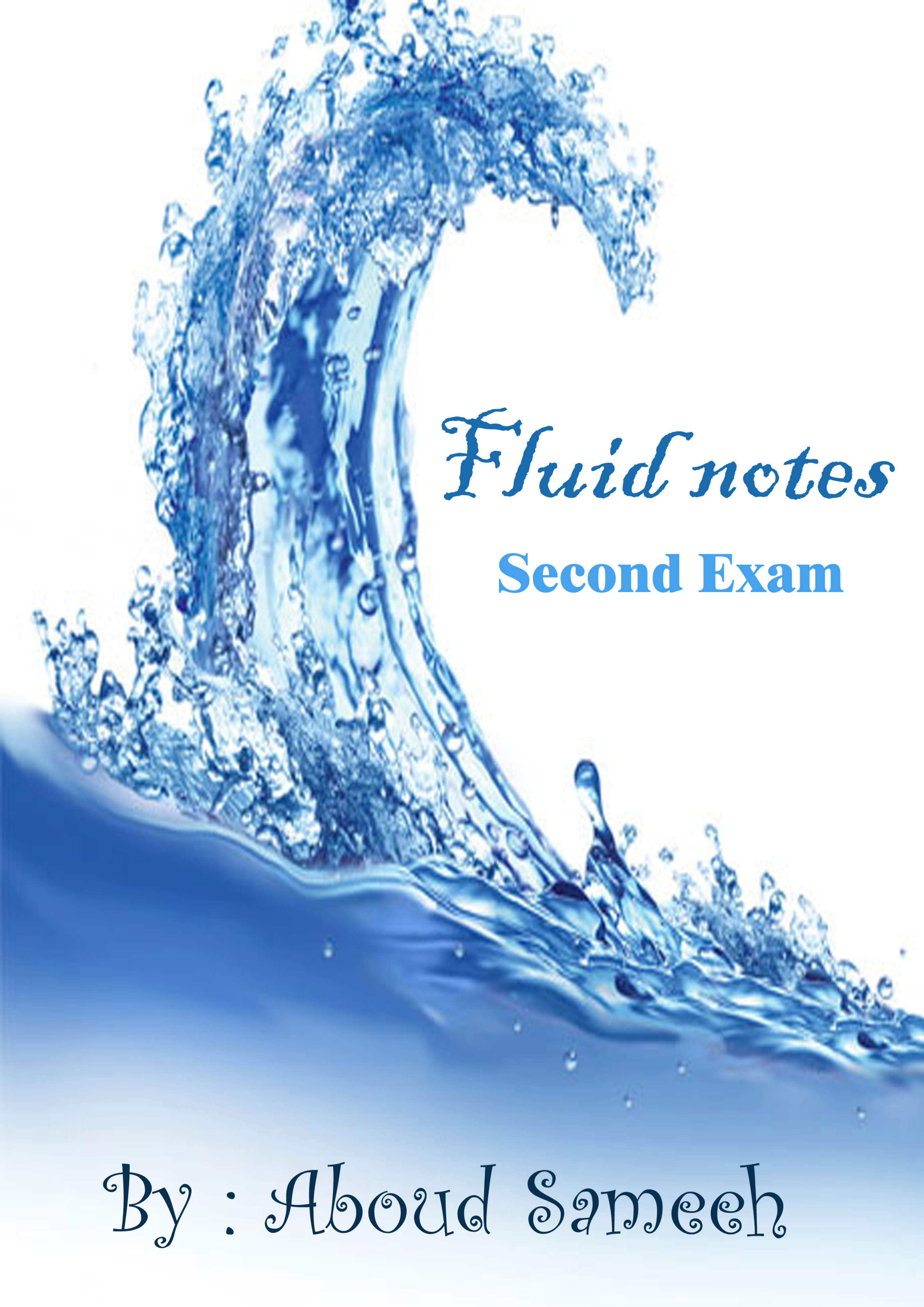


Fluid notes

Second Exam

By : Aboud Sameeh

ch #4:- The Bernoulli equation & pressure variation:

→ pressure variation occur due to: 1- elevation (Hydrostatic forces)
2- acceleration

* througout the previous analysis, we were studying the fluid @ rest only; in these chapters; the pressure variation can occur due to acceleration "motion".

* fluid in motion: (Indicates velocity, acceleration and forces)

* في المواضيع السابقة كنا ندرس الاختلاف في الضغط والمائع في حالة السكون --- والآن سندرس الموائع في حالة الحركة!!

→ there are two approachs to study the moving body:

1. Lagrangian approach: describes the motion of the body of matter of fixed Identity, so it's suitable for "Dynamics"
2. Eulerian approach: describes the motion of matter at spatial locations; so all mathematical equation in fluid mechanics written using this approach.

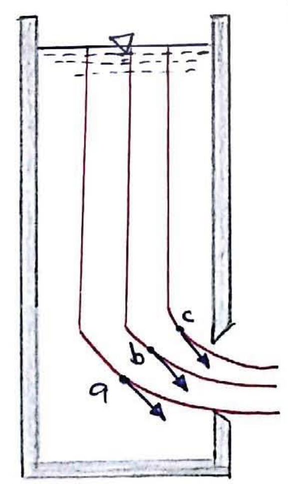
* لهذا السبب نلاحظ أنه (Eulerian approach) هو الأنسب في دراسة الموائع المتحركة، وهو يعتمد على مراقبة نقطة معينة يمر بها المائع أثناء مرور الزمن...

