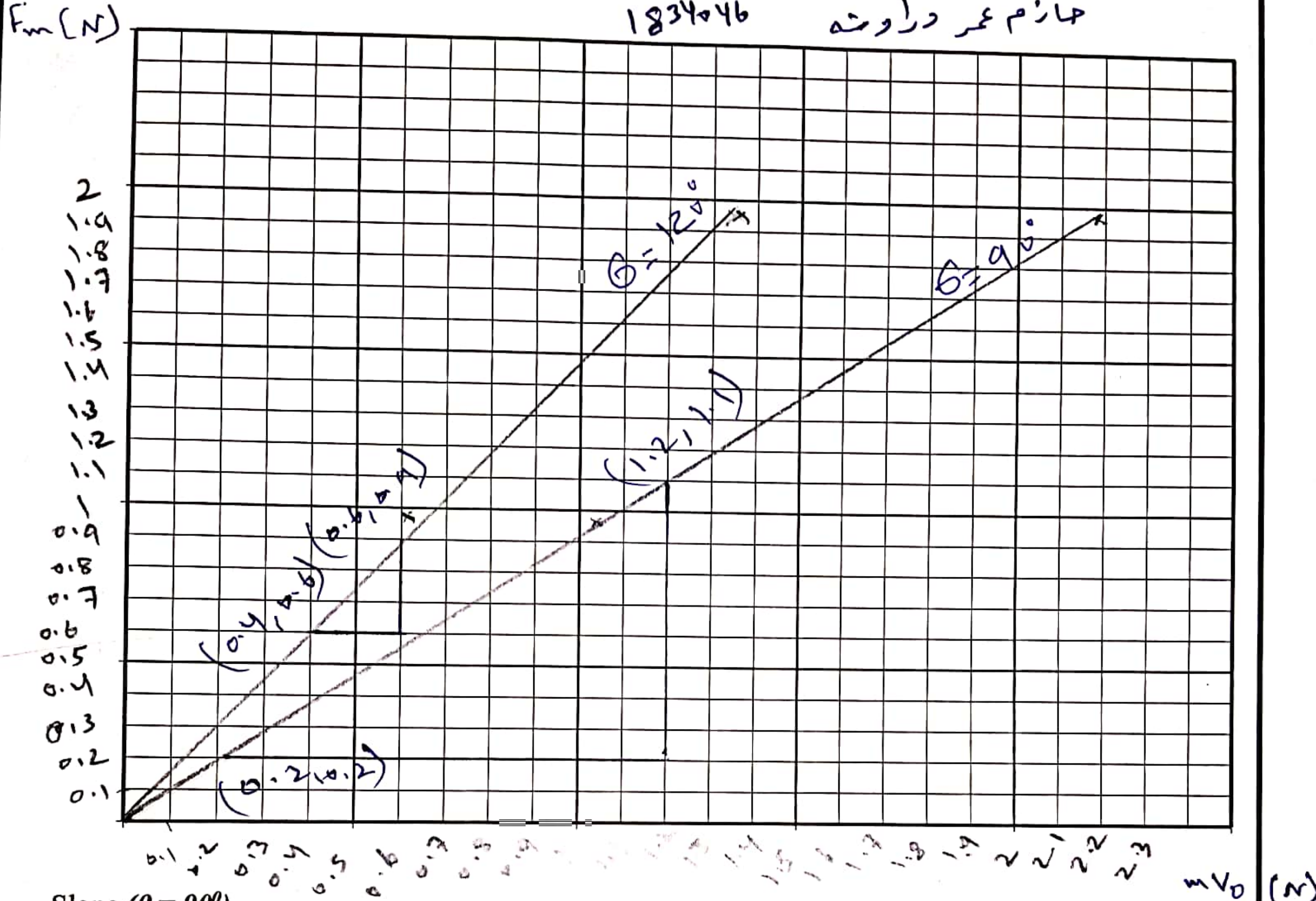

Slope *(θ = 90°)*

$$slope = \frac{\Delta y}{\Delta x} = \frac{1.1 - 0.2}{1.2 - 0.2} = 0.9$$

Slope *(θ = 120°)*

$$slope = \frac{\Delta y}{\Delta x} = \frac{0.9 - 0.6}{0.6 - 0.4} = 1.5$$

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Discussion

① a

slope as calculated

$\theta = 90: \frac{\Delta y}{\Delta x} = \frac{1.96 - 0.98}{2.19 - 1.04} = 0.85 < 1$ plate

