هيدروليك
التجربة الأولى

Hydraulics Laboratory

EXP.1: Center of pressure on a plan surface

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Section:

Date:

10/10

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

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)	$\bar{y}$ (mm)	$F_{theo.}$ (N)	$F_{exp.}$ (N)	$Y_{c.p\ calculated}$ (mm)	$Y_{c.p\ experimental}$ (mm)
400	112	62	4.56	5.7	75.44	84.05
500	130	80	5.886	7.028	90.416	96.66
600	150	100	7.35	8.31	188.33	110

- Sample of Calculations: For $m = 500\,g$

$\rightarrow$ $$\bar{y} = y - \frac{d}{2} = 130 - \frac{100}{2} = \underline{80\,mm}$$

$\rightarrow$ $$F(theo) = \rho g \bar{y} A^{dry} = (9810)(.08)(.1)(.075) = \underline{5.886\,N}$$

$\rightarrow$ $$F_{exp} = \frac{m g \cdot R_3}{R_2 - \left[\frac{\frac{yd}{2} - \frac{d^2}{6}}{y - \frac{d}{2}}\right]}$$

$$= \frac{(.5)(9.81)(.2)}{.2 - \left[\frac{\frac{(.13)(.1)}{2} - \frac{.1^2}{6}}{.13 - \frac{.1}{2}}\right]} = 7.028\,N$$

$$y_{c.p(calc)} = \bar{y} + \frac{\frac{bd^3}{12}}{(\bar{y})(b*d)}$$

$$= 80 + \frac{\frac{(75)(100)^3}{12}}{(80)(75)(100)}$$

$$= 90.416\,mm$$

$$y_{c.p(exp)} = \left[\frac{2mR_3}{\rho(2ybd - bd^2)}\right] - R_2 + y$$

$$= \left[\frac{(2)(.5)(.2)}{(1000)((2)(.130)(.075)(.1) - .075(.1)^2)}\right] - .2 + .13$$

$$= \underline{96.66\,mm}$$

1.1.2. 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)	$\bar{y}$ (mm)	$F_{theo.}$ (N)	$F_{exp.}$ (N)	$Y_{c.p\ theo.}$ (mm)	$Y_{c.p\ experimental}$ (mm)
100	54	27	1.072	1.078	36	37.364
200	78	39	2.238	2.255	52	53.9
300	98	49	3.533	3.547	65.33	65.35

- Sample of Calculations: for mass = 100g

→ $\bar{y} = \frac{y}{2} = \frac{54}{2} = \boxed{27\,mm}$

- $F_{theo} = .5\,\rho g b y^2$

$= (.5)(9810)(.075)(.054)^2$

$\boxed{= 1.072N}$

→ $F_{exp} = \frac{m g R_3}{R_2 - \frac{y}{3}} = \frac{(.1)(9.81)(.2)}{.2 - \frac{0.054}{3}} = 1.078$

$y_{cp\ \cancel{exp}\ theo} = \frac{2}{3} y = \left(\frac{2}{3}\right)(54) = 36\,mm$

$y_{cp\ exp}$ = ∑ m about Pivot point (o)

$F(R_1 + {}^{d}y + y_{cp(exp)}) = m g R_3$

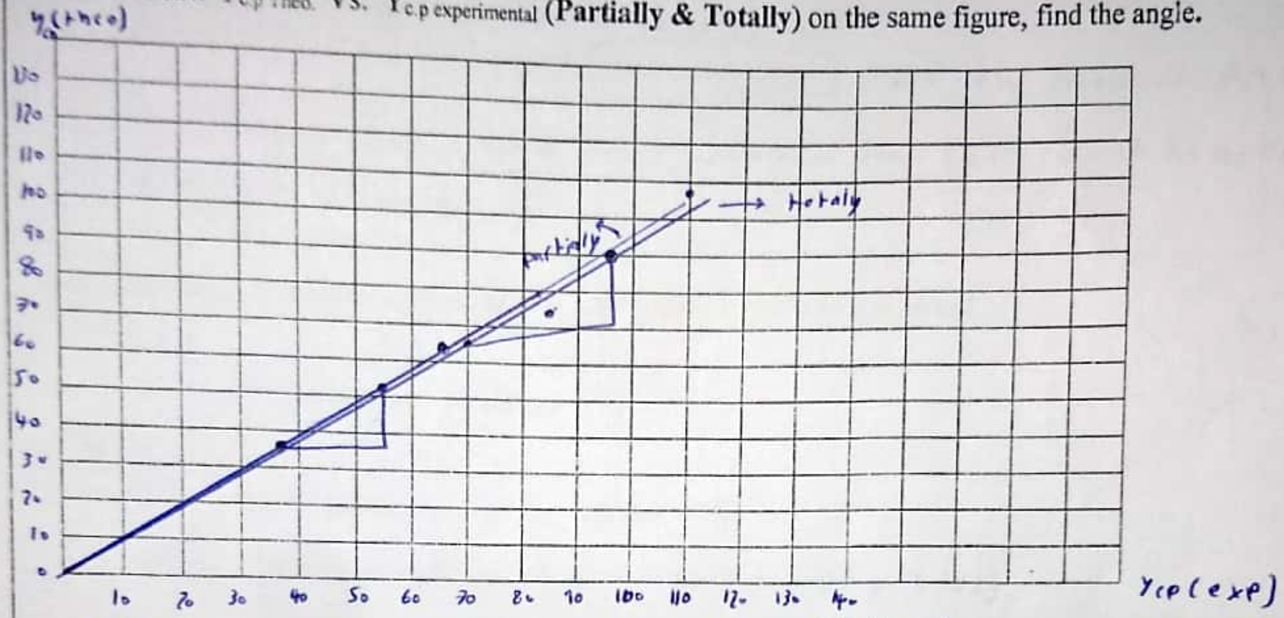
$y_{cp(exp)} = \frac{m g R_3}{F} - R_1 \cancel{+y} - {}^{d+}y$

$= \frac{(.1)(9.81)(.2)}{1.07} - .13 - .1 + 0.054$

$= 37.36\,mm$

1.2. Drawing:

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



Partialy → $\theta = \tan^{-1}(\text{slope})$

$= \tan^{-1}\left(\frac{52-36}{53.9-37.36}\right)$

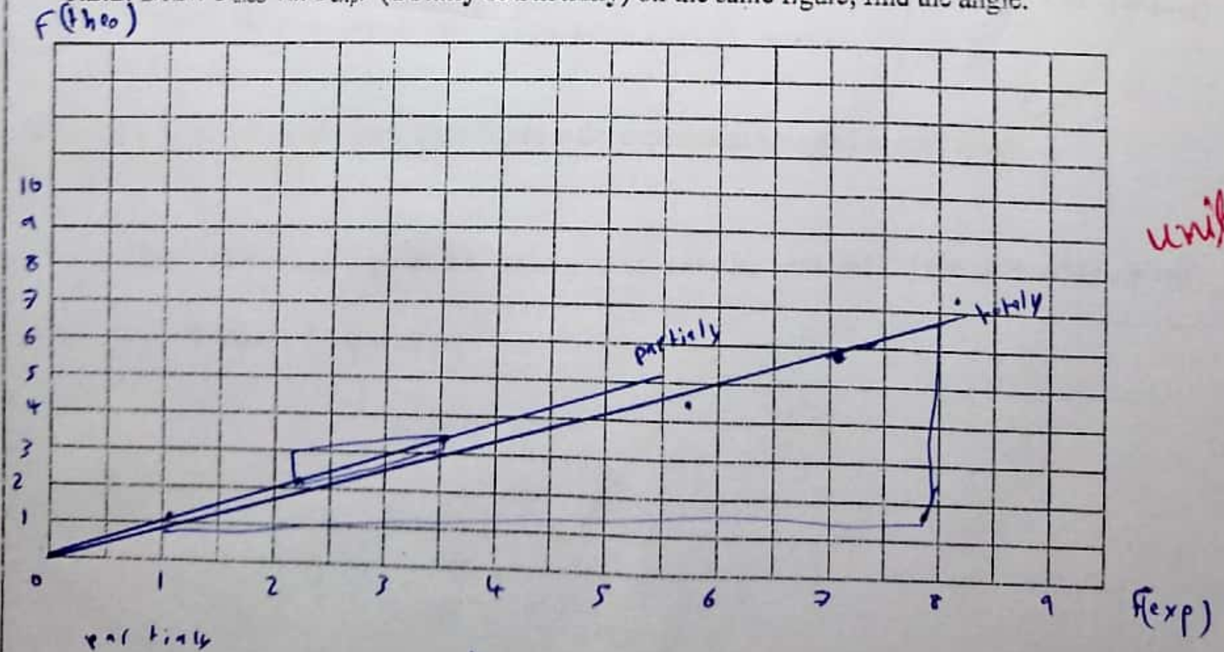
$= 44.049°$

totaly → $\theta = \tan^{-1}(\text{slope})$

$= \tan^{-1}\left(\frac{90.41-65}{96.6-70}\right)$

$= 43.689°$

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



units

partialy

$\theta = \tan^{-1}\left(\frac{3.533-2.238}{3.57-2.255}\right)$

$= 44.56$

totally

$\theta = \tan^{-1}\left(\frac{6.88-.88}{8-1}\right)$

$= 40.6013°$

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Discussions:

What is the difference between center of area and center of pressure?

