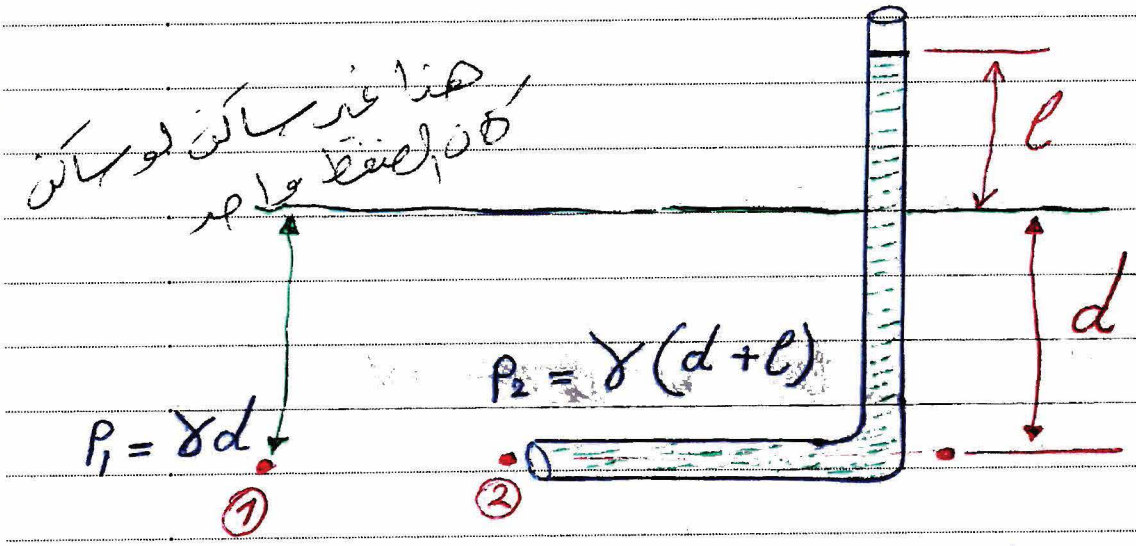
دفتر مادة..

ميكانيكا مواد ج2

0789434018
Mech.MuslimEngineer.Net
MechFet
FB.com/Groups/Mid.Group
مادة د.أيمن العلاوين

Application on pernoulli

stagnation total head tube



stagnation point

$V = zero$

$$\frac{P_1}{\gamma} + \frac{V^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2$$

$$\frac{V_1^2}{2g} = \frac{P_2 - P_1}{\gamma} = \frac{\gamma(d+\ell) - \gamma d}{\gamma}$$

$$V_1 = \sqrt{2g\ell}$$

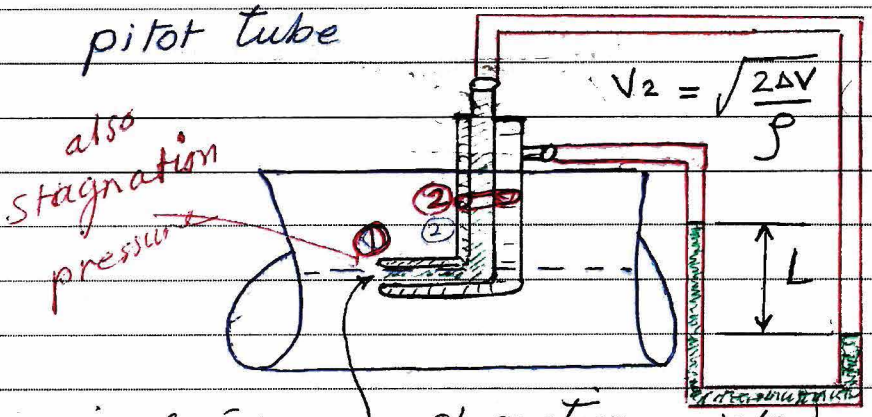
Bernoulli Equ

pressure head + velocity + elevation head = C

$$\frac{P}{\gamma} + \frac{V^2}{2g} + Z = C$$

$$P + \frac{1}{2}\rho V^2 + \gamma Z = C$$

2) pitot tube



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

stagnation point $V=0$

$h_1 \quad h_1 - h_2 = \frac{V_2^2}{2g}$ $\quad h_2$

لو ليس كذلك إذا على مستوى واحد

$Z_1 = Z_2$ تلغى

$$V_2 = \sqrt{2g\Delta h} = \sqrt{\frac{2\Delta P}{\rho}}$$

أحاول أربط دوما بالنقطة

$$\left(\frac{P_1}{\gamma_A} + Z_1\right) - \left(\frac{P_2}{\gamma_A} + Z_2\right) = \Delta h\left[\frac{\gamma_B}{\gamma_A} - 1\right]$$

$$(h_1 - h_2) = \Delta h\left[\frac{\gamma_B}{\gamma_A} - 1\right]$$

Ex : 4.73 Air pressure gage يقيس ضغط الهواء

$T_{Air} = 20^\circ C = 293^\circ K$

$P = P_{atm} = 101.325\ KPa$

$\Delta P = 3\ KPa$

$V_{air} = ??$ $V_{air} = \sqrt{\frac{2\Delta P}{\rho}} =$ $\rho \rightarrow \frac{P}{RT}$

$$= \sqrt{\frac{2(3000)}{\frac{101.325 * 10^3}{287 * 293}}} = 70.56\ m/s$$

Ex :- 4.66

Water deflects 5 cm = 0.05 m

$T_{air} = 290^\circ K$

$P = 105\ KPa$

$V_{air} = ??$ أنبوبة بيتوت

$$V = \sqrt{\frac{2\Delta P}{\rho}} = \sqrt{\frac{(2)(0.05)(9810)}{\frac{105}{0.287 * 290}}} =$$

$= 27.88\ m/s$

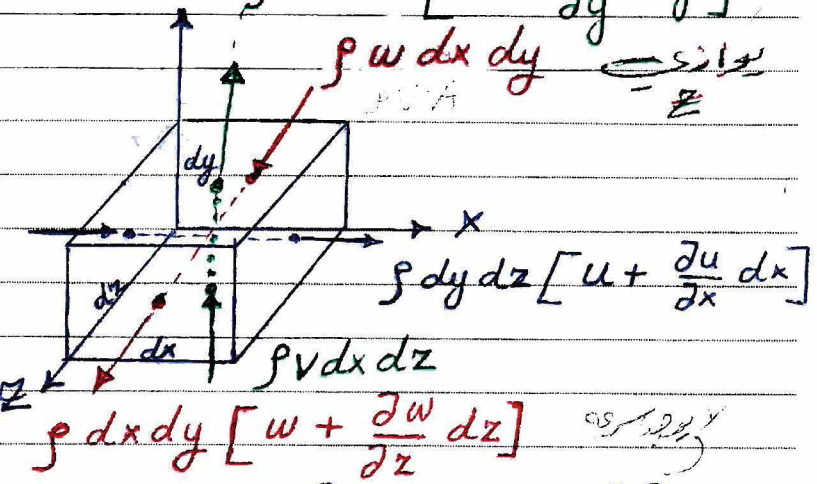
Continuity Equ differential Form

كتب أو هيئ اشتقاقه

$$\left.\frac{dm}{dt}\right|_{sys} = 0$$

$$\frac{d}{dt}\int_{C.V} \rho\, d\forall + \int_{C.S} \rho \vec{v}\cdot d\vec{A}$$

$$\frac{dm_{C.V}}{dt} = \sum \dot{m}_{in} - \sum \dot{m}_{out}$$



$\rho dx\, dz \left[v + \frac{\partial v}{\partial y} dy\right]$

$\rho w\, dx\, dy$ يوازي z

يوازي x $\rho u\, dy\, dz$

$\rho dy\, dz \left[u + \frac{\partial u}{\partial x} dx\right]$

$\rho v\, dx\, dz$

$\rho\, dx\, dy \left[w + \frac{\partial w}{\partial z} dz\right]$

كتب تشتق

$$\frac{\partial}{\partial x}[\rho u] + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}[\rho w] + \frac{\partial \rho}{\partial t} = 0$$

$$\underbrace{\rho \frac{\partial u}{\partial x} + u\frac{\partial \rho}{\partial x}}_{u} + \underbrace{\rho \frac{\partial v}{\partial y} + v\frac{\partial \rho}{\partial y}}_{v} + \underbrace{\rho \frac{\partial w}{\partial z} + w\frac{\partial \rho}{\partial z}}_{w} + \frac{\partial \rho}{\partial t} = 0$$

شبيه بـ

المعدل بالنقط

$$\rho\left[\vec{\nabla}\cdot\vec{v}\right] + \frac{D\rho}{Dt} = 0 \cdot 0$$

gradient — substantive material derivative

يتبع

إعادة الصياغ $\rho[\vec{\nabla}\cdot\vec{V}] + \frac{D\rho}{Dt} = 0.0$

في حالة ثبات السرعة مع تغير الضغط تغير في الكثافة

gradient substantive material derivative

$$\frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k} = u\frac{\partial\rho}{\partial x} + v\frac{\partial\rho}{\partial y} + w\frac{\partial\rho}{\partial z} + \frac{\partial\rho}{\partial t} = 0$$

يوجد تغيرات السرعة و الكثافة

steady in Compressible

لا يوجد كثافة ρ constant $\longrightarrow$ إذا $\frac{\partial}{\partial t} = 0$ فالتغير غير موجود في السرعة

تغير، إذا $\frac{\partial}{\partial t} = 0$

$$\vec{\nabla}\cdot\vec{V} = 0$$

سيكون التغير فقط في السرعة

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0.0 \longleftarrow \text{incompressible}$$

Ex:- the velocity for Certain flow field is given by

$$V = \underbrace{(2x^2 + y^2)\hat{i}}_{u} + \left[x^3 \pm x(y^2 - 2y)\right]\hat{j}$$

dose this a two dimension steady in Compressible flow ?

سؤال

steady in Compressible

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0.0$$

$$4x + [-x(2y-2)] \overset{??}{=} 0$$

$$4x - 2xy + 2x \neq 0$$ ☒

غير Compressible أو Incompressible flow

Ex : the x-Component of velocity for a steady incompressible 2 dimension flow in x-y plane is $u = \frac{A}{x}$ $A = 2\frac{m}{s}$ (عكس)

↳ mean $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0.0$

determine the Simplest y Component (v) for the velocity

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \qquad \frac{\partial u}{\partial x} = \frac{\partial}{\partial x}\left(\frac{A}{x}\right) = -\frac{A}{x^2}$$

$$\frac{-A}{x^2} + \frac{\partial v}{\partial y} = 0$$

$$\frac{\partial v}{\partial y} = \frac{+A}{x^2} \qquad v = \frac{A}{x^2}y + f'(x)$$

$$v = \frac{+2}{x}\hat{i} + \frac{2}{x^2}y\hat{j} \qquad v = \frac{A}{x^2}y$$

$\frac{-2}{x^2}x$ ← $\frac{-2}{x}$

Example :- the three component of velocity

$$\frac{\partial u}{\partial x} \quad u = Ax + By + Cz$$

$$\frac{\partial v}{\partial y} \quad v = Dx + Ey + Fz$$

$$\frac{\partial w}{\partial z} \quad w = Gx + Hy + Jz$$

Determine relationship between Coefficient A through J such that the Flow incompressible

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

$$A + E + J = 0$$

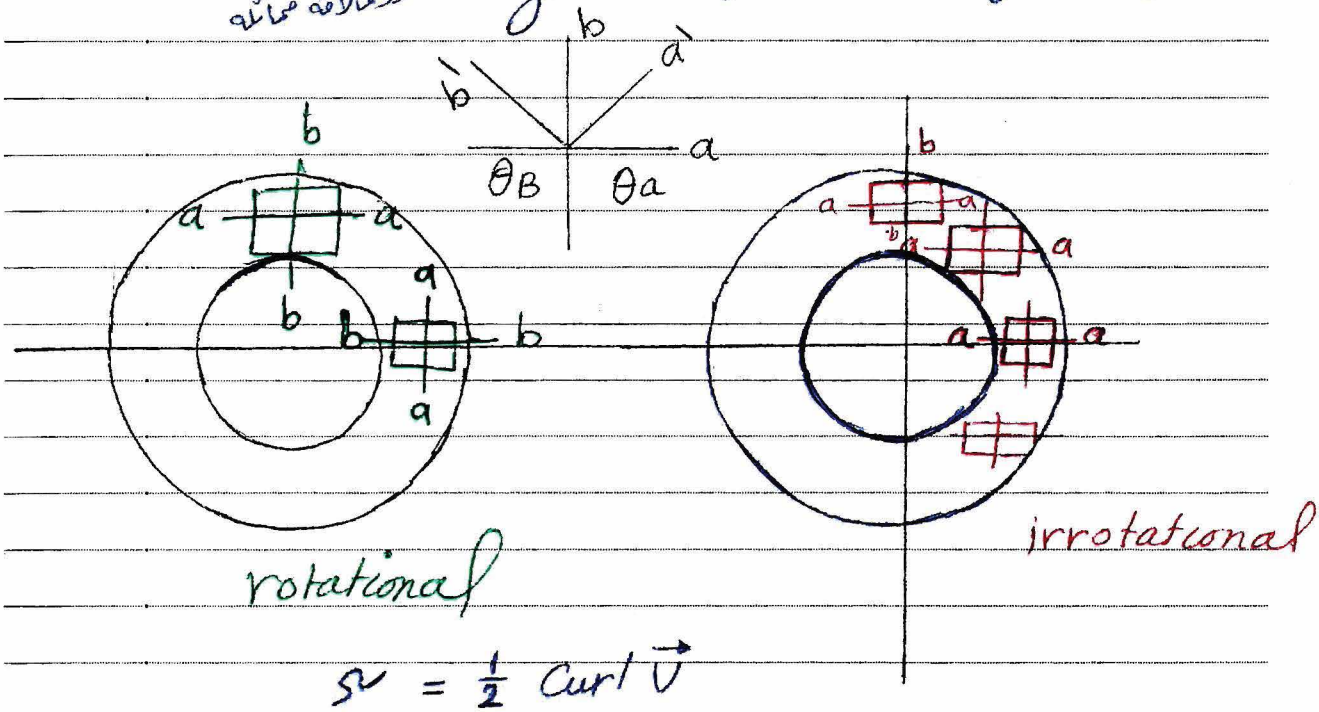
محاضرة

Rotation & Vorticity

Ω ↙ $\omega = 2\Omega$

is a vector quantity and is defined as the average angular velocity of two mutually ⊥ faces in a flow field

تعامد متبادل



$$\Omega = \frac{1}{2} Curl\, \vec{V}$$

$$Curl\, \vec{V} = \vec{\nabla} \times \vec{V}$$

$$\Omega = \frac{1}{2} \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ u & v & w \end{vmatrix}$$

$$= \frac{1}{2} \left[\left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z} \right) \hat{i} + \left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x} \right) \hat{j} + \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right) K \right]$$

يتبع

$\Omega = 0.0$ irrotational flow

$$\frac{\partial w}{\partial y} = \frac{\partial v}{\partial z}$$

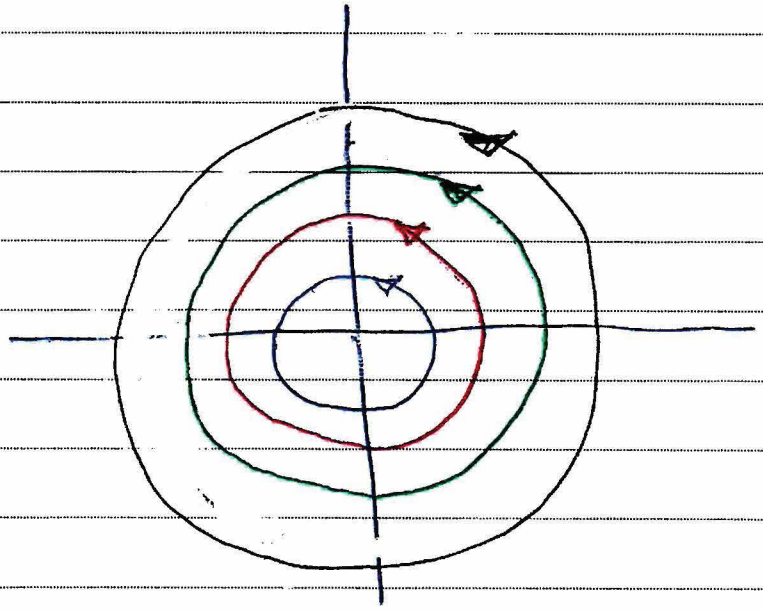
$$\frac{\partial u}{\partial z} = \frac{\partial w}{\partial x}$$

$$\frac{\partial v}{\partial x} = \frac{\partial u}{\partial y}$$

$\Omega \neq 0$ rotational flow

Vortex ⟲

Concentric Circular stream lines



$$\omega = \frac{V}{r}$$

$$\Omega = \frac{1}{2}\frac{V}{r}$$

$$\Omega_z = \frac{1}{2}\left[\frac{dv}{dr} + \frac{v}{r}\right]$$

irrotational flow $\Omega z = 0.0$

$$\frac{dV}{dr} = \frac{-V}{r} \Rightarrow \frac{dV}{V} = -\frac{dr}{r}$$

$$\boxed{Vr = Const}$$ Free Vortex

rotation $V = -r\omega$

$$\Omega = \frac{1}{2}(\omega + \omega) = \omega$$

Rotation and vorticity عاده!

Ω vector

$\omega = 2\Omega$

$$\Omega = \frac{1}{2} \text{curl } \vec{V}$$

$$= \frac{1}{2} \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ u & v & w \end{vmatrix}$$

$$= \frac{1}{2} \left[\left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z} \right) \hat{i} - \left(\frac{\partial w}{\partial x} - \frac{\partial u}{\partial z} \right) \hat{j} + \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right) \hat{k} \right]$$

$\Omega = 0$ ∴ irrotational flow

$$\frac{\partial w}{\partial y} = \frac{\partial v}{\partial z}$$

$$\frac{\partial w}{\partial x} = \frac{\partial u}{\partial z}$$

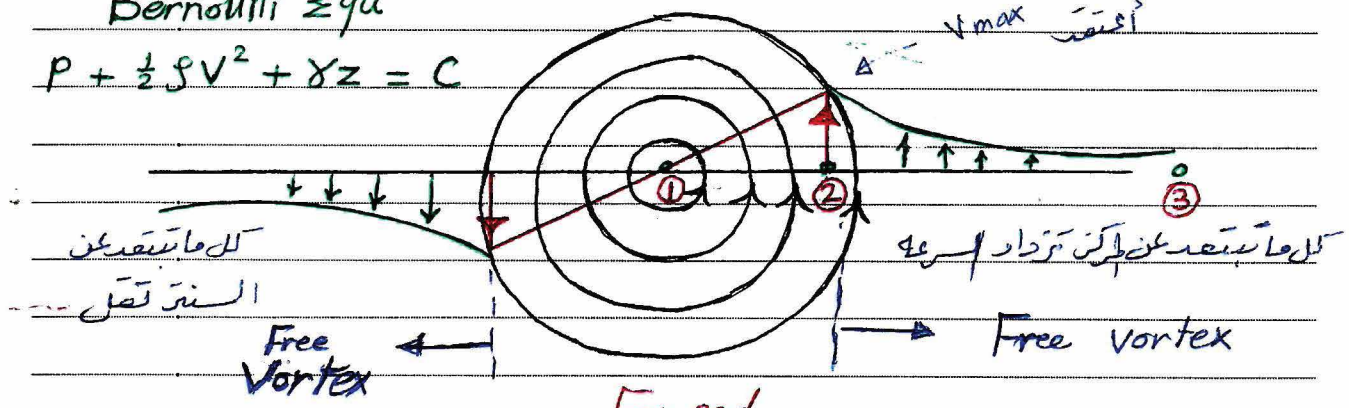
$$\frac{\partial v}{\partial x} = \frac{\partial u}{\partial y}$$

$\Omega \neq 0$ rotational flow

Vortex :- Circular Concentric Stream lines

Bernoulli equ

$$P + \frac{1}{2}\rho V^2 + \gamma z = C$$



Forced vortex Rotational

$$P + \gamma z - \frac{1}{2}\rho V^2 = Const$$

$$\omega_z = \frac{1}{2}\left[\frac{dV}{dr} + \frac{V}{r}\right]$$

rotational Flow $\omega \neq 0$

$V = r\omega$ ⟶ Forced Vortex

$$\omega_z = \frac{1}{2}\left[\frac{d}{dr}(r\omega) + \frac{r\omega}{r}\right]$$

$$= \omega \longrightarrow$$

For irrotational Flow

$$\omega_z = 0.0$$

$$\frac{dV}{dr} = -\frac{V}{r}$$

$$\int \frac{dV}{V} = \int \frac{dr}{r} \qquad \ln Vr = \ln C$$

$$Vr = Const$$

أيضاً

$$\ln V - \ln r = c \Leftrightarrow \ln\left(\frac{V}{r}\right) = c$$

V_1 و كذلك V_3 لا يوجد سرعة

1-2 Rotational Equ

باستخدام الأرقام في الرسم

$$P_1 + \gamma z_1 - \frac{1}{2}\rho V_1^2 = P_2 + \gamma z_2 - \frac{1}{2}\rho V_{2max}^2$$

$w_r = 0$ — نفس المستوى — مركز الإعصار $r = 0$ — نفس المستوى

$$P_1 - P_2 = -\frac{1}{2}\rho V_{2max}^2$$

$$P_2 = P_1 + \frac{1}{2}\rho V_{2max}^2$$

$$P_2 + \gamma z + \frac{1}{2}\rho V_{max}^2 = P_0 + \gamma z_0 + \frac{1}{2}\rho V_0^2$$

$$P_2 - P_0 = -\frac{1}{2}\rho V_{max}^2$$

$$P_1 + \frac{1}{2}\rho V_{max}^2 - P_0 = -\frac{1}{2}\rho V_{max}^2$$

فرق الضغط بين مركز

$$P_1 - P_0 = -\rho V_{max}^2$$

(بعيد عن المركز)

Ex: 4.88 $V = 10x\hat{i} - 10y\hat{j}$ ① is the Flow irrotational ?

2- dimensional Flow

$$\omega = \frac{1}{2}\begin{vmatrix} \hat{i} & \hat{j} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} \\ u & v \end{vmatrix}$$

$10x\hat{i} = 0$

$\hat{i}\frac{\partial u}{\partial y} = 0.0$

$-10y\hat{j} = 0$

$\hat{j}\frac{\partial v}{\partial x} = 0.0$

irrotational Flow

$\frac{\partial v}{\partial x} = \frac{\partial u}{\partial y} = 0$

4.91 $V = (x^2 - y^2)\hat{i} + (-2xy)\hat{j}$

Check if the flow in compressible and is the flow rotational or irrotational.

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0.0$$

اشتقاق x — اشتقاق y — اشتقاق z غير موجود

$2x + -2x + 0 = 0.0 \therefore$ incompressible

to check irrotational

$$\frac{\partial v}{\partial x} = \frac{\partial u}{\partial y}$$

$-2y = -2y \therefore$ irrotational flow

بعض ؟؟

$\Delta P = P_i - P_o = -100$ mbar $= (-100)(10^{-3})(10^5) = 10000$ Pa

1 bar $= 10^5$ Pa

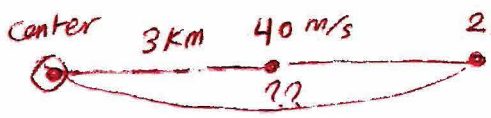
$\rho_{air} = 1.2 \frac{kg}{m^3}$

$V_{max} = ??$

$$\Delta P = -\rho V_{max}^2$$

$$-10000 = -1.2 V_{max}^2$$

$$V_{max} = \sqrt{\frac{10000}{1.2}} = 91.28 \ m/s$$



سرعة زاوية

Ex 30 in a free vortex the velocity @ a radius for 3 Km From the Center of the vortex is Equal to V_1 40 m/s at What distance From the Center the velocity will be V_2 25 m/s

Free vortex

Vr = Constant

$V_1 r_1 = V_2 r_2 \rightarrow r_2 = \left(\frac{V_1}{V_2}\right) r_1$

40 3Km 25 ??

$r_2 = \left(\frac{40}{25}\right)(3\ Km) = 4.8\ Km$

4.102

$V_{max} = 85\ m/s$

$\rho = 1.2\ \frac{kg}{m^3}$

1.2

101.325 Pa

90 KPa

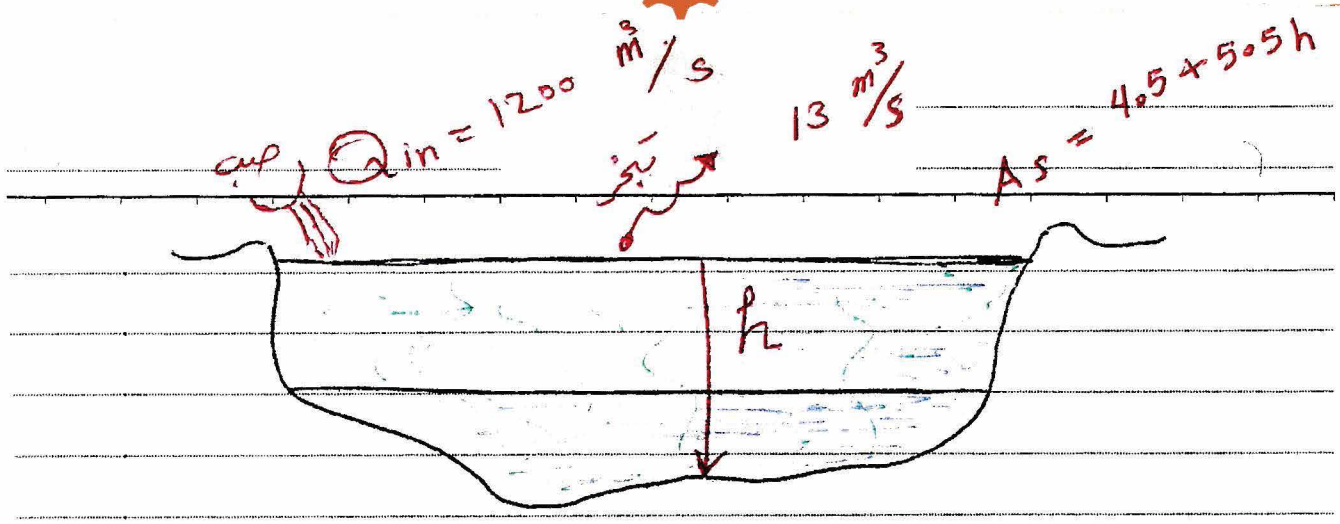
1.07

$\Delta P = P_2 - P_0 = -\rho V_{max}^2$

$= -(1.2)(85)^2 = -8670\ Pa$

$\Delta P = +101 * 10^3 - 90 * 10^3$

$= +11000$



steady $\frac{dm_{C.V}}{dt} = \sum \dot{m}_{in} - \sum \dot{m}_{out}$

$= \sum \dot{m}_{in} - \sum \dot{m}_{out}$

① For Equilibrium depth

$1200 = (13)(4.5 + 5.5h)$

$1200 = 58.5 + 71.5h$

$h = \left(\frac{1200 - 58.5}{71.5}\right) = 15.965\ m$

② determine Q_{in} such that Lake dry up

$h = 0.0$

$Q_{in} = (13)(4.5 + 0) + 0$

$= 58.5\ m^3/s$

كمية التحرك : كمية التحرك : عوامل ضرب كتلة الجزء المتحرك مرتبة عليه في سرعته المتحركة بها

عاشرا مبدأ زخم الحركة

Ch 6 Momentum principle

Reynold Transport theorem

$$\frac{dm}{dt}\Big|_{sys} = \frac{d}{dt}\int_{C.V} \rho \beta dA + \int_{C.S} \rho \beta \vec{V} \cdot dA$$

β :- Extensive property

scalar mass , E , KE , P.E

or

vector $m\vec{v}$

β :- intensive property

$$\beta = \frac{\beta}{m} \qquad \beta = \int \beta \, dm = \int \rho \beta \, d\forall$$