$(1 - \cos 90) = 1$ ✓

$\theta = 120: \frac{\Delta y}{\Delta x} = \frac{1.96 - 0.98}{1.36 - 0.62} = 1.32 > 1$

≈ 1.5 cone $(1 - \cos 120) = 1.5$ ✓

Slope as measured (from graph)

$\theta = 90 \Rightarrow slope = 0.9$

$\theta = 120 \Rightarrow slope = 1.5$

② $F = mV_o(1 - \cos\theta)$

$= mV_o(1 - \cos 280)$

$= mV_o(0.826)$

FLUIDS AND HYDRAULICS LABORATORY

Exp. #5: Fluid Friction in Pipes and Losses from Fittings

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1. Data and Calculations:

1.1 Losses due to Friction

A) PVC Pipe:

D= 3/4 in = 0.01905m, L= 1.25m, A= 0.000285m^2

Volume (m^3)	Time (sec)	h (m)	Q (m^3/sec)	V (m/sec)	Re	Flow Type	f_{exp}
0.01	24	0.107	4.16×10^{-4}	1.46	27813	Turbulant	0.015
0.01	27	0.081	3.7×10^{-4}	1.29	24574.5	Turbulent	0.015
0.01	29	0.075	3.45×10^{-4}	1.2	22860	Turbulent	0.016

B) PVC Pipe:

D= 1/2 in = 0.0127m, L= 1.25m, A= 0.000126676m^2

Volume (m^3)	Time (sec)	h_L (m)	Q (m^3/sec)	V (m/sec)	Re	Flow Type	f_{exp}
0.01	27	0.275	3.7×10^{-4}	2.92	37084	Turbulant	6.43×10^{-3}
0.01	30	0.234	3.33×10^{-4}	2.63	33401	Turbulent	6.74×10^{-3}
0.01	39	0.181	2.56×10^{-4}	1.97	25019	Turbulent	9.3×10^{-3}

C) PB Pipe:

D= 3/4 in = 0.01905m, L= 1.25m, A= 0.000285m^2

Volume (m^3)	Time (sec)	h_L (m)	Q (m^3/sec)	V (m/sec)	Re	Flow Type	f_{exp}
0.01	25	0.156	4×10^{-4}	1.4	26670	Turbulant	0.024
0.01	30	0.125	3.33×10^{-4}	1.17	22288.5	Turbulent	0.027
0.01	46	0.103	2.17×10^{-4}	0.76	14478	Turbulant	0.053

2. Losses due to Fittings:

D= 3/4in, A= 0.000285m^2

	Volume (m^3)	Time (sec)	h_L (m)	Q (m^3/sec)	V (m/sec)	K
90^0 Elbow	0.01	25	0.08	4×10^{-4}	1.4	0.8