→ fluid flow visualisation:

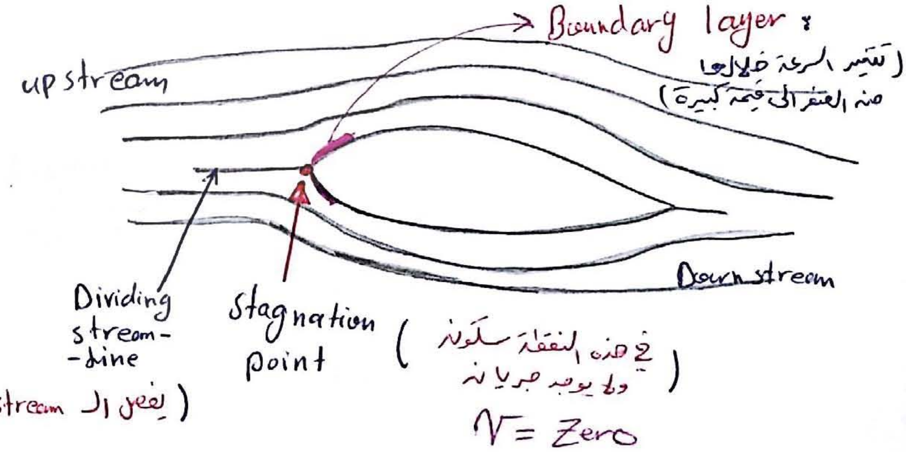
① stream lines: the lines drawn through the flow field in such manner the local velocity vector is tangent to stream line at every point along the line at that instant.

* هذه الخطوط وهمية وترسم حسب الجريان أو التدفق بحيث يكون متجه سرعة جريان المائع الحالية مماساً للخط!!

a, b, c: tangent



(يفصل ال upstream عن ال Downstream)



* Compressible and Incompressible flow: ** check E_v and compressibility!!
  - compressible flow:- density of flowing fluid varies significantly. [$\rho \neq ct$]
  - Incompressible flow:- density of flowing fluid assume constant. [$\rho = ct$]

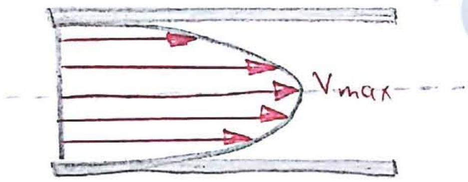
* Laminar, Transition and Turbulent flow:
  * Laminar flow: well ordered flow in which fluid layers moved smoothly with respect to each other.
  * Turbulent flow: the flow in which the mixing effect active.
  * Transitional flow: the transition stage between (laminar to turbulent)

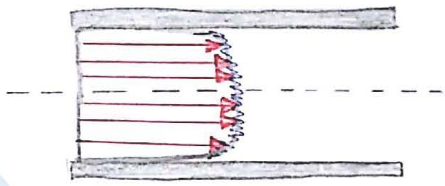
→ for flow in pipes (conduits), Reynolds number used as an index to differ types of flow:

$$R_e = \frac{\rho V D}{\mu} \equiv \frac{V D}{\nu}$$

ρ: density of fluid.
V: velocity of fluid.
D: Hydrodynamic diameter
→ for plate $= L$
→ for circular $= \frac{4A}{P}$ — A مساحة, P محيط

→ If $Re < 2000$, so it's laminar flow.
→ If $Re > 3000$, so it's Turbulent flow.
→ If $2000 < R_e < 3000$, so it's Transition flow.





* velocity profile for fully developed laminar flow; $\bar{V} = \frac{1}{2} V_{max}$
* for Turbulent flow: $\bar{V} = (0.8-0.9)\, V_{max}$

* Viscouss and non-viscouss flow:
  → viscouss flow: the flow in which the fluid has large viscouss forces enough to effect the motion of the fluid.

* Bounded, non-Bounded and semi Bounded flow:
  * Bounded: the flow which bounded by aphysical system such as "pipe"
  * semi-Bounded: the flow which partially bounded by aphysical system "open chann
  * non-Bounded: the flow with no physical bounded system "sprays"

* one - two and three dimensional flow:
  - one ↳ x-axis
  - two ↳ x-axis, y-axis
  - three ↳ x-axis, y-axis, z-axis

- now; according to streamlines and Eulerian approach we can conclude:

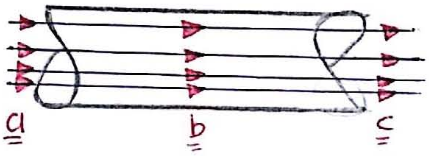
$$V = V(s, t) \quad ; \text{ So:}$$

position (s) — time (t)

magnitude — Direction

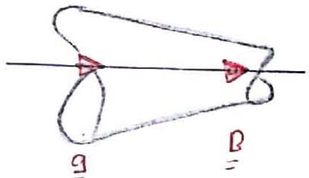
① Uniform and non uniform flow:

* Uniform flow: the flow in which velocity vector does not change from a point to another along stream line. $\left[\frac{\partial V}{\partial s} = 0.0 \right]$



*Uniform flow (No change Neither in magnitude nor direction)

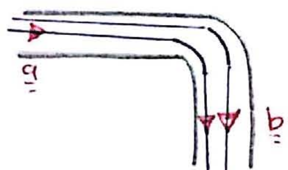
$\frac{\partial V}{\partial s} = 0.0$



* non-uniform flow

"change in magnitude"

$\frac{\partial V}{\partial s} \neq 0.0$



* non-uniform flow

"change in direction"

$\frac{\partial V}{\partial s} \neq 0.0$

② Steady and unsteady flow:

* steady flow: the velocity at a given point on a fluid path does not change with time $\left[\frac{\partial V}{\partial t} = 0.0 \right]$

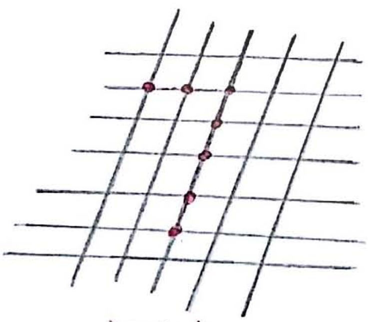
and If unsteady $\rightarrow \left[\frac{\partial V}{\partial t} \neq 0.0 \right]$

* pathlines & streaklines: also used commonly in fluid flow visualisation!!