β = mass $\qquad \beta = \frac{m}{m} = 1$ Continuity Equ

$$0 = \frac{d}{dt}\int_{C.V} \rho \, d\forall + \int_{C.S} \rho \vec{V} \cdot dA$$

$$\frac{dm_{C.V}}{dt} = \Sigma \dot{m}_{in} - \Sigma \dot{m}_{out}$$

2 $\quad \beta = m\vec{v}$

$$\beta = \frac{m\vec{v}}{m} = \vec{v}$$ [momentum per Unit mass]

$$\frac{d m \vec{v}}{dt} = \frac{m d\vec{v}}{dt} = ma = \Sigma F$$

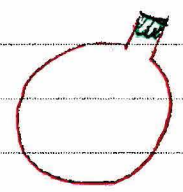
$$\Sigma F = \frac{d}{dt}\int_{C.V} \rho \vec{v}\, d\forall + \int_{C.S} \rho \vec{v}\vec{v}\cdot dA$$

$$\Sigma F = \frac{d}{dt}\int_{C.V} \rho \vec{v}\, d\forall + \int_{C.S} \rho \vec{v}\vec{v}\cdot dA$$

the same For non-accelerating C.V

For Uniform streams to and out from C.V

$\int \rightarrow \Sigma$



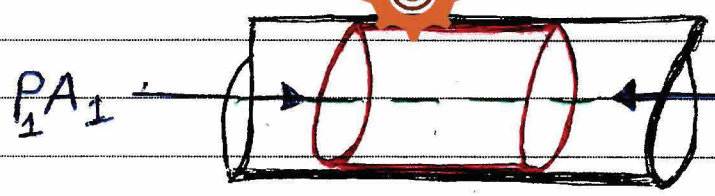
$$\Sigma F = \frac{d}{dt}\int \rho \vec{v}\, d\forall + \Sigma \dot{m}_{out} V_{out} + \Sigma \dot{m}_{in} V_{in}$$

the net Force acting on the Fluid within C.V = Rate of change of momentum within C.V + Net out Flow of momentum From C.V through C.S

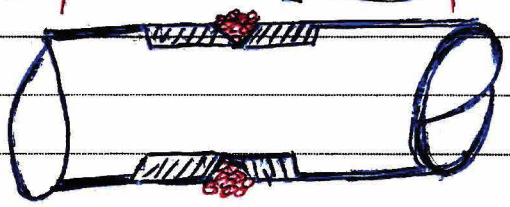
$$\Sigma F_B + \Sigma F_S$$

ΣF_B: body Forces, physical Contact is not required, gravitational Force, electric field, Magnatic field

ΣF_S: physical Contact is required pressure forces

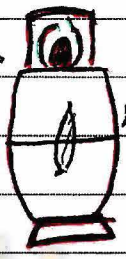


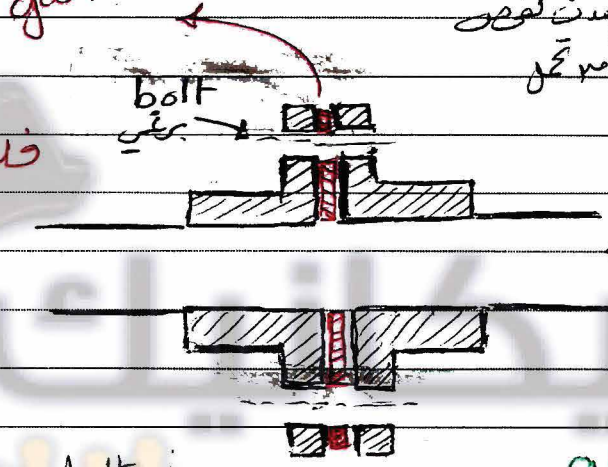
لحيم welding طرق تثبيت

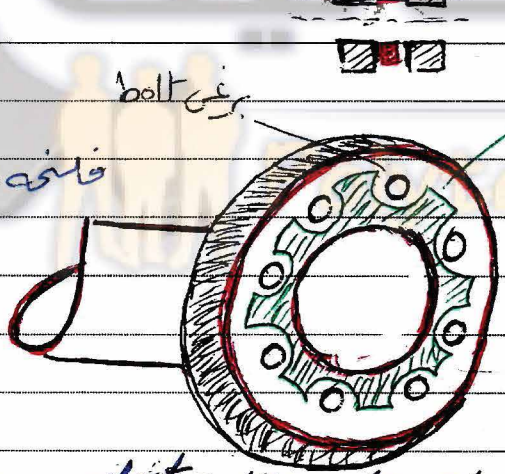


Hydrostatic test

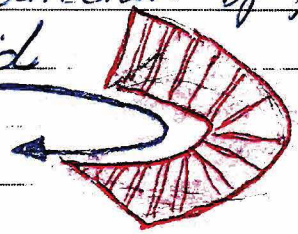
LPG

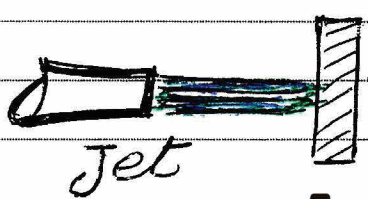


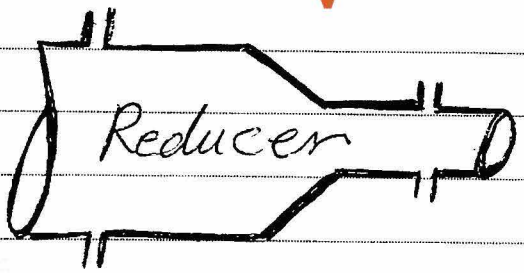


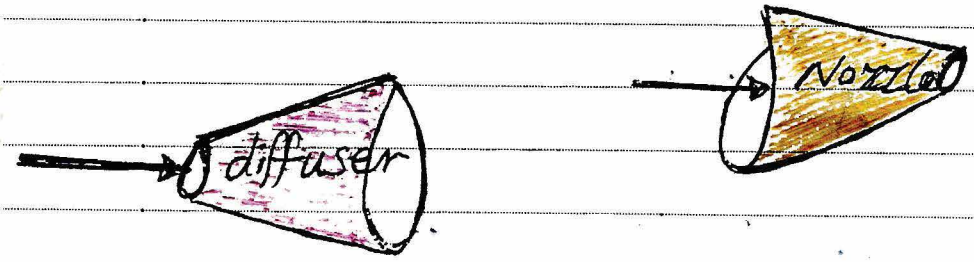


Vane) thin plate use to change direction of flow or extract energy from a fluid

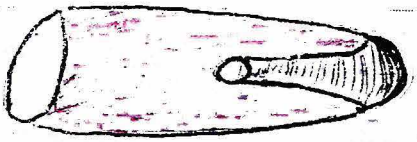






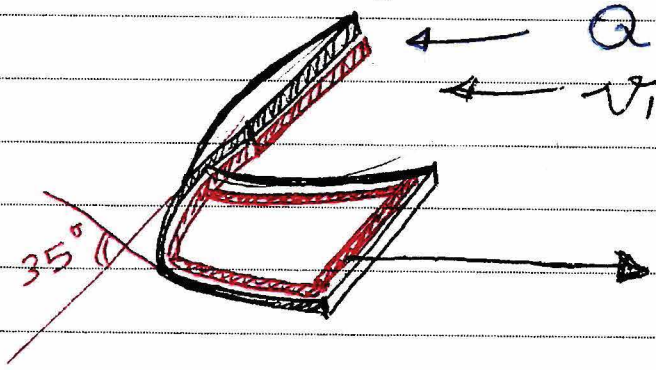


Top view



Front view

Ex :- determine the Components of the Force required to maintain the vane stationary



$Q = 0.18\ m^3/s$

$V_1 = 20\ m/s$

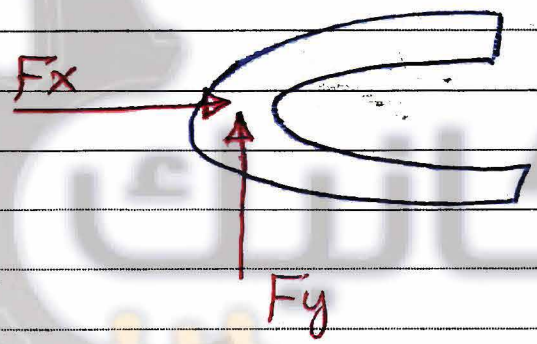
$V_2 = 18\ m/s^2$

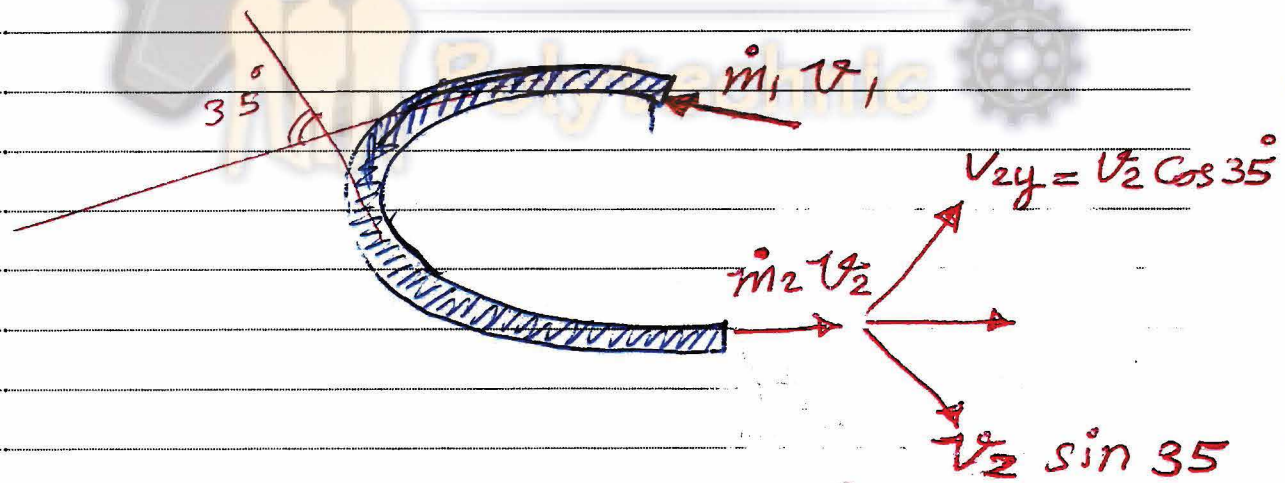
$$\Sigma F = \frac{d}{dt}\int_{C.V} \rho \vec{v}\, d\forall + \Sigma \dot{m}_{out} v_{out} - \Sigma \dot{m}_{in} v_{in}$$

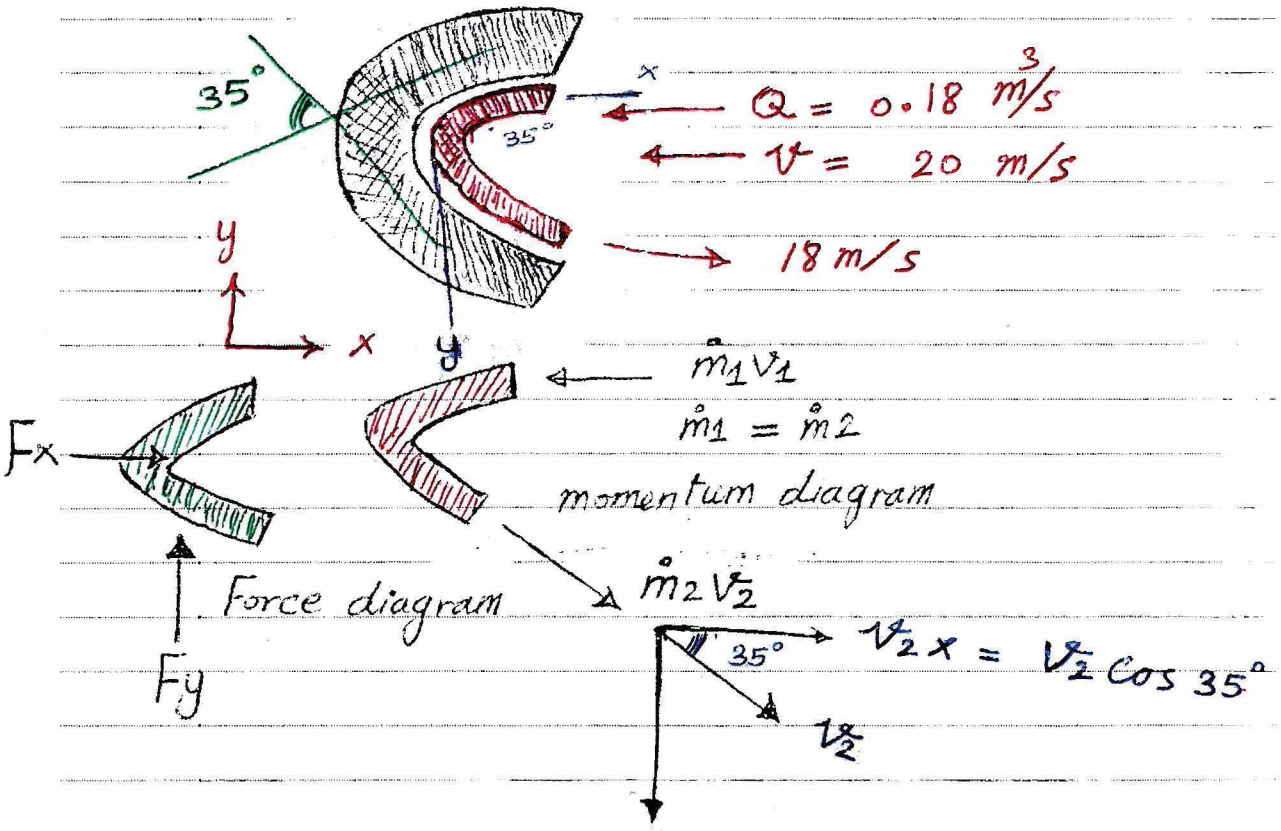
$$\Sigma F_x = \frac{d}{dt}\int_{C.V} \rho v_x\, d\forall + \Sigma \dot{m}_{out} v_{out x} + \Sigma \dot{m}_{in} v_{in x}$$

$$\Sigma F_y = \frac{d}{dt}\int_{C.V} \rho v_y\, d\forall + \Sigma \dot{m}_{out} v_{out y} - \Sigma \dot{m}_{in} v_{in y}$$

$$\Sigma F_z = \frac{d}{dt}\int_{C.V} \rho v_z\, d\forall + \Sigma \dot{m}_{out} v_{out z} - \Sigma \dot{m}_{in} v_{in z}$$







x- momentum

$$\Sigma F_x = \frac{d}{dt}\int_{C.V} \rho V_x \, dA + \Sigma \dot{m}_{out} V_{out\,x} - \Sigma \dot{m}_{in} V_{in\,x}$$

$$\dot{m} = \rho Q = \dot{m}_1 = \dot{m}_2$$

$$F_x = \dot{m}_2 V_{2x} - \dot{m}_1 V_{1x}$$

$$= \rho Q \left[V \cos 35 - (-V_1) \right]$$

$$= (1000)(0.18)\left[18 \cos 35 + 20 \right] = 6254.05 \text{ N}$$

y- momentum

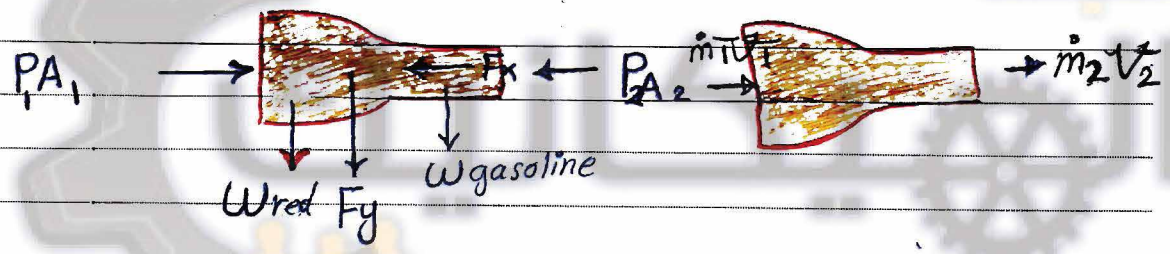
$$\Sigma F_y = \frac{d}{dt}\int_{C.V} \rho V_y \, dA + \Sigma \dot{m}_{out} V_{out\,y} - \Sigma \dot{m}_{in} V_{in\,y}$$

$$F_y = \rho Q \left[-V \sin 35 - 0 \right]$$

$$= (1000)(0.18)\left[-18 \sin 35 \right] = -1858.3 \text{ N}$$

Ex : the reducer in piping system is shown in the Figure the internal volume of the reducer is $0.2\ m^3$ and its mass is 25 kg Evaluate the total Force that must be provided by the surrounding pipe to support the reducer . the Fluid is gasoline [SG = 0.72]

P_{atm} = 98.9 KPa



Continuity Equ $\dot{m}_1 = \dot{m}_2 \Rightarrow \rho Q_1 = \rho Q_2$

$V_1A_1 = V_2A_2$

$V_1 = (12)\frac{\frac{\pi}{4}(0.2)^2}{\frac{\pi}{4}(0.4)^2} = 3\ m/s$

$Q = V_1A_1 = V_2A_2$

$= (12)(\frac{\pi}{4})(0.2)^2 = (3)(\frac{\pi}{4})(0.4)^2 = 0.377\ m^3/s$

x - momentum

$$\Sigma F_x = \frac{d}{dt}\int_{C.V}\rho V_x\,dV + \Sigma \dot{m}_{out}V_{out\,x} - \Sigma \dot{m}_{in}V_{in\,x}$$

$$P_1A_1 - F_x - P_2A_2 = \dot{m}_2V_2 - \dot{m}_1V_1 = \rho Q[V_2 - V_1]$$

$$F_x = 58.7 * 10^3(\tfrac{\pi}{4})(0.4)^2 - (109 - 98.9) * 10^3 * * (\tfrac{\pi}{4})(0.2)^2 - (0.72) * (1000) * (0.377)(0.3)$$

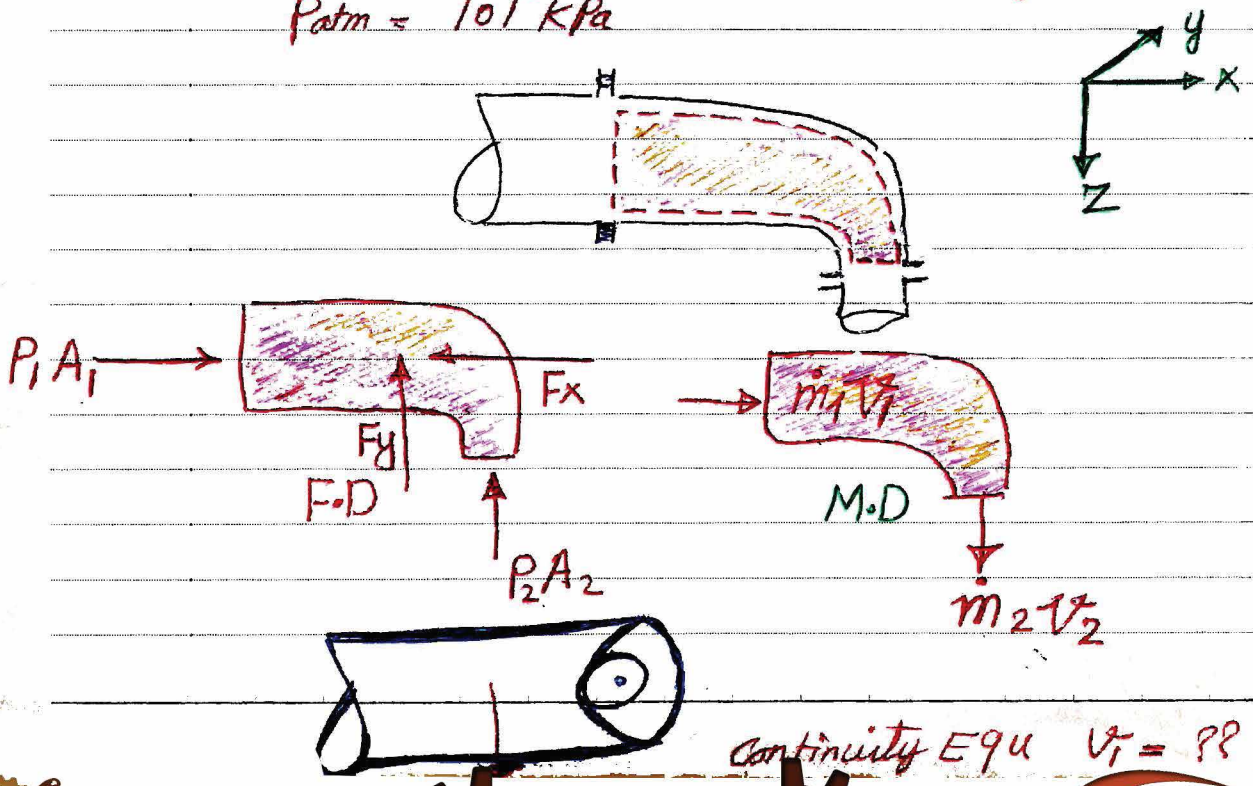
y - momentum

$$\Sigma F = \frac{d}{dt}\int_{CV} \rho v_y \, d\forall + \Sigma \dot{m}_{out} V_{out\,y} - \Sigma \dot{m}_{in} V_{in\,y}$$

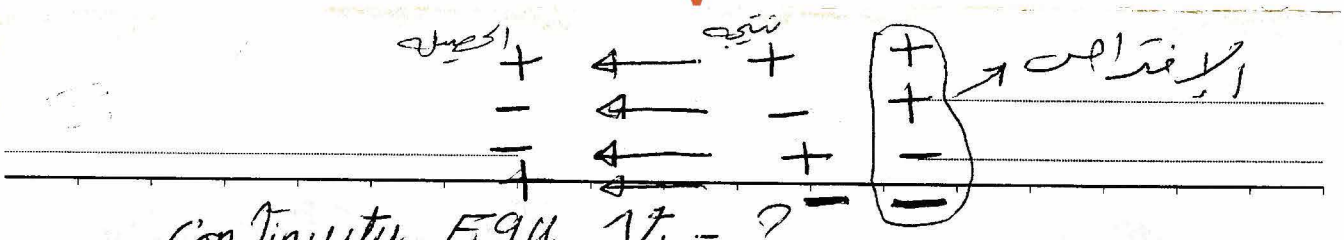
$$F_y - W_{gasoline} - W_{reducer} = 0.0$$

$$F_y = (0.2)(0.72)(9810) + 25(9.81)$$

Example 3: Water flows steadily through 90° reducing Elbow as shown in the figure at the inlet to the Elbow the pressure is 221 KPa absolute and the cross sectional area is 0.01 m^2. at the Exit of the Elbow the velocity is equal to 16 m/s and the cross sectional area is 0.0025 m^2. if the reducing Elbow lies in the horizontal x-y plane Determine the Force required to keep the Elbow in place [Volume of reducer = 0.1 m^3
mass of reducer = 7 Kg
P_{atm} = 101 KPa



Continuity Equ V_1 = ??



Continuity Equ $V_1 = ?$

$$V_1 A_1 = V_2 A_2 \longrightarrow V_1 = \frac{16(0.0025)}{0.01} = 4\ m/s$$

bernoulli Equ between 1 & 2

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

$$\frac{(221 - 101) * 10^3}{9810} + \frac{4^2}{19.62} = \frac{P_2}{9810} + \frac{16^2}{19.62}$$

$P_2 = 0$ (discharge to atmosphere)

X - momentum

لأن الجريان مستقر

$$\Sigma F_x = \frac{d}{dt}\int_{C.V} \rho V_x \, dV + \Sigma \dot{m}_{out} V_{out x} - \Sigma \dot{m}_{in} V_{in x}$$

$$P_1 A_1 - F_x = -\rho Q V_1$$

$$F_x = P_1 A_1 + \rho Q V_1 =$$

$$= (221 - 101) * 10^3 * (0.01) +$$

$$+ 1000 * (16)(0.0025)(4)$$

$$\Sigma F_y = \frac{d}{dt}\int_{CV} \rho v_y \, d\forall + \Sigma \dot{m}_{out} v_{out_y} - \Sigma \dot{m}_{in} v_{in_y}$$

للسرعة ×

لكل السرعة باتجاه السالب

$$F_y = \rho Q [-v_2]$$

$$= 1000\,(16)\,(0.0025)\,(-16)$$

$$\Sigma F_z = \frac{d}{dt}\int_{CV} \rho v_z \, d\forall + \Sigma \dot{m}_{out} v_{out_z} - \Sigma \dot{m}_{in} v_{in_z}$$

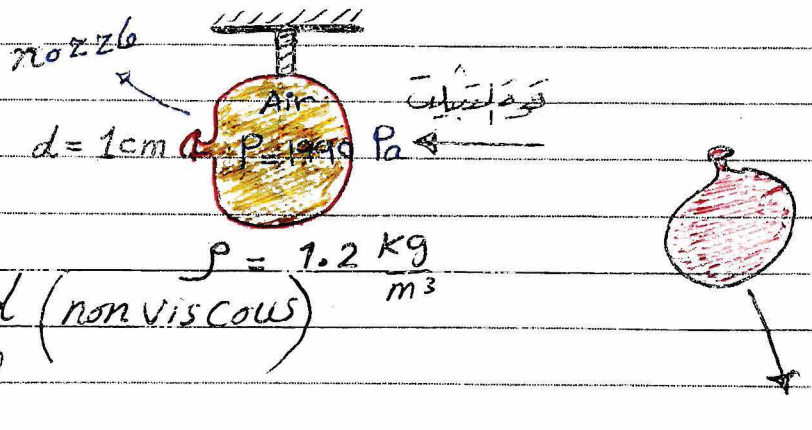
0 0

$$F_z - W_{H_2O} - W_{Bend} = 0.0$$

$$F_z = (0.1)(9810) + (7)(9.81)$$

$$F = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$$

6.6



$\rho = 1.2 \frac{kg}{m^3}$

- Flow inviscid (non viscous)
- irrotational

① $V_{Exit} = ?$

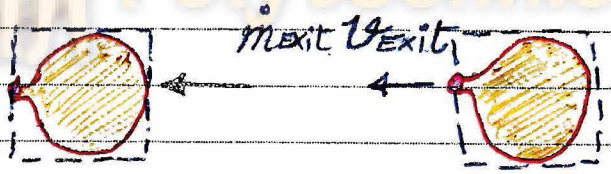
② $F_r = ?$

Bernoulli Eqn between inside of ballon and Exit

inside

$$\frac{P_{air}}{\gamma} + \frac{V_{in}^2}{2g} + z_{in} = \frac{P_{exit}}{\gamma} + \frac{V_{exit}^2}{2g} + z_{exit}$$

$$V_{Exit} = \sqrt{\frac{2P_{air}}{\rho}} = \sqrt{\frac{(2)(1990)}{1.2}} = 57.59 \frac{m}{s}$$



x - momentum steady state condition

$$\Sigma F_x = \Sigma \dot{m}_{out} V_{out\,x} - \Sigma \dot{m}_{in} V_{in\,x}$$

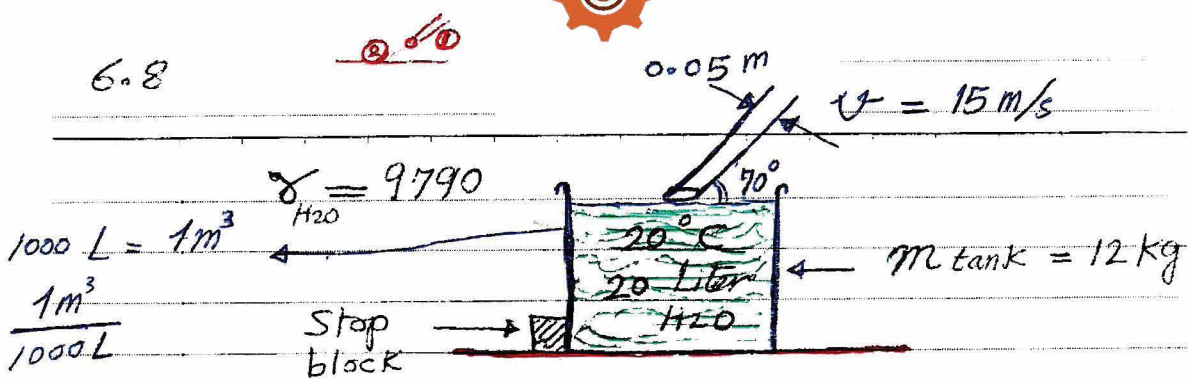
$\dot{m} = \rho A V$

$$+F_x = \dot{m}(+V_{out})$$

$$= \rho A V_{Exit}^2 = (1.2)\left(\frac{\pi}{4}\right)(0.01)^2(57.59)^2$$

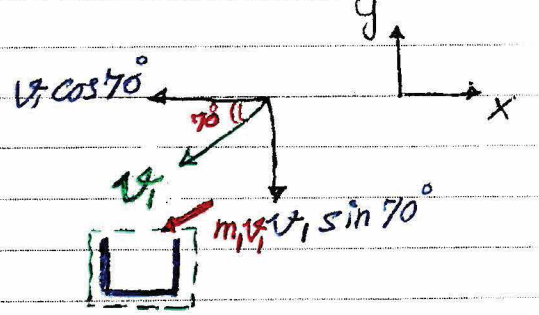
$$= 0.3126\ N$$

6.8



Find the minumum coefficient of Friction such that the Force acting on the stop block is Equal to zero