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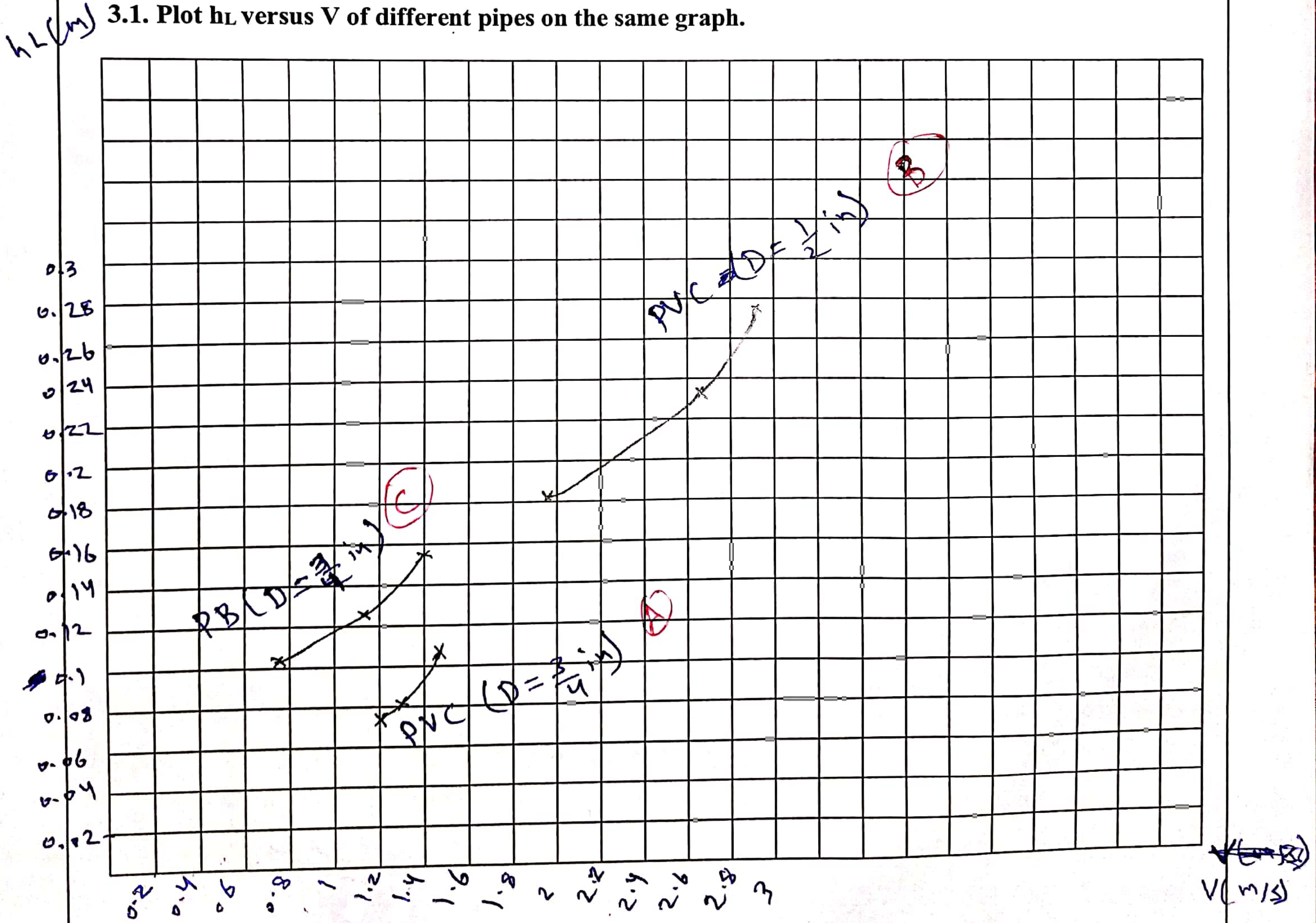
2. Sample of Calculations on each computation of PVC Pipe D= 1/2 in for trial#1:

Q (m³/s)	V (m/s)	Re	f	K for 90⁰ Elbow
$= \frac{V}{T}$ $= \frac{0.01}{27}$ $= 3.7 \times 10^{-4}\ m^3/s$	$= \frac{Q}{A}$ $= \frac{3.7 \times 10^{-4}}{0.000126676}$ $= 2.92\ m/s$	$= \frac{VD}{\nu}$ $= \frac{2.92 \times 0.0127}{10^{-6}}$ $= 37084$	$= \frac{h_L D \times 2g}{L V^2}$ $= \frac{0.275 \times 0.0127 \times 2 \times 9.81}{1.25 \times 2.92^2}$ $= 6.43 \times 10^{-3}$	$= \frac{2g\, h_L}{V^2}$ $= \frac{2 \times 9.81 \times 0.08}{1.4^2}$ $= 0.8$

3. Plots:

3.1. Plot h_L versus V of different pipes on the same graph.



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4. Discussion

1)

1. True

2. False

3. False

4. False

2) The flow is turbulent because the relationship between h_L & V is not linear ($h_L \propto V^2$)

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	Experiment 6 Specific Energy: Slow and Fast Flow	
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6.1. Data and Calculations

Data	
b= 75 mm	Q = 455 L/min
H (mm) before sluice gate	H (mm) after sluice gate
215	76
170	53
120	47

Show the equations, substitutions and results in this table:

Q (m³/sec) = 7.583×10^{-3} m³/s

h_c (Theo.) (m)	V_c (Theo.) (m/sec)	E_{min} (Theo.) (m)
$= \left(\frac{q^2}{g}\right)^{1/3}$ $= \left(\frac{\left(\frac{7.583 \times 10^{-3}}{0.075}\right)^2}{9.81}\right)^{1/3}$ $\boxed{h_c = 0.1 m}$	$= \sqrt{g \times h_c}$ $= \sqrt{9.81 \times 0.1}$ $= 0.99 m/s$	$E_{min} = \frac{3}{2} h_c$ $= \frac{3}{2} \times 0.1$ $= 0.15 m$

Before Sluice Gate

H (m)	V (m/sec)	E (m)	Fr	Flow Type
0.215	0.47	0.23	0.32	subcritical
0.17	0.59	0.19	0.46	subcritical
0.12	0.84	0.16	0.77	subcritical