Center of pressure (y_{cp}) is the $\boxed{\text{Force location}}$, but the center of Area (Centroid) is the point at which a cutout of the shape could be perfectly balanced on the tip of pin

??!

What the difference between centers of area is for totally & partially immersed?

Partially

$y < d$, rectangular surface → $\frac{y}{2}$

totally

$y \geq d$ → more pressure on the upper end of surface → $\bar{y}$ will be closer to the top → $\bar{y} = y - (d/2)$.

When the difference between center of pressure and Ӯ decreases in totally immersed or in totally immersed? Why?

in totally immersed, the pressure is increasing on the upper end of the ~~surface~~ the pressure is converted to constant, at constant pressure $y_{cp} = \bar{y}$.

According to the value of angels from figure is the experiment accepted or not? Why?
Accepted range (40-47)

Yes, because in each case, the angles was between the Accepted range (40-47)

Hydraulics Laboratory

Exp.2:Orifice and Jet Flow

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2.3. Data and Calculations

Trial No.	1	2	3
Water Level H, cm	27.6	40	
Volume, Lt.	5	5	
Time, sec.	116	99	
Actual Flow Rate Q, m³/sec.	4.31×10^{-5}	5.05×10^{-5}	
Distance from board (Orifice Center), mm: y			
X_1= 50 mm	0	0	0
X_2=100mm	5	5	
X_3=150mm		10	
X_4=200mm		26	
X_5=250mm		40	
X_6=300mm		60	
X_7=350mm		75	
X_8=400mm		110	
Coefficient of Velocity:			
Cv_1=	---	---	---
Cv_2=		1.118	
Cv_3=		1.186	
Cv_4=		0.980	
Cv_5=		0.988	
Cv_6=		0.968	
Cv_7=		1.01	
Cv_8=		0.953	
Avg. Cv Value:		~~1.024~~ 0.972	
Orifice Diameter, mm	6	6	6
Coefficient of Discharge, Cd:		.638	

Avg. Cv Final Value = 0.972

Avg. Cd Final Value = .638

−0.5

2.4. Sample of calculation

$$Q = \frac{V}{t} = \frac{5 \times 10^{-3}}{116} = 4.31 \times 10^{-5}$$

m^3/s

$$Cv = \frac{x}{2\sqrt{yh}}$$

$$= \frac{100}{2\sqrt{5 \times 400}} = 1.118$$

$$v_{theo} = \sqrt{2gh}$$

$$= \sqrt{2(9.81)(40)}$$

0.4

$$= 2.801 \ m^2/s$$

$$Q_{theo} = vA$$

$$= (2.801)\left(\frac{\pi}{4}(6 \times 10^{-3})^2\right)$$

−0.25

$$= \cancel{7.014 \times 10^{-5}} \ m^3/s \rightarrow (7.92 \times 10^{-5})$$

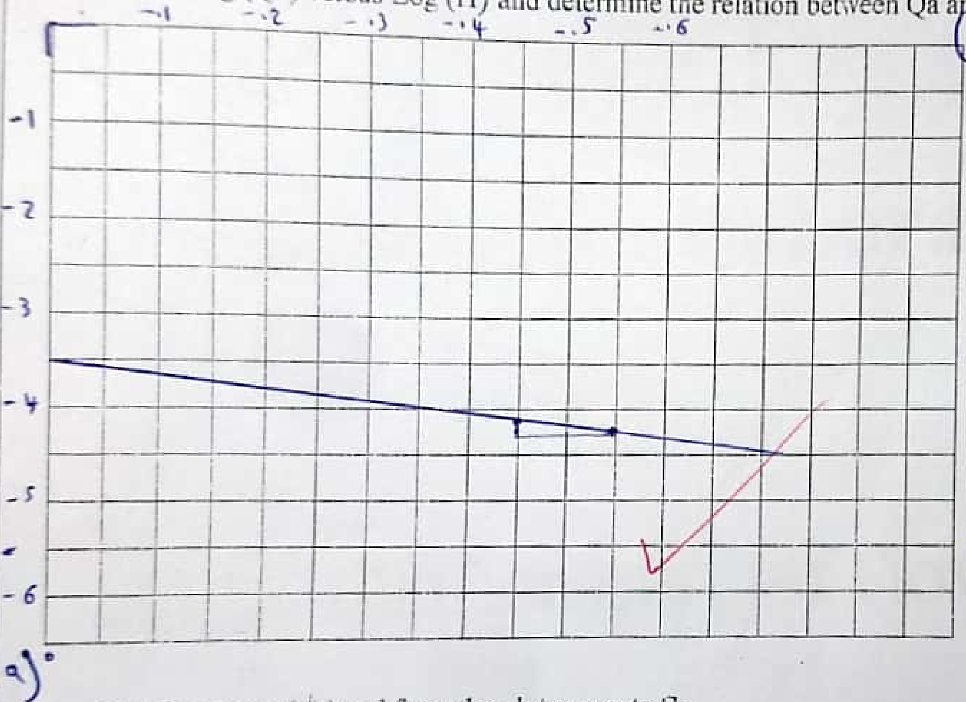
$$Cd = \frac{Q_{Ac}}{Q_{theo}} = \frac{5.05 \times 10^{-5}}{7.004 \times 10^{-5}} \rightarrow (7.92 \times 10^{-5})$$

$$= \cancel{3.82 \times 10^{-3}}$$

$$Cd = 0.638 \rightarrow 0.6376$$

Log Q_a	Log H	$\sqrt{h}$	Q_a
−4.365	−.548	.544	4.31×10^{-5}
−4.296	−.398	.632	5.05×10^{-5}

- Draw Log (Qa) versus Log (H) and determine the relation between Qa and H.



(Log H) (.4 - .6)

$a \propto h^{(\ )}$

$$slope = \frac{4.365-4.296}{.548-.398}$$

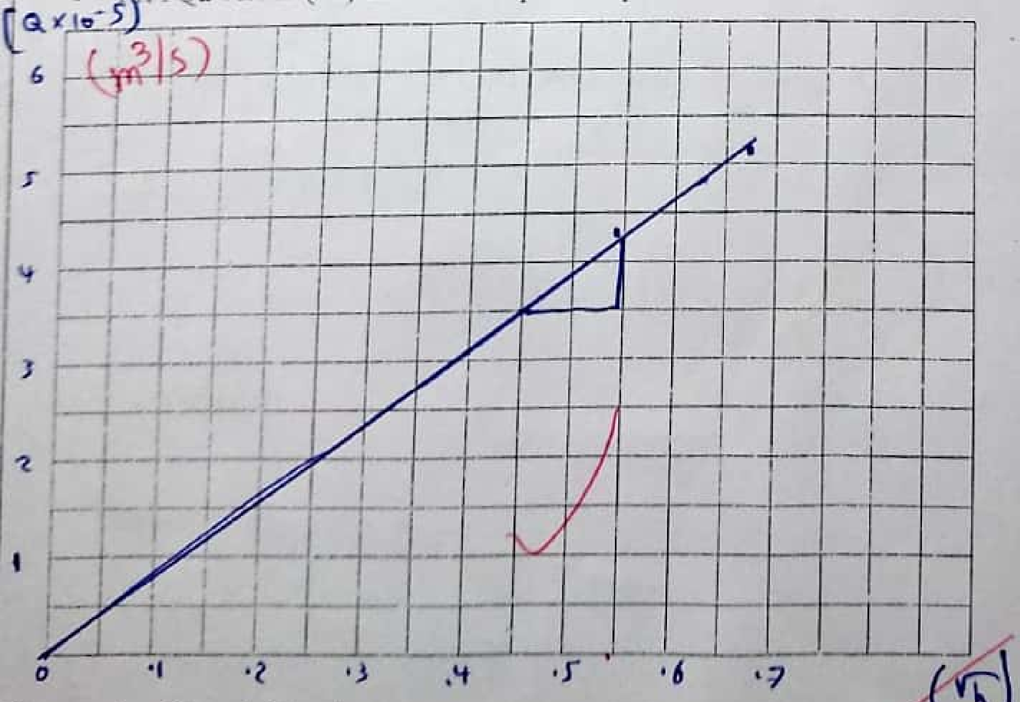
$= \boxed{0.46}$ accepted between (.4 - .6)

$$\%\,Error = \left|\frac{.5-.46}{.5}\right| \times 100\%$$

$= 8\%$

$\boxed{Q \propto h^{(.46)}}$

- Plot Qa versus ($\sqrt{h}$) and from the plot compute C_d.



slope = cd A

$cd = \frac{slope}{a}$

$$slope = \frac{4.3 \times 10^{-5} - 3.5 \times 10^{-5}}{.55 - .45}$$

$= \boxed{8 \times 10^{-5}}$

$q = cd\, A \sqrt{2g} \sqrt{h}$

$\frac{q}{\sqrt{h}} = cd\, A\sqrt{2g}$

$8 \times 10^{-5} = cd\, A \sqrt{2g}$

$$cd = \frac{8 \times 10^{-5}}{\frac{\pi}{4}(.006)^2 \sqrt{(2)(9.81)}}$$

$= 0.6387$

Comment on Cv and Cd values.