$\eta_s = ??$



$\vec{F_r} = \eta_s N$

F.D

V_2 لما صعب أو ماقدرش نحدد

$$\Sigma F_x = \frac{d}{dt}\int_{CV} \rho v_x dV + \Sigma \dot{m}_{out} v_{out\,x} - \Sigma \dot{m}_{in} v_{in\,x}$$

$$\eta N = -\dot{m} v_x$$

$$= -\rho A v_1 [-v_1 \cos 70]$$

$$= \rho A v^2 \cos 70 = \left(\frac{9790}{9.81}\right)\left(\frac{\pi}{4}(0.05)^2\right)(15)^2 \cos 70$$

$$= 150.8\ N$$

$$\Sigma F_y = \frac{d}{dt}\int_{CV} \rho v_y V + \Sigma \dot{m}_{out} v_{out\,y} - \Sigma \dot{m}_{in} v_{in\,y}$$

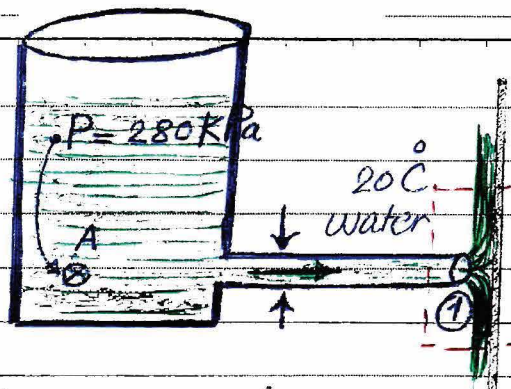
$$N - (W_{H2O} + W_{tank}) = +\rho A v^2 \sin 70$$

$$N = (0.02 * 9790) + (12 * 9.81) + 998 * \frac{\pi}{4}(0.05)^2 * 4 * (15)^2 \sin 70°$$

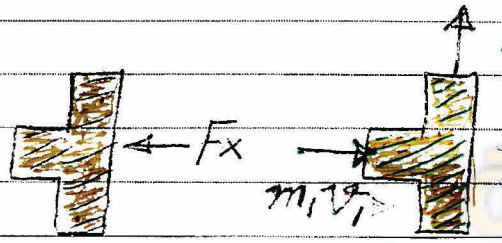
$$N = 727.82$$

$$\eta = \frac{150.8}{N} = \frac{150.8}{727.82} = 0.2072$$

6.11



What is the diameter of jet just downstream of the orifice



Bernoulli Equ between A & (1)

Continuity Equ — same level

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1$$

$$V_1 = \sqrt{\frac{2P}{\rho}} = \sqrt{\frac{(2)(280)*10^3}{998}} = 23.68 \ m/s$$

x - momentum $\sum F_x = \frac{d}{dt}\int_{C.V} \rho v_x \forall + \sum \dot{m}_{out} V_{out\,x} - \sum \dot{m}_{in} V_{in\,x}$

$\sum F_x = \sum \dot{m}_{out} V_{out\,x} - \sum \dot{m}_{in} V_{in\,x}$

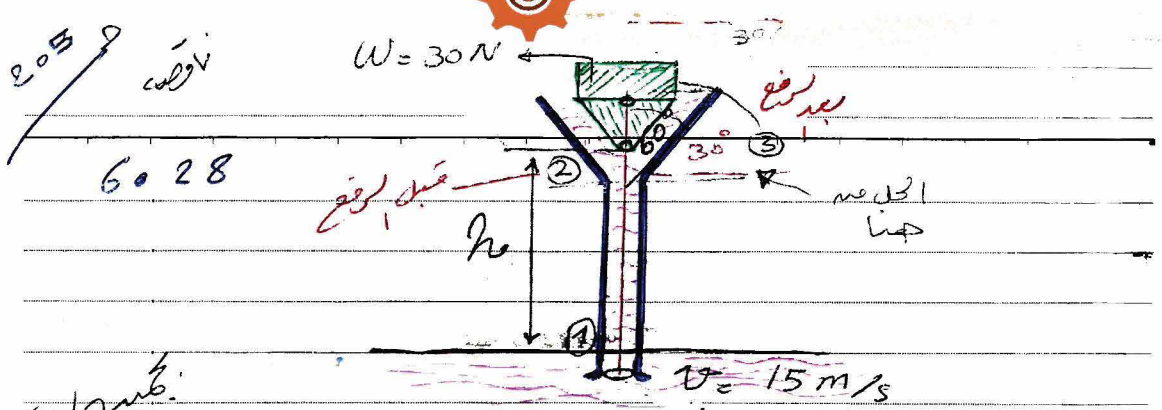
$+3000 = +\dot{m} V_1$

F_y = Fraction

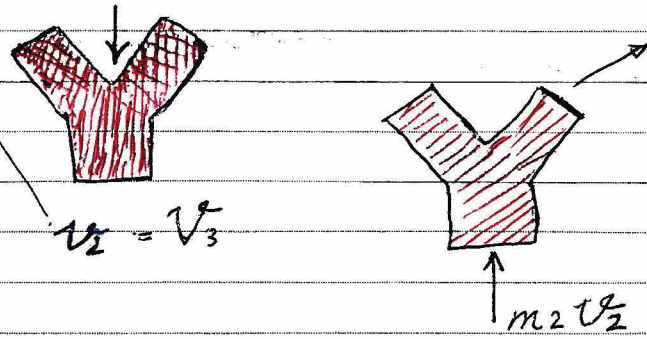
$3000 = (998) A (V_2)^2$

$$A = \frac{3000}{998 * (23.68)^2} = 5.361 * 10^{-3}$$

$$d = \sqrt{\frac{(4) * 5.361 * 10^{-3}}{\pi}} = 0.0826 \ m$$



d = 2 cm



$$\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + z_2$$

$$v_2^2 = v_1^2 + (z_1 - z_2)\,2g$$

$$\sum F_y = \sum \dot{m}_{out} v_{out\,y} - \sum \dot{m}_{in} v_{in\,y}$$

$$-30 = m_3 v_3 \sin 30 - m_2 v_2 \cos 60$$

$$v_2 = 12.72 \text{ m/s}$$

$$h = 3.71 \text{ m}$$

$$Q = v_1 A_1$$

$$1000 * (15)\left(\tfrac{\pi}{4}\right)(0.02)^2 = 4.7124 \text{ Kg}$$

$$\dot{m} = \rho Q$$

$$-30 = 4.712\,(v_3 \cos 60 - v_2)$$

$$\frac{-30}{4.712} = v_3 \cos 60 - v_2$$

$$\frac{-30}{4.712} = v_2\,(\cos 60 - 1)$$

$$z_1 - z_2 = \frac{v_2^2 - v_1^2}{2g}$$

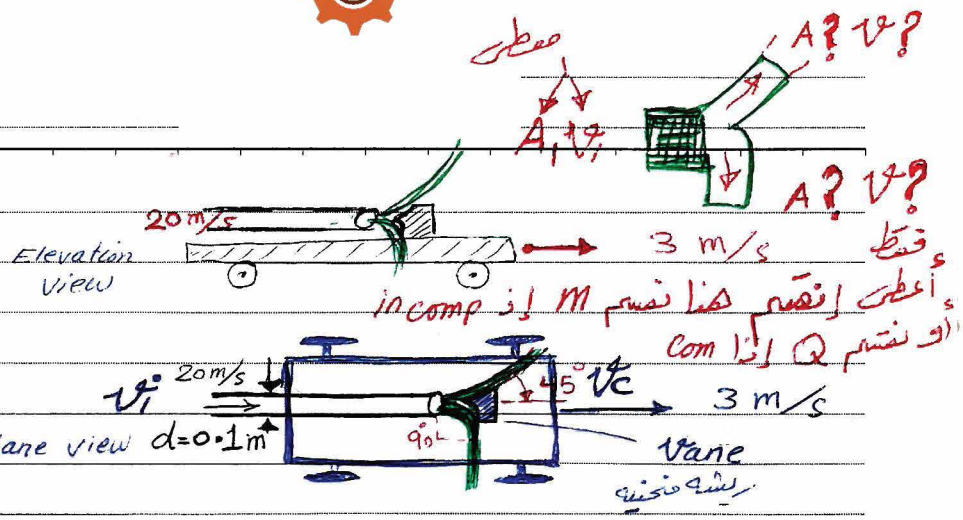
$$h = (z_2 - z_1) = \frac{v_1^2 - v_2^2}{2g}$$

$$v_2 = \frac{-30}{(4.712)(\cos 60 - 1)}$$

$$v_2 = 12.73$$

$$h = \frac{(15)^2 - (12.73)^2}{2 * 9.81} = 3.208 \text{ m}$$

6.30

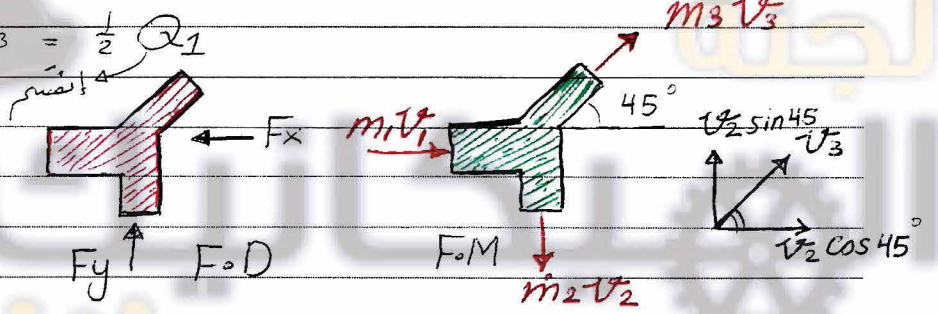


أعطى إنقسم هنا نقسم M إذا incomp
أو نقسم Q إذا com

$$V_r \text{ relative} = V_i - V_c = 20 - 3 = 17 \text{ m/s}$$

$$Q_r = A V_r = \left(\frac{\pi}{4}\right)(0.1)^2(17) = 0.133 \frac{m^3}{s}$$

$Q_2 = Q_3 = \frac{1}{2} Q_1$ إنقسم



x momentum :-

$$\Sigma F_x = \frac{d}{dt}\int_{CV} \rho V_x \, dV + \Sigma \dot{m}_{out} V_{out\,x} - \Sigma \dot{m}_{in} V_{in\,x}$$

(y) لجهة ←

$$-F_x = \dot{m} V_{3r} \cos 45^\circ + \dot{m}_2 V_2 \cos 90^\circ - \dot{m}_1 V_{1r}$$

$$= \frac{1}{2}(1000)(0.133) * 17 \cos 45 + 0 - (1000)(0.133) * (17) = -1461.61$$

y momentum :-

$$-F_x = -1461.62 \text{ N} \quad F_x = 1.461 \text{ KN}$$

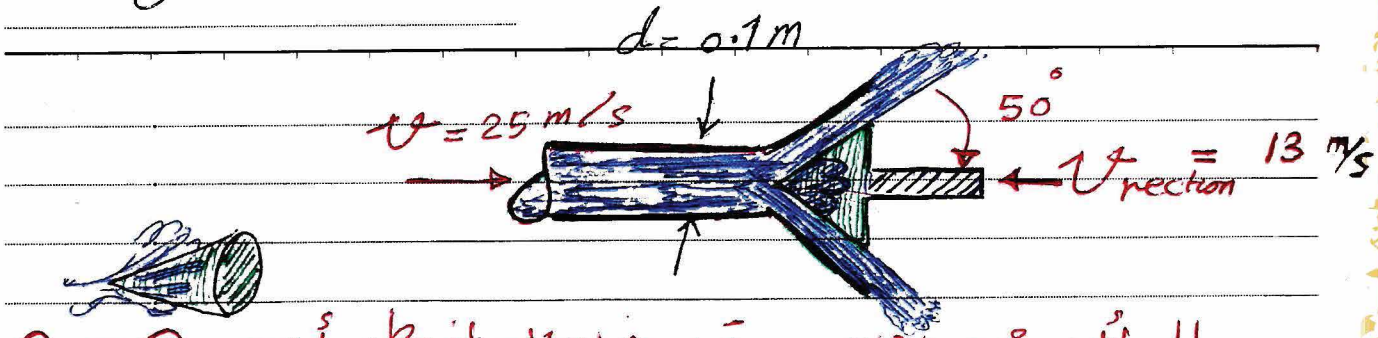
$$\Sigma F_y = \Sigma \dot{m}_{out} V_{out\,y} - \Sigma \dot{m}_{in} V_{in\,y}$$

(x) على

$$F_y = \dot{m}_3 \left[V_3 \sin 45\right] + \dot{m}_2 \left[-V_2\right] - 0$$

$$F_y = \left(\frac{1}{2}\right)(1000)(0.133)\left(17 \sin 45\right) - \left(\frac{1}{2}\right)(1000)(0.133) * 17 = -331.115 \text{ N}$$

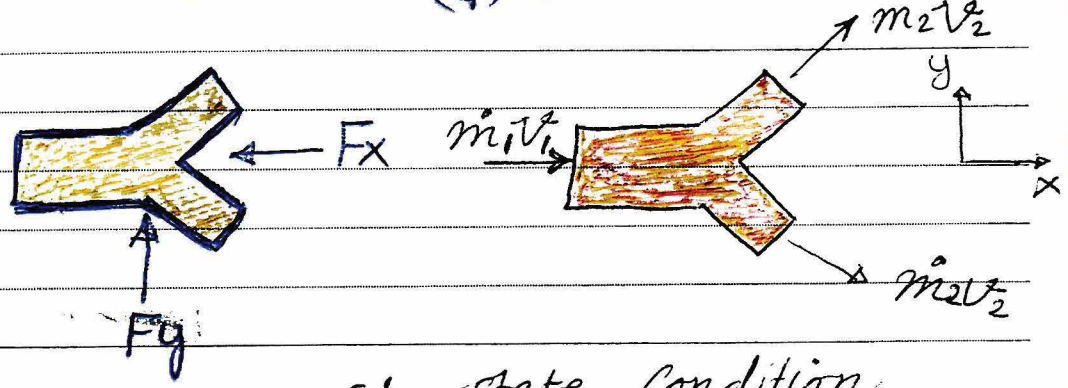
6.32



$Q_{before} = Q_{after}$ أي السائل قبل التلامس = بعد خروجه من المخروط

$$V_r = 25 + 13 = 38 \text{ m/s}$$

$$Q_r = A V_r = \left(\frac{\pi}{4}\right)(0.1)^2(38) = 0.298 \frac{m^3}{s^2}$$



x - momentum of state condition

$$\Sigma F_x = \Sigma \dot{m}_{out} V_{out} x - \Sigma \dot{m}_{in} V_{in} x$$

$$+F_x = \rho Q [V_{2r} \cos 50^\circ] - \rho Q [V_{1r}]$$

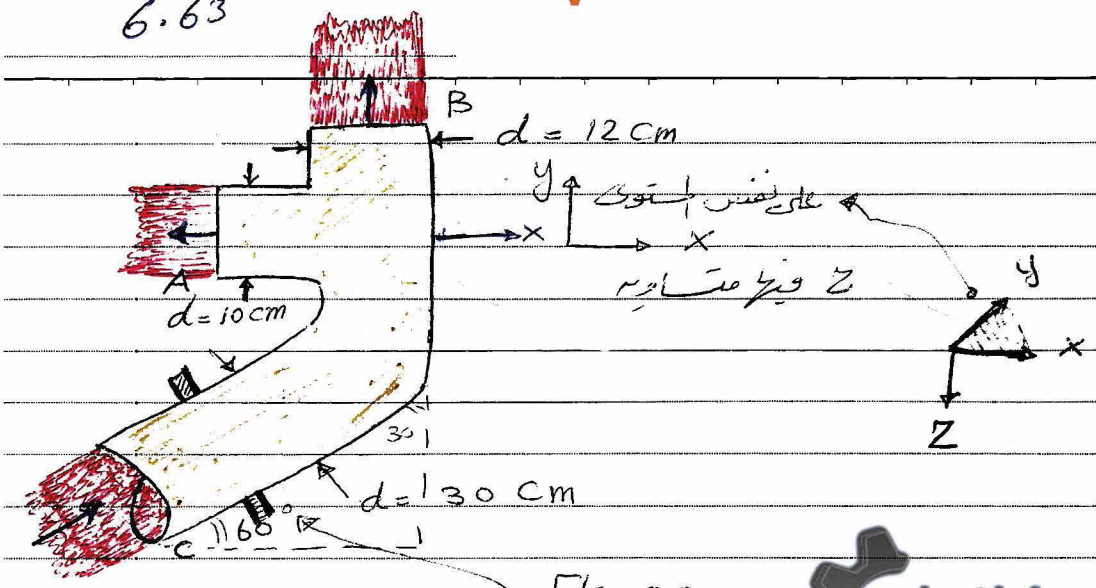
$$= (1000)(0.298)(38 \cos 50) - [1000 * 0.298 * 38] = +4045 \text{ N}$$

(+) اتجاه موجب

(-) اتجاه عكس

$$F_x = -4.045 \text{ KN}$$

6.63



$$v_A = v_B$$

$$Q_A = Q_B = Q_C = 0.5 \ m^3/s$$

$$v_C = \frac{Q_C}{A_C} = \frac{0.5}{\frac{\pi}{4}(0.3)^2} \Leftrightarrow v_C = 7.08 \ m/s$$

$$Q_A + Q_B = v_A\left[\frac{\pi}{4}(0.1)^2 + \frac{\pi}{4}(0.12)^2\right] = 0.5$$

$$v_A = \frac{0.5}{\left(\frac{\pi}{4}\right)(0.1)^2 + \left(\frac{\pi}{4}\right)(0.12)} = 26.1 \ m/s$$

in Eq of bernoulli

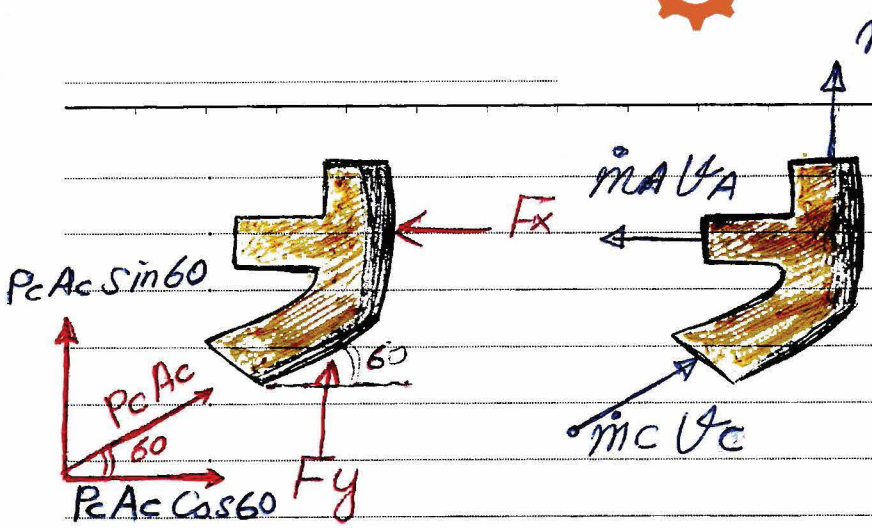
$$\frac{P_C}{\gamma} + \frac{v_C^2}{2g} + z_C = \frac{P_B}{\gamma} + \frac{v_B^2}{2g} + z_B =$$

$$\frac{P_A}{\gamma} + \frac{v_A^2}{2g} + z_A$$

$$P_C = \frac{1}{2}\rho\left[v_A^2 - v_C^2\right]$$

$$= \frac{1}{2}(1000)\left[(26.1)^2 - (7.08)^2\right] =$$

$$= 315541.8 \ Pa$$



x momentume

$$\Sigma F_x = \Sigma \dot{m}_{out} V_{outx} - \Sigma \dot{m}_{in} V_{inx}$$

$$-F_x + P_c A_c \cos 60 = \dot{m}_A [-V_A] - \dot{m}_c V_c \cos 60$$

$$\Sigma F_y = \Sigma \dot{m}_{out} V_{outy} - \Sigma \dot{m}_{in} V_{iny}$$

$$F_y + P_c A_c \sin 60 = \dot{m}_B V_B - \dot{m}_c V_c \sin 60$$

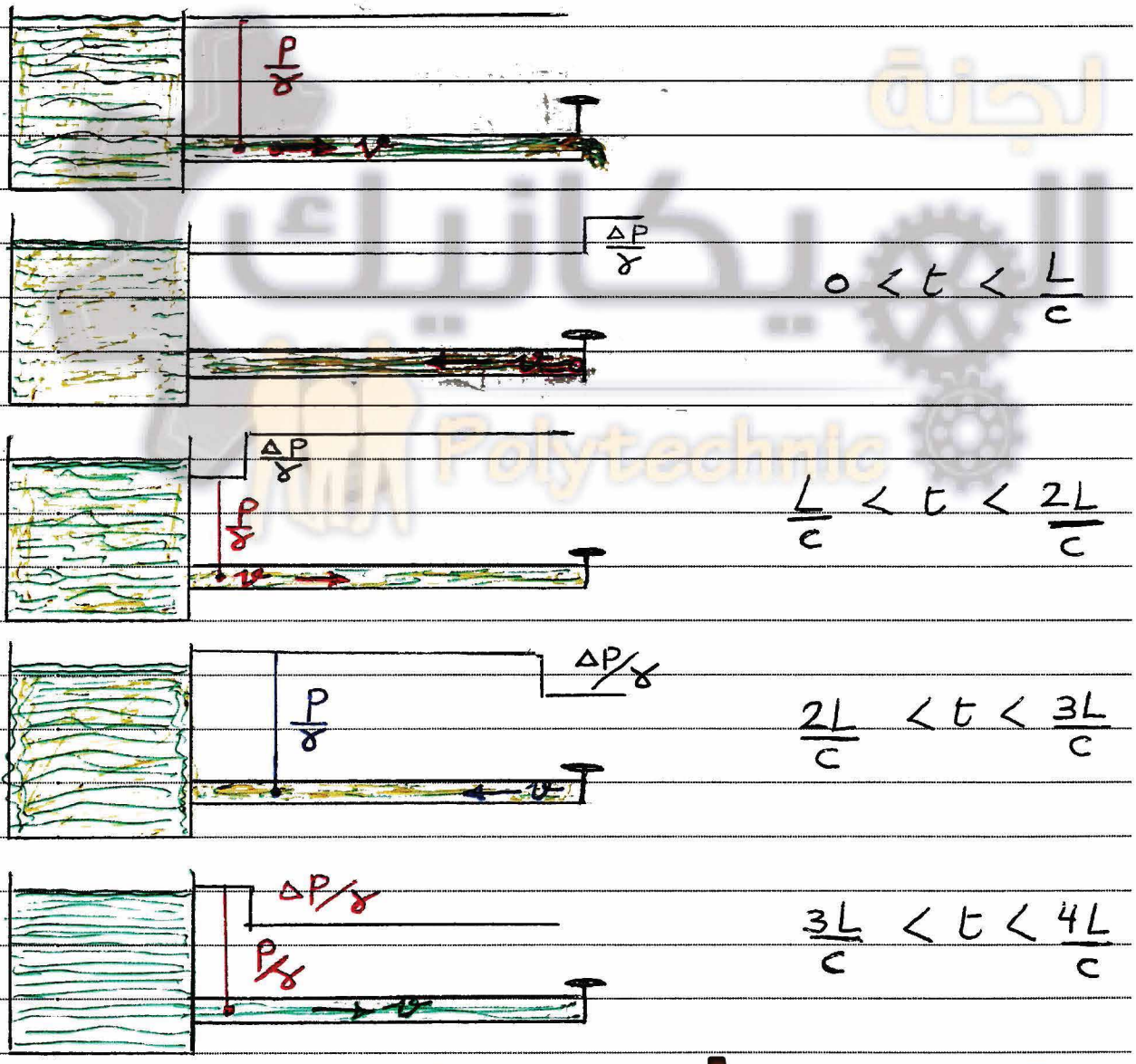
Waler hammer :- Define as rise in pressure assoiated with sudden closing of a valve at the End of pipe line and it depends on

(الضغط مصاحب بإغلاق مفاجئ)

1) density of Flowing Fluid (ρ) (للعلم عند زيادة كثافة السائل يزيد ويعتمد على كثافة السائل)

2) its velocity (v) (سرعة معامل الضغط)

3) Bulk modulus E_v = 2.2 GPa



Time one Cycle $= \frac{4L}{c}$

$t_{critical} = \frac{2L}{c}$ ← length of the pipe

← speed of sound Wave

$t_{closing} > t_{critical}$

no water hammer

$t_{closing} < t_{critical}$

water hammer will happen

$\Delta p_{\text{pressure rise}}$ = pressure rise associated with water hammer

$$\Delta p = \rho v c$$

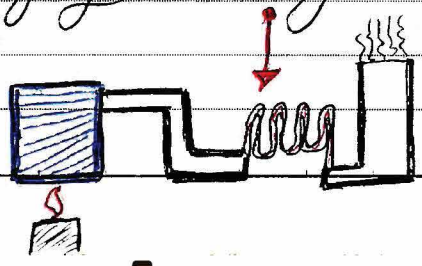
$$c = \sqrt{\frac{E \cdot v}{\rho}}$$

☆ to void water hammer

1- prevent Fast closing of the valve

2- Use air accummulators

3- safty Relief valve



Ex :- the valve @ the End of gasoline pipe line is rapidly closed .
if the inatial velocity of gasoline is 11 m/s and pressure due to water hammer is 8.45 MPa
determine E.v gasoline

$$\Delta P = \rho v c$$

$$c = \frac{\Delta P}{\rho v} = \frac{8.45 * 10^{6}}{(0.68)(1000)(11)} = 1129.67 \ m/s$$

$$C = \sqrt{\frac{E \cdot v}{\rho}} \qquad C = 1196.5$$

$$Ev = \rho C^{2} = 973.5 \ MPa$$

6.95

$L = 4\ Km$ $\quad d = 12cm = 0.12\ m$

$\rho = 1000$ $\quad Q = 0.03\ m^3/s$

$t_{closing} = 3\ S$ $\quad F_{max}$

$$t_{cr} = \frac{2L}{c} = \frac{2L}{\sqrt{\frac{E_v}{\rho}}} = \frac{2 * 4000}{\sqrt{\frac{2.2 * 10^9}{1000}}}$$

$= 5.39\ S$

$t_{cr} > t_{closing}$ there is Water Hammer

$$c = \sqrt{\frac{2.2 * 10^9}{1000}} = 1483.2\ m/s$$

$\Delta P = \rho V c$ ← 0.03

$$\Delta P = 1000 * \frac{Q}{A} * 1483.2$$

$A = \frac{\pi}{4}(12)^2$

$\Delta P = 3.936\ MPa$

$$F = \Delta P A = 3.936 * 10^6 * \left(\frac{\pi}{4}\right)(0.12)^2$$

$F = 44496\ N \rightarrow 44.5\ KN$

6.93

$d = 20\ cm \rightarrow 0.2\ m$

$Q = 0.15\ m^3/s$

$T = 10\ ^\circ C$

$t = 3\ S$

$L = ??$

$$t = \frac{4L}{c} \qquad c = \sqrt{\frac{2.2 * 10^9}{1000}} = 1483.2$$

$$L = \frac{tc}{4} = \frac{3 * 1483.2}{4} = 1112\ m$$

$$\Delta P = \rho v c = 1000 * \frac{Q}{A} * 1483.2 \qquad Q = 0.15,\ A = \left(\frac{\pi}{4}\right)(0.2)^2$$

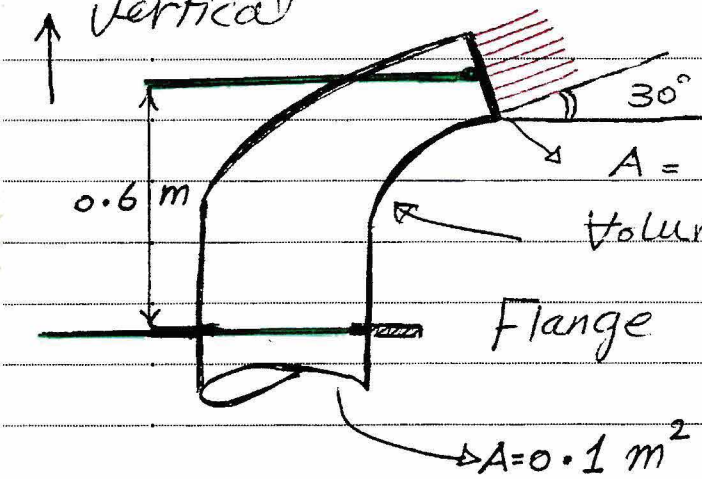
$\Delta P = 7081758.35\ Pa$

$= 7.08\ MPa$

0789434018 Mech.MuslimEngineer.Net
MechFet FB.com/Groups/Mid.Group

6.46

وكذلك 6.43
و 6.40 مثل



$H_2O = 9810 \frac{N}{m^3}$

$W_{nozzle} = 450\ N$

Ch 7 (1)