After Sluice Gate

H (m)	V (m/sec)	E (m)	Fr	Flow Type
0.076	1.33	0.17	1.54	super critical
0.053	1.91	0.24	2.65	super critical
0.047	2.15	0.28	3.17	super critical

6.2. Sample of Calculations @ H=210mm

V (m/s)	E (m)	Fr and Flow type
$V = \frac{Q}{A} = \frac{Q}{bh}$ $= \frac{7.583 \times 10^{-3}}{0.075 \times 0.21}$ $= 0.48 m/s$	$E = h + \frac{V^2}{2g}$ $= 0.21 + \frac{0.48^2}{2 \times 9.81}$ $= 0.22 m$	$= \frac{V}{\sqrt{gh}}$ $= \frac{0.48}{\sqrt{9.81 \times 0.21}}$ $= 0.33 < 1$ subcritical

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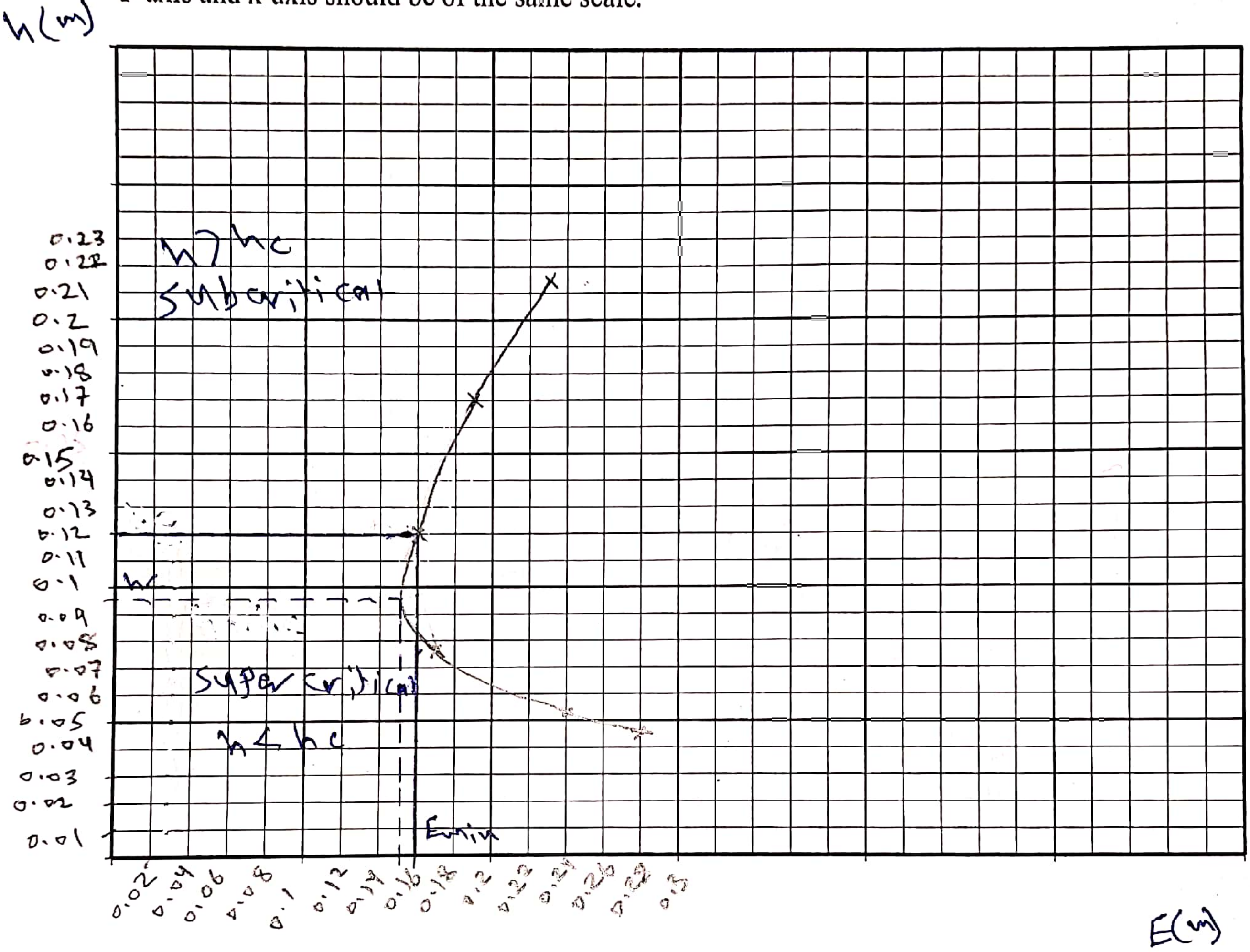
6.3. Plot

- 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.