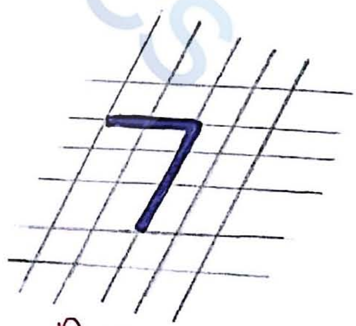
- Path line: the path of a fluid particle as it moves through the flow field.

وعلينا تمييز هذا النوع من خلال وضع ضوء في المائع عند جريانه وتتبعه...

- Streak line: the path (line) generated by tracing fluid; such as dye which injected continuously in flow



light



Dye

* **Acceleration**: it's the rate of change in velocity with respect to time

$$① \cdot \; V = V(s,t)\, e_t$$

$$a = \frac{\partial v}{\partial t} = V(s,t)\frac{\partial e_t}{\partial t} + \frac{\partial V}{\partial t} e_t$$

→ chain Rule derivative

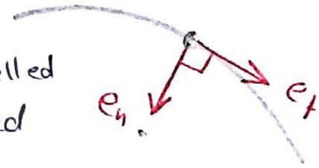
$$= V(s,t)\frac{\partial e_t}{\partial t} + \left(\frac{\partial V}{\partial s}\cdot\frac{\partial s}{\partial t} + \frac{\partial V}{\partial t}\,\frac{\partial t}{\partial t}\right)$$

$$\vec{a} = \Big[\underbrace{\frac{V^2}{r}e_n}_{\text{centripetal acceleration}} + \underbrace{\underbrace{V\frac{\partial V}{\partial s}}_{\text{convective acceleration}} + \underbrace{\frac{\partial V}{\partial t}}_{\text{local acceleration}}}_{\text{tangential acceleration}}\Big]$$

note: $\frac{\partial e_t}{\partial t} = \frac{V}{r} e_n$

r: radius of curvature

e_n: unit vector directed to the center.



→ If the flow is uniform → $\left[\frac{\partial V}{\partial s} = 0.0\right]$, convective acc. cancelled

→ If the flow is steady → $\left[\frac{\partial V}{\partial t} = 0.0\right]$, local acc. cancelled

also: "Eulerian approach"

$$u = f(x, y, z, t)$$
$$v = f(x, y, z, t)$$
$$w = f(x, y, z, t)$$

$$a_x = \frac{du}{dt} = \frac{\partial u}{\partial x}\frac{\partial x}{\partial t} + \frac{\partial u}{\partial y}\frac{\partial y}{\partial t} + \frac{\partial u}{\partial z}\frac{\partial z}{\partial t} + \frac{\partial u}{\partial t}$$
$$a_y = \frac{dv}{dt} = \frac{\partial v}{\partial x}\frac{\partial x}{\partial t} + \frac{\partial v}{\partial y}\frac{\partial y}{\partial t} + \frac{\partial v}{\partial z}\frac{\partial z}{\partial t} + \frac{\partial v}{\partial t}$$
$$a_z = \frac{dw}{dt} = \frac{\partial w}{\partial x}\frac{\partial x}{\partial t} + \frac{\partial w}{\partial y}\frac{\partial y}{\partial t} + \frac{\partial w}{\partial z}\frac{\partial z}{\partial t} + \frac{\partial w}{\partial t}$$

} chain Rule derivatives

$$\Rightarrow \; a_x = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} + \frac{\partial u}{\partial t}$$
$$a_y = u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} + \frac{\partial v}{\partial t}$$
$$a_z = \underbrace{u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z}}_{\text{Convective acc.}} + \underbrace{\frac{\partial w}{\partial t}}_{\text{local acc.}}$$

→ Convective acceleration: assosiated with the variation of velocity along streamline.

→ local acceleration: assosiated with the change in velocity with respect to time at a certain point on the stream line.

Problem 4-17: the velocity along apath line is given by $[V(m/s) = s^2 t^{1/2}]$, where "s" in meters and "t" in seconds, the radius of curvature is (0.5 m), evaluate the acceleration along and Normal to the path @ $[s = 2m]$ and $[t = 0.5 s]$

Sol:

$$a = \left(V \frac{\partial v}{\partial s} + \frac{\partial v}{\partial t}\right) e_t + \left(\frac{V^2}{r}\right) e_n$$

$$V\Big|_{\substack{s=2m \\ t=0.5s}} = s^2 t^{1/2} = (2)^2 (0.5)^{1/2} = 2.83 \ m/s$$

$$\frac{\partial v}{\partial s} = 2 s t^{1/2}\Big|_{\substack{s=2m \\ t=0.5s}} = 2(2)(0.5)^{1/2} \ 2.83 \ 1/s$$

$$\frac{\partial v}{\partial t} = \frac{1}{2} s^2 t^{-1/2}\Big|_{\substack{s=2m \\ t=0.5s}} = \frac{1}{2}(2)(0.5)^{-1/2} = 2.83 \ m/s^2$$

$$a = \left[(2.83 * 2.83) + 2.83\right] e_t + \left(\frac{2.83^2}{0.5}\right) e_n$$

$$\boxed{a = 10.8 e_t + 16 e_n \ m/s^2}$$

*Examples: for acertain flow field, the velocity of fluid is given by:

$$V = (3xy^2 - 4xt)\hat{i} + (2x^2y - 5t)\hat{j}$$

determine acceleration @ $x = 1m$, $y = 1m$, $t = 2s$!!