Energy Equation

$W = F \cdot dx$ **work** — **heat**

[Energy N.m Jole]

work → **Shaft** work associated with Shaft → Rotating Shaft

Flow work مصاحب بالشغل لعمل associated with pressure distribution

$W = F \Delta x$

$\Delta W = PA V \Delta t$

$w = \lim_{\Delta t \to 0} \frac{\Delta W}{\Delta t} = PAV$

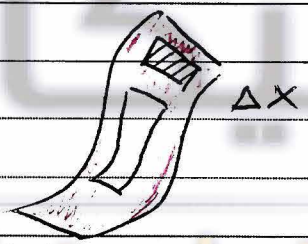
heat → Conduction توصيل بالحرارة — Convection نقل (الحمل الحراري) — Radiation بالإشعاع

$W_{sh} = T \cdot w$

$= N \cdot m \frac{1}{s}$

$= Watt$

Rate of producing work



Energy : E : Extensive property

e : Specific Energy $\frac{E}{m}$

$e_k = K.E$ For whole system

$e_p = P.E$ For whole system

$$Ue \begin{cases} Ke & molecules \\ Pe & molecules \\ atomic\ struct \\ chemical \\ electrical \end{cases}$$

$$E = K.E + P.E + U$$

$$E = \frac{1}{2} m V^2 + mgz + U$$

$$e = \frac{1}{2} V^2 + gz + u$$

* Reynolds Transport theorm :-

$$\frac{dB}{dt}\Big|_{sy} = \frac{d}{dt}\int_{CV} \rho \beta \, dV + \int_{C.S} \rho \beta \vec{V} \cdot d\vec{A}$$

$$\int_{C.S} \rho \beta \vec{V} \cdot d\vec{A} \rightarrow \sum \rho \beta \vec{V} \cdot A$$

B : Extensive property — $\forall$

β : intensive property — β U_u

Ch 4 Ch 5 (1) $B = m$ $\beta = 1$

Continuity Equ

Ch 6 (2) $B = m\vec{V}$ $\sum F = ma = \frac{d}{dt}\int_{CV} \rho v \, dV + \int_{C.S} \rho v \vec{V}_{rel}$

$\sum$ Mom out $-$ $\sum$ Mom in

(3) $B = E \qquad \beta = e = \frac{1}{2}v^2 + gz + u$

$$\frac{dE}{dt}\Big|_{sy} = \frac{d}{dt}\int_{C.V} \rho\left[\frac{1}{2}v^2 + gz + u\right] dV + \int_{C.S} \rho\left[\frac{1}{2}v^2 + gz + u\right] \vec{v} \cdot d\vec{A}$$

First Law of Thermodynamics
Conservation of Energy

Energy neither be Created nor destroyed but Can be transformed from one from to another

$$\frac{dE}{dt}\Big|_s = \dot{Q} - \dot{W}$$

Rate

$\dot{W}_F$

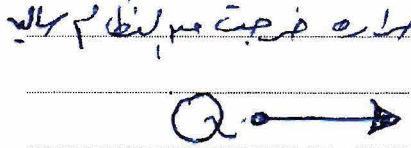
$\dot{W}_{shaft} = \dot{W}_t - \dot{W}_p$

$\dot{Q}$: net Rate of heat transfer to the same

$\dot{W}$: Net Rate of producing work

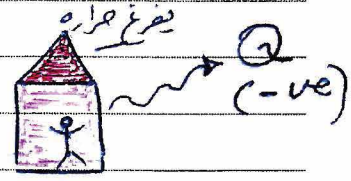
Q:- positive (+ve) if added to system
negative (-ve) if rejected or Last from the system

موجبة حراره دخلت النظام
سالبة حراره خرجت من النظام



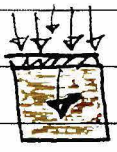
(+ve) تسخين غرفه

(-ve) برودة حالة عدد يبرد غرفه



موجبة شغل يعمله النظام
سالبة شغل يعمل على النظام

(+ve) work



(-ve) work

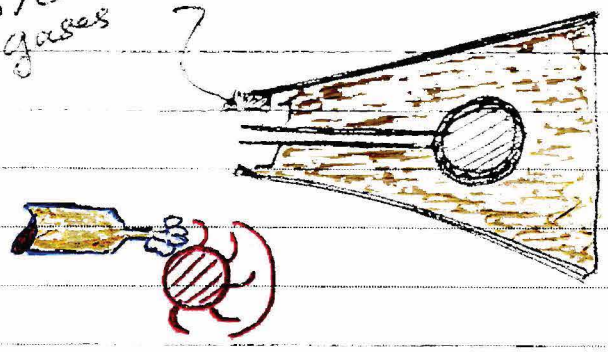
W.: — (+ve) positive if done by the system
work
(-ve) if done on the system

Turbine : Extract Energy From a Fluid
ينتزع يستقبل الطاقه من السائل

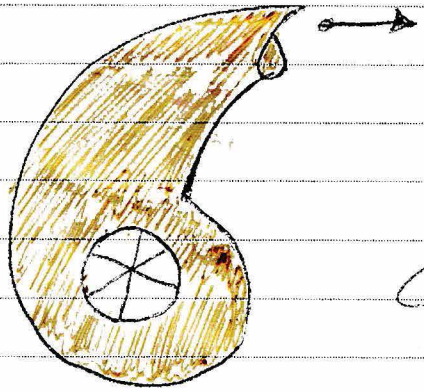
Pump يعني
Compressor → To supply energy to the Fluid
توريد الطاقه للسائل

Pump → For liquid (Cavitation)
Compressor → For gases
it gas or vapor

Steam H2O or gases



- gas turbine
- Steam turbine
- wind turbine
- pelton wheel turbine



Centrifugal
Reciprocating type
Gear pump

Ch.4 Energy Eqn

$$E = K.E + P.E + U \quad (5)$$

1st Law of thermodynamics's

$$\frac{dE}{dt} = \dot{Q} - \dot{W} \longrightarrow \text{rate of producting}$$

معدل إنتاج

$\dot{Q}$ ← Rate of transfer معدل تحويل

$$= \frac{dK.E}{dt} + \frac{dP.E}{dt} + \frac{dU}{dt}$$

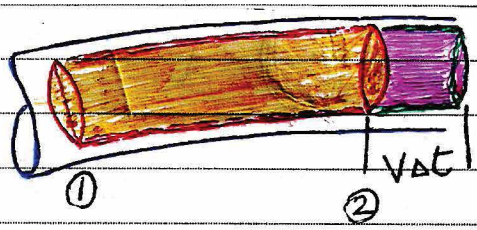
$$K.E = \frac{1}{2}mv^2 \longrightarrow K.e = \frac{1}{2}v^2$$

$$P.E = mgz \longrightarrow P.e = gz$$

$$U = \longrightarrow u = \frac{U}{m} = u$$

$\dot{W}$

- Shaft work لا تعتمد على إضغط — work assoiated with shaft
  - $\dot{W}_t$ positive +ve
  - $\dot{W}_s = \dot{W}_t - \dot{W}_P$
  - $\dot{W}_P$ = -ve
- Flow work ⟶ work associated with pressure distribution تعتمد على توزيع إضغط



$$W_f = -P_1A_1V_1$$

$$= P_1A_1V_1$$

$$W_{f_2} = F\Delta x \quad (F = PA)$$

$$= P_2A_2V\Delta t$$

$$W_{f_2} = \frac{P_2A_2V\Delta t}{\Delta t}$$

$$= P_2A_2V_2$$

$$= P_2A_2 \cdot V_2$$

$$W_{flow} = \Sigma PV \cdot A$$

$$= \Sigma \frac{P}{\rho}\rho V \cdot A$$

$$\int \frac{P}{\rho}\rho v \cdot dA$$

$$\frac{dE}{dt}\Big|_{sy} = \dot{Q} - \dot{W} = \frac{dK.E}{dt} + \frac{dP.E}{dt} + \frac{dU}{dt}$$

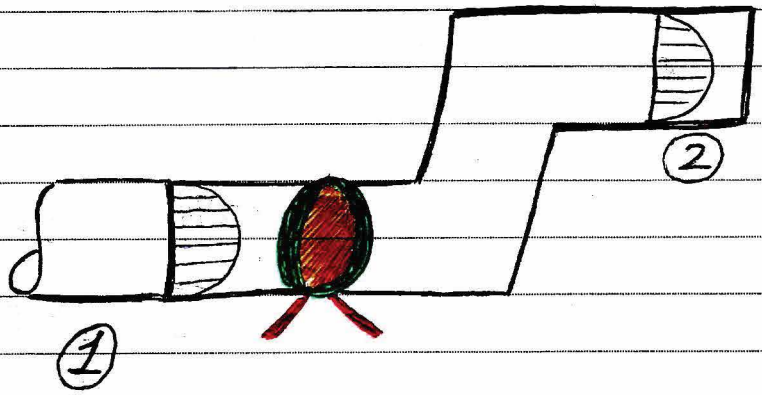
$$\frac{d}{dt}\int_{C.V} \rho\left[\frac{1}{2}v^2 + gz + u\right] dA + \int_{C.S} \rho\left[\frac{1}{2}v^2 + gz + u\right]\vec{v}\cdot d\vec{A}$$

$$\Sigma \rho\left[\frac{1}{2}v^2 + gz + u\right]\vec{v}\cdot A$$

$$\dot{Q} - (\dot{W}_{sh}) - \dot{W}_f = \dot{Q} - (\dot{W}_t + \dot{W}_p) - \dot{W}_f \quad (\dot{W}_p: \text{flow work})$$

$$= \frac{d}{dt}\int_{C.V} \rho\left[\frac{1}{2}v^2 + gz + u\right] dA + \Sigma \rho\left[\frac{1}{2}v^2 + gz + u\right] * \vec{v}\cdot\vec{A}$$

$$\dot{Q} + \dot{W}_p = \dot{W}_t + \frac{d}{dt}\int_{C.V} \rho\left[\frac{1}{2}v^2 + gz + u\right] dA + \Sigma \rho\left[\frac{1}{2}v^2 + gz + \underbrace{u + P_v}_{\text{enthalpy}}\right]\vec{v}\, dA$$



$v = \frac{1}{\rho}$ Energy Eqn :o

بسم الله

(7) head pump $\frac{P_{output}}{\gamma Q} = hp$

$$\frac{P_1}{\gamma} + \alpha_1 \frac{\vec{v}^2}{2g} + z_1 + \frac{\dot{W}p}{\dot{m}g} = \frac{P_2}{\gamma} + \alpha \frac{v_2^2}{2g} +$$

SVA ← $\frac{\dot{W}p}{\dot{m}g}$

$$+ z_2 + \frac{\dot{W}t}{\dot{m}g} + \frac{1}{g}(u_2 - u_1) - \frac{Q}{mg}$$

SVA ← $\frac{\dot{W}t}{\dot{m}g}$ ← $ht = \frac{P_{input}}{\gamma Q}$

$\frac{P}{\gamma}$ = pressure head

z = elevation head

$\frac{v^2}{2g}$ = velocity head

عامل تصحيح الطاقة الحركية

α_1, α_2 = Kinetic energy Correction factor = $\frac{\dot{W}}{W}$ = معدل الطاقة الحركية للسائل / وزن السائل

= K.E/Time for the flowing fluid

معدل الطاقة الحركية للسائل المتدفق

K.E/Time for Uniform flow

معدوم على معدل الطاقة الحركية للسائل متدفق

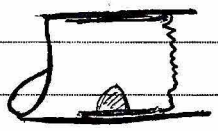
$\alpha = \frac{1}{A}\int \left(\frac{V}{\bar{V}}\right)^3 dA$ $\bar{V}$ = mean velocity, V = local velocity

$\alpha = 1$ Uniform flow

$\alpha = 2$ Laminar flow with parabolic velocity profile ← يسمى الملف المكافئ

$\frac{u}{u_o} = \left(1 - \frac{r^2}{R^2}\right)$ $\alpha = \frac{4}{3}$

For fully developed turbulent flow



$\alpha \cong 1.0$

plug tube turbulent Flow $\alpha = 1.05$

$m = hp$ = head of pump $\frac{\dot{W}p}{\dot{m}g} = \frac{\dot{W}p}{\gamma Q}$

$\frac{Fx}{t} = x \frac{F}{t}$ ← Weight

= Work/Time supplied to the flowing Fluid

weight/Time of the flowing Fluid

$$\dot{W}P = \dot{m} g h_p$$

$$\dot{W}P = \rho Q g h_p = \gamma Q h_p$$

output power

$$\eta_{pump} = \frac{\dot{W}P}{Ws}$$

- Friction
- leakage
- Viscous effect

h_t = head of turbine $\quad \frac{\dot{W}t}{mg}$ → input power

$$\dot{W}t = \dot{m} g h_t$$

$$\dot{W}t = \gamma Q h_t$$

input power

$$\eta = \frac{\dot{W}\text{out put}}{\dot{W}t}$$

① η mech Turbine كفاءة التربين

② η electr generator كفاءة المولد الكهربائي

h_L = head loss always (+ve)

$$= \frac{1}{g}(u_2 - u_1) - \frac{\dot{Q}}{mg}$$

الجزء الحراري في معادلة الطاقة

= thermal part of energy eqn

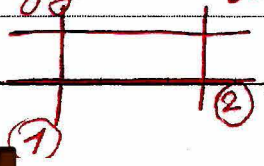
represents Transformation of Useful

تمثل تغيير الشكل أو تحويل أو نقل

mechanical work into thermal (non useful)

عمل ميكانيكي مفيد إلى حراري غير مفيد

energy dissipation



(9)

$$\frac{P_1}{\gamma} + \alpha_1 \frac{\vec{V_1}^2}{2g} + z_1 + h_p = \frac{P_2}{\gamma} + \alpha_2 \frac{\vec{V_2}^2}{2g} + z_2$$

$h_t + h_L$

reduced to bernoulli Eqn ← نواقص المعادلة

no Shaft work $h_p = h_t = 0$

no heat transfer $h_2 = 0$

fully developed flow $\alpha_1 = \alpha_2 = 1$

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2$$

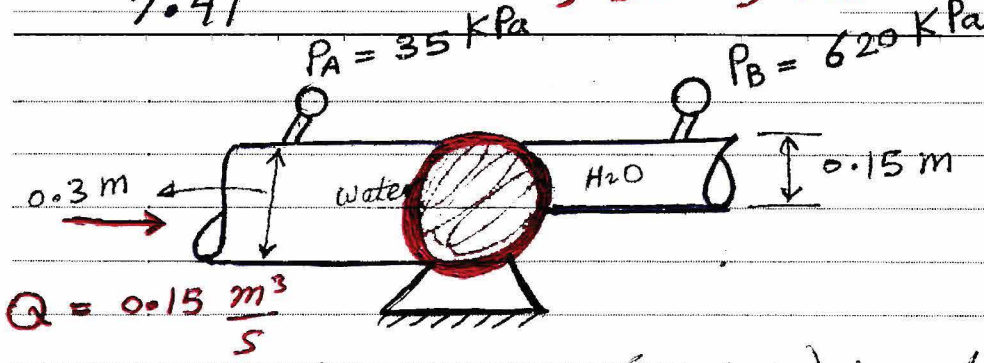
الجزء الحراري في معادله الطاقه اللي تتمثل في تحويل العمل الطاقي للسيال إلى حراري غير مفيد

(10)

$\dot{m}_A = \dot{m}_B$

$\rho Q_A = \rho Q_B \longrightarrow$ steady

7.41



What power (in kW) is delivered to the flow ?

$\alpha_A \alpha_B = 1$

$W_P = \gamma Q h_P$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + \cancel{Z_A} + h_P = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + \cancel{Z_B} + \cancel{h_t} + \cancel{h_L}$$

$$h_P = \frac{P_B - P_A}{\gamma} + \frac{V_B^2 - V_A^2}{2g}$$

$$V_A = \frac{Q}{A_A} = \frac{4Q}{\pi d^2} = \frac{(4)(0.15)}{(\pi)(0.3)^2}$$

$= 2.12$ m/s

$$V_B = \frac{(4)(0.15)}{(\pi)(0.15)^2} = 8.49 \text{ m/s}$$

$$h_P = \frac{(620 - 35) * 10^3}{9810} + \frac{(8.49)^2 - (2.12)^2}{19.62}$$

$= 63.07$ m

shift (8) (30) = hP

(11)

$$\dot{W}_P = \gamma Q h_p = (9810)(0.15)(63.07)$$

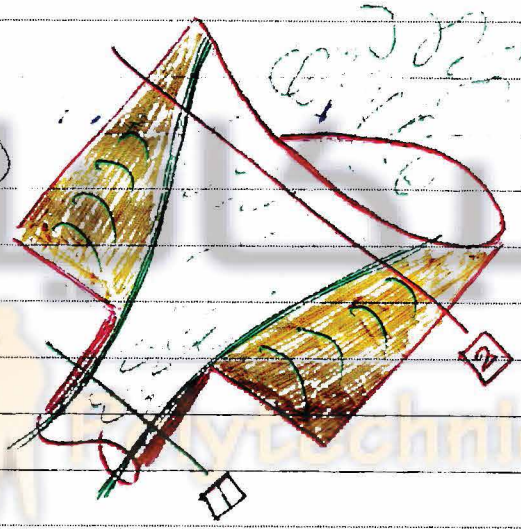
$$= 92.8 \text{ KW}$$

$\eta_P = 0,87$ det Wel

$$\eta_P = \frac{\dot{W}_P}{\dot{W}_S} \longrightarrow W_S = \frac{\dot{W}_P}{\eta} = \frac{92.8}{0.87}$$

$$= 106.7 \text{ KW}$$

h = head loss always (+ve)



توسع مفاجئ sudden expansion

a hrupt expansion

$$h_L = \frac{(V_1 - V_2)^2}{2g}$$

h_L — الفقد

عما أنها موجبة فإنه لابد أن V_1 كبير لابد أن تنقص من V_2 الصغيرة لكي يكون الناتج موجب دائماً

أو يقلل فالناتج يصبح سالباً موجب

Ch 7 Energy principle

$$\frac{P_1}{\gamma} + \alpha_1 \frac{\overline{v_1}^2}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \alpha \frac{\overline{v_2}^2}{2g} + Z_2 + h_t + h_L$$

$$\alpha = \frac{1}{A}\int \left(\frac{v}{V}\right)^3 dA$$

$$h_p = \frac{\dot{W}_P}{\dot{m}g}$$

$$\dot{W}_P = \gamma Q h_p$$

$$\eta_p = \frac{\dot{W}_P}{W_S}$$

$$h_t = \frac{\dot{W}_t}{\dot{m}g}$$

$$\dot{W}_t = \gamma Q h_t$$

$$\eta_t = \frac{\dot{W}_{out}}{\dot{W}_{turb}}$$

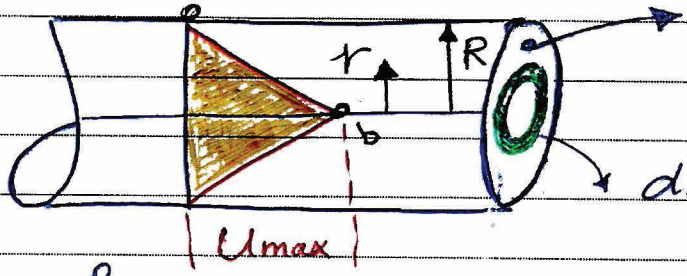
$$h_L = \frac{1}{g}(u_2 - u_1) - \frac{\dot{Q}}{\dot{m}g}$$

$\eta_{machine\ turbine}$

$\eta_{electric\ generator}$

Ex :- For the velocity distribution show in the Fig

Determine α ?



$A = \pi R^2$

$dA = 2\pi r dr$

$$\alpha = \frac{1}{A}\int_0^R \left(\frac{V}{\bar{V}}\right)^3 dA \qquad \bar{V} = \frac{Q}{A} = \frac{\int_0^R u\,dA}{A}$$

$$u = ar + b$$

u_{max} @ $r = 0$ $\longrightarrow$ $b = U_{max}$

$u = 0$ @ $r = R$ $\longrightarrow$ $a = -\frac{U_{max}}{R}$

$$u = -\frac{U_{max}\, r}{R} + U_{max}$$

$$= U_{max}\left[1 - \frac{r}{R}\right]$$

$$\bar{V} = \frac{Q}{A} = \frac{\int_0^R u\,dA}{A}$$

$$\bar{V} = \frac{\int_0^R U_{max}\left[1 - \frac{r}{R}\right] 2\pi r\,dr}{\pi R^2}$$

$$= \frac{2\pi U_{max}\left[\frac{r^2}{2} - \frac{r^3}{3R}\right]\Big|_0^R}{\pi R^2}$$

$$= \frac{2\pi U_{max}\left[\frac{R^2}{2} - \frac{R^3}{3}\right]}{\pi R^2} = U_{max}\left[\frac{2}{2} - \frac{2}{3}\right]$$

$$\alpha = \frac{1}{A}\int_0^R \left(\frac{u_{max}\left(1-\frac{r}{R}\right)}{\frac{1}{3}u_{max}}\right)^3 2\pi r\,dr$$

$$= \frac{1}{\pi R^2} * 54\pi \int_0^R \left(1-\frac{r}{R}\right)^3 r\,dr$$

$$= \frac{54}{R^2}\int_0^R \left(1-\frac{r}{R}\right)^3 r\,dr$$

$$= \frac{54}{R^2}\int_1^0 (z)^3(1-z)R * -R\,dz$$

$$= -54\int_1^0 z^3(1-z)\,dz$$

$$= -54\int_1^0 z^3 - z^4\,dz$$

$$= -54\left[\frac{z^4}{4} - \frac{z^5}{5}\right]_1^0$$

$$= -54\left[0 - \left[\frac{1}{4}-\frac{1}{5}\right]\right] = \frac{54}{20} = 2.7$$

على جنب

$$z = 1-\frac{r}{R} \qquad dz = \frac{1}{R}dr$$

$$z^3 = \left(1-\frac{r}{R}\right)^3 \qquad dr = -R\,dz$$

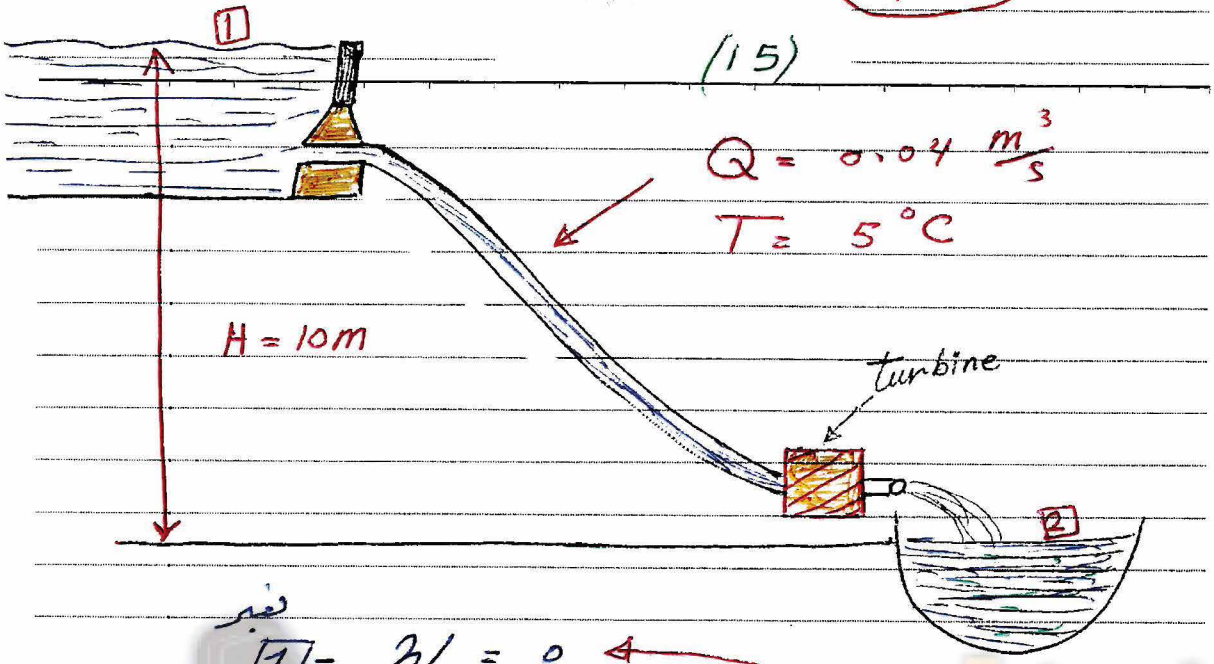
$$r = (1-z)R$$

@ $r = 0$ $\quad z = 1$

@ $r = R$ $\quad z = 0$

Ex: 7.43

7.43



نفرض

1- $h_L = 0$

2- $h_L = 5.5\ m$

$\eta_t = \eta_g = 100\%$

$\eta_t = 0.7$

$\eta_g = 0.9$

Energy Eqn

$$\frac{P_1}{\gamma}^{0} + \alpha_1 \frac{V_1^2}{2g}^{\approx 0} + Z_1 + h_p = \frac{P_2}{\gamma}^{0} + \alpha_2 \frac{V_2^2}{2g}^{\approx 0} + Z_2 + h_t + h_L$$

$h_p = 0.0$

$h_t = Z_1 - Z_2 = 10\ m$

$\dot{W}_t = \gamma Q h_t = (9810)(0.04)(10) = 3924\ W$

$\frac{100}{100} = 1$ $\quad \eta_t = \frac{\dot{W}_{out}}{\dot{W}_t}$ $\quad W_{act} = \dot{W}_t = 3.924\ KW$

η => خطأ $\quad \dot{W}_{out} = \eta_t * W_t = 3.924 * 0.7 = 2.7468\ KW$

$\%100$ $\quad \dot{W}_{out} = \frac{100}{100} * 3.924 = 3.924\ KW$

Condition Energy Eqn

$$h_t = (z_1 - z_2) - h_L$$

$$= 10 - 5.5 = 4.5\ m$$

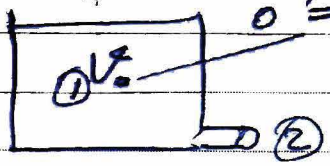
$$\dot{W}_t = \gamma Q h_t = (9810)(0.04)(4.5) = 1765.8\ W$$

$$\dot{W}_{out} = \dot{W}_t \eta_t \eta_g$$

$$= (1765.8)(0.7)(0.9) = 1112.4\ W$$

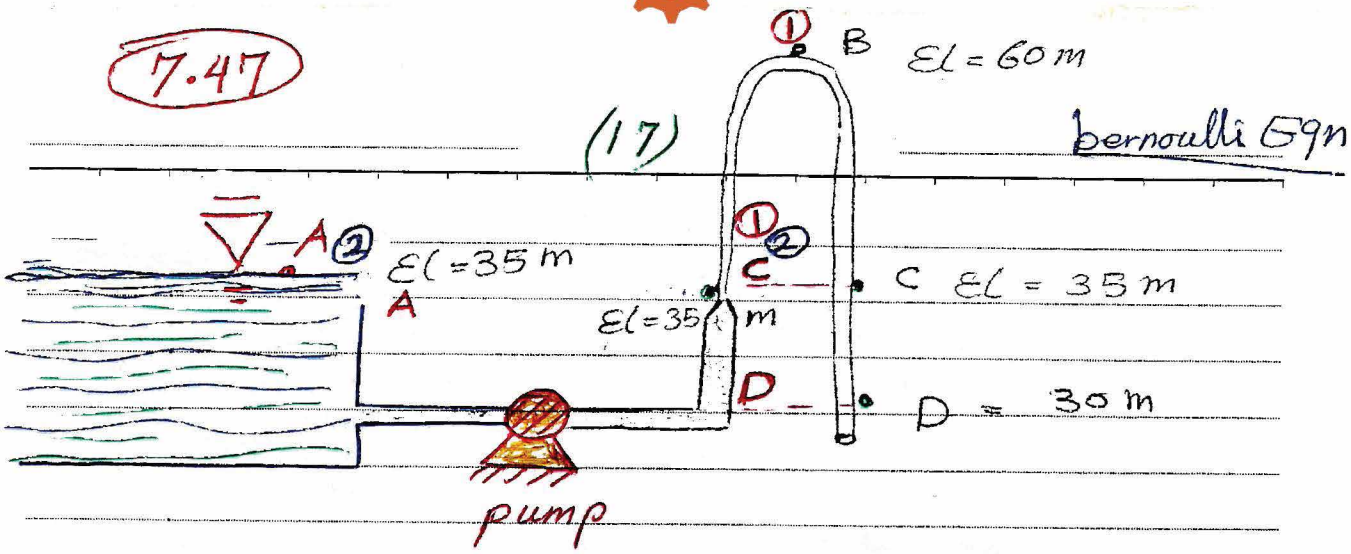
مثلاً

لو اعتبرنا أن $\eta \simeq 0$



إذا كانت $\frac{100}{100}$ لا يوجد فقد h_L وكذلك W_{out} تكون مساوية لـ W_t و إذا كانت غير ذلك فلابد أن يكون فقد h_L ينقص من ☆ الإرتفاع $(z_1 - z_2)$ واضرب W_t ثم اضرب W_{out} عند طريق $\eta_t \eta_g$

