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ملخص

مختبر موائع وهيدروليكا

إعداد : لانا العتوم

Exp #1:- Center of Pressure on a plan Surface

⇒ " Hydrostatic Force " ⇐

✓ Force ⇒ $F = \bar{P} A = \rho g \bar{h} A$, $\bar{h}$: Distance from Surface of water to center of shape.

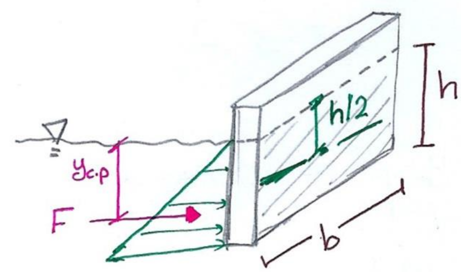
✓ Center of pressure ⇒ " Force location "

$$y_{c.p} = \bar{h} + \frac{I}{A \cdot \bar{h}}$$

* For Rectangular shape:-

$$y_{c.p} = \frac{h}{2} + \frac{\frac{1}{12} b h^3}{b . h . \frac{h}{2}} = \frac{h}{2} + \frac{h}{6} = \frac{2}{3} h$$

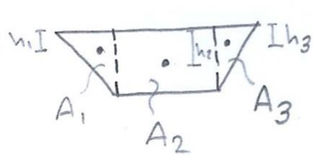
$$\bar{h} = \frac{h}{2}$$

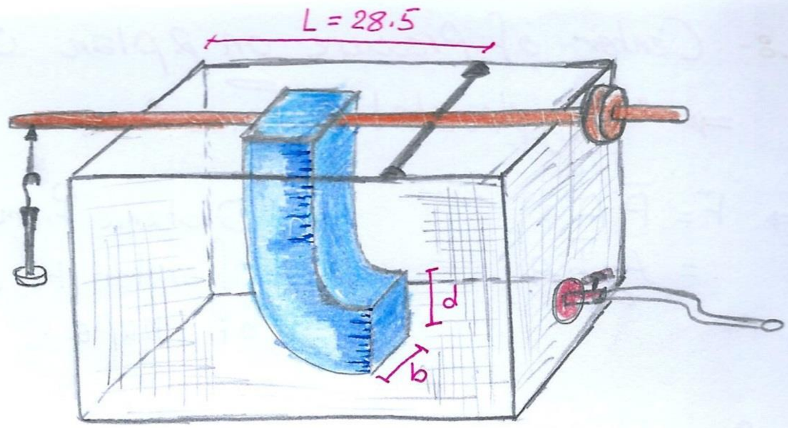


* For other shape

$$\bar{h} = \frac{\sum A_i h_i}{\sum A_i} \quad ; \quad A : \text{Area}$$

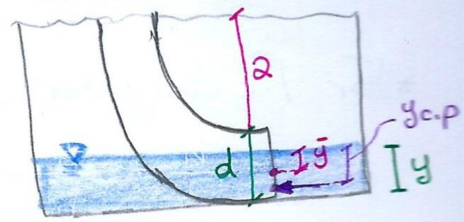
i.e :





d = 10cm
b = 7cm.

* Case I : Partially full "Partially immerged" [y<d]



✓ $F = \rho g \frac{y}{2} (b \cdot y)$

✓ $y_{c.p \text{ calculated}} = \bar{y} + \frac{I}{\bar{y} A}$

$= \frac{2}{3} y$ --- Measured from surface.

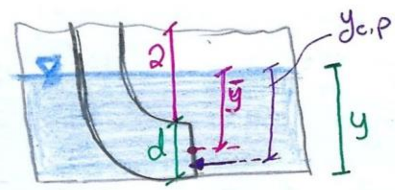
✓ $y_{c.p \text{ exp.}} \Rightarrow \Sigma$ Moment about "pin"

$mg \cdot L = F(a + d - y + y_{c.p\,exp.}) \Rightarrow y_{c.p\,exp.}$ ✓

* $\bar{y} = \frac{y}{2}$

* $A = y \cdot b$

* Case II : Totally immerged [y>d]



✓ $F = \rho g \bar{y} A$

✓ $\bar{y} = y - \frac{d}{2}$

✓ $A = d\,b$

✓ $y_{c.p\ calc.} = \bar{y} + \frac{I}{\bar{y} A}$

$$= \left(y - \frac{d}{2}\right) + \frac{\frac{1}{12} b d^3}{\left(y - \frac{d}{2}\right)(b.d)}$$

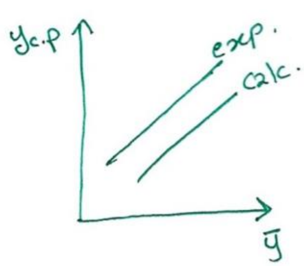
✓ $y_{c.p\ exp} \Rightarrow \Sigma M.$

$mg.L = F(a + d - y + y_{c.p_{exp.}}) \Rightarrow y_{c.p_{exp}}$ ✓

*Note :-

→ Center of pressure ($y_{c.p}$) is always Deeper than the Center of Area ($\bar{y}$) ; because the Pressure of water increases by depth.

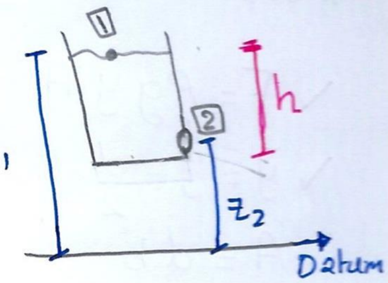
→ $y_{c.p}$ Vs $\bar{y}$



Exp# 2: Orific & Jet Flow .