Sol: $u = 3xy^2 - 4xt \Rightarrow u = 3(1)(1)^2 - 4(1)(2) = -5 \ m/s$

$\frac{\partial u}{\partial x} = 3y^2 - 4t \Rightarrow \frac{\partial u}{\partial x} = 3(1)^2 - 4(2) = -5$

$V = 2x^2y - 5t \Rightarrow V = 2(1)^2(1) - 5(2) = -8 \ m/s$

$\frac{\partial u}{\partial y} = 6xy \Rightarrow \frac{\partial u}{\partial y} = 6(1)(1) = 6$

* $\frac{\partial u}{\partial t} = -4x = -4(1) = -4$

$$a_x = u \frac{\partial u}{\partial x} + V \frac{\partial u}{\partial y} + \cancel{w \frac{\partial u}{\partial z}} + \frac{\partial u}{\partial t}$$

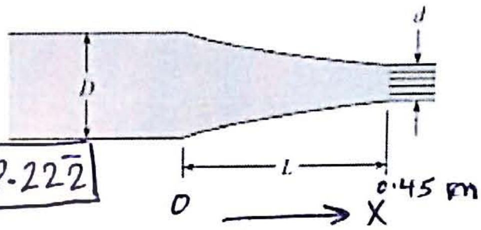
$w = 0$ (2D flow)

$$a_x = \left[(-5 * -5) + (-8 * 6) + (-4)\right] = [25 - 48 - 4] = -27 \ m/s^2$$

$a_y =$ حلها كل بنفس الطريقة ^ ^

Chapter 4: acceleration

Q20 The nozzle in the figure is shaped such that the velocity of flow varies linearly from the base of the nozzle to its tip. Assuming quasi–one-dimensional flow, what is the convective acceleration midway between the base and the tip if the velocity is 0.5 m/s at the base and 1.5 m/s at the tip? Nozzle length is 45 cm



since the velocity is linear, so:

$V = ax + b$

$@\, x = 0\,\text{m} \Rightarrow V = 0.5\,\text{m/s} \Rightarrow 0.5 = a(0) + b \Rightarrow \boxed{b = 0.5}$

$@\, x = 0.45\,\text{m} \Rightarrow V = 1.5\,\text{m/s} \Rightarrow 1.5 = a(0.45) + 0.5 \Rightarrow \boxed{a = 2.22\bar{2}}$

$V\,@\,\text{midway}\ (x = \frac{0.45}{2}) \Rightarrow V = 2.\bar{2}\bar{2}\,(\frac{0.45}{2}) + 0.5$

$\boxed{V = 1\ \text{m/s}}$

$\frac{\partial V}{\partial s} = 2.2\bar{2}\ s^{-1}$

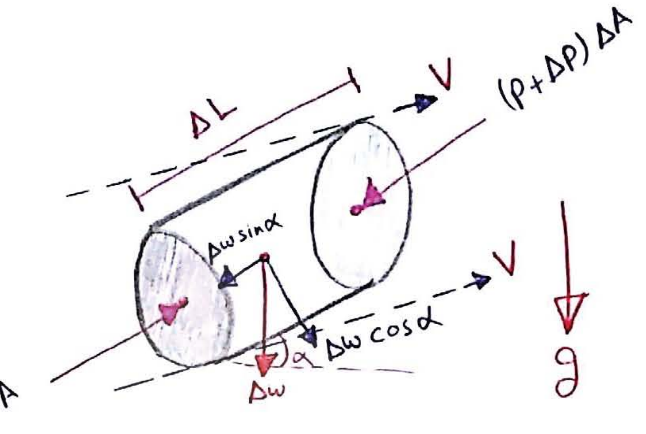
$\partial s \equiv \partial x$

$a_c = V\frac{\partial V}{\partial s} = 1 * 2.2\bar{2} = \boxed{2.\bar{2}2\ \ m/s^2}$

ملاحظة: طالما أن توزيع السرعة (linear) فيمكن حساب السرعة من العلاقة: $\frac{V_{tip} + V_{base}}{2}$ "أيضاً" !!

*Euler's equation:

* element of fluid;
do your analysis ---
apply newtons 2^{nd} law:



* $\Delta w = \gamma \Delta V = \gamma \Delta A \Delta L$
* $\sin\alpha = \frac{\Delta Z}{\Delta L}$
* $\rho = \frac{m}{V}$
* $m = \rho \Delta A \Delta L$

$$\sum F_L = m a_L$$

$$F_{pressure} + F_{gravity} = m a_L$$

$$P\Delta A - \left[(P+\Delta P)\Delta A\right] - \left[\gamma \Delta A \Delta L \frac{\Delta Z}{\Delta L}\right] = (\rho \Delta A \Delta L)\, a_L$$

$\div V$

$$-\Delta P \Delta A - \gamma \Delta A \Delta L \frac{\Delta Z}{\Delta L} = (\rho \Delta A \Delta L)\, a_L$$

$$-\frac{\Delta P}{\Delta L} - \gamma \frac{\Delta Z}{\Delta L} = \rho a_L$$

limit

$$-\frac{\partial P}{\partial L} - \gamma \frac{\partial Z}{\partial L} = \rho a_L \Rightarrow \frac{\partial}{\partial L}(P + \gamma Z) = \rho a_L$$

for incompressible flow ($\gamma = ct$)

Euler's law ^_^

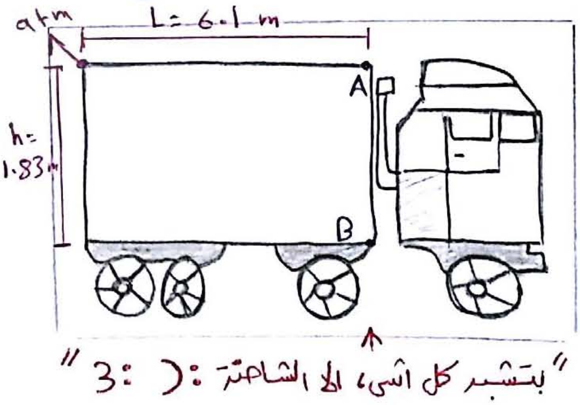
$$\boxed{\frac{\partial}{\partial L}(P+\gamma Z) = -\rho a_L}$$

لاحظنا أن ازدياد الضغط يكون بعكس اتجاه التسارع !!

* example: the tank shown is filled completely with gasoline which has specific weight of (6.6 kN/m³), the truck is decelerating at a rate of (3.05 m/s²)

a) If the tank trailer is (6.1 m long) and if the pressure @ the top rear of the tank is atmospheric, what is the pressur @ A??

b) If the tank is (1.83 m high), what is the maximum pressure in the tank?