Hint: start y-axis and x-axis from (0, 0).
Y-axis and x-axis should be of the same scale.



E_{min} (Experimental)	h_c (Experimental)
0.151 m	0.096 m

6.4. Discussion سيتم ادراجها لاحقا

	theo	exp.
hc	0.101	0.096
Emin	0.1515	0.151

~~Depths~~

hc theo > hc exp ✗ not accepted

Emin theo > Emin exp ✓ accepted

FLUIDS AND HYDRAULICS LABORATORY
Exp.6: Specific Energy: Slow and Fast Flow

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1. Data and Calculations:

1.1. Data collected from experiment:

Q (L/min)	Q (m^3/s)	h_1(mm)	h_2(mm)	L_j(cm)
250	0.00417	50	86	56
150	0.0025	30	76	39
50	0.00083	6	73	20

2.1. Calculations:

h_1(m)	$h_{1;Theo.}$(m)	V_1(m/s)	$E_{1Exp.}$(m)	Fr_1	Flow Type
0.05	0.053	1.112	0.113	1.59	super critical
0.03	0.029	1.11	0.093	2.05	super critical
0.006	0.0045	1.84	~~0.18~~ 0.18	7.6	super critical

h_2(m)	$h_{2;Theo.}$(m)	V_2(m/s)	$E_{2Exp.}$(m)	Fr_2	Flow Type
0.086	0.09	0.65	0.11	0.71	sub critical
0.076	0.073	0.44	0.086	0.51	sub critical
0.073	0.062	0.15	0.074	0.18	sub critical

hj(m)	Lj(m)	$Lj_{Theo.}$(m)	$\Delta E_{Exp.}(h_L)$ (m)	$\Delta E_{Theo.}(h_L)$ (m)
0.036	0.56	undular jump	0.003	0.0027
0.046	0.39	0.34	0.007	0.011
0.067	0.2	0.45	0.106	0.17

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2.1. Sample of Calculations:
Show sample of calculation for trial no.1:

$h_{1;Theo.}$(m)	V_1(m/s)	$E_{1Exp.}$(m)	Fr_1	Flow Type
$= \frac{h_2}{2}\left(\sqrt{1+8Fr_2^2}-1\right)$ $= \frac{0.086}{2}\left(\sqrt{1+8(0.71)^2}-1\right)$ $= 0.053$ m $V_2 = \frac{Q}{A} = \frac{0.00417}{0.075 * 0.086}$ $= 0.65$ m/s $Fr_2 = \frac{V_2}{\sqrt{g h_2}}$ $= \frac{0.65}{\sqrt{9.81 * 0.086}} = 0.71$	$= \frac{Q}{A} = \frac{Q}{b h_1}$ $= \frac{0.00417}{0.075 * 0.05}$ $= 1.112$ m/s	$E_1 = h_1 + \frac{V_1^2}{2g}$ $= 0.05 + \frac{1.112^2}{2 * 9.81}$ $= 0.113$ m	$Fr_1 = \frac{V_1}{\sqrt{g h_1}}$ $= \frac{1.112}{\sqrt{9.81 * 0.05}}$ $= 1.5971$ super critical	super critical

Hj(m)	Lj(m)	$Lj_{Theo.}$(m)	$\Delta E_{Exp.} h_L$ (m)	$\Delta E_{Theo.} h_L$ (m)
$Hj = h_2 - h_1$ $= 0.086 - 0.05$ $= 0.036$ m	$Lj = \frac{56}{100}$ $= 0.56$ m	From Table 8.5 $Fr_1 = 1.59 < 1.7$ $\Rightarrow$ undular jump	$= E_1 - E_2$ $= 0.113 - 0.11$ $= 0.003$ m $E_2 = h_2 + \frac{V_2^2}{2g}$ $= 0.086 + \frac{0.65^2}{2 * 9.81}$ $= 0.11$ m	$= \frac{(h_2 - h_1)^3}{4 h_1 h_2}$ $= \frac{(0.086 - 0.05)^3}{4 * 0.086 * 0.05}$ $= 0.0027$ m

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1. True
2. True
3. True
4. True
5. False

	Experiment 8 The Flow Beneath a Sluice Gate (An Undershot Weir)	
ID: 1834046	Name: حازم عمر دراوشة	SEC...1..