→ Energy eqn. 1,2 :-

$$\overset{0.0}{\frac{P_1}{\rho g}} + \overset{0.0}{\frac{V_1^2}{2g}} + Z_1 = \overset{0.0}{\frac{P_2}{\rho g}} + \frac{V_2^2}{2g} + Z_2$$



$$\hookrightarrow Z_1 - Z_2 = \frac{V_2^2}{2g} = h$$

$$\hookrightarrow \underset{\text{theor.}}{V_2} = \sqrt{2gh}$$; h : in meter .

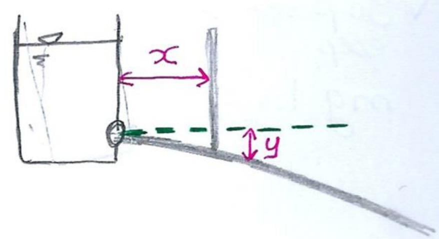
معادلات الحركة

$$\rightarrow y = \frac{1}{2} g t^2$$

$$\checkmark\ t = \frac{x}{V}$$

$$\hookrightarrow y = \frac{1}{2} g \left(\frac{x}{V}\right)^2$$

$$\hookrightarrow \underset{\text{act}}{V} = \sqrt{\frac{g}{2y}}\, x$$



* Part I : Coefficient of velocity -- (C_v)

$$C_v = \frac{V_{act}}{V_{theor.}}$$

$$= \frac{\sqrt{\frac{g}{2y}}\, x}{\sqrt{2gh}} = \frac{x}{2\sqrt{yh}}$$

* Part 2 :- Coefficient of Discharge (cd)

$$C_d = \frac{Q_{act}}{Q_{theor.}}$$

✓ $Q_{theor} = V_{theor.} * A_{orifice}$

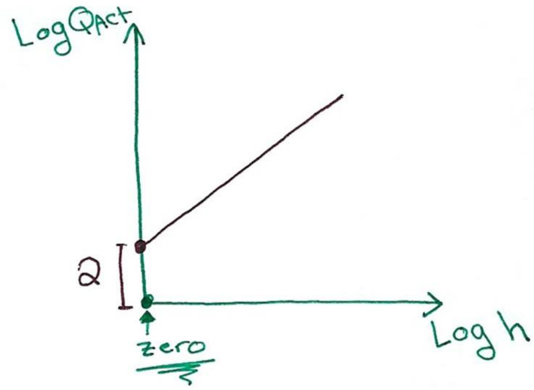
$$= \sqrt{2gh} * \frac{\pi}{4} d^2$$

✓ $Q_{act} = \dfrac{\forall olume}{Time}$

* $Q_{act} = C_d \cdot Q_{theor.}$

$$Q_{Act} = C_d * \frac{\pi}{4} d^2 * \sqrt{2gh}$$

* $$\log Q_{Act} = \underbrace{\log\left[cd\ \frac{\pi}{4} d^2 \sqrt{2g}\right]}_{a} + \frac{1}{2} \log h$$

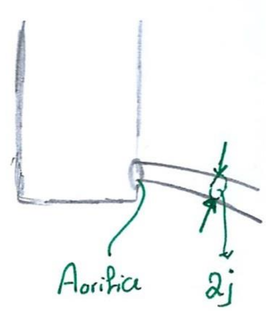


* $$C_d = \frac{10^{a}}{\frac{\pi}{4} d^2 (2g)^{\frac{1}{2}}}$$

* part 3: Contraction (C_c)

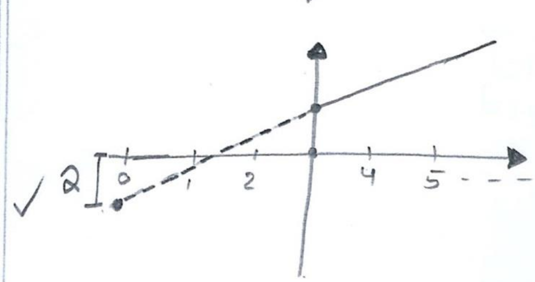
✓ $C_d = C_v \cdot C_c$

✓ $C_c = \dfrac{a_j}{A_{orific}}$



اذا مش Zero ← نمد الخط لحتى اوصل

لل Zero



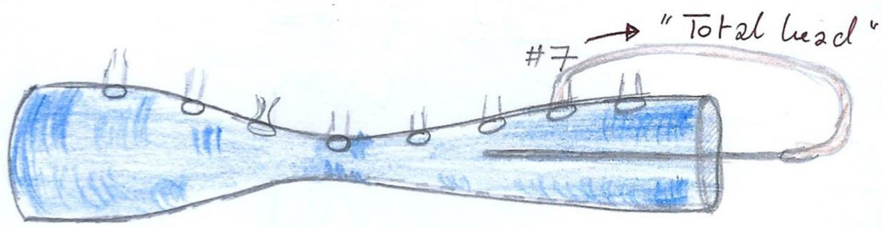
Exp 3: Bernulli's Theorem App. Flow through Venturi Tube

Energy eqn:

$$\underbrace{\frac{P_1}{\rho g}}_{\text{pressure head}} + \underbrace{\frac{V_1^2}{2g}}_{\text{Velocity head}} + \underbrace{Z_1}_{\text{Potential head}} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + \underbrace{h_L}_{\text{head loss}}$$

* $\left.\frac{P_1}{\rho g} + Z_1\right] \Rightarrow$ pezometric head.

* Venturi Tube



Energy eqn between 1 & 7 for example.