7.47



$$\dot{W}_p = \gamma Q h_p$$

From B C

$$\frac{P_C}{\gamma} + \frac{v_C^2}{2g} + z_C = \frac{P_B}{\gamma} + \frac{v_{2B}^2}{2g} + z_{2B}$$

$$v_C^2 = 2g(60 - 35)$$

$$v_1^2 = \sqrt{(19.62)(25)} = 22.147 \text{ m/s}$$

From C A

$$\frac{P_1}{\gamma} + \alpha_1 \frac{v_1^2}{2g} + z_A + h_p = \frac{P_2}{\gamma} + \alpha_2 \frac{v_2^2}{2g} + z_2 + h_t + h_L$$

$$z_A + h_p = \alpha_2 \frac{v_2^2}{2g} + z_2$$

$$h_p = 24.98 \text{ m} \leftarrow 25 \text{ m}$$

$$Q = vA = 22.14 * 90 * 10^{-4}$$

$$\dot{W}_p = \gamma Q h_p$$

$$WP = 48.836 \text{ KW}$$

Energy principle

$$\frac{P_1}{\gamma} + \alpha_1 \frac{\bar{v}_1^2}{2g} + z_1 + ph = \frac{P_1}{\gamma} + \alpha_1 \frac{v^2}{2g} + z_2 + ht + hL$$

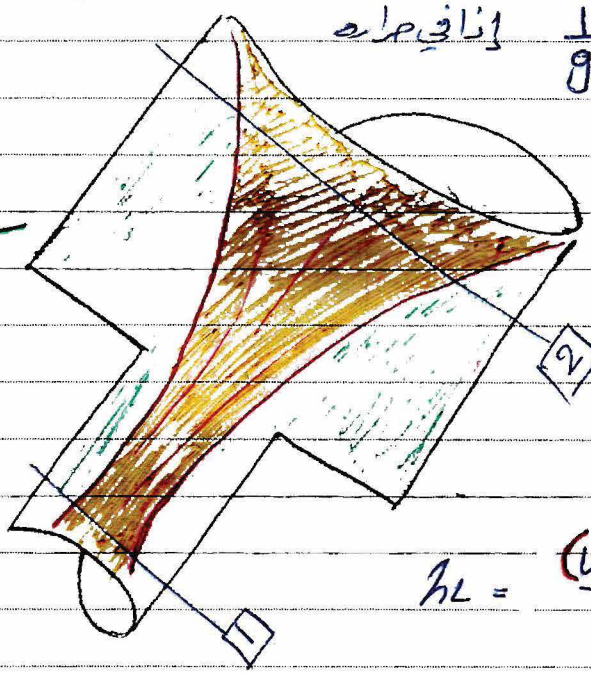
$\alpha_1 \frac{\bar{v}_1^2}{2g}$ ← $\frac{1}{A}\int \left(\frac{v}{\bar{v}}\right)^3 dA$

ph ← $\frac{\dot{w}p}{\dot{m}g}$, $\dot{w}p = \gamma Q hp$

ht ← $\frac{\dot{w}t}{\dot{m}g}$, $wt = \gamma Q ht$

hL ← إذا في ضياع $\frac{1}{g}(v_2 - v_1) - \frac{Q}{\dot{m}g}$, γQ

سرعات متساوية



Continuity Momentum Energy Eqn

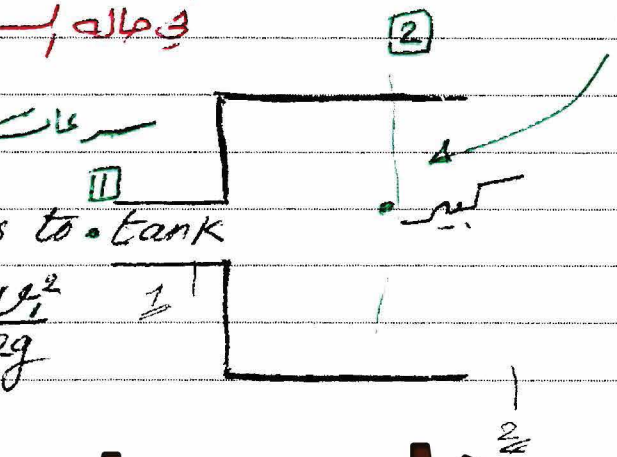
$$hL = \frac{(v_1 - v_2)^2}{2g}$$

في حالة إسطوانة في tank

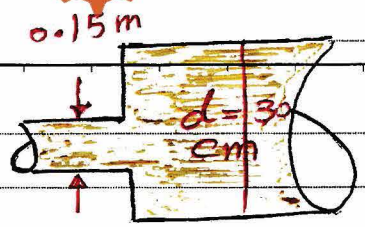
سرعات متساوية

pipe Expands to a tank

$$hL = \frac{v_1^2}{2g}$$



7.59



$Q = 0.1\ m^3/s$

$h_L = ?$

$$v_1 = \frac{Q}{A_1} = \frac{0.1}{\frac{\pi}{4}(0.15)^2} = 5.66\ m/s$$

$$v_2 = \frac{Q}{A_2} = \frac{0.1}{\frac{\pi}{4}(0.3)^2} = 1.4\ m/s$$

كل قطعة واحدة من $\frac{v^2}{2g}$ مربع

$$h_L = \frac{(v_1 - v_2)^2}{2g} = \frac{(v_1 - v_2)^2}{2g} = \frac{(1.5 - 5.66)^2}{19.62} = 0.918\ m$$

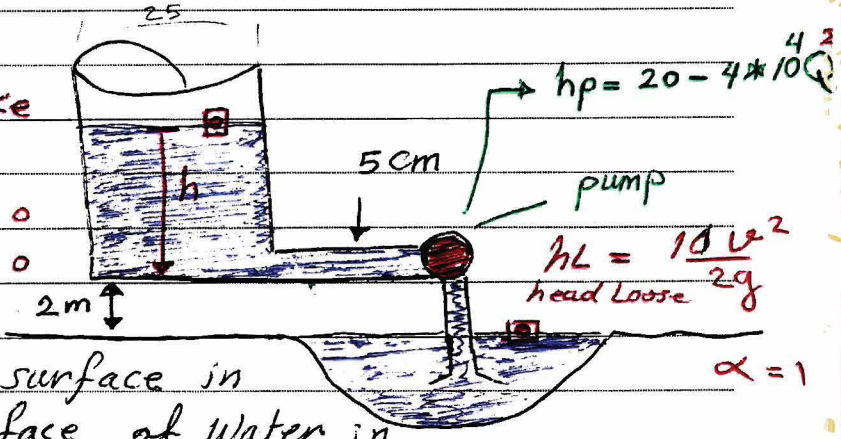
توجيه (اعلى)

power dissipated $= \gamma Q h_L = 9810 * 0.1 * 0.918$

$= 955\ W$

تفريغ تشتيت

واسراف



How long will lake to Fill the tank

$h = 10\ m$ @ $t = 0$

$h = 0$

Apply Energy Eqn between the Water surface in river and Free surface of Water in tank.

$$\frac{P_1}{\gamma} + \alpha \frac{v_1^2}{2g} + z_1 + h_p = \frac{P_2}{\gamma} + \alpha_2 \frac{v_2^2}{2g} + z_2 + h_t + h_L$$

$$h_p = (z_2 - z_1) + \frac{11 v^2}{2g}$$

توجيه

$h_p = (z_2 - z_1) + h_L$

h_L → pipe major loss $\frac{11 v^2}{2g}$

expansion major $\frac{v^2}{2g}$

$$20 - 40000 Q^2 = 12 + 2 + \frac{11 v^2}{2g}$$

$$v = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4}(0.05)^2} = (509.55) Q^2$$

$$v^2 = 259645\, Q^2$$

$$20 - 4000Q^2 = h + 2 + 145571Q^2$$

$$18 - h = 185571Q^2$$

$$Q = \frac{(18-h)^{\frac{1}{2}}}{430.8} = A_{tank}\frac{dh}{dt}$$

$$(18-h)^{-\frac{1}{2}}dh = \frac{1}{430.8 * A_{tank}}dt$$

$$-2(18-h)^{\frac{1}{2}}\Big|_0^{10} = \frac{1}{430.8\left(\frac{\pi}{4}\right)(5)}(t-0)$$

$$t = (2)(430.8)\left(\frac{\pi}{4}\right)(25)\left[18^{\frac{1}{2}} - 8^{\frac{1}{2}}\right]$$

$$= 23912.7 \text{ Se}$$

$$= 6.64 \text{ houre}$$

$\frac{100}{100}$ ك

$$Q = \left(\frac{\pi}{4}\right)(25)^2(10) = 1963.25\ m^3$$

$P_1 = 35$ KPa

$v_1 = 8$ m/s

$d = 1.5$ m [1] [2] $d = 3$ m

[1] power dissipated in the transition

[2] P_2

[3] Force required to hold the transition in place.

$$Q = v_1A = 8 * \left(\frac{\pi}{4}\right)(1.5)^2 = 14.13\ m^3/s \qquad Q_1 = Q_2$$

$$v_1A_1 = v_2A_2 \qquad v_2 = \frac{v_1A_1}{A_2}$$

[2] $v_2 = \frac{v_1 A_1}{A_2} = \frac{\frac{\pi}{4}(1.5)^2}{\frac{\pi}{4}(3)^2}(8) = 2\ m/s$

$h_L = \frac{(v_1 - v_2)^2}{2g} = \frac{(8-2)^2}{2g} = 1.83\ m$

power dissipated $= \gamma Q h_L$

$= (9810)(14.13)(1.83)$

$= 253.67\ KW$

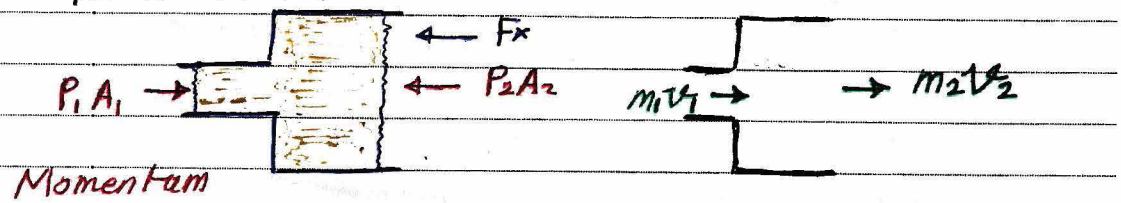
(2)

$\frac{P_1}{\gamma} + z_1 + \alpha_1 \frac{v_1^2}{2g} + h_p = \frac{P_2}{\gamma} + z_2 + \alpha_2 \frac{v_2^2}{2g} + h_t + h_L$

$P_2 = P_1 + \frac{1}{2}\rho(v_1^2 - v_2^2) - \gamma h_L$

$P_2 = (35 * 10^3) + \frac{1}{2} * 1000 (8)^2 - (2)^2) - 9810 * 1.83$

$P_2 = 47\ KPa$



Momentum

$\Sigma F_x = \Sigma \dot{m}_{out} v_{out_x} - \Sigma \dot{m}_{in} v_{in_x}$

$P_1 A_1 - P_2 A_2 - F_x = 1000 * 14.13 (2 - 8)$

$F_x = 1000 * 14.13 (-6) + \left[47 * 10^3 * \frac{\pi}{4}(3)^2\right] - \left[35 * 10^3 * \frac{\pi}{4}(1.5)^2\right] =$

[1] $Q = A_1 v_1 = (8)(\frac{\pi}{4})(1.5)^2 = 14.13\ m^3/s$

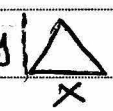
تكملة $Q_1 = Q_2$ $v_2 = \frac{A_1 v_1}{A_2} = \frac{(\frac{\pi}{4})(1.5)^2}{\frac{\pi}{4}(3)^2}(8)$

$= 2\ m/s$

$h = \frac{(v_1 - v_2)^2}{2g} = \frac{(8-2)^2}{2g} = 1.83\ m$

مساحة المستطيل $x \cdot y =$ محيطه $2(x+y)$

مساحة المربع x^2 محيطه $4x$

مساحة المثلث $\frac{1}{2} \times y$  محيطه مجموع أضلاعه

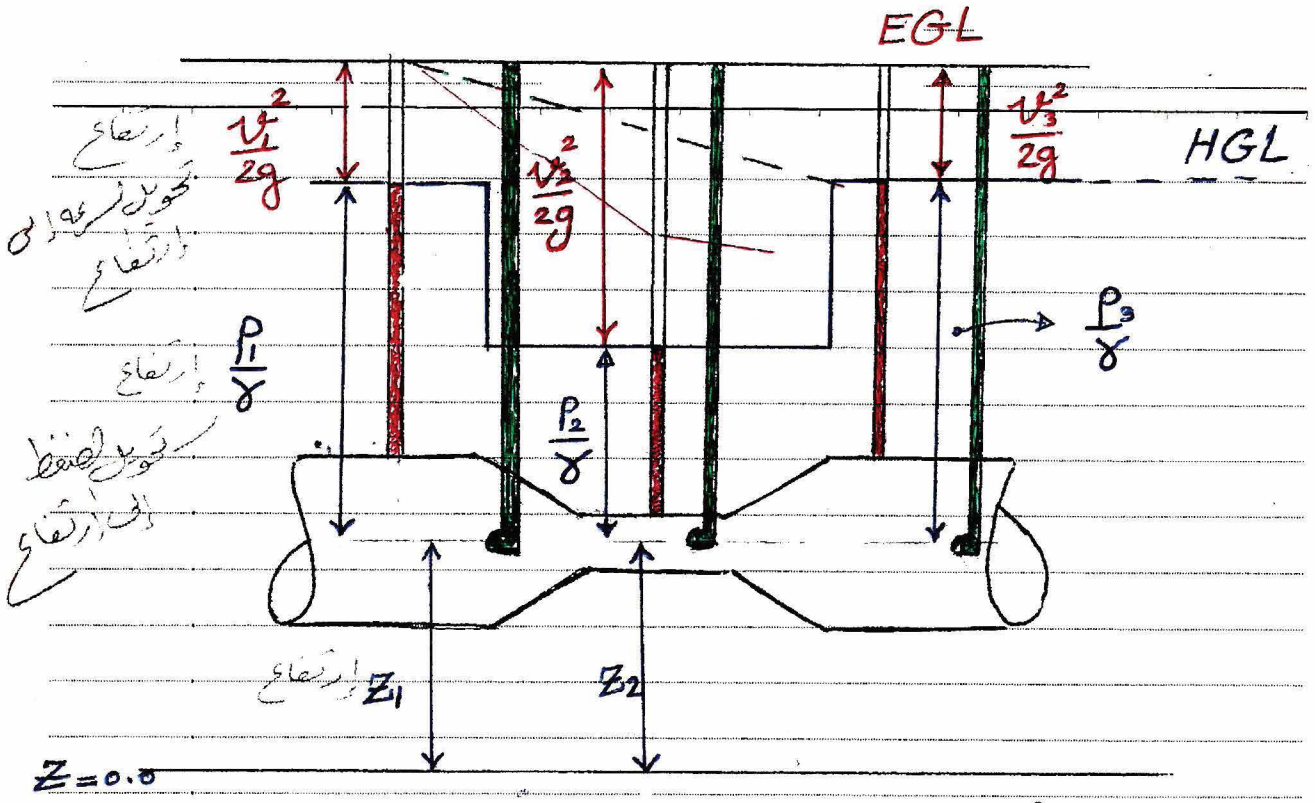
مساحة الدائرة πr^2 $\frac{\pi}{4} d^2$ محيطها $2\pi r$ πd

مساحة الكرة $4\pi r^2$ πd^2 حجم الكرة $\frac{4}{3}\pi r^3$ $\frac{\pi}{6} d^3$

المساحة الكلية للمكعب $6x^2$ حجم المكعب x^3

حجم الإسطوانة مساحتها $\pi r^2 h$ $\frac{\pi}{4} d^2 h$ $2\pi r h$ $\pi d h$

حجم المخروط $\frac{1}{3}\pi r^2 h$ $\frac{\pi}{12} d^2 h$ مساحته $\frac{2}{3}\pi r h$ $\frac{\pi}{3} d h$



HGL ⇐ Connect the Free surface of Liquid in piezometer $\frac{P}{\gamma} + Z$ ارتفاع الضغط + ارتفاع

EGL ⇐ Connects Free surfaces in st tubes

$\frac{P}{\gamma} + \frac{v^2}{2g} + Z$ total head

by definition EGL locates above HGL by a distance $\frac{v^2}{2g}$

For reservoirs (Large tanks) Lakes the Speed of Free surface of Fluid is Equal to Zero so:

EGL + HGL are coincided (بتطابق)

with the Free surface of Liquid

* EGL & HGL approch to Each other if velocity ↓ decrease and diverge (بتباعد بتفرق) if velocity ↑

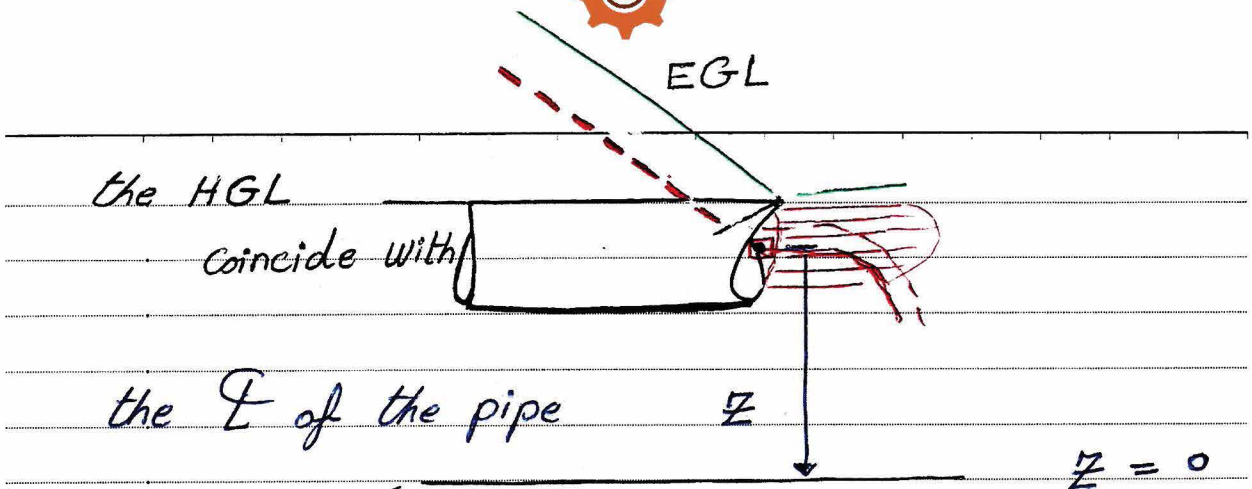
For open Channel Flow

HGL Coincides (بتطابق) with the Free Surface of Flowing Fluid $\left(\frac{P}{\gamma} = 0\right)$ (يحدث في نفس الوقت بتطابق يحتل نفس المكان والزمان)

EGL is Located $\frac{V^2}{2g}$ above the Free surface .

For a pipe dischanges to atmosphere

$$\frac{P}{\gamma} + Z$$



فقد طاقة ميكانيكية تحول conversion to thermal Energy طاقة] Causes EGL & HGL to slope down Ward in direction of Flow.

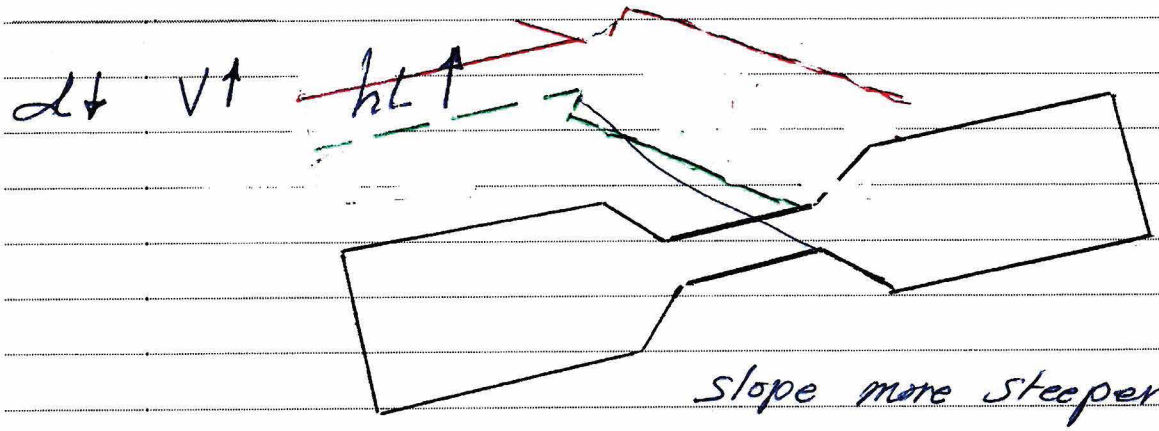
Mechanical Energy loss [

slope is an indication head loss h_L

Head loss W

$$h_L = \frac{FL}{D} = \frac{V^2}{2g}$$

F:= Friction coeff

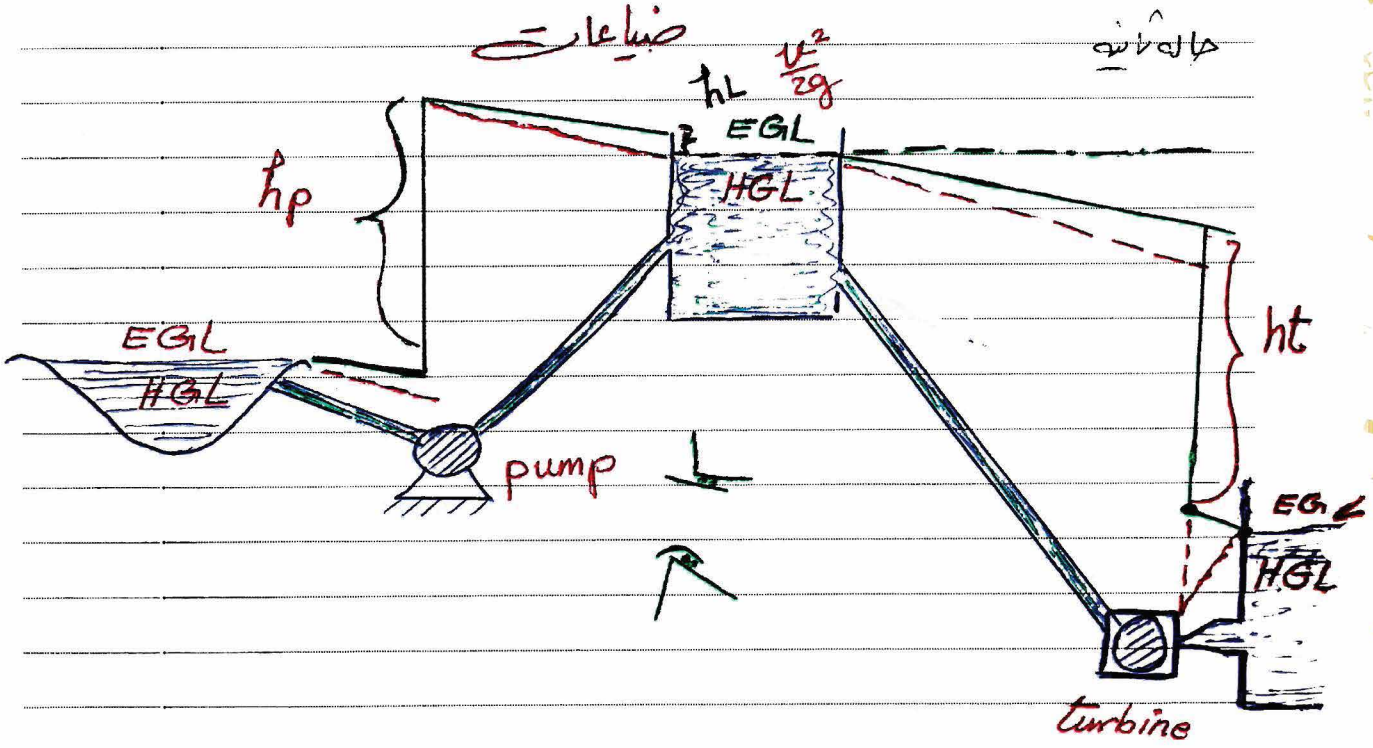


and the distance between Lines in Larger

ارتفاع مفاجئ — انخفاض مفاجئ أو ارتفاع

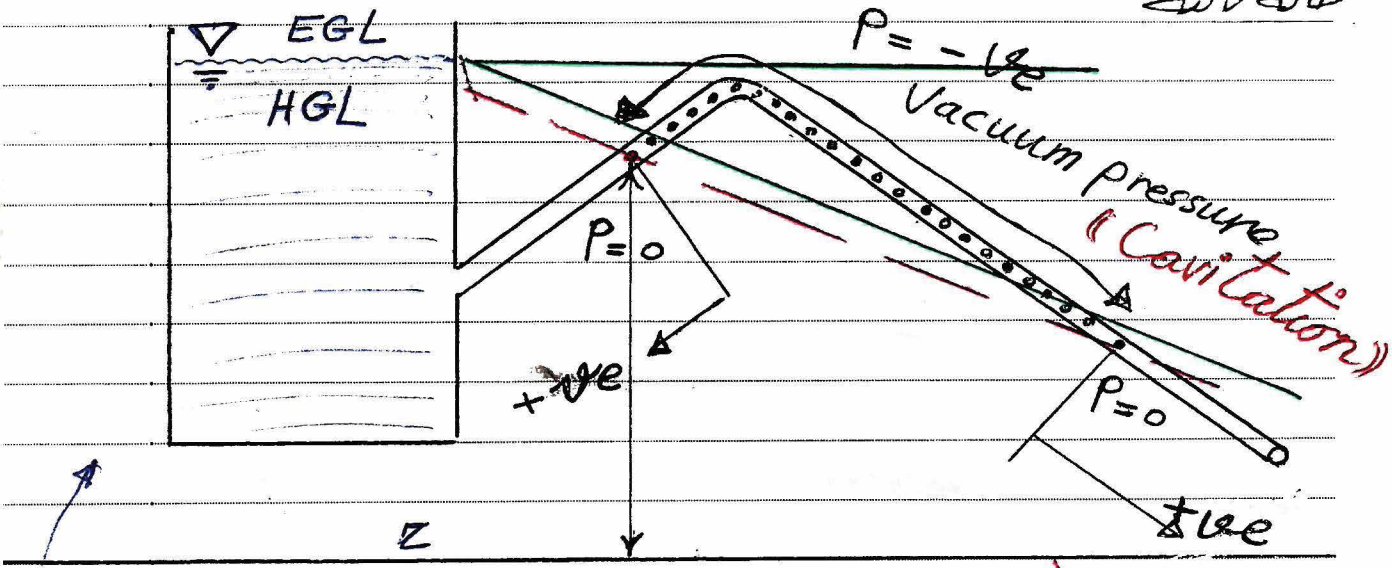
✡ steep or abrupt rize in EGL and HGL due to Energy addition to the Fluid ⟶ pump