Don't forget to make your report tidy and neat ☺

8.1. Data and Calculations

8.1.1. Data

h_g= 15 mm		h_g= 20 mm	
Q (L/min)	h_o (mm)	Q (L/min)	h_o (mm)
60	145	60	84
50	83	50	50

8.1.2. Calculations

	h_o (m)	Q (m^3/sec)	$Q_{theo.}$ (m^3/sec)	Cd	$h^{0.5}$
h_g= 15 mm	0.145	$1*10^{-3}$	$1.9*10^{-3}$	0.53	0.38
	0.083	$0.83*10^{-3}$	$1.44*10^{-3}$	0.58	0.29

	h_o (m)	Q (m^3/sec)	$Q_{theo.}$ (m^3/sec)	Cd	$h^{0.5}$
h_g= 20 mm	0.084	$1*10^{-3}$	$1.93*10^{-3}$	0.52	0.29
	0.05	$0.83*10^{-3}$	$1.49*10^{-3}$	0.56	0.22

8.2. Sample of Calculations @ h_g= 15 mm

Q (m^3/sec)	$Q_{theo.}$ (m^3/sec)	Cd
$= \frac{\cancel{60}\ \cancel{L}}{\cancel{min}} * \frac{1\ m^3}{1000\ \cancel{L}} * \frac{1\ \cancel{min}}{\cancel{60}\ sec}$ $= 1*10^{-3}\ m^3/s$	$= b h_g \sqrt{2 g h_o}$ $= 0.075*0.015\sqrt{2*9.81*0.145}$ $= 1.9*10^{-3}\ m^3/s$	$= \frac{Q_{actual}}{Q_{theo.}}$ $= \frac{1*10^{-3}}{1.9*10^{-3}}$ $= 0.53$

8.3. Plot

- Plot Q_{act} versus $h_o^{0.5}$ for each h_g.

  Hint: Best-fit line must be pass through (0, 0).

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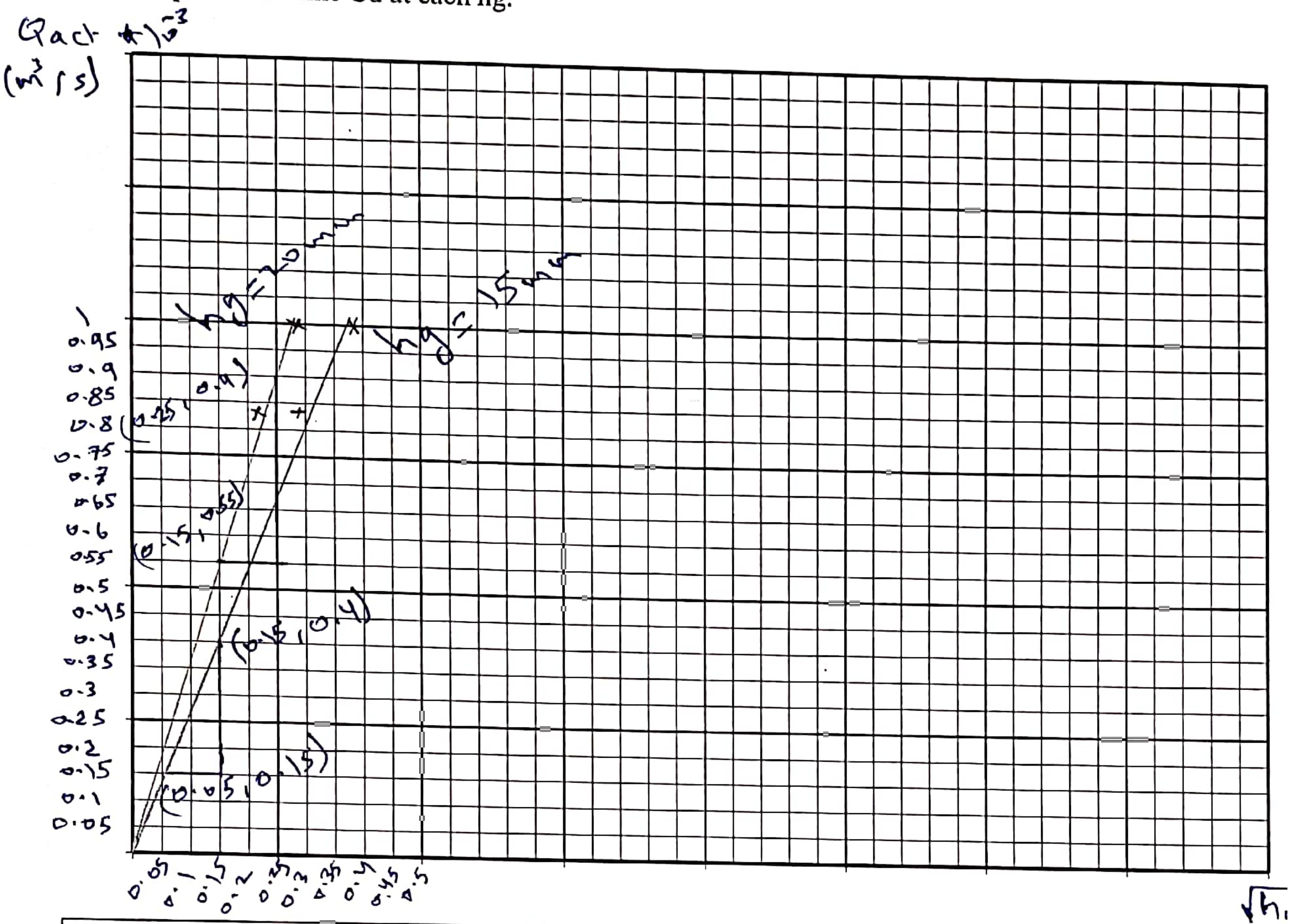
- From the plot determine Cd at each hg.