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + \cancel{Z_1} = \frac{P_7}{\rho g} + \frac{V_7^2}{2g}\,^{\nearrow 0.0} + \cancel{Z_7}$$

↳ $$\underbrace{\frac{P_{tip}}{\rho g}}_{\text{total head}} = \frac{P_1}{\rho g} + \frac{V_1^2}{2g}.$$

@ #7
↳ stagnation Point
↳ $V=0$
↳ $P_7 = P_{tip}$

*part 2 :- Energy eqn. between 1 & 3 For example.

$$\underbrace{\frac{P_1}{\rho g}}_{h_1} + \frac{V_1^2}{2g} + \cancel{Z_1} = \underbrace{\frac{P_3}{\rho g}}_{h_3} + \frac{V_3^2}{2g} + \cancel{Z_3} + \cancel{h_L} \rightarrow \text{Ignor}$$

$$h_1 + \frac{V_1^2}{2g} = h_3 + \frac{V_3^2}{2g} \quad ; \quad Q_1 = Q_3$$

$$A_1 V_1 = A_3 V_3$$

$$V_3 = \frac{A_1 V_1}{A_3}$$

$$\hookrightarrow h_1 + \frac{V_1^2}{2g} = h_3 + \left[\frac{A_1 V_1}{A_3}\right]^2 * \frac{1}{2g}$$

$$2g(h_1 - h_3) = \left(\frac{A_1^2}{A_3^2} - 1\right) V_1^2$$

$$\hookrightarrow V_1 = \sqrt{\frac{2g(h_1 - h_3)}{\left(\frac{A_1}{A_3}\right)^2 - 1}} \Rightarrow V_{theort.}$$

$$\hookrightarrow V_3 = \sqrt{\frac{2g(h_3 - h_1)}{\left(\frac{A_3}{A_1}\right)^2 - 1}}$$

✓ $Q_{1\,theort} = A_1 V_{1\,theort.} = A_1 \sqrt{\frac{2g(h_1 - h_3)}{\left(\frac{A_1}{A_3}\right)^2 - 1}}$

✓ $Q_{act} = \frac{\text{Volume}}{\text{Time}}$

oR ✓ $Re = \frac{VD}{\nu}$

✓ $Cd = \frac{Q_{Act}}{Q_{theort.}}$

✓ $\Delta P = \Delta h * \gamma_w$

✓ $Re = \rho V D / \mu$

✓ Velocity head = Total head − pressure head .

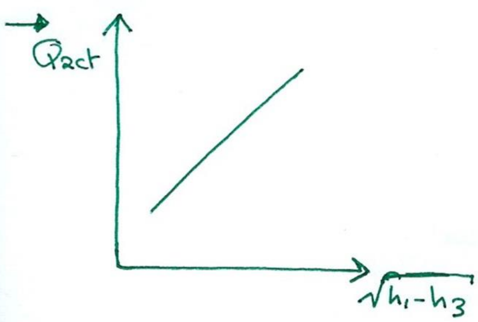
*Notes:- D: Diameter .

→ $H_v \propto \frac{1}{D}$ → $H_s \propto D$ → $H_T \propto D$

→ Re < 2000 → laminor .

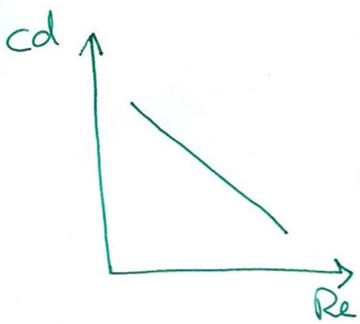
Re (2000 − 4000) → Transition .

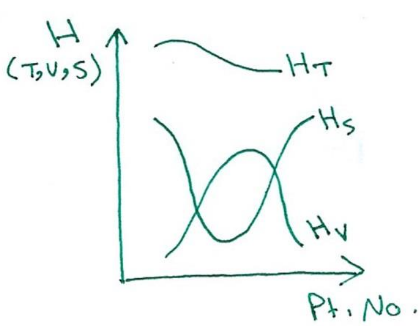
Re > 4000 → Turbinant .



$$Q_{Act} = C_d\, A_1 \sqrt{\frac{2g\,(h_1 - h_3)}{\left(\frac{A_1}{A_3}\right)^2 - 1}}$$

$$\text{slope} = C_d\, A_1 \sqrt{\frac{2g}{\left(\frac{A_1}{A_3}\right)^2 - 1}}$$





Exp #4 : Impact of water Jet.

* Momentum eqn :-

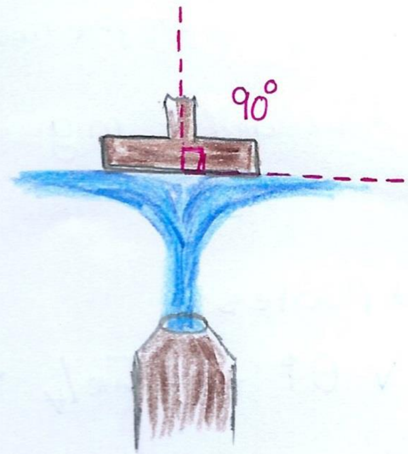
$$\cancel{\bar{P}_1 A_1} + \rho Q V_1 = \cancel{\bar{P}_2 A_2} + \rho Q V_2 \pm F$$