−0.5

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Hydraulics Laboratory

Exp.3: Bernoulli's Theorem Application-
Flow through Venture Tube

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9.5/10

Thanks

$\nu = 10^{-6}$

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 (Ht), and Discharge (V, t))

Volume (L)	Time (Sec)	Readings (cm)	Point 1	Point 5
5	36	H_P	282	50
		H_t	310	302
5	40	H_P	200	19
		H_t	235	219

25

A1(m^2)	4.908×10^{-4}
A5(m^2)	7.854×10^{-5}

10

1.697×10^{-4}

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	36	1.38×10^{-4}	.232	1.697×10^{-4}	0.8138	1.757	17570	0.4816
5	40	1.25×10^{-4}	.181	1.499×10^{-4}	0.833 ~~0.4207~~	1.5915	15915	0.4254

for point 1

- Sample of Calculations:

$$Q_1 = \frac{V}{t} = \frac{0.005}{36} = 1.38 \times 10^{-4} \ m^3/s$$

$$Q_{theo} = A_5 \sqrt{\frac{2(9.81)(.232)}{1 - \left(\frac{7.854 \times 10^{-5}}{4.908 \times 10^{-4}}\right)}}$$

$$= 1.697 \times 10^{-4} \ m^3/s$$

$$Q_1 = V_5 A_5$$

$$V_5 = \frac{Q}{A_5} = \frac{1.38 \times 10^{-4}}{7.854 \times 10^{-5}} = 1.757 \ m/s$$

$$Q_A = C_d A_5 \sqrt{\frac{2g(h_1 - h_5)}{1 - (A_5/A_1)^2}}$$

$$1.38 \times 10^{-4} = C_d (7.854 \times 10^{-5}) \sqrt{\frac{(2)(9.81)(.232)}{1 - \left(\frac{7.854 \times 10^{-5}}{4.908 \times 10^{-4}}\right)^2}}$$

$$C_d = 0.8138$$

$$Re = \frac{VD}{\nu} = \frac{(1.757)(0.010)}{1 \times 10^{-6}}$$

$$= 17570$$

Discussion:

- True or false (correct the false):

1. The relation between (RE) & (Cd) is not direct. T
2. Venture meter used to measure theoretical flow rate. F to measure the acual flow rate.
3. Pitot tube used to measure velocity head directly. F to ~~calculate~~ measure total head
4. Manometer used to measure pressure head. ~~F~~ T to measure static head

-0.25

- Comment on Cd value and compare the calculated one with the determined from fig.3.2.

-0.25 cd from figure= 0.7547

cd calc= 0.83

because the error in experminta

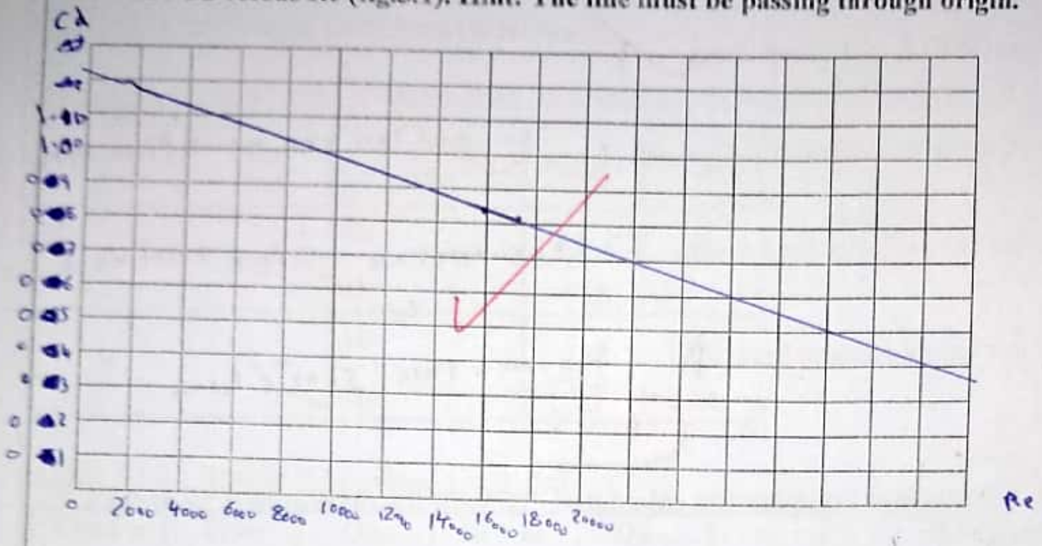
- $Q_{act} \neq Q_{theo}$ or Cd<1, why?

~~because the errors from expermental~~

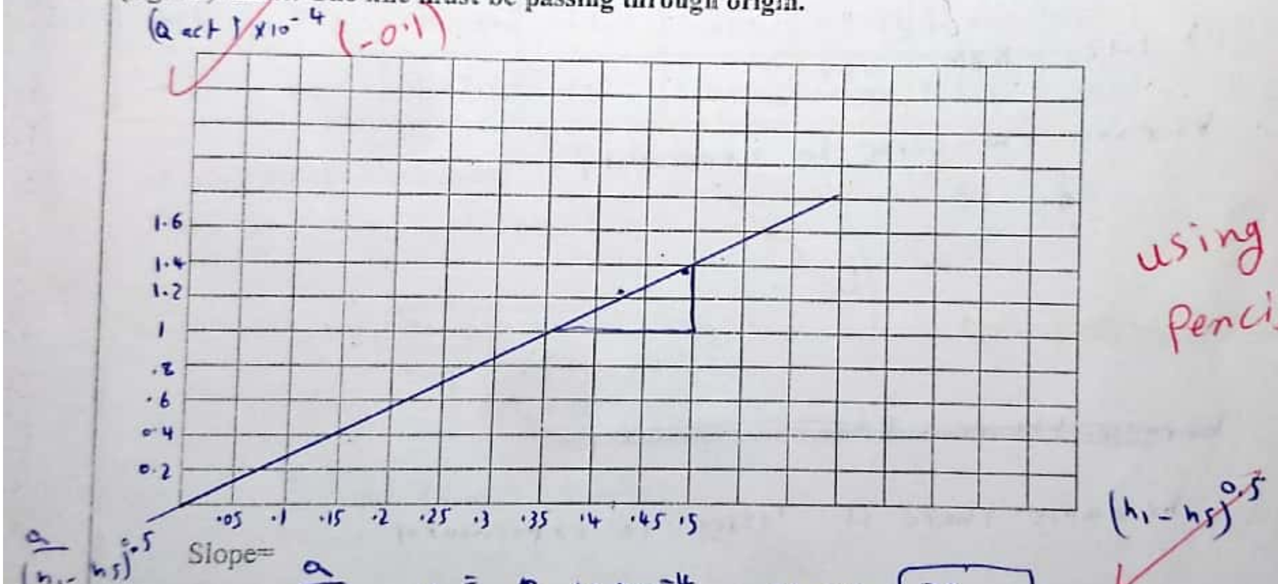
because there is losses in expermental

3.3 Results Plot

3.3.1 Plot Cd versus Re (fig.3.1). Hint: The line must be passing through origin.



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



using pencil

$\frac{Q}{(h_1-h_5)^{.5}}$ Slope= $\frac{Q}{(h_1-h_2)^{.5}} = 2.66\times10^{-4} = Cd\, A5\sqrt{\frac{2g}{1-\left(\frac{A5}{A_1}\right)^2}}$

-0.25 ???