h_g= 15 mm		h_g= 20 mm	
Slope	Cd	Slope	Cd
$= \frac{\Delta Q_{act}}{\Delta \sqrt{h_o}}$ $= \frac{(0.4-0.15)*10^{-3}}{0.15-0.05}$ $= 2.5*10^{-3}\ m^{2.5}/s$	$\frac{\Delta Q}{\Delta \sqrt{h_o}} = C_d b h_g \sqrt{2g}$ $C_d = \frac{\Delta Q}{\Delta \sqrt{h_o} * b h_g \sqrt{2g}}$ $= \frac{2.5*10^{-3}}{0.075*0.015*\sqrt{2*9.81}}$	$= \frac{(0.9-0.55)*10^{-3}}{0.25-0.15}$ $= 3.5*10^{-3}\ m^{2.5}/s$	$= \frac{3.5*10^{-3}}{0.075*0.02*\sqrt{2*9.81}}$ $= 0.53$

$= 0.502$

8.4. سيتم ادراج اسئلة المناقشة لاحقا

1. True
2. True
3. False
4. False

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Acidity: capacity of water to neutralize base (strong base $\xrightarrow{like}$ NaOH)

sample no.	V of sample (ml)	Burette reading (ml)		V of NaOH (ml)	Mineral acidity (mg/L as $CaCO_3$)
		initial	final		
1	100	13	13	0	0
2	100	17.7	17.7	0	
		avg. volume		0	

$$\text{mineral acidity} = \frac{V_{NaOH} * N_{NaOH} * 50*10^3}{V \text{ of sample}} = \frac{0 * 0.02 * 50000}{100} = 0$$

sample no.	V of sample (ml)	Burette reading (ml)		V of NaOH (ml)	Total acidity (mg/L as $CaCO_3$)
		initial	final		
1	100	13	17.7	4.7	43
2	100	17.7	21.6	3.9	
		avg. Volume		4.3	

1) True
2) False
3) False
4) True
5) False
6) False
7) False
8) False
9) False
10) True

$$\text{Total alkalinity} = \frac{(\cancel{V_1} + V_2) * N_{NaOH} * 50*10^3}{V \text{ of sample}}$$

$$= \frac{(0 + 4.3) * 0.02 * 50000}{100}$$

$$= 43 \text{ mg/L as } CaCO_3$$

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Alkalinity: capacity of water to neutralize acid (strong acid $\xrightarrow{like}$ H_2SO_4)

Sample No.	V of sample (ml)	Burette reading (ml)		V of H_2SO_4 (ml)	phenolphthalein alkalinity (mg/L as $CaCO_3$)
		initial	final		
1	100	6.3	6.8	0.5	9
2	100	0.1	1.4	1.3	
		avg. Volume		0.9	

$$\text{ph.ph Alk.} = \frac{0.9 * 0.02 * 50 * 10^3}{100} = 9 \text{ mg/L as } CaCO_3$$

Sample No.	V of sample (ml)	Burette reading (ml)		V of H_2SO_4 (ml)	Total alkalinity (mg/L as $CaCO_3$)
		initial	Final		
1	100	6.8	52.8	46	467
2	100	1.4	47	45.6	
		avg. volume		45.8	

$$\text{T. alk} = \frac{(0.9 + 45.8) * 0.02 * 50000}{100} = 467 \text{ mg/L as } CaCO_3$$