*part I : Flate Plate ⇒ $\theta = 90°$

$$\rho V_0 Q - \rho V_1 Q \cancel{\cos 90}^{0} = F$$

$$F = \rho V Q$$

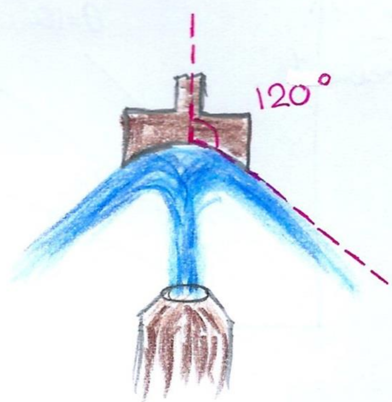
* $v_0 \cong v_1 \Rightarrow \left[V_1^2 = V_0^2 - \cancel{2gy}^{\approx 0} \right]$; y: very small



*part II : Cone ⇒ $\theta = 120°$

$$\rho V_0 Q - \rho V_1 Q \underbrace{(-0.5)}_{\cos 120} = F$$

$$F = 1.5 \rho V Q$$



*part III : Hemisphere ⇒ $\theta = 180°$

$$\rho V_0 Q - \rho V Q \underbrace{(-1)}_{\cos 180} = F$$

$$F = 2 \rho V Q$$

* $\dot{m} = \rho Q$, Momentum $= \dot{m} . V = \rho Q V$

* $Q = \frac{Volume}{Time}$

* Force :

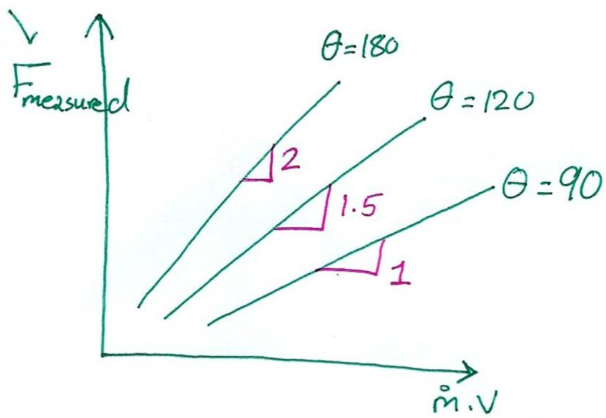
$F_{calc.}$ ⇒ As previous "At each case"

$F_{measured} = mg$.

* Notes:

✓ $\theta \uparrow \rightarrow Time \downarrow \uparrow \rightarrow Q \downarrow , V \downarrow$

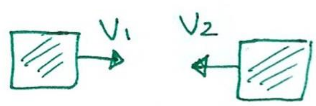
✓



✓

1 to 2

; $V_{Relative} = V_1 - V_2$



; $V_{Relative} = V_1 + V_2$

* Exp #5: Fluid Friction in pipes & losses From Fitting

* Fitting ⇒ Elbow, T-section, Sudden Expansion or Contraction, Valves, ...etc.

* Major loss:-

$$h_l = F \frac{L}{D} \frac{V^2}{2g}$$

, L: length of pipe
D: Diameter of pipe.
V: Velocity.

↳ F:

laminor ⇒ $f = \frac{64}{Re}$, $Re < 2000$

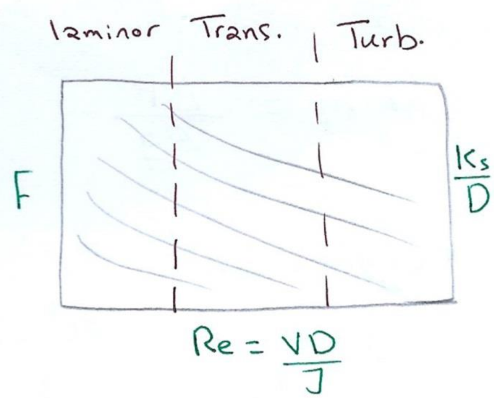
OR Moody Diagram.

turbinant ⇒ $f = 0.0055 \left[1 + \left(20000 \frac{Ks}{D} + \frac{10^6}{Re}\right)^{\frac{1}{3}}\right]$

↳ $4000 < Re < 10^7$

Ks up to 0.01

Transition ⇒ Moody Diagram.



* $h_L \propto V \Rightarrow$ laminor

$$h_L = F \frac{L}{D} \frac{V^2}{2g} \quad , F = \frac{64}{Re} \quad , Re = \frac{\rho V D}{\mu}$$

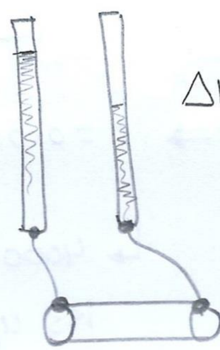
$$\hookrightarrow h_L = \frac{64 \mu}{\rho V D} \frac{L}{D} \frac{V^2}{2g}$$

$$h_L = (---) * V$$

* $h_L \tilde{\propto} V^2 \Rightarrow$ turbinant

* fitting (Minor head losses).