Cd= $2.66\times10^{-4} = Cd\,(7.854\times10^{-5})\sqrt{\frac{(2)(9.81)}{1-\left(\frac{7.854\times10^{-5}}{4.908\times10^{-4}}\right)^2}}$

$Cd = 0.7547$

Hydraulics Laboratory

Exp.4: Impact of water jet

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Section #:

Day & Date: 13/2/2019

EXP.4: Impact of water jet

4.1. Data and Calculations

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	17	2.941×10^{-4}	5.851	5.8	1.7057	1.4715	1.70578
300	5	14	3.571×10^{-4}	7.104	7.0624	2.52198	2.943	2.52198
450	5	11	4.545×10^{-4}	9.042	9.00939	4.09476	4.4145	4.09476

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	22	2.2727×10^{-4}	4.52139	4.45634	1.01279	1.4715	2.02558 ~~1.01279~~
300	5	15	3.333×10^{-4}	6.63079	6.58625	2.19519	2.943	4.39 ~~2.19519~~
450	5	12	4.1667×10^{-4}	8.28938	8.2538	3.43911	4.4155	6.878 ~~3.43911~~

table 2

4.2. Sample of Calculations:

$A = \frac{\pi}{4}(.008)^2 = 5.0265\times10^{-5}\ m^2$

①

$Q = \frac{V}{t} = \frac{0.005}{\cancel{5.0265\times10^{-5}}\ 22} = 2.7727\times10^{-4}\ m^3/s$

$V_n = \frac{Q}{A} = \frac{2.7727\times10^{-4}}{\frac{\pi}{4}(.008)^2} = 4.52139\ m/s$

$V_o = \sqrt{V_n^2 - 2gs} = \sqrt{(4.52139)^2 - (2)(9.81)(3\times10^{-2})} = 4.45634\ m/s$

momentum $= (m)(V_o) = \rho Q V_o = (1000)(2.7727\times10^{-4})(4.45634) = 1.01279\ N$

$F_m = mg = (.15)(9.81) = 1.4715\ N$

$F_{calc} = \overset{2\rho Q V_o}{(2)(1000)(\cancel{\ }\ 2.2727\times10^{-4})(4.45634)} = \overset{2.02558}{\cancel{1.01279}}\ N$

3. Discussion

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

90° slope = 0.92 < 1

180 slope = 1.2667 < 2

4.3.2 – write the correct answer:

180−30 = 150

- When the internal angle =30^0, the impact equation $\dot{m} V_o (1-\cos 150°)$.
- When the impact angle increases the flow rate decrease.
- For flat plate, the theoretically force equalize the external weight in balance case= ----------

external force = mg

theo force $\rho a V_o (1-\cos\theta)$

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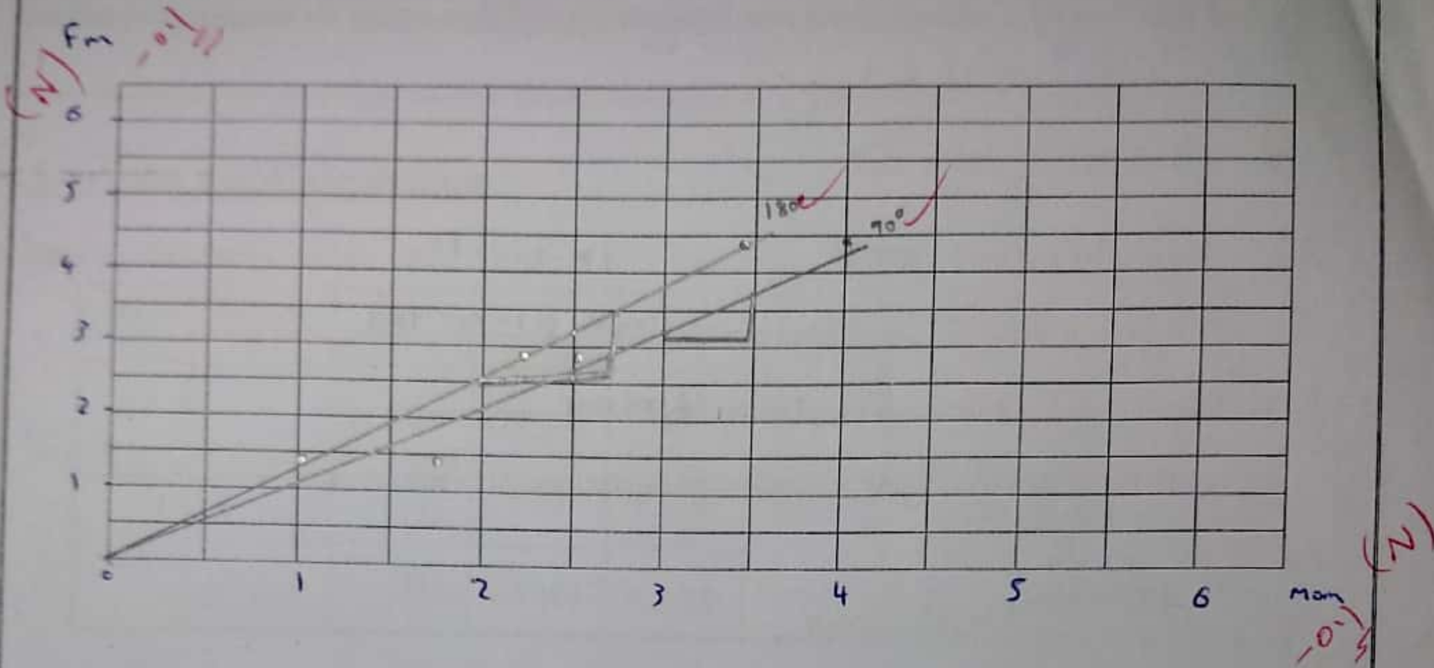
- Plot $F_{measured}$ on the target (for all targets on the same figure) versus the rate of momentum ($m^{\cdot} * V_O$), the lines must be passing through origin.



Slope (90^0) = $\frac{\Delta Fm}{\Delta m} = \frac{3.7 - 3.24}{3.5 - 3} = 0.92$

Slope (180^0) = $\frac{3.5 - 2.55}{2.75 - 2} = 1.2667$

Hydraulics Laboratory

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

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Day & Date:

5.1 Losses due to Friction

A) PVC Pipe:

D= 3/4 in = 0.01905m   L= 1.00m   A= 0.000285m^2

Volume (m^3)	Time (sec)	h_L (m)	Q (m^3/sec)	V (m/sec)	Re	Flow Type	f
.010	15	.500	6.667×10^{-4}	2.3392	44561.76	turb	0.03744
.010	18	.383	5.55×10^{-4}	1.9491	37130.355	turb	0.03768
.010	24	.258	4.167×10^{-4}	1.462	27851.1	turb	0.04511

B) ~~PVC~~ PB Pipe 0.01905 m

D= ~~1/2~~ 3/4 in = ~~0.0127m~~   L= 1.00m   A= 0.000 285 m^2 ~~A=0.000126676m^2~~

Volume (m^3)	Time (sec)	h_L (m)	Q (m^3/sec)	V (m/sec)	Re	Flow Type	f
.005	22	.7	2.2727×10^{-4}	0.79743	15191.0415	turb	.41144
.005	28	.52	1.7857×10^{-4}	0.62656	11935.968	turb	.495
.005	38	.325	1.3157×10^{-4}	0.461649	8794.41345	turb	.569972

C) ~~PB~~ PVC Pipe: 0.0127 m

D= ~~3/4~~ 1/2 in = ~~0.01905m~~   L= 1.00m   A=0.000126676 m2   ~~A=0.000285m^2~~

Volume (m^3)	Time (sec)	h_L (m)	Q (m^3/sec)	V (m/sec)	Re	Flow Type	f
.005	24	.755	2.0833×10^{-4}	1.644581	20886.28	turb	0.06955
.005	33	.448	1.5151×10^{-4}	1.19604	15189.708	turb	0.0780334
.005	46	.3	1.0869×10^{-4}	0.858015	10896.79	turb	0.101539

2. Losses due to Fittings and Valves

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	24	.11	4.166×10^{-4}	1.46148	1.00973

5.2. Sample of Calculations: (-0.25)

$$Q = \frac{V}{T} = \frac{.01}{15} = 6.67\times10^{-4}\ m^3/s$$

$$v = \frac{Q}{A} = \frac{6.67\times10^{-4}}{.000285} = 2.3392\ m/s$$

$$Re = \frac{VD}{\nu} = \frac{(2.3392)(.01905)}{1\times10^{-6}} = 44561.76$$

type of flow (-0.25)

$$F = \frac{h_L D 2g}{L v^2} = \frac{(.5)(.01905)(2)(9.81)}{(1)(2.3392)^2} = 0.03744$$