✡ steep Fall in EGL + HGL if Energy is extracted From Fluid such as turbine

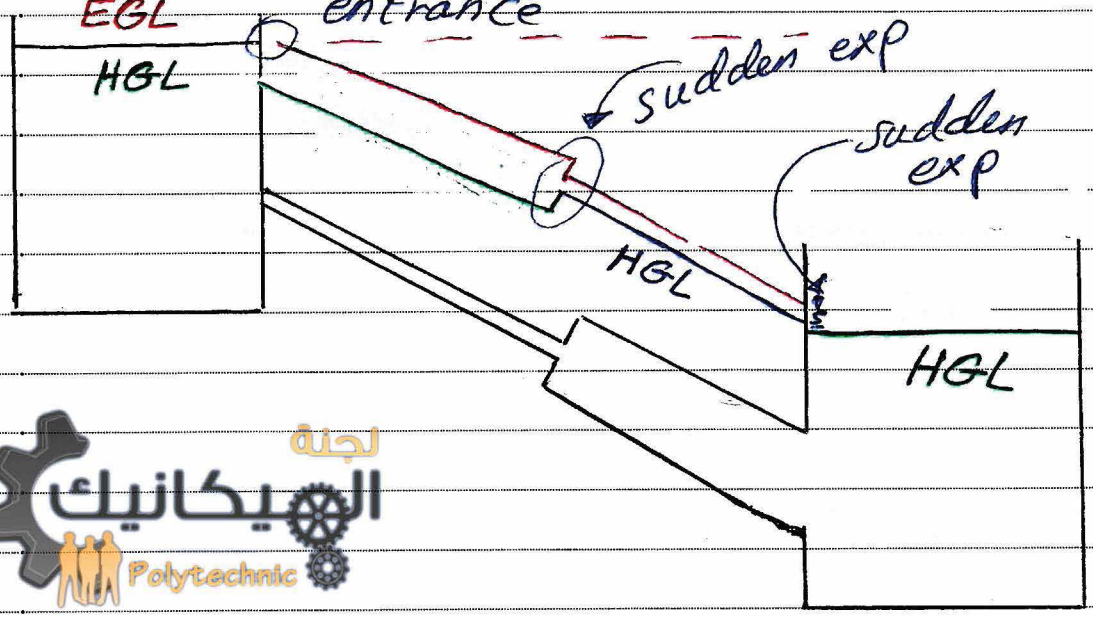


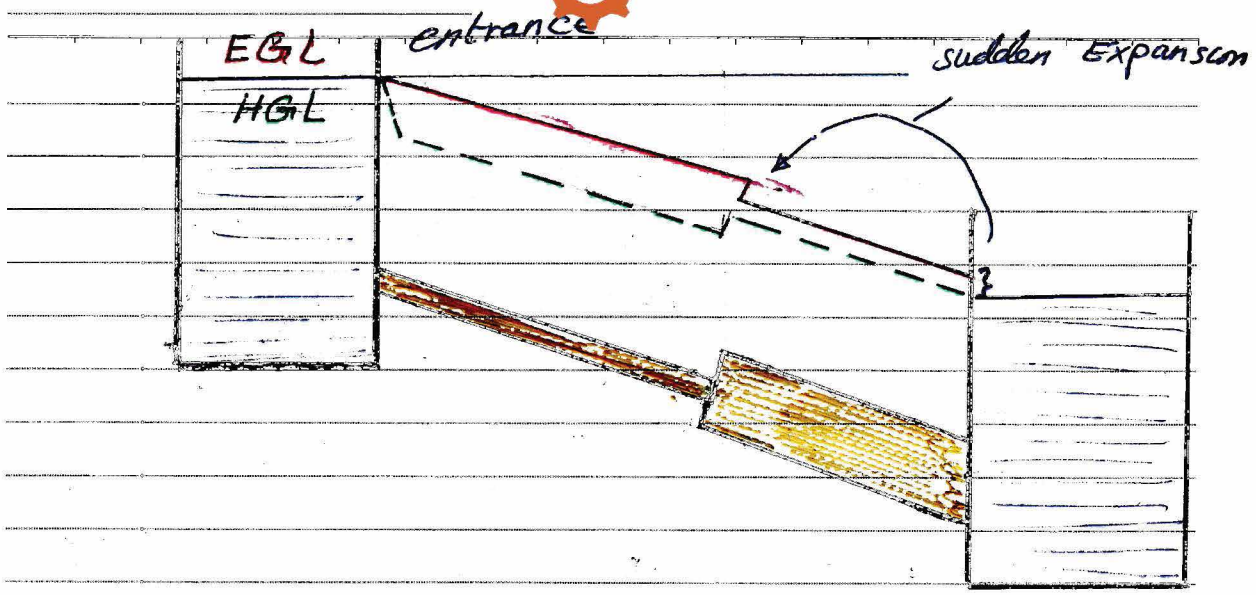
$$HGL = \frac{P}{\gamma} + Z$$

حالة ثالثة

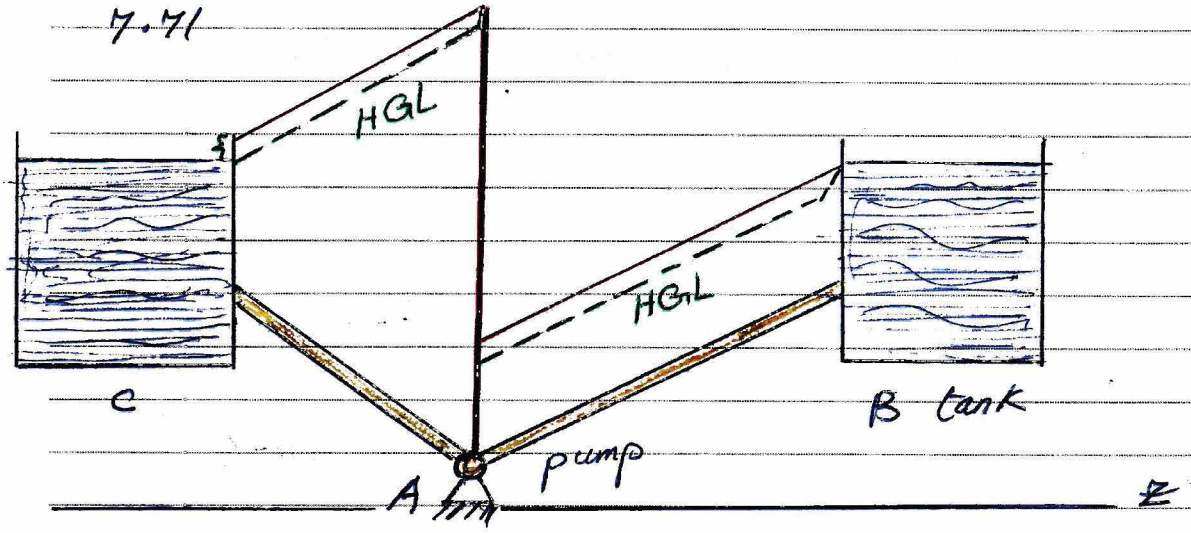


Vacuum pressure ($P < P_{atm}$) occurs if the pipe located above the HGL.





7.71



1] Flow From B to C HGL slopes this direction

2] at A pump :- sudden rise in HGL

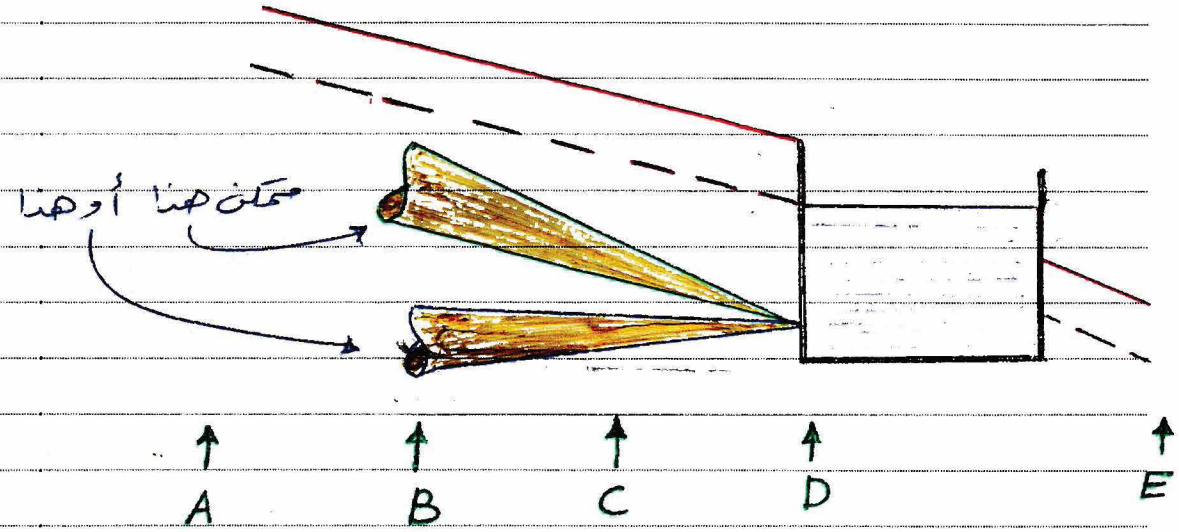
$\angle BA \neq \angle AC$ ⟶ Diffrence

$\angle AC < \angle BA$

more steeper in AC Which means larger velocity and Smaller diamater

No Vacuum in the System HGL always above the system.

7 & 7 2

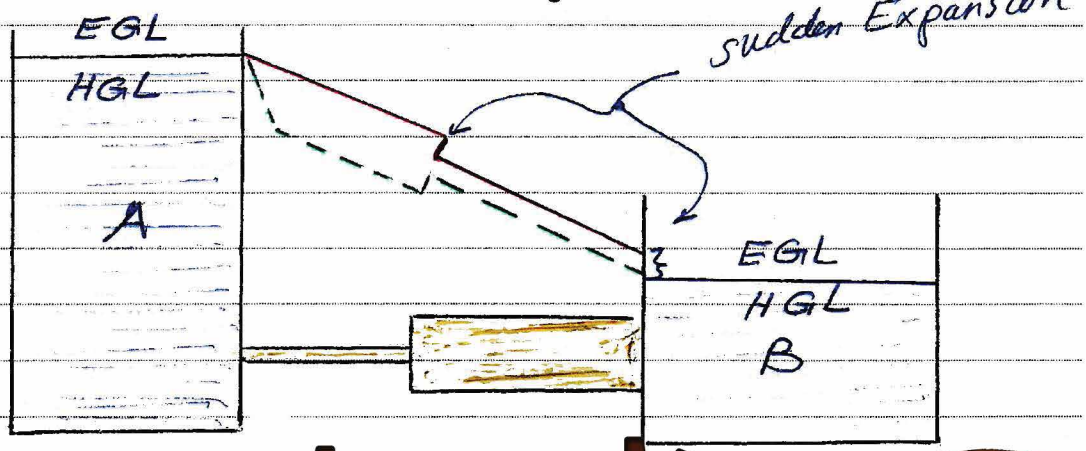


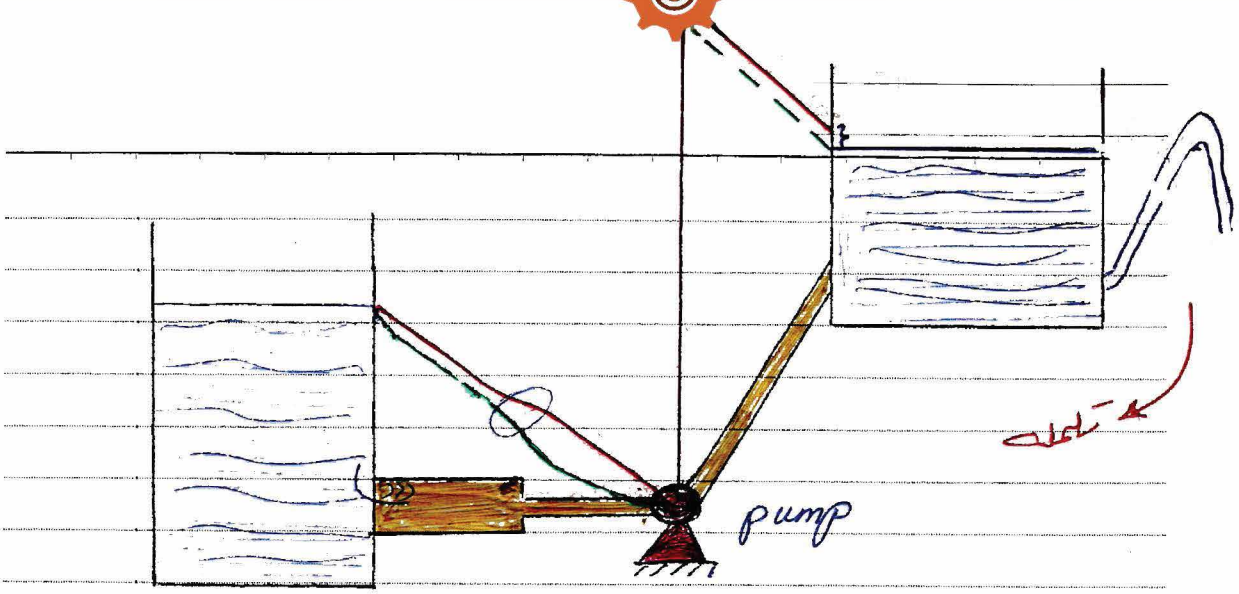
1) Flow From A to E

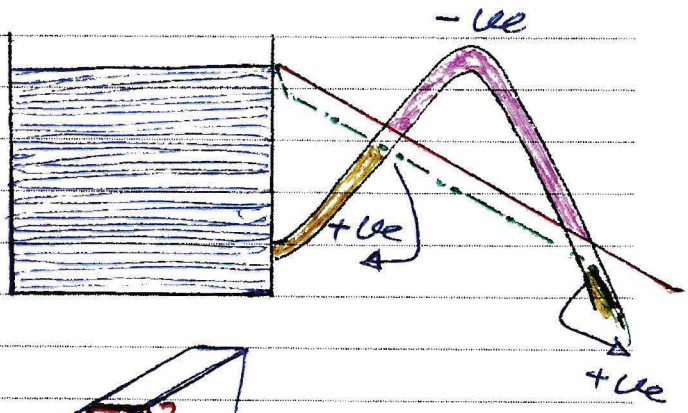
2) At D there is a reservoir (tank)
HGL & EGL are coincided

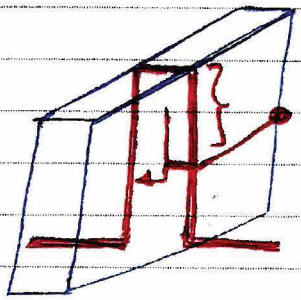
③ at E pipe has a Uniform diameter
Slope = Const
Space between EGL & HGL is Const

④ No pump in the System.









أنبوب أو قناة

Chapter 10

Flow in Conduits

- velocity
- Q
- Energy Eqn
- Shear stress

pipe tube or duct that is completely filled with a flowing Fluid

tube → ○ ← pipe

Flowing conduits

transfaring water توصيل طلمبات

hot water From boiler ماء ساخن من السخان

tube to transfer gas LPG توصيل بغاز

duct

Reynolds Number $Re = \frac{\rho V D}{\mu} = \frac{V D}{\nu}$

μ ← dynamic viscosity — ν Kinematic

أثر الإضطراب

$Re < 2000$ Laminar → mixing effect as not active

$2000 < Re < 3000$ transition كفترة نشط

$Re > 3000$ turbulent تيارات دوامية Eddy Current and mixing effect is a active

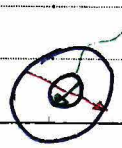
Non Circular C.S.A Hydraulic Diam

$$D_h = \frac{4A}{\text{wet permeter}}$$

○ $D_H = \frac{4 \cdot \frac{\pi}{4} d^2}{\pi d} = d$ (4 مساحة، محيط) — $D_H = \frac{4A}{\text{محيط}}$

□ $D_H = \frac{4 s^2}{4s} = s$

$D_H = \frac{4WH}{2W+2H} = \frac{2WH}{W+H}$



$D_H = \frac{(4)\frac{\pi}{4}(d_o^2 - d_i^2)}{\pi d_i + \pi d_o} = d_o - d_i$ ← $(d_o - d_i)(d_o + d_i)$

Ch 10 Flow in conduits

classification

$$Re = \frac{\rho v D}{\eta} = \frac{\rho \left(\frac{Q}{A}\right) D}{\eta} = \frac{\rho Q D}{\frac{\pi}{4} D^2 \eta} = \frac{4 \rho Q}{\pi D \eta} = \frac{4 \dot{m}}{\pi D \eta}$$

$Re < 2000$ Laminar

$2000 < Re < 3000$ transition انسياب جزئي

$Re > 3000$ turbulent

Conduits wet

For partially Filled pipe (open channel Flow)

Completely Filled with a flowing Fluid

Tube pipe duct

تحديد بالأحجام ← specifying size

O.D × thickness

Nominal pipe size NPS

20 × 2 → thickness

20mm ← outer diameter قطر الحائط الخارجي

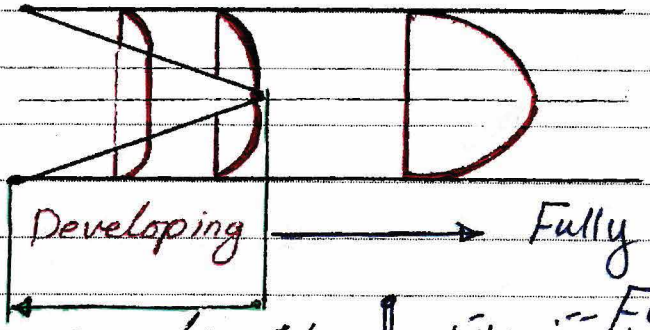
Nominal pipe diameter + schedule

لائحة جدول

ملحق في التفاصيل

O.D thickness

+ schedule			
$\frac{1}{2}$ sch 40	oD	thick	I.d
sch 80	0.84	0.109	0.84 − 2(0.109)
⋮ x L		0.147	0.84 − 2(0.109)



طول الدخول entrance length

Laminar Flow

$\frac{Le}{D} = 0.05\,Re$

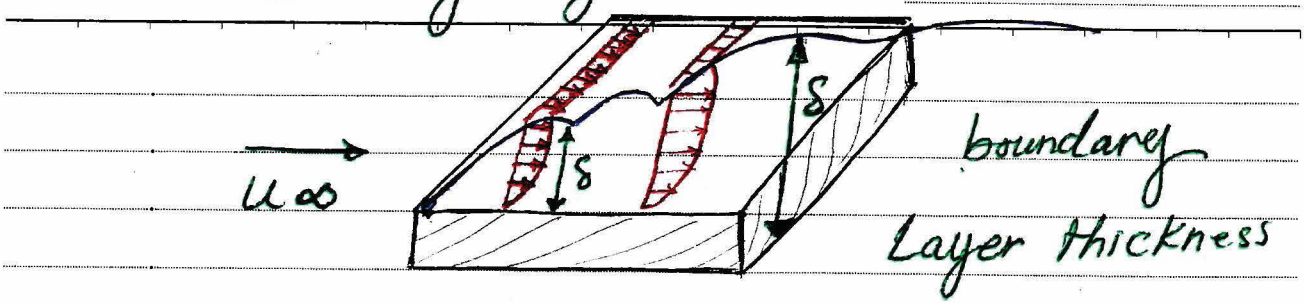
turbulent $\frac{Le}{D} = 50$

صورة جانبية لسرعة Flow تتغير باتجاه التدفق velocity profile dose not change in the Flow direct

4 - Categories of Flow أصناف التدفق

1) developing Laminar Flow
2) Fully developed Laminar Flow
3) Developing turbulent Flow
4) Fully developed turbulent Flow

Boundary Layer



Head loss ⇐

Energy Eqn

$$\frac{P_1}{\gamma} + \alpha_1 \frac{v_1^2}{2g} + z_1 + h_p = \frac{P_2}{\gamma} + \alpha_2 \frac{v_2^2}{2g} + z_2 + h_t + h_L$$

h_L ← طاقة إلى Head loss

تحويل أو تحول

Conversion of Mech Energy into thermal Energy

تحول الطاقة إلى طاقة حرارية

أو أساسي فقد رئيسي

Major losser → * Straight pipe

Darcy weisback Eqn

* Fitting → Minor lossers

* Elbow

* Tee

$$h_f = h_L = \frac{fL}{D} * \frac{v^2}{2g}$$

* Valve → gate valve / Globe valve / check valve

كوع مستدير

$$h_l = K \frac{v^2}{2g}$$

مجهول

K :- loss Coeff in table

Transition → Sudden Expation

sudden → Contraction

معامل الإحتكاك

F : Friction coeff
Darcy Friction Coeff
Friction resistance coeff
} chart Moody chart or Eqn

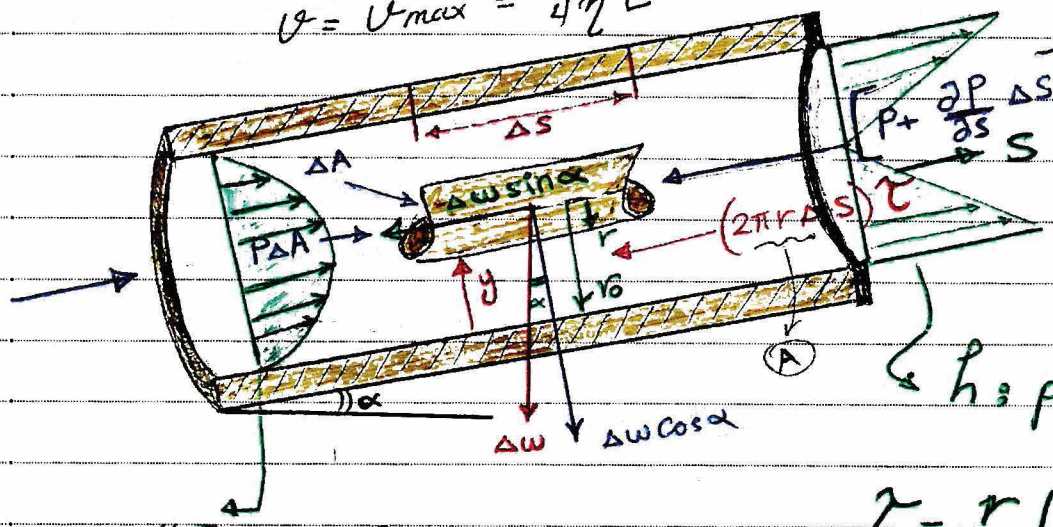
L : o Length of the pipe طول الماسورة
D : o diameter of the pipe قطر الماسورة

Darcy weisback Eqn

Fully developed laminar or turbulent Flow in Circular or non Circular flow passage

stress distribution in pipe Flow

at $r=0$ $v = v_{max} = \frac{r_o^2}{4\eta}\left[-\gamma \frac{dh}{ds}\right]$ at $r=r_o$ $v=0.0$



h : piezometric head

$$\frac{r_o}{4\eta}\left[-\gamma \frac{dh}{ds}\right]\left[1-\frac{r^2}{r_o^2}\right]$$

$$\tau = \frac{r}{2}\left[-\gamma \frac{dh}{ds}\right]$$

تكملة

Momentum Eqn in the S- direction

$$\Sigma F_s = 0.0$$

$$P\Delta A - \Delta W \sin\alpha - \left[P + \frac{\partial P}{\partial s}\Delta s\right]\Delta A - \tau(2\pi r \Delta s) = 0.0$$

$$\tau = \frac{r}{2}\left[\frac{-d}{ds}(P+\gamma z)\right] = \frac{r}{2}\left(\frac{-\gamma d}{ds}\left(\frac{P}{\gamma} + z\right)\right)$$

(h = slope of HGL -ve)

τ = Shear stress Varies Linearly with @ the Center $r = 0$ $\tau = 0.0$

τ_{max} @ $r = r_o$ $\tau = \frac{r_o}{2}\left[-\gamma \frac{dh}{ds}\right]$

Head loss ∞ From the drawing

$r_o = r + y$ $r = r_o - y \rightarrow \frac{dr}{dy} = -1$

Laminar Flow

$\tau = \eta \frac{dV}{dy}$ ← velocity gradiant

$\tau = \eta \frac{dV}{dr}\frac{dr}{dy}$

$$\boxed{\tau = -\eta \frac{dV}{dr}}$$

$$\frac{r}{2}\left[-\gamma \frac{dh}{ds}\right] = -\eta \frac{dV}{dr}$$

$h_f = \frac{4\tau L}{D\gamma}$ $\frac{8\tau}{\rho V^2}$ ← $f = \frac{4\tau}{\rho V^2/2}$ معامل الاحتكاك

$$dv = \frac{-r}{2\eta}\left[-\gamma\frac{dh}{ds}\right]dr$$

$$v = \frac{-r^2}{4\eta}\left[-\gamma\frac{dh}{ds}\right] + c$$

← بالتكامل بعد التكامل

$$v = 0,0 \quad @ \quad r = r_0$$

$$0 = \frac{-r_0^2}{4\eta}\left[-\gamma\frac{dh}{ds}\right] + c$$

$$c = \frac{r_0^2}{4\eta}\left[-\gamma\frac{dh}{ds}\right]$$

$$\boxed{v = \frac{r_0^2}{4\eta}\left[-\gamma\frac{dh}{ds}\right]\left[1-\left(\frac{r}{r_0}\right)^2\right]}$$

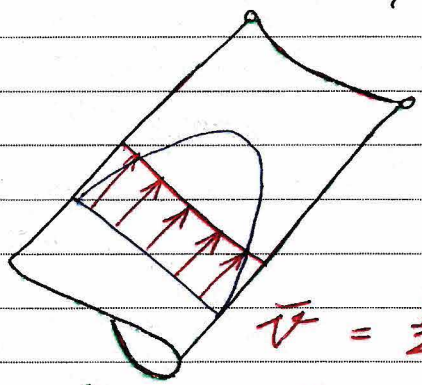
$v=0$ $r=r_0$

$r=0$ v_{max}

عند r_0 يصبح السائل ساكن

يتبع

كليا



$$\bar{v} = \frac{1}{2}v_{max}$$

$$v = \frac{-r^2}{4\eta}\left[-\gamma\frac{dh}{ds}\right] + \frac{r_0^2}{4\eta}\left[-\gamma\frac{dh}{ds}\right]$$

نفس

$$v = \frac{r_0^2}{4\eta}\left[-\gamma\frac{dh}{ds}\right] - \frac{r^2}{4\eta}\left[-\gamma\frac{dh}{ds}\right]$$

$$= \frac{1}{4\eta}\left[-\gamma\frac{dh}{ds}\right](r_0^2 - r^2)$$

بالضرب $\frac{v_0^2}{r_0^2}$

$$v = \frac{r_0^2}{4\eta}\left[-\gamma\frac{dh}{ds}\right]\left(1-\left(\frac{r}{r_0}\right)^2\right)$$

$$\bar{v} = \frac{Q}{A} = \frac{\int v_0 \, dA}{A} =$$

$$= \frac{\int_0^{r_0} \frac{r_0^2}{4\eta} \left(-\gamma \frac{dh}{ds}\right) \left[1 - \frac{r^2}{r_0^2}\right] 2\pi r \, dr}{\pi r_0^2}$$

$$= \frac{-\gamma}{2\eta} \frac{dh}{ds} \left[\frac{r^2}{2} - \frac{r^4}{4r_0^2}\Big|_0^{r_0}\right]$$

$$= \frac{1}{2\eta} \left[-\gamma \frac{dh}{ds}\right] \left[\frac{r_0^2}{2} - \frac{r_0^2}{4}\right]$$

$$\bar{v} = \frac{r_0^2}{8\eta} \left[-\gamma \frac{dh}{ds}\right]$$

$$v_{max} = \frac{r_0^2}{4\eta} \left[-\gamma \frac{dh}{ds}\right]$$

$$\bar{v} = \frac{1}{2} v_{max}$$

Ch 10

$$\tau = \frac{r}{2}\left[-\gamma \frac{dh}{ds}\right]$$

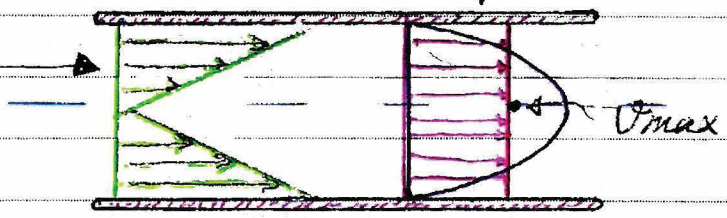
$$v = \frac{r_o^2}{4\eta}\left[-\gamma \frac{dh}{ds}\right]\left[1-\left(\frac{r}{r_o}\right)^2\right]$$