"بتشبر كل اشي الا الشاحنة :(:3"

a) from atm to A:

$$\frac{\partial}{\partial L}(P + \gamma Z) = -\rho a_L$$

$$\int \frac{\partial P}{\partial L} + \underbrace{\frac{\partial Z}{\partial L}}_{zero}\gamma = -\rho a_L$$

$$\frac{P_A - P_{atm}}{L} = -\rho a_L$$

لأن التسارع سالب في الاتجاه من A الى Atmo

$$P_A - 0 = -\frac{\gamma}{g} * L * (-3.05)$$

$$P_A = -\frac{6.6 * 10^3}{9.81} * 6.1 * (-3.05) = 12,517 \text{ KPa gage}$$

(B) move $\underline{A \to B}$, ans $P_B = 24.59$ KPa "gage" *

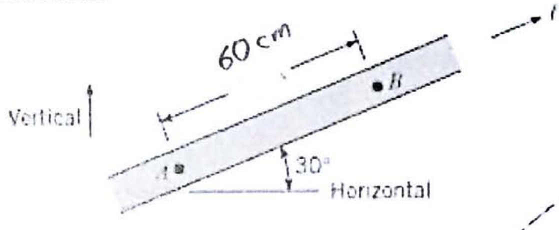
7

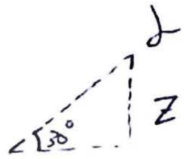
ملاحظة: اتجاه الجريان (السرعة) لا يمكننا تحديده من هذه المعطيات
لذا الجواب الوحيد الصحيح هو D

Euler's equation

Q35 A liquid with a specific weight of 15717 N/m3 is in the conduit. This is a special kind of liquid that has zero
Viscosity. The pressures at points *A* and *B* are 9 kpa and 5 kpa, respectively. Which one (or more) of the following conclusions can one draw with certainty?
(a) The velocity is in the positive ℓ direction.
(b) The velocity is in the negative ℓ direction.
(c) The acceleration is in the positive ℓ direction.
(d) The acceleration is in the negative ℓ direction.

apply euler equation between A & B





$$\frac{\partial}{\partial L}(p+\gamma z) = -\rho a_L$$

$$\frac{\partial p}{\partial L} + \frac{\partial z}{\partial L}\gamma = -\rho a_L$$

$$\frac{\partial z}{\partial L} = \sin 30^\circ = \boxed{0.5}$$

$$\frac{P_B - P_A}{L} + 0.5\gamma = -\rho a_L$$

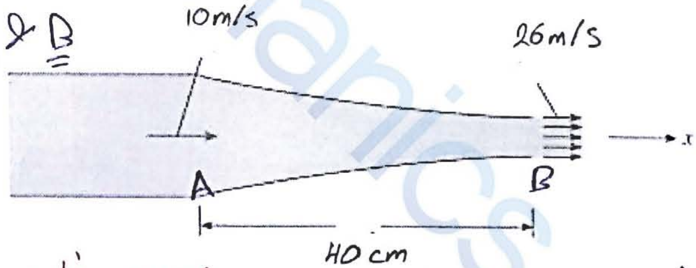
$$P_B - P_A = [-\rho a_L - 0.5\gamma] * L$$

$$(5\times10^3) - (9\times10^3) = [-\rho a_L L - 0.5\gamma L] \Rightarrow a_L = \frac{-4\times10^3 + 0.5\gamma L}{-\rho L} = \boxed{\frac{4\times10^3}{-\rho(0.6)} - 0.5g}$$

هذه الكمية سالبة الاشارة
لذا الاجابة الصحيحة
(d)

Q36 If the velocity varies linearly with distance through this water nozzle, what is the pressure gradient, *dp/dx*, halfway through the nozzle? (γ = 9810 N/ m3)

apply Euler equation between A & B



$$\frac{\partial}{\partial x}(p + \cancel{\gamma z}) = -\rho a_x \quad \text{zero (Horizontal)}$$

$$\boxed{\frac{\partial p}{\partial x} = -\rho a_x}$$

لأنه المطلوب في المنتصف

$$a_x = a_{convective} = V\frac{\partial v}{\partial x}\Big|_{halfway} \Rightarrow V_{mid} = \frac{10+26}{2} = 18\,m/s$$

$$\frac{\partial v}{\partial x} = 40\,s^{-1}$$

oR; $V = ax + b$

$@x=0 \Rightarrow V = 10 = a(0) + b \Rightarrow \boxed{b=10}$

$@x=0.4 \Rightarrow V = 26 = a(0.4) + 10$

$a = 40$

$$\boxed{V = 40x + 10}$$

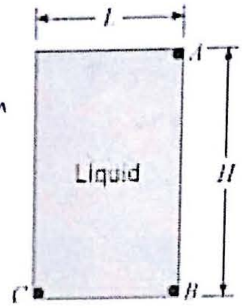
velocity Distribution --

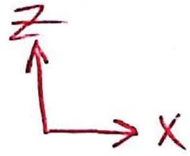
$$\frac{\partial p}{\partial x} = -\rho\left(V\frac{\partial v}{\partial x}\right)$$

$$\frac{\partial p}{\partial x} = -\rho(18 * 40) = -1000(18*40)$$

$$= 720 * 10^3 \text{ Pa/m}$$

Q37 The closed tank shown, which is full of liquid, is accelerated downward at $1.5g$ and to the right at $0.9g$. Here $L = 1$m, $H = 5$m, and the specific gravity of the liquid is 1 . Determine $pC - pA$ and $pB - pA$.