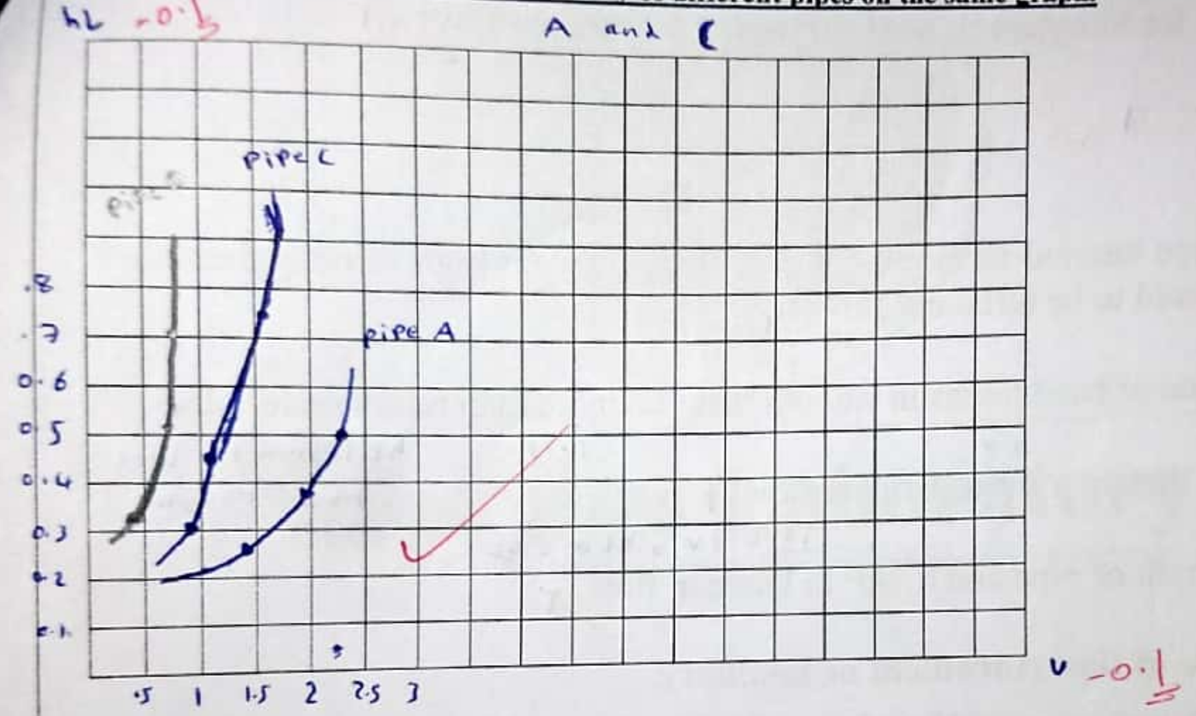
$$K = \frac{h_L 2g}{v^2} = \frac{(.11)(2)(9.81)}{(1.46148)^2} = 1.00973$$

5.3 Drawing

-0.2

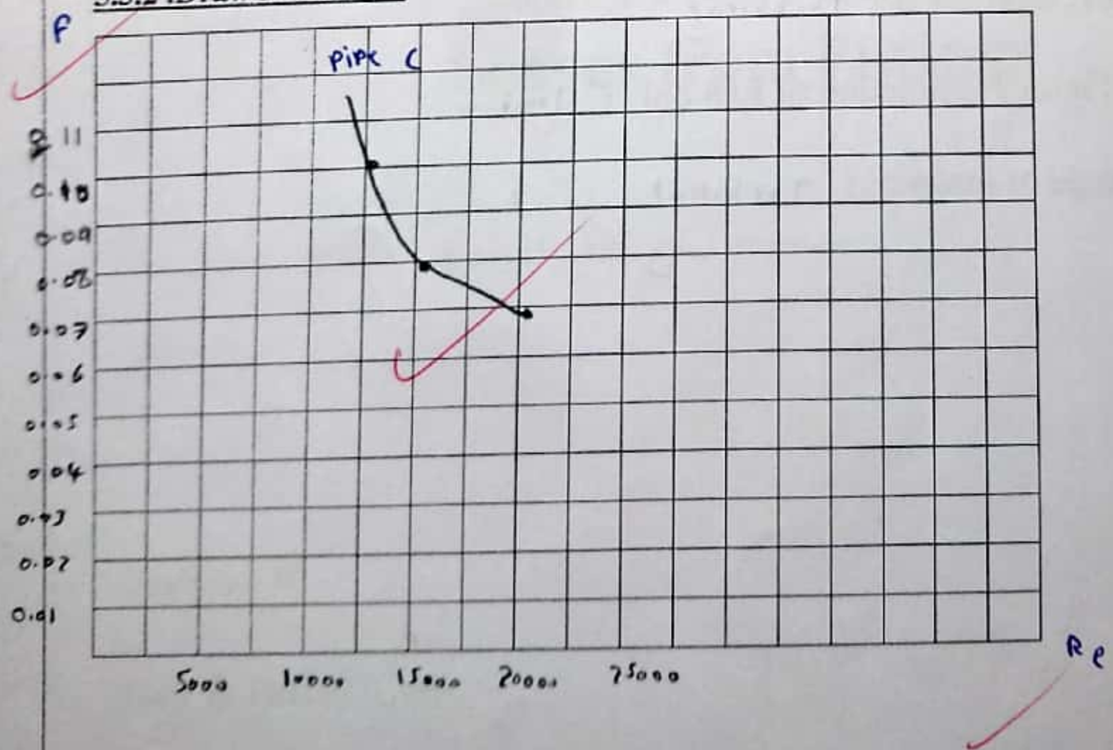
5.3.1. Draw head losses versus velocity of different pipes on the same graph.

2 pipe



5.3.2 .Draw f versus Re.

1 pipe



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~~ less than rough material. F
  hL in smooth Less than rough
- If v=2v then hl α ~~4v²~~ 2v in laminar flow. F
  if v=2v → hL α 2v
- hL α length of pipe and α $1/d^2$ in laminar flow. T

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

From the figure 5.3.1, the flow is (Turbulent).

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

hL effected by the type of material (Turbulent).

Hydraulics Laboratory

Exp.6: Fast and Slow Streams, Critical Depth, and Specific Energy

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Date:

$Q = VA$

Table 6.1. Variation of V and E with the height of water. $v_c = \frac{q}{h}$

Q(L/min)= 49.1 Q(m³/s)= 8.1833×10^{-4} h_c= V_c= .4748 E_{min}.(theo.)= .0344 m

H before sluice gate (m)	A before sluice gate (m²)	V before sluice gate (m²/s)	E before (m)	Fr #	Flow type	H after (m)	A after sluice gate (m²)	V after sluice (m²/s)	E after (m)	Fr #	Flow type
.183	0.013725	0.05962	0.18318	0.04449	sub	.01	7.5×10^{-4}	1.0911	0.0706	3.4836	super
.084	6.3×10^{-3}	0.129893	0.0848	0.143	sub	.011	8.25×10^{-4}	0.9919	0.06114	3.0195	super
.055	4.125×10^{-3}	0.19638	0.057	0.27	sub	.015	1.125×10^{-3}	0.7274	0.04196	1.8962	super
.04	3×10^{-3}	0.27277	0.04379	.435	sub	.034	2.55×10^{-3}	0.32	0.0392	.554	sub

$h_c = 0.0229$

6.2. Sample of calculations:

A= $(h_b)(b) = (.183)(.075) = .013725 m^2$

V= $\frac{Q}{A} = \frac{8.1833 \times 10^{-4}}{0.013725} = 0.05962$ -0.5

E= $h + \frac{v^2}{2g} = .183 + \frac{(.05962)^2}{(2)(9.81)} = 0.18318$ -0.5

Fr= $\frac{V}{\sqrt{g h_m}} = \frac{.05962}{\sqrt{(9.81)\left(\frac{.013725}{.075}\right)}} = 0.04449$

Flow type = .04449 < 1 ∴ subcritical

hc (Theo.) = $\left(\frac{q}{g}\right)^{\frac{1}{3}} = \left(\frac{\left(\frac{8.1833 \times 10^{-4}}{.075}\right)^2}{9.81}\right)^{\frac{1}{3}} = 0.02298 m$

Emin. (Theo.) =

$\cancel{h + \frac{v^2}{2g} = .183}$ $\frac{3}{2} h_c = \left(\frac{3}{2}\right)(0.02298) = 0.0344 m$