$$h_L = K \frac{V^2}{2g} \quad ; K : \text{fitting loss Coefficient}$$



$\Delta h = h_L$

* In pipe , horizantal, Constant "D"

$$\frac{P_1}{\rho g} + \cancel{\frac{V_1^2}{2g}} + \cancel{Z_1} = \frac{P_2}{\rho g} + \cancel{\frac{V_2^2}{2g}} + \cancel{Z_2} + h_L$$

$$\hookrightarrow h_L = \frac{\Delta P}{\rho g}$$

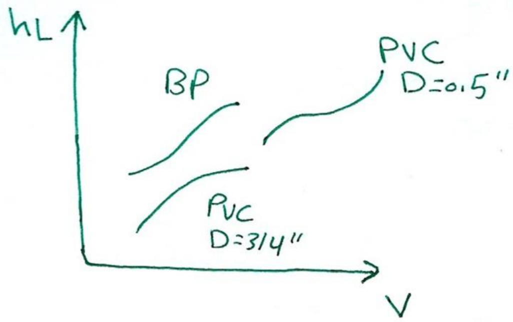
* English Unit

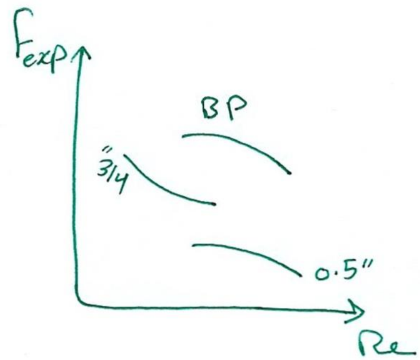
$\rho g = 62.4 \ lb/ft^3$

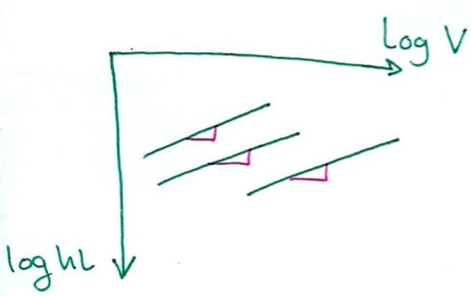
$\rho = 1.94 \ slug/ft^3$

$g = 32.2 \ ft/sec^2$

*Notes :-

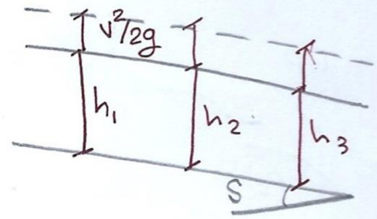






slope → ≈ 2 → Turb.
→ ≈ 1 → Laminar

Exp # 6: Uniform Flow & Determination of roughness Coefficients ...



* Uniform Flow:

$h_1 = h_2 = h_3 = \cdots$

$V_1 = V_2 = V_3 = \cdots$

* Uniform flow seldom occurs in the Nature.

* Main equations:

✓ Manning open channel;

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

✓ Chezy

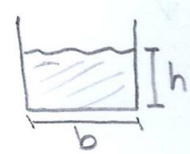
$$Q = C R^{\frac{1}{2}} S^{\frac{1}{2}} A$$

✓ Darcy

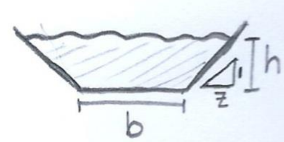
$$Q = \sqrt{\frac{8g}{f}} R^{\frac{1}{2}} S^{\frac{1}{2}} A$$

* $Q = VA$

* $R = \frac{A}{P}$ → Rect.: $R = \frac{b \cdot h}{2h + b}$



→ Trap.: $R = \frac{bh + zh^2}{b + 2h(1+z^2)^{\frac{1}{2}}}$



* $C = \sqrt{\frac{8g}{f}}$, * $C = \frac{R^{1/6}}{n}$, * $f = \frac{8g}{C^2}$

* n_{Avg} : "Part 2" [Grass]

✓ ال n اللي رح نحسبها من المعادلة هي n_{Avg} لانه الجوانب الها n_1 والقاع الها n_2 ....

✓ لحتى احسب ال $n_2 \equiv n_{grass}$ ، بعوض على قوانين ال n_{Avg} حيث انه n_{Avg} حسبناها ، n_1 من الفرع الأول من التجربة ، n_2 المجهولة

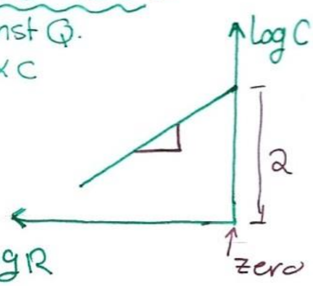
✓ $n_{Avg} = \frac{P R^{5/3}}{\sum \frac{P_i R_i^{5/3}}{n_i}}$; Trap.

✓ $n_{Avg} = \left(\frac{\sum P_i n_i^{3/2}}{P}\right)^{2/3}$

✓ $n_{Avg} = \left(\frac{\sum P_i n_i^{2}}{P}\right)^{\frac{1}{2}}$

* Notes :-

Const Q.
$R \propto C$



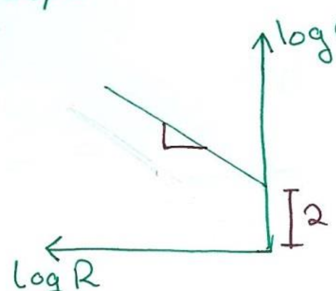
$C = \frac{R^{1/6}}{n}$

$\log C = \frac{1}{6}\log R - \log n$

$a = -\log n$

slope $= \frac{1}{6}$

Const. slope
$R \propto \frac{1}{C}$



$a = -\log n$

slope $= \frac{1}{6}$

* Slope ↑ → h ↓

* Slope ⇒
Reading Value * 0.2 = slope.

* C : Chezy Coefficient, it's Function of the roughness of the channel bottom & walls & the Depth of flow that determind experimentally.

* n : Manning Coefficient, it's the resistance of the bed of a channel to the flow of water in it.

* f : Darcy Friction factor, it's Usually Selected from a chart Known as Moody Diagram that relate Friction Factor to Reynolds No. & Relative roughness of a pipe.