Sol: ① $P_B - P_A$; apply Euler equation in Z-direction

$$\frac{\partial}{\partial z}(p + \gamma z) = -\rho a_z$$

$$\frac{\partial p}{\partial z} + \frac{\partial z}{\partial z}\gamma = -\rho a_z \qquad \frac{\partial z}{\partial z} \rightarrow (-1)$$

$$\frac{P_B - P_A}{5} = -\rho(1.5g) - \gamma$$

$$P_B - P_A = 5 * [(1000 * 1.5 * 9.81) + 9810]$$

$$P_B - P_A = 24525 \text{ Pa} =$$

(B ضغط < A ضغط)

② $P_C - P_A$; apply Euler equation in x-direction $P_C - P_A = \overset{Hor}{(P_C - P_B)} + \overset{Ver}{(P_B - P_A)}$

$$\frac{\partial}{\partial x}(p + \gamma z) = -\rho a_x$$

$$\frac{\partial p}{\partial x} + \cancel{\frac{\partial z}{\partial x}}^{\,zero}\gamma = -\rho a_x$$

$$\frac{P_C - P_B}{1} = -\rho(-0.9g)$$

التسارع بعكس الاتجاه

$$P_C - P_B = 1 * -1000 * -0.9 * 9.81 = +8829 \text{ Pa}$$

$$P_C - P_A = \overset{Hor}{(P_C - P_B)} + \overset{Ver}{(P_B - P_A)}$$

$$= 8829 + -24525 = \boxed{}$$

* pressure distribution in rotating fluid:

→ it's situation in which a fluid rotates as a solid body are found in many engineering applications. "e.g: centrifugal separator"

* from Euler's equation: $\frac{\partial}{\partial L}(p+\gamma z) = -\rho a_L$, but in rotation the L-direction is replaced by $\underline{r}$ which indicates the distance between center of rotation and any point; it's become: $\frac{\partial}{\partial r}(p+\gamma z) = -\rho a_r \rightarrow a_r = \frac{-V^2}{r}$

$$\rightarrow -\frac{\partial}{\partial r}(p+\gamma z) = -\rho \frac{V^2}{r} \quad (V = \omega r)$$

⊖ve cause it's away from the centere of curvature.

$$\rightarrow -\frac{\partial}{\partial r}(p+\gamma z) = -\rho \frac{\omega^2 r^2}{r}$$

$$\rightarrow \frac{\partial}{\partial r}(p+\gamma z) = -\rho \omega^2 r$$

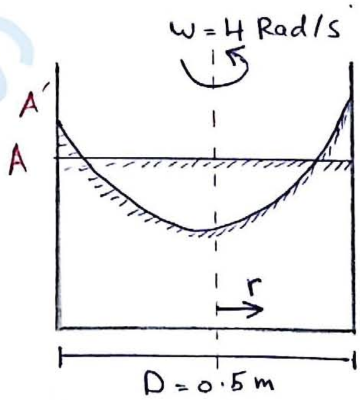
∫ integrate

$$\rightarrow p + \gamma z = \frac{\rho r^2 \omega^2}{2} + \text{constant}$$

$$\boxed{p + \gamma z - \frac{\rho r^2 \omega^2}{2} = C} \quad \text{OR} \quad \boxed{\frac{p}{\gamma} + z - \frac{\omega^2 r^2}{2g} = C}$$

Rotational equation's

* **example:** a cylindrical tank of liquid shown is rotating at a rate of (4 rad/s) the tank diameter is (0.5 m), find the elevation difference between the liquid at the center and the wall during rotation



Sol: $\cancel{\frac{p_1}{\gamma}} + z_1 - \cancel{\frac{\omega^2 r_1^2}{2g}} = \cancel{\frac{p_2}{\gamma}} + z_2 - \frac{\omega^2 r_2^2}{2g}$

atm, $r_1 = 0$, atm

$$z_1 = z_2 - \frac{\omega^2 r_2^2}{2g}$$

$$\Delta z = z_2 - z_1 = \frac{\omega^2 r_2^2}{2g}$$

$$= \frac{(4)^2 * (0.25)^2}{2 * 9.81}$$

$$= 0.0509 \text{ m}$$

$$= 5.09 \text{ cm}$$

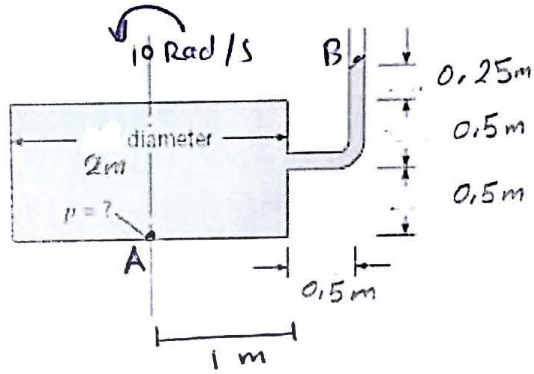
3.33

A-A: before rotation.

A'-A': after rotation

Pressure distribution in rotating flows

Q41 This closed tank, which is 2m in diameter, is filled with water (ρ = 1000 kg / m3) and is spun around its vertical centroidal axis at a rate of 10 rad/s. An open piezometer is connected to the tank as shown so that it is also rotating with the tank. For these conditions, what is the pressure at the center of the bottom of the tank?



apply Rotational equation between A & B

$$P_A + \gamma Z_A - \rho \frac{r_A^2 \omega^2}{2} = P_B + \gamma Z_B - \rho \frac{r_B^2 \omega^2}{2}$$

Zero (واقع على مركز الدوران) Zero (atm)

$$P_A = \gamma (Z_B - Z_A) - \rho \frac{r_B^2 \omega^2}{2}$$

$$= 9810 (1.25 - 0) - \left(1000 \frac{1.5^2 * 10^2}{2}\right)$$

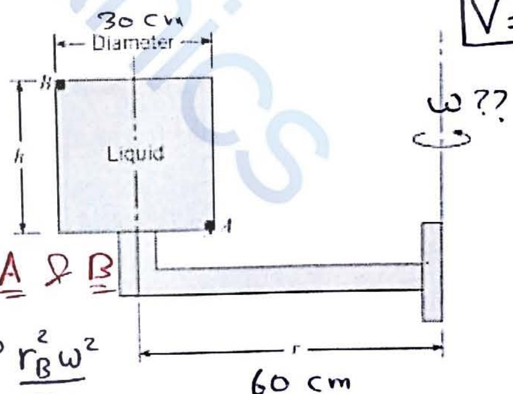
$$= 12,2625 - 112.5$$

$$\boxed{P_A = -100.2375 \text{ kpa}}$$

Q42 A tank of liquid (S = 0.80) that is 30 cm in diameter and 30 cm high (h = 30 cm) is rigidly fixed (as shown) to arotating arm having a 60 cm radius. The arm rotates such that the speed at point A is 6m/s. If the pressure at A is 1200 pa, what is the pressure at B?