$v = 0$ at $r = r_o$; $v = v_{max}$ at $r = 0$

v_{max} @ $r = 0.0$

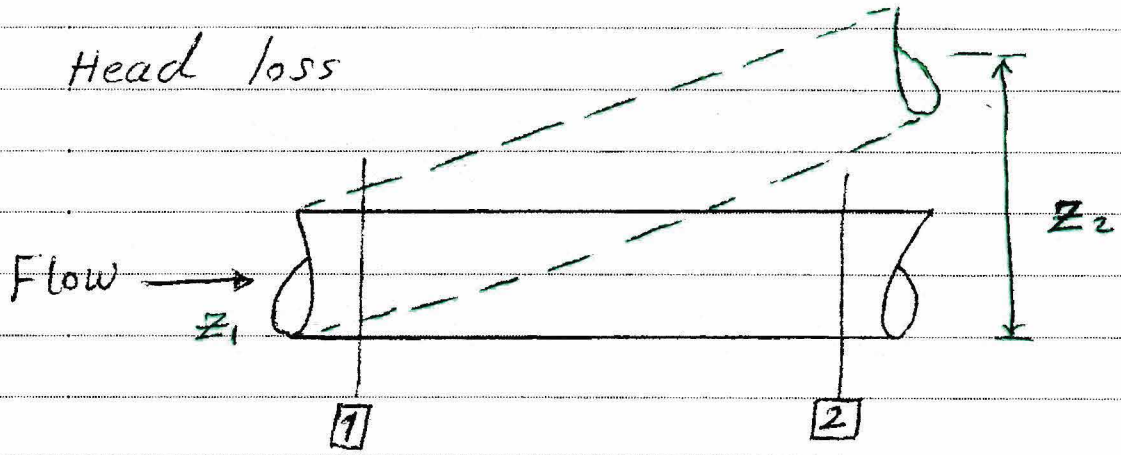
$$v_{max} = \frac{r_o^2}{4\eta}\left[-\gamma \frac{dh}{ds}\right]$$

$$\bar{v} = \frac{r_o^2}{8\eta}\left[-\gamma \frac{dh}{ds}\right]$$



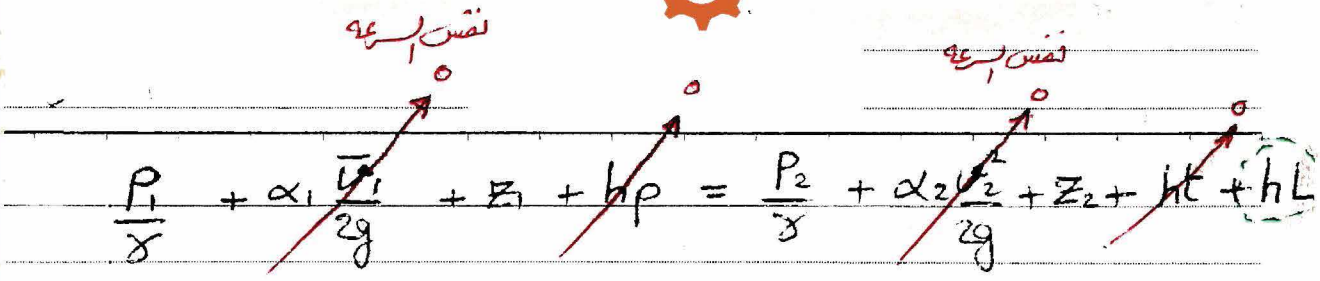
$$\bar{V} = \frac{1}{2} v_{max}$$

Head loss



A_1 = steady state Condition

$$\dot{m}_1 = \dot{m}_2$$



$$\frac{P_1}{\gamma} + \alpha_1 \frac{\bar{v}_1^2}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \alpha_2 \frac{\bar{v}_2^2}{2g} + Z_2 + h_t + h_L$$

$$\left(\frac{P_1}{\gamma} + Z_1\right) - \left(\frac{P_2}{\gamma} + Z_2\right) = h_L = h_f$$

h_1 $\qquad$ h_2

h_f ← head loss due to Friction

$$(h_1 - h_2) = h_f$$

$$\left(\frac{d}{2}\right)^2 = r^2$$

$$\bar{v} = \frac{r_0^2}{8\eta}\left[-\gamma \frac{dh}{ds}\right] = \frac{D^2}{32\eta}\left[-\gamma \frac{dh}{ds}\right]$$

$$-\int_0^L dh = \int_0^L \frac{32\bar{v}\eta}{\gamma D^2}\, ds$$

$$-(h_2 - h_1) = \frac{32\bar{v}\eta}{\gamma D^2}(L)$$ بعد التبسيط

$$h_f = \frac{32\bar{v}\eta}{\gamma D^2} L = \frac{fL}{D}\frac{\bar{v}^2}{2g}$$

Darcy weisbach Eqn

$$h_f = h_L = \frac{fL}{D}\frac{\bar{v}^2}{2g} \qquad f = \frac{64\eta}{\rho \bar{v} D} = \frac{64}{Re}$$

$$\boxed{f = \frac{64}{Re}} \rightarrow \text{Laminar Flow}$$

Ch.10

Ex 8 oil [S.G = 0.960 $\eta = 650 * 10^{-3}$ Pa·s]

Flow in a 100 m 4 nominal sch 40 Cast iron pipe Determine pressure difference For a Flow rate of 0.01 m^3/s

[4" sch 40 Internal diameter = 10.23 cm]

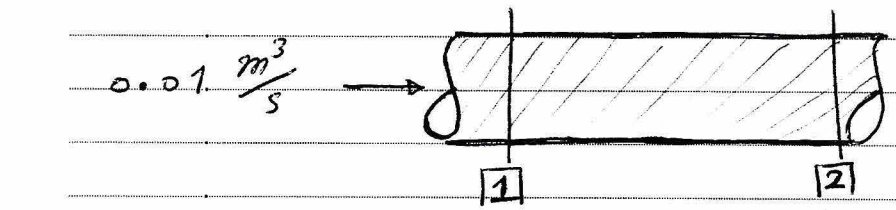
First :- check Flow Re

$$Re = \frac{\rho v D}{\eta} \Longrightarrow v = \frac{0.01}{\left(\frac{\pi}{4}\right)(0.1023)^2}$$

لاحظ $\cong 1.22$ m/s

$$Re = \frac{(960)(1.22)(0.1023)}{650 * 10^{-3}} = \underset{183.9}{184.3} < 2000 \text{ Laminar Flow}$$

حساب إطالب



Energy Eqn reduce to $\frac{P}{\gamma}$

نبسطها بطلع

$$\left(\frac{P_1}{\gamma}\right) + \frac{v_1^2}{2g} + Z_1 + H_p = \left(\frac{P_2}{\gamma}\right) + \frac{v_2^2}{2g} + Z_2 + H_T + H_L$$

$$h_L = h_F = \frac{P_1 - P_2}{\gamma}$$

$$P_1 - P_2 = \gamma h_F$$

$$= \gamma \frac{FL}{D} \frac{v^2}{2g}$$

$$F = \frac{64}{183.9} = 0.348$$

$$P_1 - P_2 = \frac{(0.96)(9810)(0.348)(100)(1.22)^2}{(0.1023)(19.62)}$$

$$= 243\ KPa$$

Region between smooth pipe Line & edge of Fully rough turbulent Flow

$$F = F\left(Re\ \frac{Ks}{D}\right)$$

طريقة استخراج f ← من جدول

For Exmple

Turbulent هنا زود

1) $Re = 8 * 10^6$, $\frac{Ks}{D} = 0.00005$ } $f = 0.011$

2) $Re = 1.5 * 10^5$, $\frac{Ks}{D} = 0.004$ } $f = 0.029$ ← let take this by Swamee Eqn

3) $Re = 5 * 10^5$, $\frac{Ks}{D} = 0.003$ } $f = 0.027$

ويوجد طريقة Swamee Eqn

For turbulent Flow

Swamee Eqn

$$f = \frac{0.25}{\left(\log\left[\frac{Ks}{3.7d} + \frac{5.74}{Re^{0.9}}\right]\right)^2}$$

or

$$f = \frac{1.32}{\left(\ln\left(\frac{Ks}{3.7d} + \frac{5.74}{Re^{0.9}}\right)\right)^2}$$

إذا عطاني Flow rate أو diam

$$Re = \frac{vD}{\nu}$$

$$Re\, f^{\frac{1}{2}} = \frac{D^{\frac{3}{2}}}{\nu}\left[\frac{2g\,hf}{L}\right]^{\frac{1}{2}}$$ وممكن

تحليل

لو قطر البوب حتى يعشى

$$Re = \frac{vD}{\nu} \rightarrow v = \frac{Re\,\nu}{D} \longrightarrow (1)$$

$$hf = \frac{FL}{D}\frac{v^2}{2g} \rightarrow v = \left(\frac{2g\,hf}{LF}\right)^{\frac{1}{2}} D^{\frac{1}{2}} \longrightarrow (2)$$

From (1) & (2)

$$\frac{Re\,\nu}{D} = \left(\frac{2g\,hf}{LF}\right)^{\frac{1}{2}} D^{\frac{1}{2}}$$

$$Re\, f^{\frac{1}{2}} = \frac{D^{\frac{3}{2}}}{\nu}\left(\frac{2g\,hf}{L}\right)^{\frac{1}{2}}$$

Ch. 10 ضياعات مرتبطة بالحنفية

$$\frac{P_1}{\gamma} + \alpha_1 \frac{v_1^2}{2g} + z_1 + h_p = \frac{P_2}{\gamma} + \alpha_2 \frac{v_2^2}{2g} + z_2 + h_t + h_L$$

$$\dot{W}_p = \gamma Q h_p$$

head loss

major (متصرعل) — minor losses (أقل قيمة)

Flow in pipe — للأكواع والبلايات الطويلة

Darcy Weisbach Eqn — loss في الجدول (table)

$$h_L = h_f = \frac{fL}{D}\frac{v^2}{2g}$$ — Equivalent length

$$h_L = K\frac{v^2}{2g}$$

Laminar Flow — Turbulent Flow — Moody diagram

$$f = \frac{64}{Re}$$

swamee

$$f = \frac{0.25}{\left(\log\left(\frac{K_s}{3.7d} + \frac{5.74}{Re^{0.9}}\right)\right)^2}$$

sudden Exp (توسيع فجائي) $h_L = \frac{(v_1 - v_2)^2}{2g}$ → (+ve) always

tank (ضياع الخروج)

$$L = \frac{v^2}{2g} = K\frac{v^2}{2g} \leftarrow K = 1.0$$

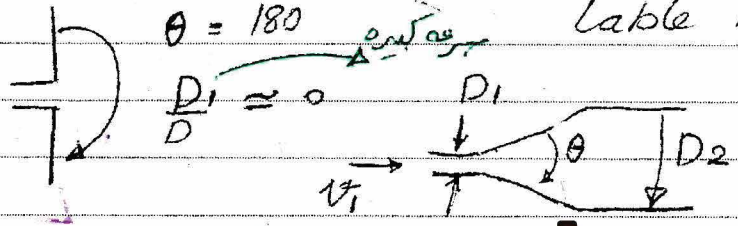
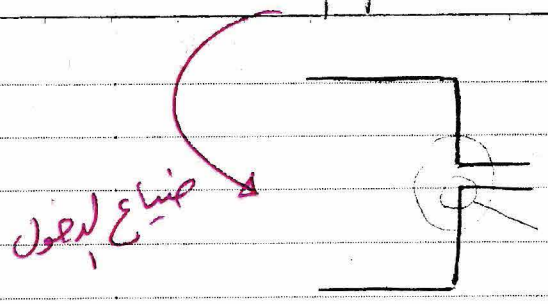
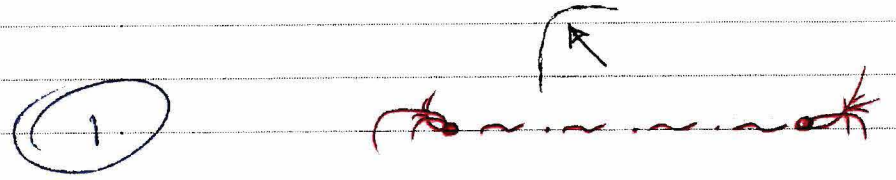


Table 10.3 ص

pipe Entrance



صناع المعول



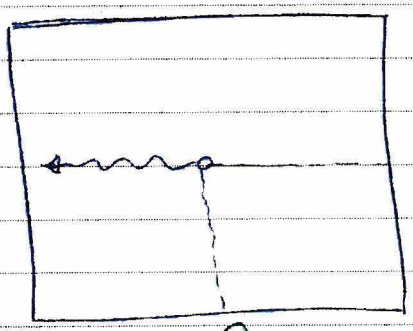
1

solving Turbulent Flow problems

Case 1 :- Required head loss

Given ① Q, ② L ③ kind of the pipe (Ks)

يطلب ④ D = ؟؟؟ given



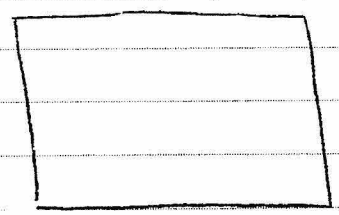
2

Case 2 :- Q Required

Given ① head loss [pressure drop]

③ kind ④ pipe length ⑤ D

$$Re\, f^{\frac{1}{2}}\, \frac{D^{\frac{3}{2}}}{\nu}\left[\frac{2gh_f}{L}\right]^{\frac{1}{2}}$$



$Re \rightarrow v \rightarrow Q$

" Case 2 "

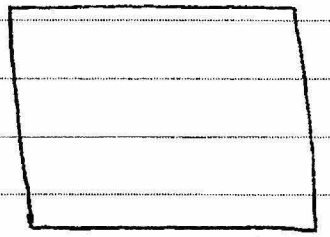
$$Q = 2.22\, D^{\frac{5}{2}} \left[\frac{g\, hf}{L}\right]^{\frac{1}{2}} \log \left[\frac{Ks}{3.7d} + \frac{1.78 * \nu}{D^{\frac{3}{2}}\sqrt{\frac{ghf}{L}}}\right]$$

(3)

Case 3 Required D

Q , head Loss (pressure drop) kind of pipe

?



Ks ?
D ?

$$Re = \frac{VD}{\nu} \qquad D = 0.66 \left[Ks^{1.25} \left(\frac{L Q^2}{ghf}\right)^{4.75} + \nu Q^{9.4} \left(\frac{L}{ghf}\right)^{5.2} \right]^{0.04}$$

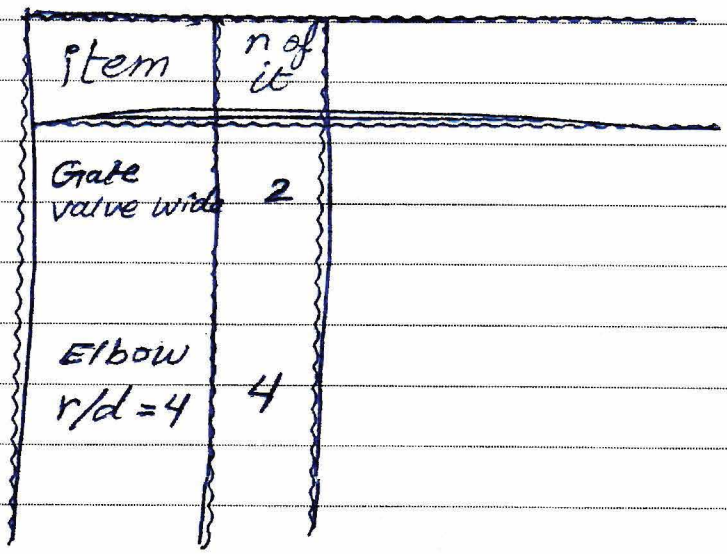
(2) Q
(3) D
Ks
L
(1) hf

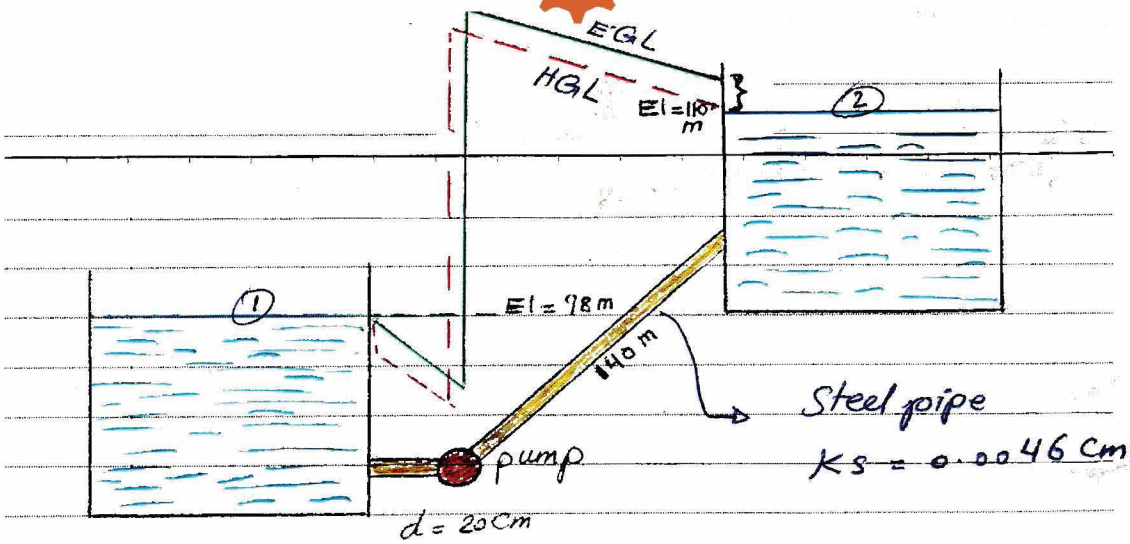
Ch. 10

Ex 8 determine the required power that must be supplied by the pump to lift oil [S.G = 0.94 & Kinematic viscosity $10^{-5}\ m^2/s$]

From the low reservoir to upper one with $0.2\ m^3/s$ Volumetric flow rate. the Following components are used to assemble the pipes but are not shown in the Fig.

Also Sketch the HGL & EGL For the Shown system.





$$\frac{P_1}{\gamma} + \alpha_1 \frac{v_1^2}{2g} + z_1 + hp = \frac{P_2}{\gamma} + \alpha_2 \frac{v_2^2}{2g} + z_2 + ht + hL$$

$$hp = (z_2 - z_1) + hL$$

$$= (z_2 - z_1) + \frac{fL}{D}\frac{v^2}{2g} + \sum K \frac{v^2}{2g}$$

$K_{ent} + K_{exit} + 2K_G v_t$

$4Re^{13}\frac{v^2}{2g}$

$$Q = vA$$

$$v = \frac{Q}{A} = \frac{4Q}{\pi D^2} = \frac{(4)(0.2)}{\pi (0.2)^2} = 6.37 \text{ m/s}$$

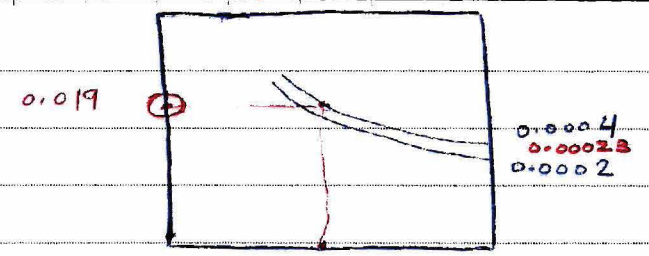
$$Re = \frac{vD}{\nu} = \frac{(6.37)(0.2)}{10^{-5}} = 1.27 * 10^5$$ turbulent

$$\frac{Ks}{D} = \frac{0.00046}{0.2} = 0.00023$$ moody

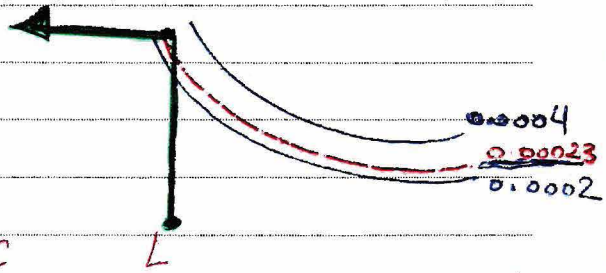
moody

swamee

$$f = \frac{0.25}{\left(\log\left[\frac{0.00023}{3.7} + \frac{5.74}{(1.27 * 10^5)^{0.9}}\right]\right)^2} = 0.0184$$



item	K
Entrance	0.5
Exit	1.0
K valve	0.2
K elbow	0.16



$$h_p = (110 - 98) + \frac{6.37^2}{19.62}\left[\frac{0.0184 * 140}{0.2} + 0.5 + 1 + 2(0.2) + 4(0.16)\right]$$

$$= 12 + 31.89 = 43.89 \text{ m}$$

$$\dot{W}_p = \gamma Q h_p = (0.94)(9810)(0.2)(43.89) = 80945.4 \text{ W} = 80.94 \text{ KW}$$

if $\eta_p = 0.92$ What is required Electrical power

$$\dot{W}_s = \frac{\dot{W}_p}{\eta_p} = \frac{80.94}{0.92} = 87.98 \text{ KW}$$

$$\eta_p = \frac{W_p}{W_s} \quad \text{output} \rightarrow \text{مفيد} \quad \text{input} \rightarrow \text{داخله}$$

$$\eta_t = \frac{W \text{ output}}{W t}$$

(2) استخدم v وليس Q

benZene [SG = 0.876 $\eta = 0.601 * 10^{-3}$ Pa.s]

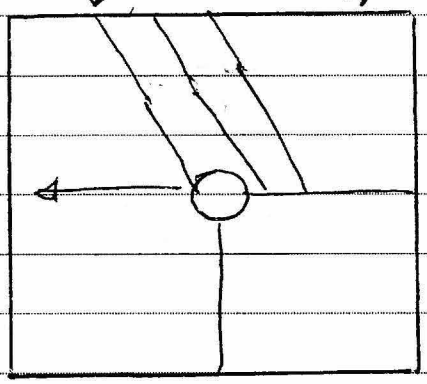
flows through a 12 nominal sch 80

steel pipe [ID = 0.2889 m $\varepsilon = ks = 0.00046cm$]

the pressure drop at points 850 m a part is 34 KPa

Determine Q = ??

$$Ref^{\frac{1}{2}} = \frac{D^{\frac{3}{2}}}{\nu}\left(\frac{2ghf}{L}\right)^{\frac{1}{2}}$$



$\frac{ks}{D}$

$$Re = \frac{vD}{\nu}$$

قانون

$$Q = -2.22 D^{\frac{5}{2}}\left(\frac{ghf}{L}\right)^{\frac{1}{2}} \log\left(\frac{ks}{3.7D} + \frac{1.78\nu}{D^{\frac{3}{2}}\left(\frac{ghf}{L}\right)^{\frac{1}{2}}}\right)$$

$$D = 0.66\left[ks^{1.25}\left(\frac{LQ^2}{ghf}\right)^{4.75} + \nu Q^{9.4}\left(\frac{L}{ghf}\right)^{5.2}\right]^{0.04}$$

example benzene S.G = 0.876

$\eta = 0.601 * 10^{-3}$ Pa.s

ID = 0.2889 m Ks = 0.0046 Cm

L = 350 m ΔP = 34 KPa

$$Q = -2.22 D^{\frac{5}{2}} \left(\frac{g\,hf}{L}\right)^{\frac{1}{2}} Log\left(\frac{Ks}{3.7D} + \frac{1.78\,\vartheta}{D^{\frac{3}{2}}\sqrt{\frac{g\,hf}{L}}}\right)$$

$$\vartheta = \frac{\eta}{\rho} = \frac{0.601 * 10^{-3}}{0.876 * 1000} = 6.86 * 10^{-7}\ m^2/s$$

$$hf = \left(\frac{P_1}{\gamma} + Z_1\right) - \left(\frac{P_2}{\gamma} + Z_2\right) = \frac{34 * 10^3}{9810 * 0.876} = 3.96\ m$$

$$Q = -2.22 (0.2889)^{\frac{5}{2}} \left(\frac{2 * 9.81 * 3.96}{350}\right)^{\frac{1}{2}} \log 2$$

$$\log\left(\frac{0.0046 * 10^{-2}}{3.7 * 0.2889} + \frac{1.78 * 6.86 * 10^{-7}}{(0.2889)^{\frac{3}{2}}\sqrt{\frac{19.62 * 3.96}{350}}}\right)$$

$$Q = 0.1385\ \frac{m^3}{s}$$

From moody Charat :-

$$\frac{Ks}{D} = \frac{0.000046}{0.2889} = 0.00016$$

$$Ref^{\frac{1}{2}} = \frac{D^{\frac{3}{2}}}{\vartheta}\left(\frac{2g\,hf}{L}\right)^{\frac{1}{2}}$$

$$= \frac{(0.2889)^{\frac{3}{2}}}{6.86 * 10^{-7}}\left(\frac{19.62 * 3.96}{350}\right)^{\frac{1}{2}} = 1.066 * 10^{+5}$$

Moody إلناتج لفوق ←

$f = 0.018$

$Re = 8 * 10^5$

$R = 8.43 * 10^5$

From Re

$$R = \frac{vD}{\nu}$$

$$8 * 10^5 = \frac{v * 0.2889}{6.86 * 10^{-7}} \longrightarrow 2.17 \ m/s$$

$$Q = vA = 2.17 * \frac{\pi}{4}(0.2889)^2 = 0.142 \ m^3/s$$

from f ≃

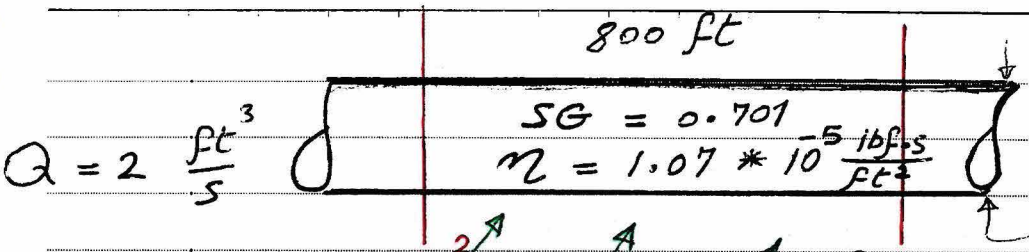
$$h_f = 3.96 = \frac{0.0145 * 350}{0.2889} * \frac{v^2}{19.62}$$

$$v = 2.1 \ m/s$$

and $Q = 0.138 \ m^3/s$

(3) Ex :- a riveted steel pipe line [$K_s = 0.0165$ ft] used to convey (ينقل من مكان إلى آخر) a 2 ft^3/s of gasoline [S.G = 0.701, $\eta = 1.07 * 10^{-5} \ \frac{lbf \cdot s}{ft^2}$] a distance of 800 ft the available pump can overcome a pressure drop of 40 psi select a suitable pipe size For the installation

$\Delta P = 40 \frac{lbf}{in^2}$



$$\frac{P_1}{\gamma} + \alpha_1 \frac{v_1^2}{2g} + z_1 - h_p = \frac{P_2}{\gamma} + \alpha_2 \frac{v_2^2}{2g} + z_2 + h_t + h_L$$

ملغي لأنها ثابتة وأيضا مقطع ثابت

$$\frac{P_1 - P_2}{\gamma} = h_L = h_f = \frac{fL}{D} \frac{v^2}{2g}$$

$$P_1 - P_2 = 40 \frac{lbf}{in^2} * \frac{144\ in^2}{1\ ft^2}$$

$$= 5760 \frac{lbf}{ft^2}$$

$$h_f = \frac{P_1 - P_2}{\gamma} = \frac{5760}{(0.701)(1.94)(32.2)} =$$

$$= 131.5\ ft$$

$$v = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

$$v^2 = \frac{Q^2}{A^2} = \frac{16 Q^2}{\pi^2 D^4}$$

$$h_f = \frac{fL}{D} \cdot \frac{v^2}{2g}$$

$$h_f = \frac{fL}{D} \cdot \frac{16Q^2}{\pi^2 D^4} \cdot \frac{1}{2g} = \frac{8 f L Q^2}{\pi^2 D^5 g}$$

$$D^5 = \frac{8 f L Q^2}{\pi^2 g h_f}$$

ثوابت

$$D = \left[\frac{8 L Q^2}{\pi^2 g h_f}\right]^{\frac{1}{5}} \cdot f^{\frac{1}{5}}$$

تحويلات

$1\ ft = 12\ in$

$1\ ft^2 = (12\ in)^2$

$= 144\ in^2$

$\rho = 1000 \frac{kg}{m^3} * \left(\frac{0.3048\ m}{1\ ft}\right)^3 * \frac{1\ slug}{14.59\ kg} = 1.94 \frac{slug}{ft^3}$

$g = 9.81 \frac{m}{s^2} * \frac{1\ ft}{0.3048} = 32.18$

$\cong 32.2$

$0.906633 \cong 0.907$

$$D = \left[\frac{8 * 800 * 2^2}{\pi^2 * 32.2 * 131.5}\right]^{\frac{1}{5}} * f^{\frac{1}{5}} \qquad \frac{1}{5} = 0.2$$

$$D \cong 0.907 f^{0.2}$$

★ هنا يبدأ الصعب فيزيا

Assume $f = 0.03$

$$D = (0.907)(0.03)^{0.2} = 0.449 \text{ ft}$$

$$\frac{Ks}{D} = \frac{0.0165}{0.449} = 0.036$$

$$Re = \frac{(0.701)(1.94)\left[\frac{4(2)}{\pi(0.449)^2}\right](0.449)}{1.07 * 10^{-5}}$$