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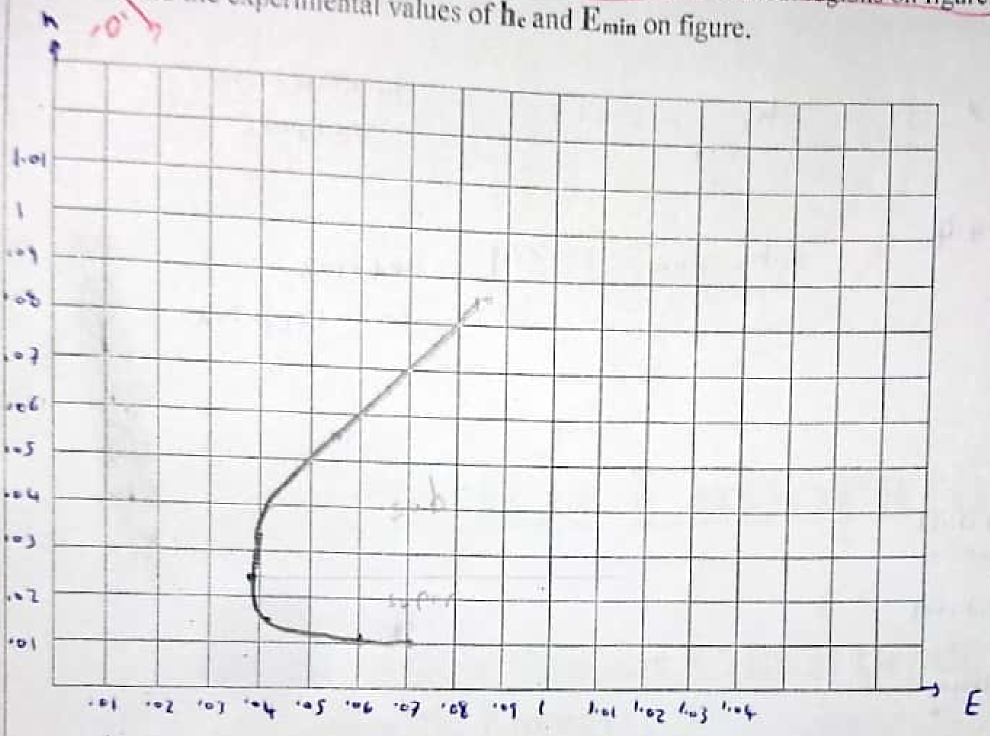
6.3. Plot:

- Plot **h** versus **E** and show the Supercritical and Subcritical regions on figure.
- Find the experimental values of $\mathbf{h_c}$ and $\mathbf{E_{min}}$ on figure.

-1



$E_{min\,exp} = 0.037m$ ~~but $E_{min\,the} = 0.0344m$~~

$h_{c\,exp} = 0.023$ ~~but $h_{c\,the} = 0.0229$~~

6.4. Discussions:

- Compare theoretical values with experimental values. (Accepted or not accepted).

$E_{min_{exp}} = 0.037$

$E_{min_{theo}} = 0.0344$

$h_{c_{exp}} = 0.023$ ∴ so closed so accepted

$h_{c\ theo} = 0.0229$ ∴ closed so accepted

Write the type of flow:

h > hc (subcritical).

V > Vc (supercritical).

Fr < 1 (subcritical).

Hydraulics Laboratory

Exp.#7: Hydraulic Jump

Student name: Faisal marwan Muwalla

ID#: 1736527

8.75/10

Section #:

Day & Date:

0.075 $Q = VA$

$\frac{0.045}{1200}$

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)	E_1 (m)	E_2 (m)
39.8	6.633×10^{-4}	7	45	.08835	0.046968
44.8	7.4667×10^{-4}	8	47	.086932	0.049286
40.6	6.7667×10^{-4}	7.5	44	0.081249	0.046142
45.1	7.51667×10^{-4}	8	47	0.08798	0.04931
49.8	8.3×10^{-4}	9	48	0.086059	0.050709

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)	h_2 theo (m)
1.2634	4.8212	super	[illegible]	.19653	0.29579	sub	6.8358×10^{-3}	0.038	0.041382	0.043548	0.044355
~~[illegible]~~ 1.24445	4.4421	super	0.02017	.21182	0.31194	sub	7.839×10^{-3}	0.039	0.037646	0.039432	0.04641
1.2029	4.4347	super	0.01889	~~[illegible]~~ .20505	0.3121	sub	7.345×10^{-3}	0.0365	0.035107	0.03682	0.04343
1.2527	4.4716	super	0.020256	.21323	0.314	sub	7.93×10^{-3}	0.039	0.03667	0.03942	0.04674
1.2296	4.1381	super	0.021779	.23055	0.3359	sub	9.1046×10^{-3}	0.039	0.03535	0.03434	0.048361

Notes:

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

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7.3. Sample of calculations:
Note: Use experiment value in your calculations.

1) $Q = \frac{Q(L/min)}{(1000)(60)} = \frac{39.8}{(1000)(60)} = 6.33\times10^{-4}\ m/s$

2) $v_1 = \frac{Q}{(h_1)(0.075)} = \frac{6.633\times10^{-4}}{(.007)(.075)} = 1.2634\ m/s$

3) $E_1 = h_1 + \frac{v_1^2}{2g} = .007 + \frac{(1.2634)^2}{(2)(9.81)} = .08835\ m$

4) $E_2 = h_2 + \frac{v_2^2}{2g} = .045 + \frac{(.19653)^2}{(2)(9.81)} = 0.046968\ m$

5) $Fr_1 = \frac{v_1}{\sqrt{g h_1}} = \frac{1.2634}{\sqrt{(9.81)(.007)}} = 4.8212 > 1 \therefore$ ~~sub~~ super

-0.25

6) $h_j = h_2 - h_1 = .045 - .007 = 0.038\ m$

7) $hL_{exp} = E_1 - E_2 = .08835 - .046968 = 0.041382\ m$

8) $hL_{theo} = \frac{(h_2 - h_1)^3}{4 h_1 h_2} = \frac{(\cancel{.045 - .007})^3}{4(\cancel{.007})(.041)}$ ~~0.044355 m~~ $= \frac{(.044355 - 6.8358\times10^{-3})^3}{(4)(.044355)(6.8358\times10^{-3})} = 0.043548\ m$

9) $h_2\ theo = \frac{h_2}{2}\left(\sqrt{1+8Fr_1^2} - 1\right) = \left(\frac{.045}{2}\right)\left(\sqrt{1+8(4.8212)^2} - 1\right) = 0.044355\ m$

(10) = $L = (220)(h_1)\tanh\left(\frac{Fr_1 - 1}{22}\right)$

$= (220)(.007)\left(\tanh\left(\frac{4.8212 - 1}{22}\right)\right)$

$= 0.24\ m$

7.4 .Discussion:

7.4.1. Compare theoritical value with experimantal value (is the experiment accepted or not)?

h_1 theo = 6.8358 mm
h_1 exp = 7 mm
so close
∴ accepted

hL theo = 0.043548 m
hL exp = 0.041382 m
so close
then accepted

h_2 theo = ~~0.454~~ 44.35 mm
h_2 exp = 45 mm
so close
∴ accepted

in general

-0.5

7.4. 2.True or False (correct the false):

1. E_1 less than E_2. F → $E_1 > E_2$

2. After the jump, the flow has low velocity and high flow depth. T

3. Flow down stream of the jump is supercritical. F - down stream is subcritical -0.5

4. Hydraulic jump accurs when the flow forced to change its status from slow flow to supercritical. F from super to sub

5. E1+hl=E2 F $E_1 = E_2 + hL$

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Hydraulics Laboratory

EXP.8: The Flow Beneath a Sluice Gate

Student name: Faisal Marwan Muwalla

Student No.: 1736527

9

Section #:

Day and Date: 20/3/2019

8.1. Data and Calculations

Data:

h_g=15mm

Table 1: variations of h_0 with Q

Q (L/min)	h_0 (mm)
78.1	177
72.7	156
68.4	139

h_g=20mm

Table 2: variations of h_0 with Q

Q (L/min)	h_0 (mm)
68.4	82
72.7	96
77.7	109

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
.177	1.3016×10^{-3}	2.096×10^{-3}	0.6209	.4207
.156	1.21×10^{-3}	1.968×10^{-3}	0.6148	.3949
.139	1.14×10^{-3}	1.857×10^{-3}	0.6138	.3728

Cd avg= 0.6165

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
.082	1.14×10^{-3}	1.902×10^{-3}	0.5993	.2863
.096	1.21×10^{-3}	2.058×10^{-3}	0.5879	.3098
.109	1.295×10^{-3}	2.193×10^{-3}	0.5905	.3301