note

$\boxed{V = \omega r}$



$V_A = 6$ m/s , $P_A = 1200$ Pa , P_B ??

$$V_A = \omega r_A \Rightarrow \omega = \frac{V_A}{r_A} = \frac{6}{0.6 - \frac{0.3}{2}} = 13,33 \text{ Rad/s}$$

30 cm

apply Rotational equation Between A & B

$$P_A + \gamma Z_A - \frac{\rho r_A^2 \omega^2}{2} = P_B + \gamma Z_B - \rho \frac{r_B^2 \omega^2}{2}$$

Zero

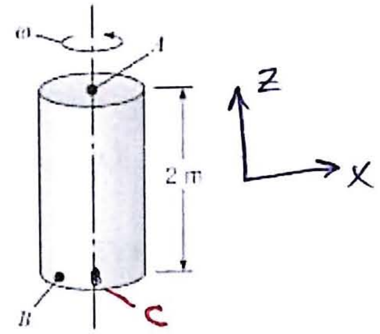
$$1200 - \left(\frac{1000 * 0.45^2 * 13.33^2}{2}\right) = P_B + (9810 * 0.3) - \frac{1000 * (0.6 + 0.15)^2 * 13.33^2}{2}$$

$$\boxed{P_B =}$$

Euler + Rotational

Q44 A closed tank of liquid ($S = 1.2$) is rotated about a vertical axis (see the figure), and at the same time the entire tank is accelerated upward at 4 m/s2. If the rate of rotation is 10 rad/s, what is the difference in pressure between points A and B (pB - pA)? Point B is at the bottom of the tank at a radius of 0.5 m from the axis of rotation, and point A is at the top on the axis of rotation.

$\omega = 10\ Rad/s$, $r_B = 0.5m$, $a_z = 4\ m/s^2 \uparrow$



$P_A - P_B = ??$ " $P_A - P_B = (P_C - P_B) + (P_A - P_C)$

* apply Rotational equation between $\underline{B}$ & $\underline{C}$:

$$P_B + \gamma \cancel{Z_B} - \rho \frac{r_B^2 \omega^2}{2} = P_C + \gamma \cancel{Z_C} - \rho \frac{\cancel{r_C^2} \omega^2}{2}$$

Zero zero zero (على محور الدوران)

S.G

$$P_C - P_B = \frac{\rho \omega^2 r_B^2}{2} = -\frac{1000 * 1.2 * 10^2 * 0.5^2}{2} = -15{,}000\ Pa$$

* apply Euler equation between $\underline{A}$ & $\underline{C}$:

$$\frac{\partial}{\partial z}(p + \gamma z) = -\rho a_z$$

بنفس الاتجاه

(+)

$$\frac{\partial p}{\partial z} + \frac{\partial z}{\partial z}\gamma = -\rho a_z \Rightarrow \frac{P_A - P_C}{2} + \gamma = -\rho * (4) \Rightarrow P_A - P_C = -33144\ Pa$$

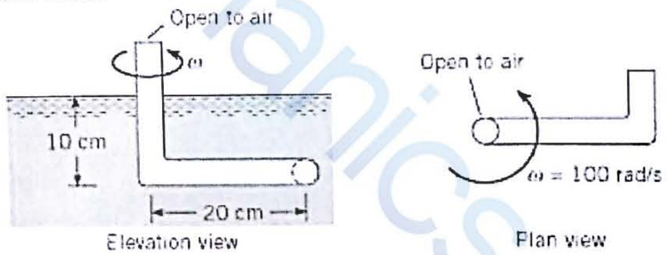
$$\Rightarrow P_A - P_B = -15000 - 33144 = \boxed{-48144\ Pa}$$

Q46 An arm with a stagnation tube on the end is rotated at 100 rad/s in a horizontal plane 10 cm below a liquid surface as shown. The arm is 20 cm long, and the tube at the center of rotation extends above the liquid surface. The liquid in the tube is the same as that in the tank and has a specific weight of 10,000 N/m3. Find the location of the liquid surface in the central tube.

$\omega = 100\ Rad/s$

$r = 0.2\ m$

$\gamma = 10\ kN/m^3$



$\boxed{\text{ans:}}$ L = 0 ; (liquid surface in the tube is the same as elevation as outside surface

* والله ماني حالم

* Rotation of fluid: it's a vector quantity which defined as the (Ω) average angular velocity of two initially mutually perpendicular forces in a flowing fluid.

" $\dot{\theta} = \frac{1}{2} \text{curl } \vec{V}$ " → check the derivatives from text book

$$\left.\begin{aligned} \rightarrow \Omega_z &= \frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right) \\ \rightarrow \Omega_x &= \frac{1}{2}\left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}\right) \\ \rightarrow \Omega_y &= \frac{1}{2}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}\right) \end{aligned}\right\}$$

So the rate of Rotation vector is given by:

$$\Omega = \Omega_x \hat{i} + \Omega_y \hat{j} + \Omega_z \hat{k}$$

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

* these equations used to check whether the flow is rotational or not!!

So: If → $\frac{\partial w}{\partial y} = \frac{\partial v}{\partial z}$ & $\frac{\partial u}{\partial z} = \frac{\partial w}{\partial x}$ & $\frac{\partial v}{\partial x} = \frac{\partial u}{\partial y}$ the flow is irrotational

* example: the vector $\vec{V} = 10x\,\hat{i} - 10y\,\hat{j}$, represents a two dimensional velocity field, is the flow irrotational??