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

↳ $Q_{Manning} = Q_{chezy}$

$\frac{1}{n} R^{2/3} \cancel{S^{\frac{1}{2}}} \cancel{A} = C R^{\frac{1}{2}} \cancel{S^{\frac{1}{2}}} \cancel{A}$

↳ $C = \frac{R^{1/6}}{n}$ #

*Exp #7: Fast & Slow Flow ... 1
Specific Energy ... 2
Specific Force ... 3

*part 1:

Fast Flow	Slow Flow
Supercritical	Subcritical
$Fr > 1$	$Fr < 1$
$h < h_c$	$h > h_c$
$V > V_c$	$V < V_c$
$S > S_c$	$S < S_c$

Note
Slow:
$h\uparrow, V\downarrow, E\uparrow, F\uparrow$
Fast:
$h\downarrow, V\uparrow, E\uparrow, F\uparrow$

*Critical: "Rectangular channel"

$$V_c = \sqrt{g h_c} = Q/A_c = Q/b \cdot h_c$$

$$h_c = \left(\frac{q^2}{g}\right)^{\frac{1}{3}}$$

$$q = Q/b$$

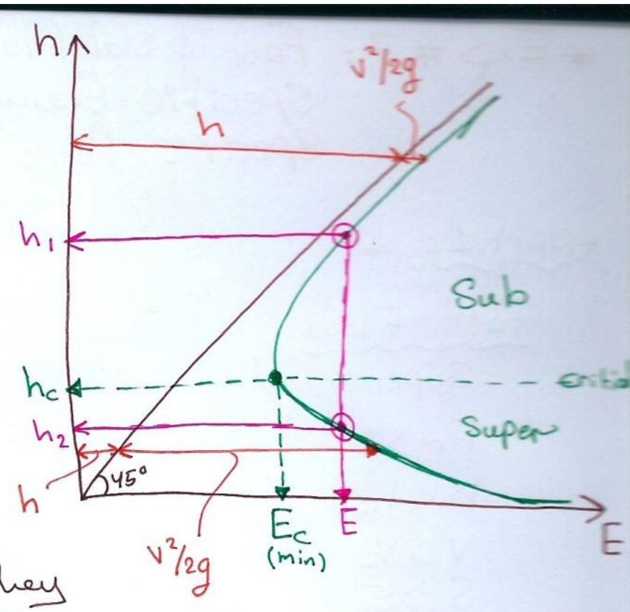
$$E_c = \frac{3}{2} h_c \Rightarrow E_c = \left[h_c + \frac{V_c^2}{2g}\right] = h_c + \frac{g h_c}{2g} = \frac{3}{2} h_c \ \#$$

$$R_c = \frac{A_c}{P_c} = \frac{b h_c}{b + 2h_c}$$

$$S_c = \frac{n^2 V_c^2}{R_c^{4/3}}$$, Eng. Unit $\Rightarrow S_c = \dfrac{n^2 V_c^2}{1.486^2 R_c^{4/3}}$

$$S_c = \frac{V_c^2}{C^2 R_c}$$

* part 2: Sp. Energy ...



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

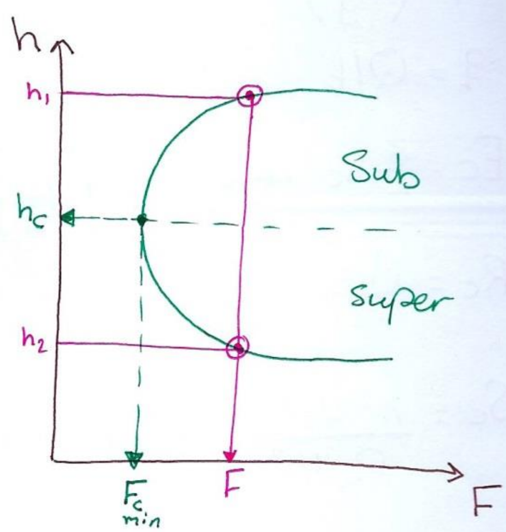
$\alpha \approx 1$.

$$V = \frac{q}{h} \equiv \frac{Q}{A} = \frac{q * b'}{h * b'}$$

* المحاور (لازم) نفس ال Scale

✓ There are two depths, they have the specific Energy, they called alternative depths one of the them Subcritical Flow (h_1) & the Second one is the Super Criticial Flow (h_2).

* Part 3: Sp. Force



$$F = \frac{h^2}{2} + \frac{q^2}{gh}$$

↳ Momentum eqn;

$P_1 A + \rho Q V = \text{const}$.

$\Rightarrow P = \rho g \frac{h}{2}$, $Q = q b$, $V = \frac{q}{h}$

↳ $\rho g \frac{h}{2}(h b) + \rho (q b)\left(\frac{q}{h}\right) = \text{const}$

$\div \rho g b$

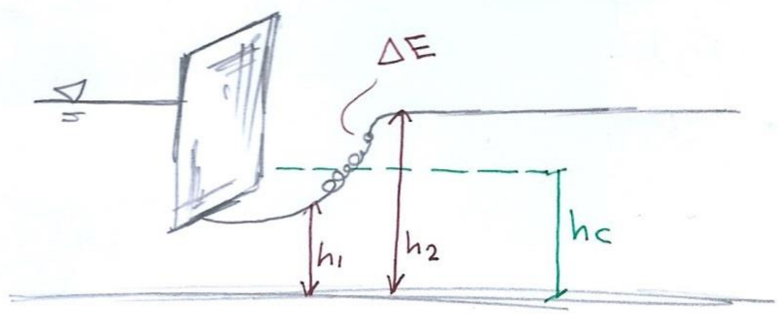
↳ $\frac{h^2}{2} + \frac{q^2}{gh} = \text{const.} = F$ #

✓ There are Two depth have the same sp. Force they called {Sequence OR Conjugate} depths, $h_1 \Rightarrow$ Sub
$h_2 \Rightarrow$ Super

Exp# 8 : Hydraulic Jump...