(ρ = 0.701, v = $\left[\frac{4(2)}{\pi(0.449)^2}\right]$, D = 0.449, $\eta = 1.07 * 10^{-5}$)

$$Re = 7.21 * 10^5$$

نفترض F ← تطلع D منها تطلع C_d

ثم تطلع Re وتطلع $\frac{Ks}{D}$

$f = 0.062$ اعتمد بالجدول

$$D = (0.907)(0.062)^{0.2} = 0.52 \text{ ft}$$

إعادة

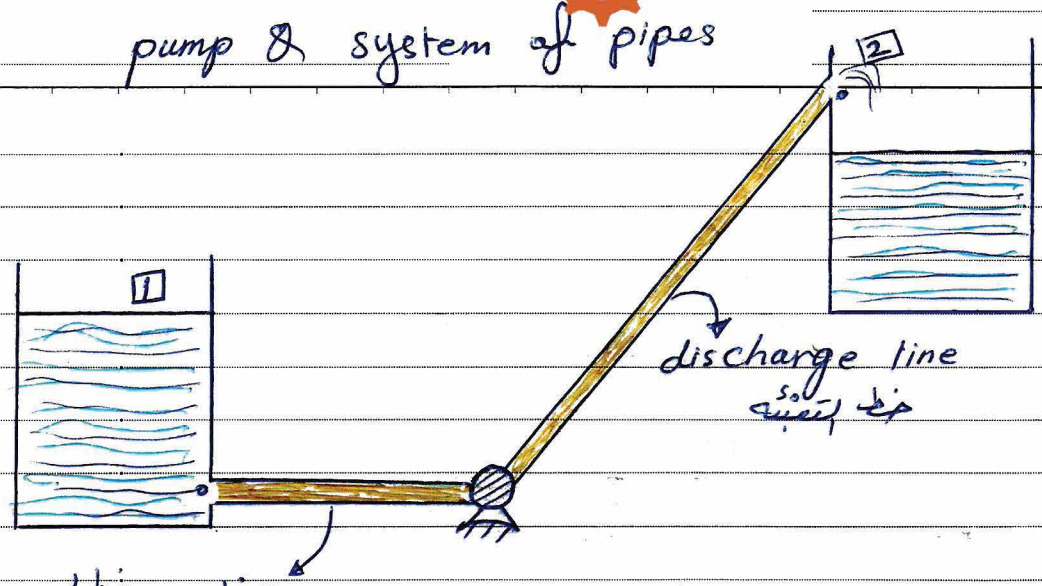
$$\frac{Ks}{D} = \frac{0.0165}{0.52} = 0.0317$$

$$Re = \frac{(0.701)(1.94)\left[\frac{4(2)}{\pi(0.52)^2}\right](0.52)}{1.07 * 10^{-5}} \cong 6.22 * 10^5$$

$f = 0.0586$

$$D = (0.907)(0.0586)^{0.2} = 0.514$$

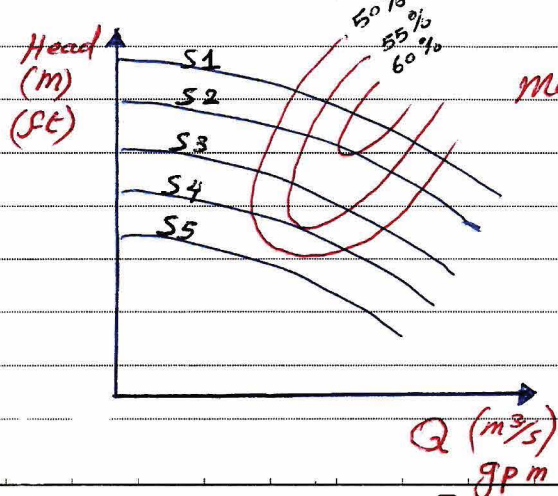
pump & system of pipes



Centrifugal pump :— is a machine that Used a set of rotating blades situated with in a housing to add energy to a Flowing Fluid .

the Energy added to the Fluid is represented by the head of the pump

$$\dot{W} = P = \gamma Q h_p$$

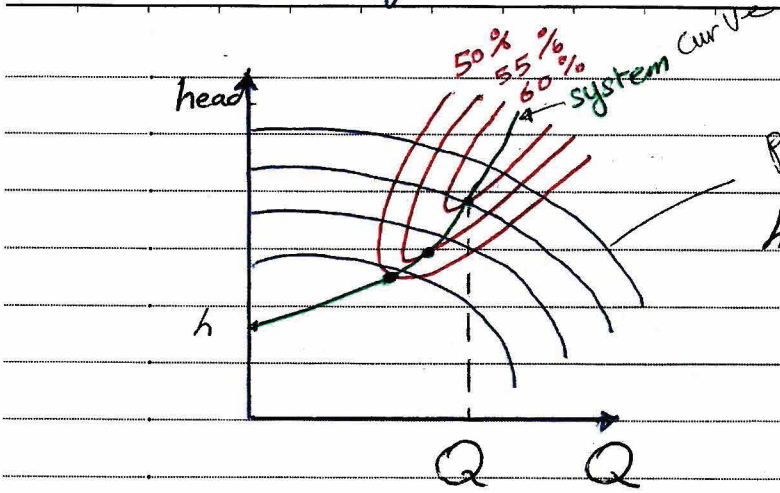


من manufacturer

تناسب عكسي مع (Q)

(hp)

pumps :-

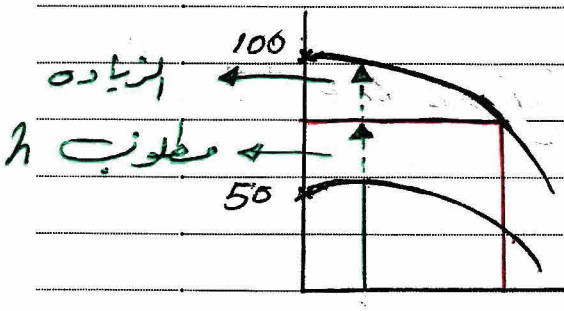


$$h_p = z_2 - z_1 + \frac{v^2}{2g}\left[\sum \frac{fL}{D} + \sum k\right]$$

4.2 15- 20%

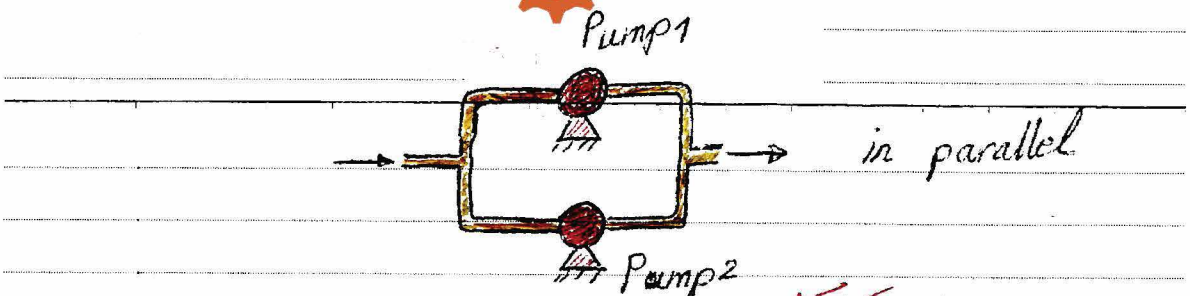
$$\eta_p = \frac{\dot{W}_P}{W_{supply}} \qquad W_s = \frac{W_P}{\eta}$$

Connection of pumps

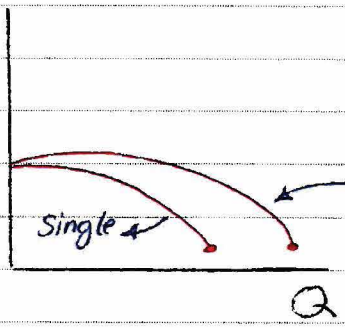


two pumps in series

على التوالي يرفع أو يزيد الرفع



نفس الإرتفاع لكل كلب الطلمبة



Example the Following table provides the results of a pumps performance test

1	Q discharge (gpm) →	0	200	400	600	800	1000
2	h (ft) ↑	150	145	135	120	90	50

1+2 ① plot characteristic are for single pump

1+3 ② ″ ″ ″ for two pumps in series

2+4 ③ ″ ″ ″ for two pumps in parallel

④ what pumps configuration is required for flow rate of 1700 gpm & head loss of 60 ft

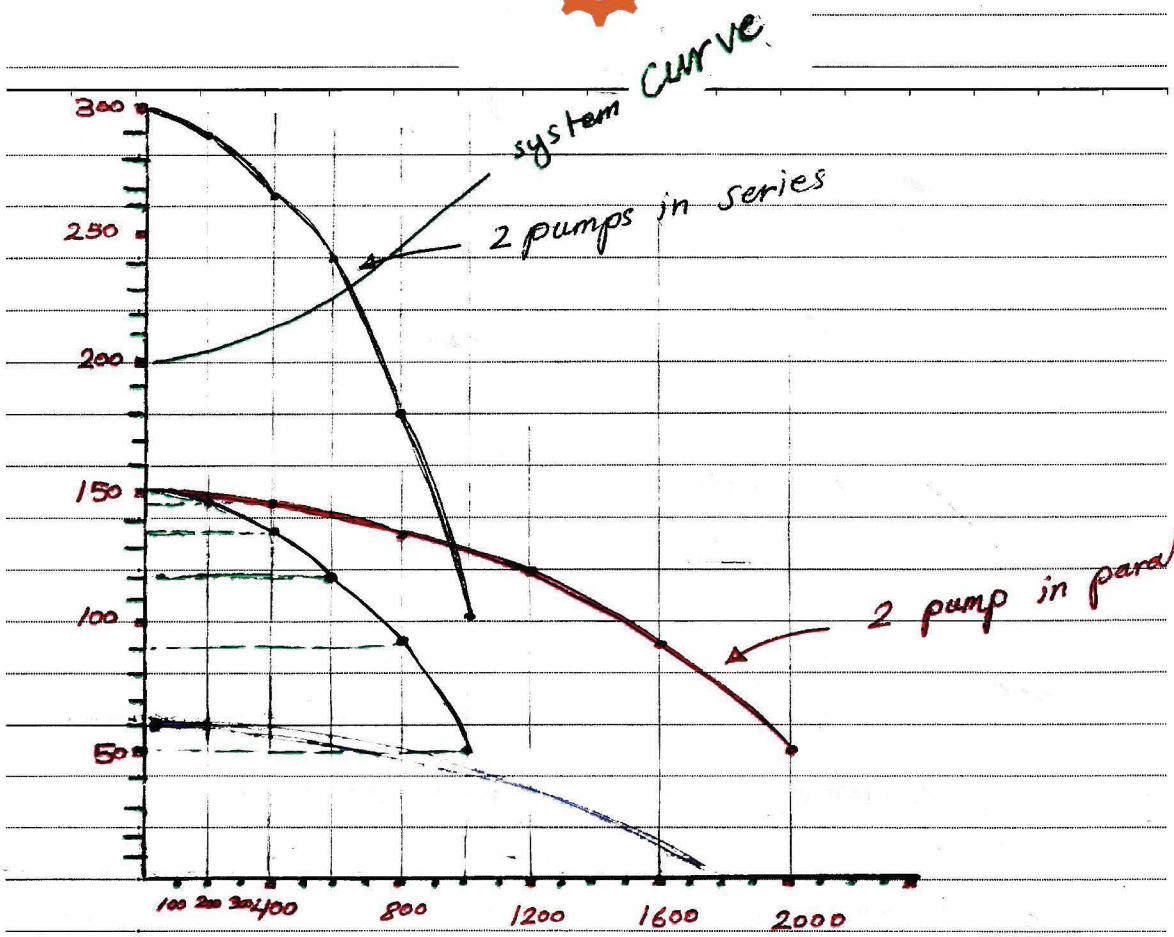
⑤ what pumps configuration is required for flow rate of 1700 gpm & head loss of 170 ft

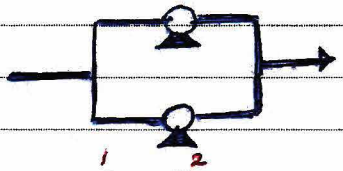
3 two pumps in series (h)

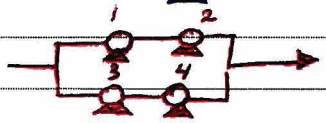
300 290 270 240 180 100

4 two pumps in parallel (Q)

0 400 800 1200 1600 2000



(4)  its need 2pumps in parallel

(5)  its needs 4 pumps two parall with two series

$$\frac{P_1}{\gamma} + \alpha_1 \frac{v_1^2}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \alpha \frac{v_2^2}{2g} + Z_2 + h_t + h_L$$

$$h_p = (Z_2 - Z_1) + h_L \begin{cases} \frac{fL}{D}\frac{v^2}{2g} \\ h_{L\,min} \sum K \frac{v^2}{2g} \end{cases}$$

$$h_p = (Z_2 - Z_1) + \frac{v^2}{2g}\left(\frac{\sum FL}{D} + \sum K\right)$$

$$v = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

$$v^2 = \frac{16Q^2}{\pi^2 D^4}$$

$$h_p = (Z_2 - Z_1) + \frac{16Q^2}{2\pi^2 D^4 g}$$

$$h_p = \text{——} + (\quad) Q$$

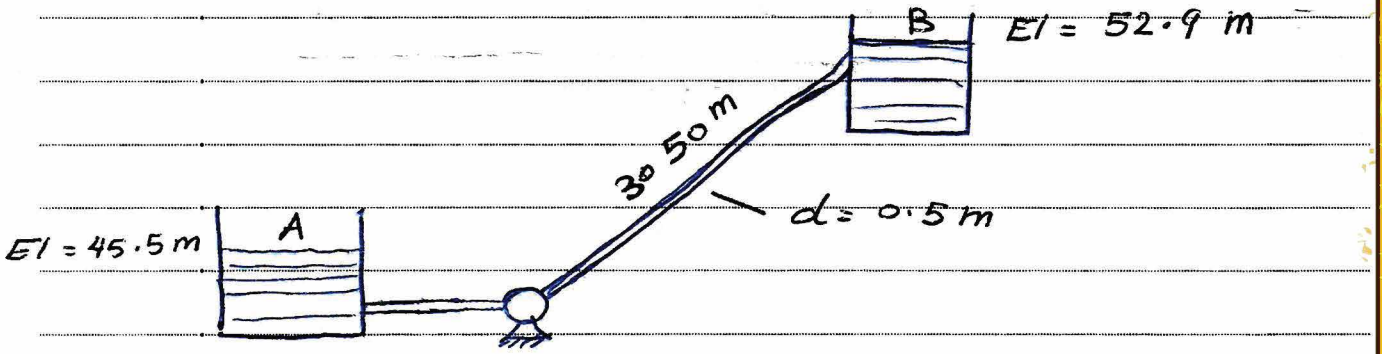
Ex :- Consider a pump-pipe line system that delivers water From reservoir A [$E_A = 45.5\ m$] to reservoir B [$E_B = 52.9\ m$]
the length of pipe is 3050 m and has a diameter of 0.5 m and $f = 0.02$

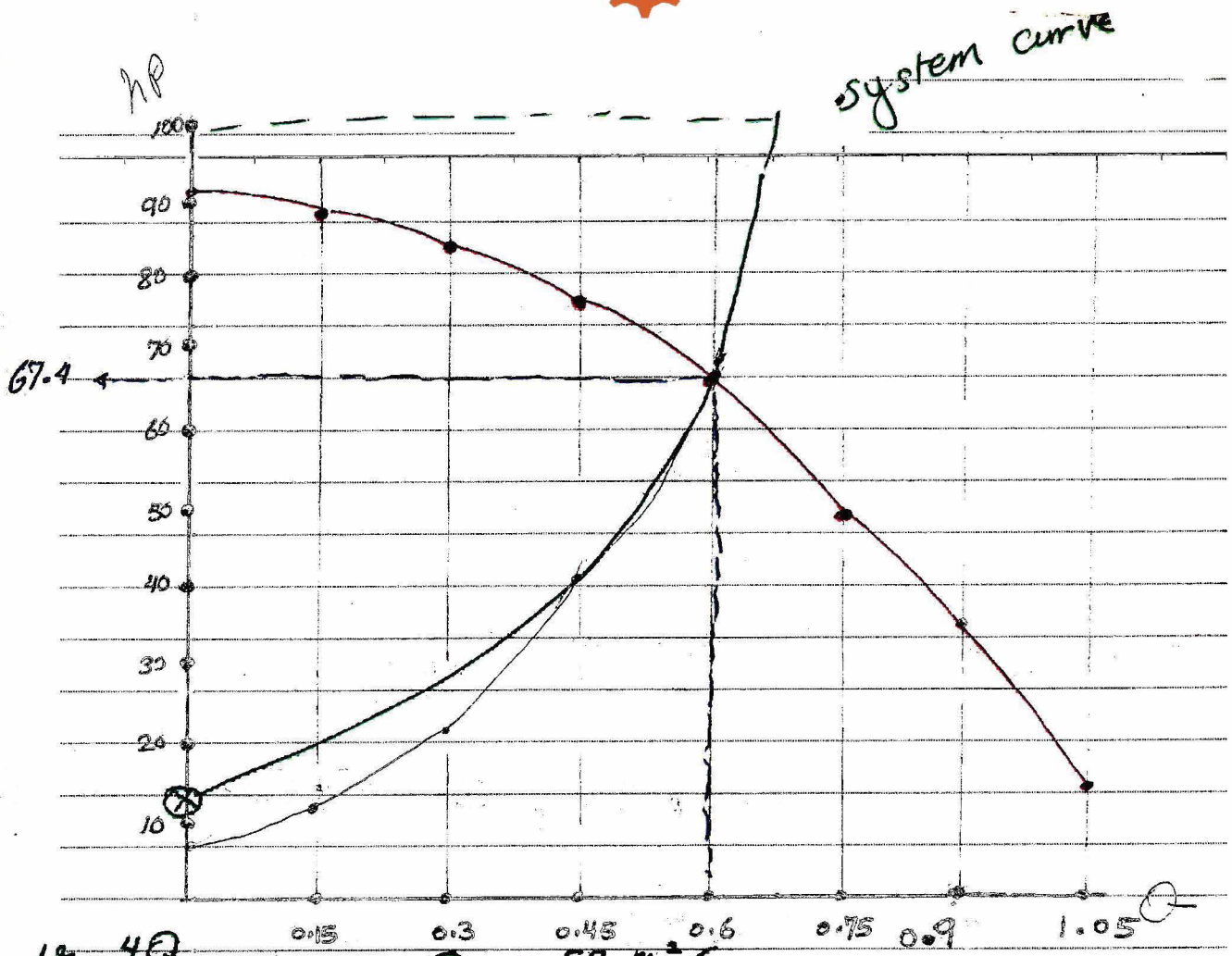
the performance test gives

$Q\ m^3/s$	$h(m)$	hp
0	91.4	7.4
0.15	89.8	
0.3	85.1	22.44
0.45	77.2	67.4
0.60	65.9	~~101.2~~
0.75	52.6	
0.9	36.3	
1.05	15.7	

Minor losser include
① Entrance
② Exit
③ swing type Check valve
$K = 2.5$

Determine Q discharge





$Q = 0.59\ m^3/s \longrightarrow V = \frac{4Q}{\pi D^2}$

$$h_p = (Z_B - Z_A) + \frac{v^2}{2g}\left[\frac{fL}{D} + K_{ent} + K_{ent} + K_{valve}\right]$$

$$= (52.9 - 45.5) + \frac{16Q^2}{\pi^2 D^4 (19.62)}\left[\frac{0.02 * 3050}{0.5} + 0.5 + 1 + 2.5\right]$$

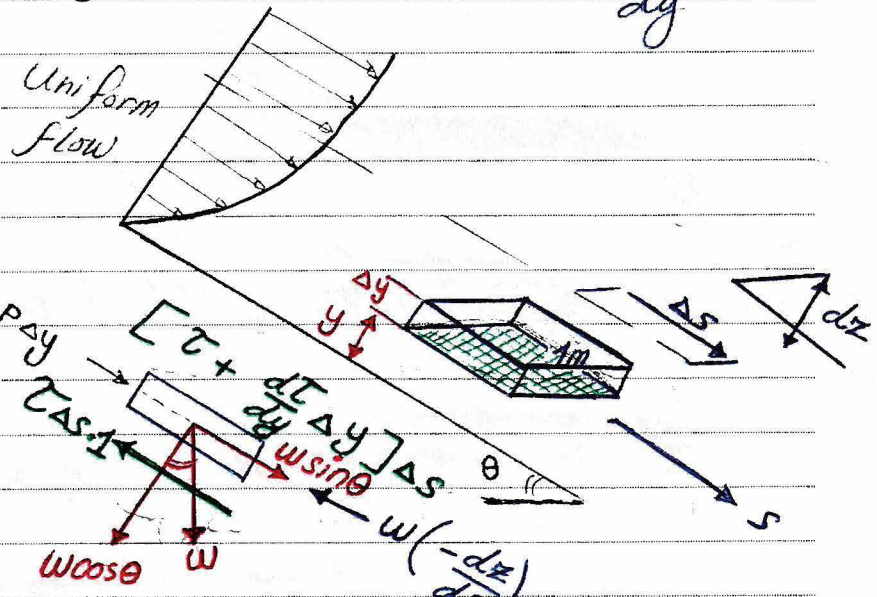
$$= \boxed{h_p = 7.4 + 166.74Q^2}$$

Ch.. 9

Surface Resistance.

viscous Shear stresses ⟶ drag force

Laminar Flow τ = Shear stress = $\eta \frac{du}{dy}$



Momentum Eqn reduced to

$\Sigma F_s = 0$

$$p\Delta y - \left[P + \frac{dP}{ds}\Delta s\right]\Delta y + \left[\tau + \frac{d\tau}{dy}\Delta y\right]\Delta s - \tau\Delta s + \gamma \Delta s A_y \left(\frac{-dz}{ds}\right) = 0$$

تسرع Shear stress

$$\frac{d\tau}{dy}\Delta s \Delta y = \frac{dP}{ds}\Delta s \Delta y + \gamma \Delta s \Delta y \frac{dz}{ds}$$

$$\frac{d\tau}{dy} = \frac{d}{ds}\left[P + \gamma z\right]$$

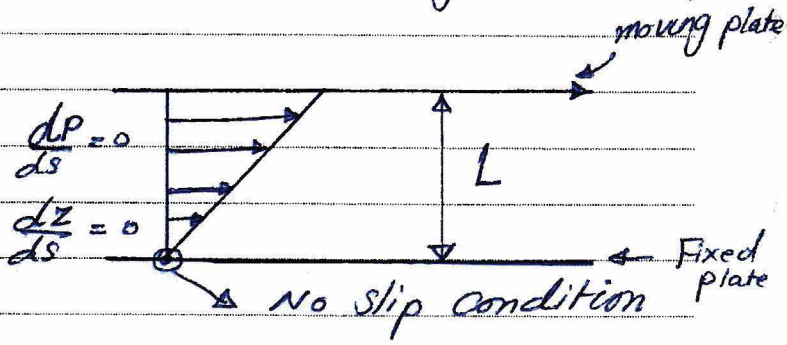
Shear stress gradient is Equal to piezometric pressure gradient

$$\frac{d\tau}{dy} = \gamma \frac{d}{ds}\left[\frac{P}{\gamma} + z\right]$$

$$\frac{d\tau}{dy} = \gamma \frac{dh}{ds}$$

Coutlee Flow :- No pressure gradient

horizontal plate



Laminar flow

$$\tau = \eta \frac{du}{dy}$$

$$\frac{d\tau}{dy} = \eta \frac{d^2u}{dy} = \frac{d}{ds}\left[p + \gamma z\right]$$

$$\frac{d^2u}{dy^2} = \frac{\gamma}{\eta}\frac{dh}{ds} \quad \star$$

Boundary condition

at $u = 0 \quad y = 0$

at $u = u \quad y = L$

Eqn $\star$ reduced to $\frac{d^2u}{dy^2} = 0.0$

$$\frac{du}{dy} = C_1 \qquad u = C_1 y + C_2$$

Using B.C at $\boxed{C_2 = 0.0}$

Using B.C (b) $C_1 = \frac{u}{L}$

$$\boxed{u = \frac{y}{L} u}$$

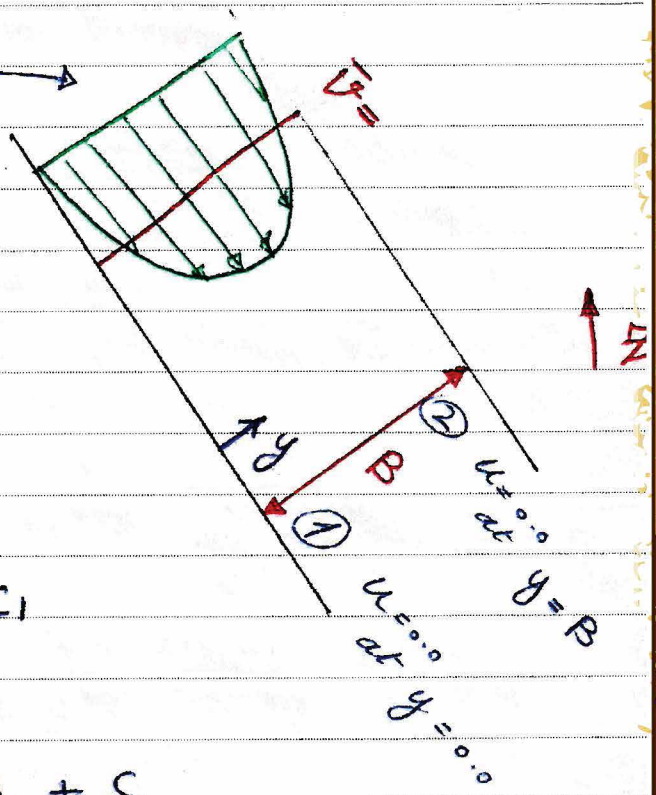
this Eqn shows that velocity varies linear with distance from the wall

9.1
9.2

☆ Uniform flow between two parallel plate

Uniform flow →

velocity is a function of y only



$$\frac{d^2u}{dy} = \frac{\gamma}{\eta}\frac{dh}{ds}$$

نكامل

$$\frac{du}{dy} = \frac{\gamma}{\eta}\frac{dh}{ds}y + C_1$$

$$u = \frac{\gamma}{2\eta}\frac{dh}{ds}y^2 + C_1y + C$$

Use b.c ① $C_2 = 0.0$

$$0 = \frac{\gamma}{2\eta}\frac{dh}{ds}B^2 + C_1B$$

$$C_1 = \frac{-\gamma}{2\eta}\frac{dh}{ds}B$$

$$u = \frac{-\gamma}{2\eta}\frac{dh}{ds}\left[By - y^2\right]$$

max. velocity will be @ the mid plane

$$v_{max} = \frac{-\gamma}{2\eta}\left[\frac{dh}{ds}\right]\left[\frac{B^2}{2} - \frac{B^2}{4}\right]$$

$$= \frac{-\gamma}{8\eta}\left[\frac{dh}{ds}\right]B^2$$

Flow rate per Unit width q $\bar{v} = \frac{q}{B} =$

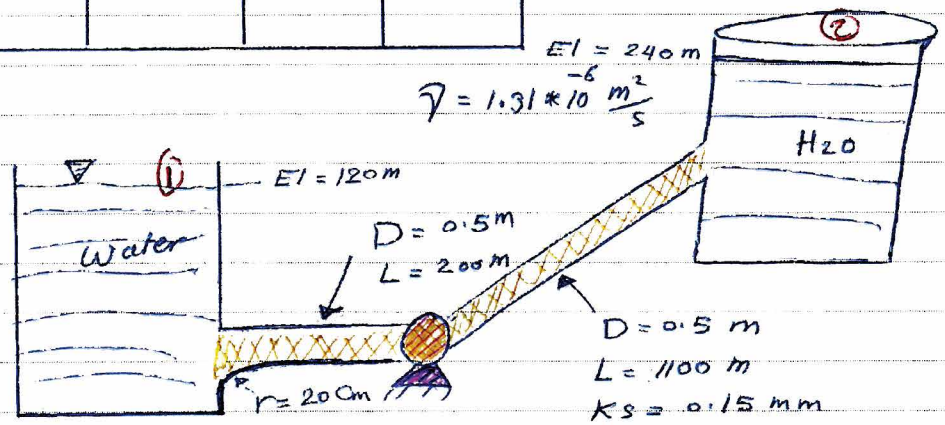
$$= -\frac{B^2\gamma}{12\eta}\frac{dh}{ds}$$

$$q = \frac{B^3\gamma}{12\eta}\frac{dh}{ds} = \int_0^B u\,dy \quad \frac{\bar{v}}{d_{max}} = \frac{2}{3}$$

Example For the pump pipe line system shown in fig Determine Q(m^3/s) and the velocity in the 0.5m pipe

الحل

Item	No of it	Item	No of it
gate valve	2	Smooth elbow $\frac{r}{d}=2$	3
globe valve	1		
ho			



pump Chavastrastic

Q (m^3/s)	0.0	0.1	0.2	0.3	0.4	0.5	0.6
h (m)	130	129	124	114	96	73	43

وكل عام وانتم بخير
بمناسبات النور الحبيب
أبي العلاء
كتابه الطالب / خالد عمان العتيبي