Cd avg= 0.5925

8.2. Sample of calculation

Hg=15mm

$$Q_A = \frac{Q(L/min)}{(60)(1000)} = \frac{78.1}{60000} = 1.3016\times10^{-3}\ m^3/s$$

$$Q_{theo} = b h_g \sqrt{2 g h_0}$$

$$= (0.075)(.015)\sqrt{(2)(9.81)(.177)} = 2.096\times10^{-5}\ m^3/s$$

$$Cd = \frac{Q_A}{Q_{th}} = \frac{1.3016\times10^{-3}}{2.096\times10^{-3}} = 0.6209$$

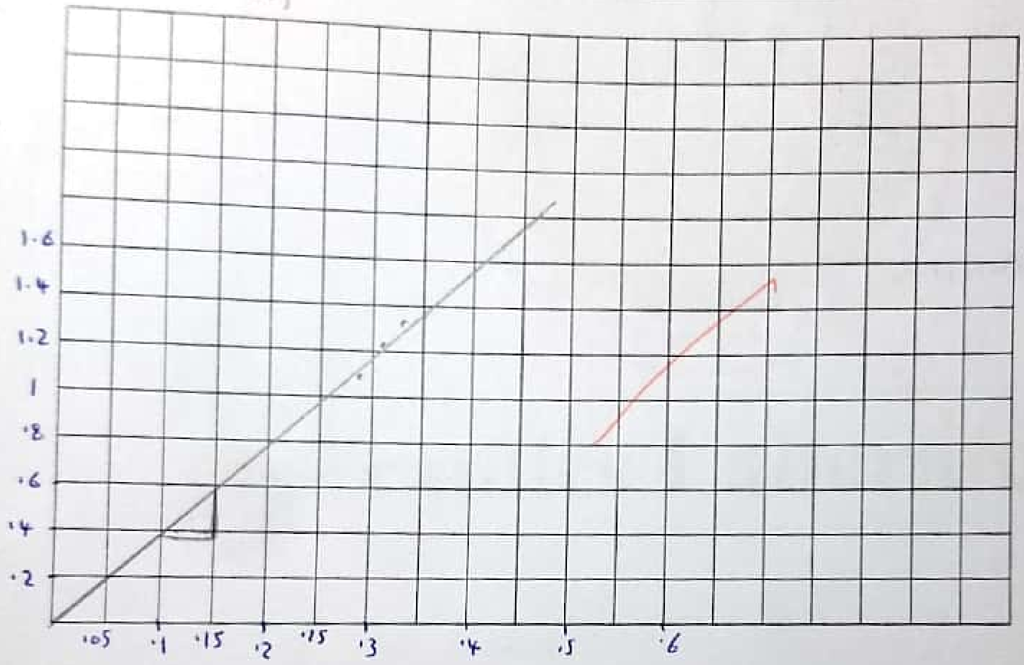
-0.5

$$h_0 = \frac{h_0\,mm}{1000} = \frac{177}{1000} = .177\ m$$

$$\sqrt{h_0} = \sqrt{.177} = .4207$$

8.3. Plots:

- Plot Q_a versus $\sqrt{h_o}$ for h_g=20mm, from the plot determine C_d. Best-fit line must be pass through (0, 0).



slope = $\frac{.57 - .39}{.15 - .1}$

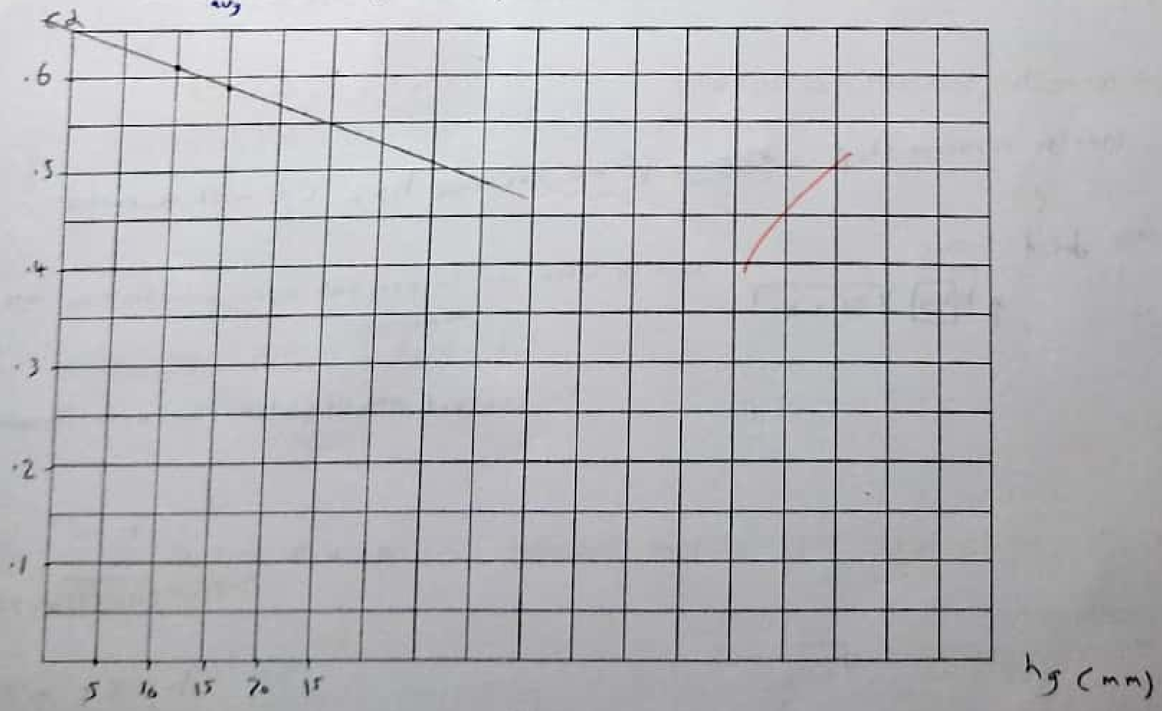
$= 4 \times 10^{-3}$

Slope = $\frac{Q_A}{\sqrt{h_o}} = C_d\, b h_g \sqrt{2g}$

$\rightarrow 4 \times 10^{-3} = c_d (.075)(.02)\sqrt{2 \times 9.81}$

$c_d = 0.602$

Plot $C_{d\,avg}$ (from table) versus h_g.



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8.4. Discussion

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

Cd from table@hg=20mm: 0.5925

Cd from figure@hg=20mm: 0.602

Accepted or not: Accepted

Why: $Cd < 1$

- What is the relation between Cd and hg? Why?

yes, inverse relationship, ~~[illegible]~~ if we increase hg, Cd will decrease

hL

becace $\downarrow Cd = \frac{Q_A}{\uparrow b \boxed{hg} \sqrt{2g \times h_0}}$ and when we increase the opening under the gate or decrease

to control and regulate the open channel flow

- If h_0= 10.5cm, h1=15mm, Q= 73*10^-3 m³/min. Calculate :

$Q = VA \rightarrow V_0 = \frac{\frac{73 \times 10^{-3}}{60}}{(.105)(0.075)} = .154 m/s$

A) H_L(head losses)=

B) V_g(theoretical velocity)= $\sqrt{2gh_0}$

$= \sqrt{(2)(9.81)(.105)} = 1.4353$ m/s

$V_1 = 1.081$ m³/s

$h_0 + \frac{V_0^2}{2g} = h_1 + \frac{V_1^2}{2g} + h_L$

$.105 + \frac{(.154)^2}{(2 \times 9.81)} = .015 + \frac{(1.081)^2}{(2)(9.81)} + h_L$

$.1062087 = .074559 + h_L$

$\rightarrow h_L = 0.031649$ m

$\frac{8.75}{10}$ +1

Hydraulics Laboratory

EXP.9: The Flow Through Rectangle Sharp Crested Weir.