* Sudden Change in the Flow Classification From Super Critical to Subcritical Flow in which there is a head losses through the jump, reach between (5% - 85%) of the Up stream (U.S.) specific Energy.

* Apply Momentum eqn to Find the relationship between depth before H.j (h_1) & depth AFter H.j (h_2) *** (Not Energy eqn) ***



$$\frac{h_1^2}{2} + \frac{q^2}{g h_1} = \frac{h_2^2}{2} + \frac{q^2}{g h_2} \quad \text{Rect.}$$

$$h_2 = \frac{h_1}{2}\left[\sqrt{1+8\,Fr_1^2} - 1\right]$$

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

$$\Delta E = E_1 - E_2 \quad ; \quad E = h + \frac{V^2}{2g}$$

$$\Delta E = \frac{(h_2-h_1)^2}{4 h_2 h_1}$$

* height of jump:

$$h_j = h_2 - h_1$$

$$\frac{h_j}{E_1} = \frac{\sqrt{1+8Fr_1^2} - 3}{Fr_1^2 + 2} \rightarrow \text{if } h_2 \text{ is Unknown.}$$

* lenght of H.j :-

✓ $L_j = h_1 \left[220 \tanh\left(\frac{Fr_1 - 1}{22}\right)\right]$; tanh ⇒ on Calculator Click $\boxed{hyp}$, then Choose the No. of tanh OR $\tanh(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}$

✓ $L_j = 6h_2$; $4 < Fr < 20$
↲ يفضل عدم استخدامها ...

✓ From table 8.5 "Page 269"
⇒ function of (Fr_1)

$Fr_1 > 1$; Super
دائماً

Notes:-

✓ with Const. Q & Small opening sluicegate.

$h_1 \downarrow$, $h_2 \uparrow$, $L_j \uparrow$, $h_j \uparrow$, $V_1 \uparrow$, $V_2 \downarrow$

✓ with Const. Sluice gate opening & Small Q

$h_1 \downarrow$, $h_2 \downarrow$, $L_j \uparrow$, $h_j \downarrow$, $V_1 \downarrow$, $V_2 \downarrow$

✓ ΔE (+ve), But in Exp. it's (-ve) because of [sluice gate & weir], As:
Sluice gate detract (h_1) Value, in other hand weir increases (h_2) Value ⇒ So $h_1 < h_2$
$E_1 < E_2$

Exp #9: Weirs ...

* Types of weir:

a) Broud crested weir (made of concrete).

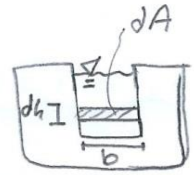
b) Sharp crested weir (made of steel).

✓ Rectangle ✓ Triangle (Notch weir) ✓ semi-circle ✓ Trap.

*Part 1: Rectangular sharp crested weir:-

✓ $Q_{Actual} = Cd\ \frac{2}{3} b (2g)^{\frac{1}{2}}\ H^{3/2}$

↳ $Q_{Act} = K * H^{N}$



✓ $Q_{theor.} = \frac{2}{3} b (2g)^{\frac{1}{2}}\ H^{3/2}$ ⇒ $dQ = v\, dA = \sqrt{2gh}\ \cdot b \cdot dh$

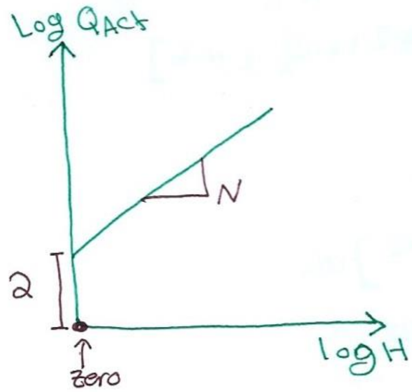
$Q_{theor} = b (2g)^{\frac{1}{2}} \int_0^H h^{\frac{1}{2}} dh$

$= b (2g)^{\frac{1}{2}} \frac{2}{3} h^{3/2} \Big]_0^H$

$= \frac{2}{3} b (2g)^{\frac{1}{2}}\ H^{3/2}$ #

✓ $Cd = \frac{Q_{Act}}{Q_{theort.}}$

*N, Cd ⇒ Unknown;



$$Cd = \frac{10^{2}}{\frac{2}{3} b (2g)^{\frac{1}{2}}}$$

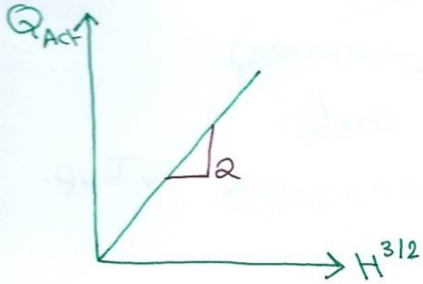
$* 2 = \log(cd\ \frac{2}{3} b (2g)^{\frac{1}{2}}) = \log(K)$

$*$ slope $= N$ "Power of H"

$= \frac{3}{2}$

* Cd ⇒ "Unknown"

N ⇒ "Known"



$$Q_A = C_d \frac{2}{3} b (2g)^{\frac{1}{2}} H^{3/2}$$

$$a = slope = C_d \frac{2}{3} b (2g)^{\frac{1}{2}}$$

* Note ⇒ $b\uparrow$, $H\downarrow$, $h_L\downarrow$, $C_d\uparrow$

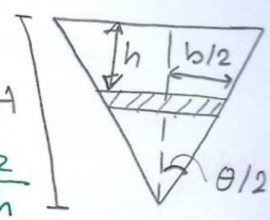
* Part 2 : Triangle weir :