1) $P < \frac{1}{2} T \rightarrow$ it contains CO_3^{-2} & HCO_3^-

carbonate & bicarbonate

$(OH^-) = 0)$

$$CO_3^{-2} = 2P = 2(9) = 18 \text{ mg/L as } CaCO_3$$

$$HCO_3^- = T - 2P = 467 - 18 = 449 \text{ mg/L as } CaCO_3$$

2) since $P = 0$

$$\text{so } T.alk = \frac{20 * 0.2 * 50 * 10^3}{100} = 2000 \text{ mg/L as } CaCO_3$$

$T = HCO_3^-$ (Total alkalinity)

	Experiment 10 Pumps in Parallel and Series	
ID: 1834046	Name: حازم عمر خليفه دراوشه	SEC.1.

1. Data and Calculations:

1. 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 (m³/sec)	h_{avg} (m)
65	65	-0.1	0.6	-0.1	0.8	7.1	9.2	2.16×10^{-3}	8.15
55	12	-0.1	0.99	-0.1	1.03	11.1	11.5	1.12×10^{-3}	11.3
35	10	-0.1	1.1	-0.1	1.12	12.2	12.44	0.00075	12.3
20	8	-0.087	1.2	-0.1	1.15	13.1	12.74	0.00047	12.9

Sample of calculations @ Q= 65 L/min

H_a (m)	H_b (m)	Q_t (m³/sec)	h_{avg} (m)
$=(P_{A2}-P_{A1}) \times 10.197$ $=(0.6 - -0.1) \times 10.197$ $= 7.1\,m$	$=(P_{B2}-P_{B1}) \times 10.197$ $=(0.8 - -0.1) \times 10.197$ $= 9.2\,m$	$= Q_A + Q_B$ $= 65 + 65$ $= 130\,L/min$ $= 2.16 \times 10^{-3}\,m^3/s$	$= \frac{H_A + H_B}{2}$ $= \frac{7.1 + 9.2}{2}$ $= 8.15\,m$

2. Series Connection

Q (L/min)	P_1 (Bar)	P_2 (Bar)	P_3 (Bar)	P_4 (Bar)	H_a (m)	H_b (m)	Q_t (m³/sec)	h_t (m)
65	-0.1	0.95	0.82	1.9	10.7	11.01	1.08×10^{-3}	21.71
55	-0.087	1.05	1.02	2.12	11.6	11.2	9.16×10^{-4}	22.8
35	-0.087	1.17	1.15	2.33	12.8	12	0.00058	24.8
20	-0.082	1.24	1.24	2.43	13.5	12.1	0.00033	25.6

Sample of calculations @ Q= 65 L/min

H_a (m)	H_b (m)	Q_t (m³/sec)	h_{avg} (m)
$=(P_{A2}-P_{A1}) \times 10.197$ $=(0.95 - -0.1) \times 10.197$ $= 10.7\,m$	$=(P_{B2}-P_{B1}) \times 10.197$ $=(1.9 - 0.82) \times 10.197$ $= 11.01\,m$	$= Q$ $= \frac{65}{60000}$ $= 1.08 \times 10^{-3}\,m^3/s$	$= H_A + H_B$ $= 10.7 + 11.01$ $= 21.71\,m$

3. Single Pump

Q (L/min)	P_1 (Bar)	P_2 (Bar)	H (m)	Q_t (m³/sec)	Power input (watt)	Power output (watt)	Efficiency
65	-0.45	0.8	12.7	1.08×10^{-3}	2.42	134.6	55.6
55	-0.3	1.1	14.3	9.16×10^{-4}	2.36	128.5	54.45
35	-0.2	1.4	16.31	0.00058	1.92	93.3	48.6
20	-1	0.65	16.82	0.00033	1.54	55	35.7

Sample of calculations @ Q= 65 L/min

H (m)	Q_t (m³/sec)	Power output (watt)	Efficiency
$=(P_2-P_1) \times 10.197$ $=(0.8 - -0.45) \times 10.197$ $= 12.7\,m$	$= Q$ $= \frac{65}{60000}$ $= 1.08 \times 10^{-3}\,m^3/s$	$= \rho g Q_t H_t$ $= 9810 \times 1.08 \times 10^{-3} \times 12.7$ $= 134.6\,W$	$= \frac{Power_{out}}{Power_{in}}$ $= \frac{134.6}{2.42}$ $= 55.6$

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2- T & F:

1) F

2) T

3) we need to buy another pump and connect it with the first one in parallel

Std. Name: حازم عمر خليفه دراوشه ID: 1834046

2. Plot

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