Student name: Faisal Marwan Mawalla

Student No.: 1736527

Section #:

Day and Date:

9.1. Data and Calculations

Data:

Rectangular Weir:

b= 75mm

Table 1: variations of H with Q for rectangular weir

Q (L/min.)	H (mm)
48	25
60.5	28
33.4	21

Calculations:

Rectangular Weir:

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}	$H^{3/2}$
0.025	8×10^{-4}	8.754×10^{-4}	0.91	~~[illegible]~~	-3.0969	3.9528×10^{-3}
0.028	1.0085×10^{-3}	1.0376×10^{-3}	0.97	~~[illegible]~~	-2.9964	4.685×10^{-3}
0.021	5.567×10^{-4}	6.7398×10^{-4}	0.82	~~[illegible]~~	-3.2543	3.0431×10^{-3}
				-1.602		
				-1.528		
				-1.677		

9.2. Sample of calculation

$$Q_{act}\ (m^3/s) = \frac{Q_{L/min}}{1000\times60} = \frac{48}{60000} = 8\times10^{-4}\ m^3/s$$

$$Q_{theo} = \frac{2}{3} b \sqrt{2g}\, H^{3/2} = \left(\frac{2}{3}\right)(0.075)\left(\sqrt{2\times9.81}\right)(.025)^{3/2} = 8.754\times10^{-4}\ m^3/s$$

$$Cd = \frac{Q_{act}}{Q_{theo}} = \frac{8\times10^{-4}}{8.754\times10^{-4}} = 0.91$$

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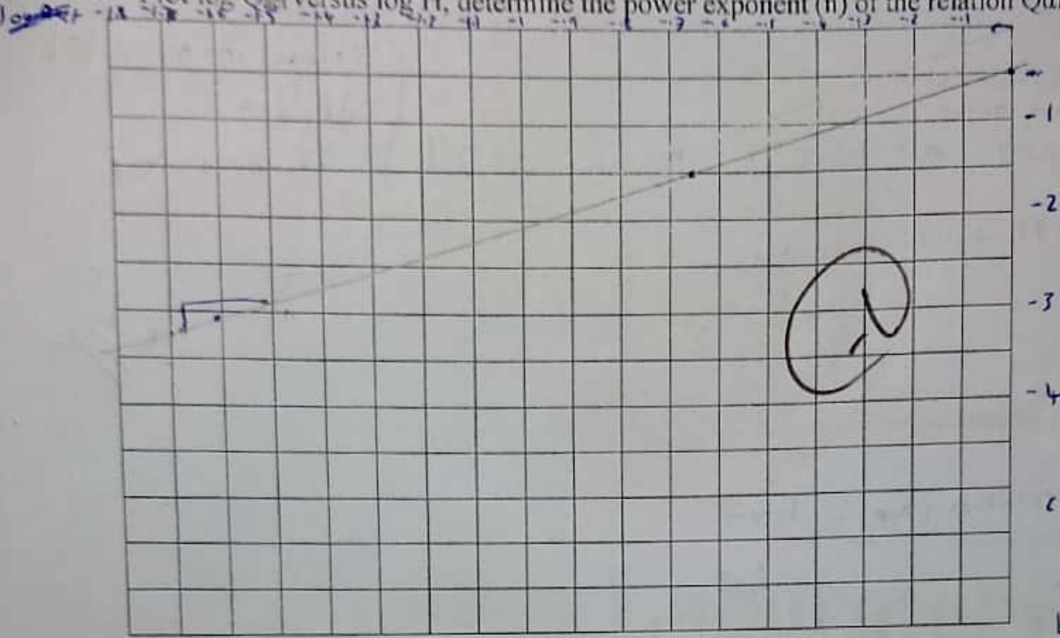
9.3. Plots

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



slope= $\frac{-3.2543 - -2.9964}{-1.677 - -1.528}$

= 1.7308

a= .5

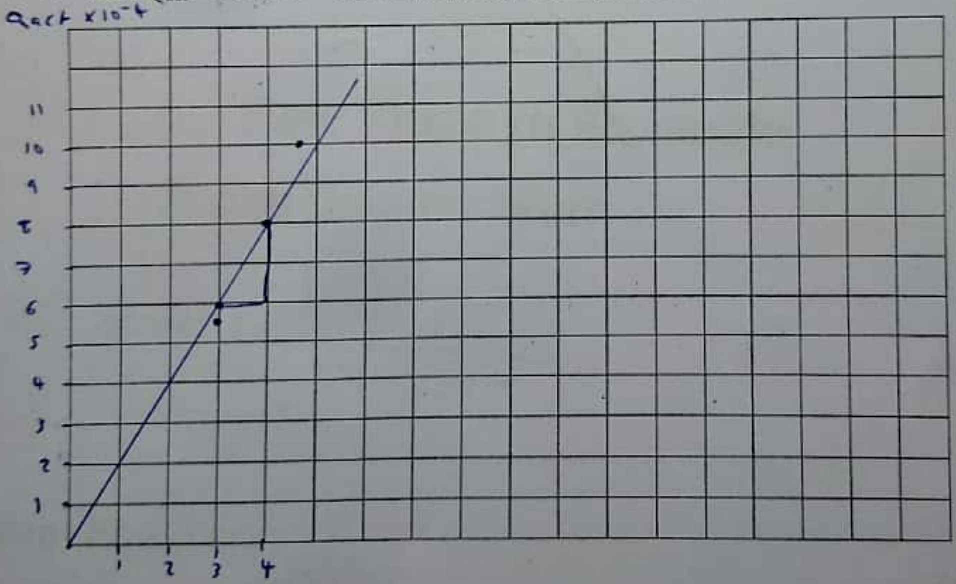
$a = \frac{2}{3} cd\, b \sqrt{2g}$

cd= 2.757

inter cept= $\log\left[\left(\frac{2}{3}\right)(b)(\sqrt{2g})\, cd\right]$ =التقاطع

= .5

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



slope= $\frac{(8-6)\times 10^{-4}}{(4-3)(\times 10^{-3})}$

slope = 0.2

$= \frac{2}{3} cd\, b \sqrt{2g}$

$.2 = \frac{2}{3} cd \times .075 \sqrt{2 \times 9.81}$

→ Cd = 0.9

- Plot Cd versus H.

the relation is linear relationship

9.4. Discussion

- Comment on the value of :

first graph

Cd = 2.257 not accepted because cd > 1

second graph

cd = 0.9

accepted < 1

slope?

n ~~$\frac{3}{2}$~~ 1.73 ≈ 1.5 accepted

-0.25

- Discuss the relation between Cd and H.

the relationship is linear

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when H increase , cd increase.

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Hydraulics Laboratory

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EXP.10: pumps

Student name: Faisal Marwan Muwalla

Student No.: 1736527

Section #:

Day and Date:

Parallel Connection

Table 10.1.1: Data and Calculations for Parallel Connection

Q_A m³/hr (~~L/min.~~)	Q_B m³/hr (~~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)	€
6	6	-0.049	1.32	-0.053	1.32	13.955	13.995	3.33×10^{-3}	13.975	
9	9	-0.05	1.2	-0.053	1.25	12.742	13.2828	5×10^{-3}	13.012	
12	12	-0.052	1.02	-0.055	1.12	10.927	11.977	6.667×10^{-3}	11.452	

Series Connection

Table10. 1.2: Data and Calculations for Series Connection

Q m³/hr (~~L/min.~~)	P_{A1} (Bar)	$P_{\cancel{A2}\,2}$ (Bar)	$P_{\cancel{B1}\,3}$ (Bar)	$P_{\cancel{B2}\,4}$ (Bar)	h_A (m)	h_B (m)	Q_t (m^3/s)	h_t (m)	€
6	-0.045	1.3	1.35	2.55	13.71	12.232	1.667×10^{-3}	25.942	
9	-0.045	1.2	1.2	2.32	12.691	11.416	2.5×10^{-3}	24.107	
12	-0.05	1.1	1.05	2.05	11.722	10.193	3.33×10^{-3}	21.915	

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)	€
6	-0.075	1.35	14.525	1.667×10^{-3}	
9	-0.075	1.35	14.525	2.5×10^{-3}	
12	-0.1	1.0	11.213	3.33×10^{-3}	

2. Sample of calculations:

Parrallel

$$H_A = \frac{\Delta P}{\rho g} \times 10^5 = \frac{1.32 - -0.049}{(1000)(9.81)} \times 10^5 = 13.955 \text{ m}$$

$$H_B = \frac{\Delta P}{\rho g} \times 10^5 = \frac{1.32 - 0.053}{(1000)(9.81)} \times 10^5 = 13.995 \text{ m}$$

ok

$$Q_T = \frac{Q_A + Q_B}{3600} = \frac{6+6}{3600} = 3.33 \text{ m}^3/\text{s}$$

$$H_{avg} = \frac{h_1 + h_2}{2} = \frac{13.995 + 13.955}{2} = 13.975 \text{ m}$$

sereis

$$H_A = \frac{\Delta P}{\rho g} \times 10^5 = \frac{1.3 - -0.045}{(1000)(9.81)} \times 10^5 = 13.71 \text{ m}$$

$$Q_T = \frac{Q_A}{3600} = \frac{6}{3600} = 1.667 \times 10^{-3} \text{ m}^3/\text{s}$$

$$H_T = h_A + h_B = 13.71 + 12.232 = 25.942 \text{ m}$$

single

$$H = \frac{\Delta P}{\rho g} \times 10^5 = \frac{1.35 - -0.075}{(1000)(9.81)} \times 10^5 = 14.525 \text{ m}$$

$$Q = \frac{Q}{3600} = \frac{6}{3600} = 1.667 \times 10^{-5}$$

10.3. Plots:

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