✓ $Q_{Act} = C_d \frac{8}{15} (2g)^{\frac{1}{2}} \tan\frac{\theta}{2} \cdot H^{5/2}$

↳ $Q_{Act} = K \, H^N$

✓ $Q_{theort} = \frac{8}{5} (2g)^{\frac{1}{2}} \tan\frac{\theta}{2} H^{5/2}$ ⇒

✓ $C_d = \frac{Q_{Act}}{Q_{theor.}}$



$\tan\frac{\theta}{2} = \frac{b/2}{H-h}$

$b = 2\tan\frac{\theta}{2} [H-h]$

⇒ $dQ = v\,dA = \sqrt{2gh}\, b \cdot dh$

$$Q = \int \sqrt{2gh}\; 2\tan\left(\frac{\theta}{2}\right) [H-h]\, dh$$

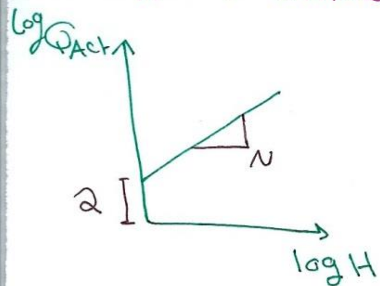
$$= 2(2g)^{\frac{1}{2}} \tan\frac{\theta}{2} \int_0^H \left(h^{\frac{1}{2}} H - h^{3/2}\right) dh$$

$$= 2(2g)^{\frac{1}{2}} \tan\frac{\theta}{2} \left[\frac{2}{3} h^{3/2} H - \frac{2}{5} h^{5/2}\right]_0^H$$

$$= 2(2g)^{\frac{1}{2}} \tan\frac{\theta}{2} \left[\frac{2}{3} H^{5/2} - \frac{2}{5} H^{5/2}\right]$$

$$= \frac{8}{5} (2g)^{\frac{1}{2}} \tan\frac{\theta}{2} H^{5/2} \quad \#$$

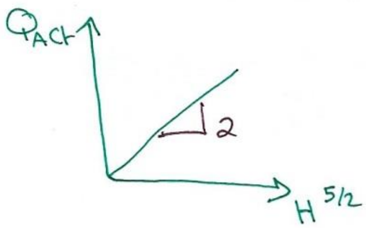
* Cd, N ⇒ "Unknown"



$$2 = \log\left(Cd\,\frac{8}{15}\,(2g)^{\frac{1}{2}}\,\tan\frac{\theta}{2}\right) = \log(k)$$

$$N = \text{slope} = 5/2$$

* Cd ⇒ "Unknown"



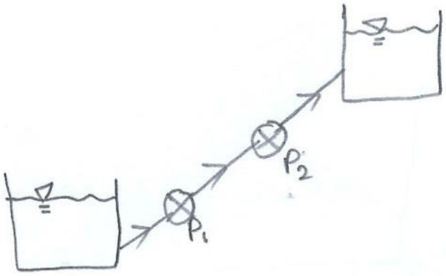
$$Q_{Act} = Cd\,\frac{8}{15}\,(2g)^{\frac{1}{2}}\,\tan\frac{\theta}{2}\,H^{5/2}$$

$$\text{slope} = 2 = Cd\,\frac{8}{15}\,(2g)^{\frac{1}{2}}\,\tan\frac{\theta}{2}$$

* Note ⇒ $\theta\uparrow$, $h_L\downarrow$, $Cd\uparrow$, $H\downarrow$

Exp # 10 8- Pumps...

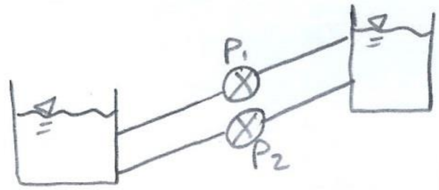
* Series :-



$Q = Q_1 = Q_2$

$H_T = H_1 + H_2$

* Parallel :-



$Q_T = Q_1 + Q_2$

$H_T = H_1 = H_2$

* Power :-

$Pow = \rho g \underbrace{Q}_{[m^3/s]} \underbrace{\Delta H}_{[m]}$; [watt]

Pressure $P = \rho g \Delta H$; [Pascal]

$Pow = \frac{Q\,H\,S}{366}$ S → sp. gravity ; Q : [m³/hr] or [gal/min]
H : [m] or [ft]
Pow : [kw] or [hp]

$Pow = \frac{\rho g Q \Delta H}{550}$; [hp]

$Pow = Q * \Delta P * 10^5$ → Bar to Pascal *effeciency:-

$$\eta = \frac{output}{Input}$$

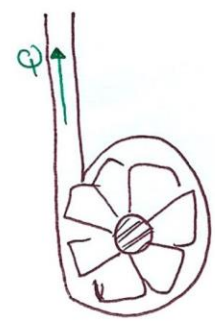
*pumps:

Electrical power → Mechanical → Hydropower

$\sqrt{3}\ I.V\cos\phi$ $T.\omega$ $Q.\Delta P.*10^5$

Torque . omega

$$\eta_{over\ all} = \frac{Q.\Delta P * 10^5}{\sqrt{3}\ I\ V\cos\phi}$$



*Note:-

given parallel $H=10$
$Q=20$

Switch to series , H? Q?

$Q=10$

$H=20$