Sol: velocity components are:

x على $U = 10x \longrightarrow \frac{\partial u}{\partial y} = 0$

y على $V = -10y \longrightarrow \frac{\partial v}{\partial x} = 0$

so; $\frac{\partial v}{\partial x} = \frac{\partial u}{\partial y}$ "irrotational"

* example: the velocity components for a two-dimensional flow are:

$$u = \frac{cx}{(y^2 + x^2)} \quad , \quad V = \frac{cy}{(x^2 + y^2)}$$; check if the flow is rotational

Sol: $\frac{\partial v}{\partial x} = \frac{\partial u}{\partial y} \Rightarrow \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} = 0$

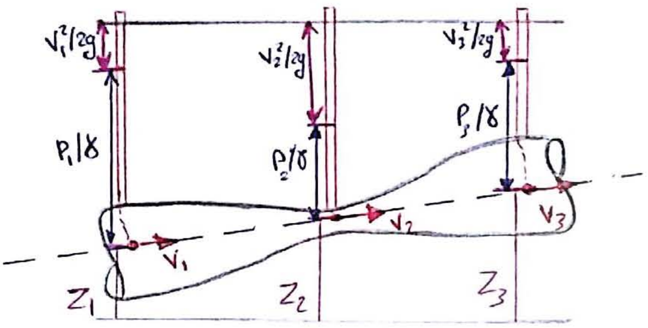
$$\frac{-2xcy}{(x^2+y^2)^2} - \frac{-2ycx}{(y^2+x^2)^2} = 0$$, the flow is irrotational

* example: a two-dimensional flow field is defined by $[u = x^2 - y^2]$ and $[V = -2xy]$, is the flow irrotational?

Sol: $\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x} = -2y - (-2y) = 0$; so the flow is irrotational

* سهل ^_^

* **Bernoulli equation:** the integration of Euler's equation along path line with many assumptions such:
1- steady flow.
2- Incompressible flow.
3- Irrotational flow.
4- non-viscouss flow.
5- no heat transfer.
6- no shaft work.

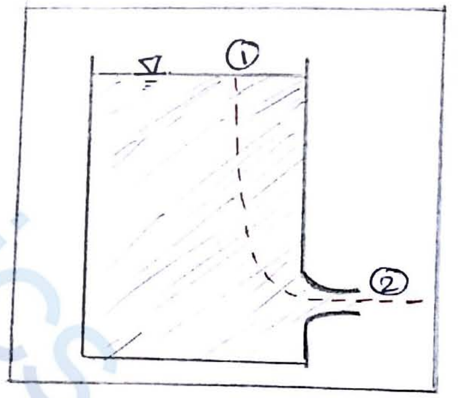


Z: elevation head
$\frac{V^2}{2g}$: velocity head
$\frac{P}{\gamma}$: pressure head

← الجدير بالذكر أن مجموع $\left[\frac{P}{\gamma} + \frac{V^2}{2g} + Z\right]$ يبقى ثابتاً عند أي نقطة على ال "streamline"

$$\begin{pmatrix}\text{pressure}\\ \text{head}\end{pmatrix} + \begin{pmatrix}\text{velocity}\\ \text{head}\end{pmatrix} + \begin{pmatrix}\text{elevation}\\ \text{head}\end{pmatrix} = \text{constant}$$

<u>example:</u> an open tank is filled with water and drains through a port at the bottom of the tank; the elevation of the water in the tank is (10 m) above the drain; the drain port is at atmospheric pressure; find the velocity of the liquid in the drain port.



<u>Sol:</u> apply Bernoulli equation between 1 & 2

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

atm, $\simeq$ Zero, atm

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

$$V_2 = \sqrt{2g\,\Delta Z}$$

$$= \sqrt{2 \times 9.81 \times 10} = \sqrt{196.2} \simeq 14 \text{ m/s}$$

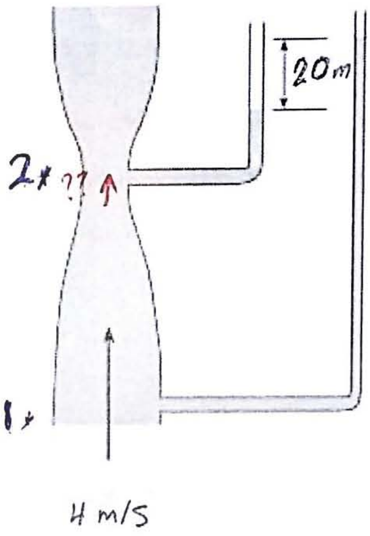
* ملاحظة: السرعة عند نقطة 1 صغيرة جداً مقارنة بـ 2 وسيشرح السبب في chapter 5

* $\frac{P_2}{\gamma}$ ، $\frac{P_1}{\gamma}$ مفتوحات للغلاف الجوي لذلك الضغط = Zero "gage"

Bernoullii equation along streamline

Q61 Water flows through a vertical contraction (venturi) section. Piezometers are attached to the upstream pipe and minimum area section as shown. The velocity in the pipe is 4 m/s. The difference in elevation between the two water levels in the piezometers is 20 cm. The water temperature is 293 K. What is the velocity (m/s) at the minimum area?

apply Bernoulli equation between 1 & 2



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

$$\rho \frac{V_2^2}{2} = \rho \frac{V_1^2}{2} + (P_1 + \gamma Z_1) - (P_2 + \gamma Z_2)$$

piezometric pressure

$$(P_1 + \gamma Z_1) - (P_2 - \gamma Z_2) = \gamma \Delta h$$ "piezometer equation"

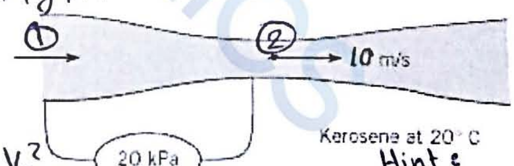
so; $\Delta P_z = 9810 * 0.2 = 1962$

$$1000 * \frac{V_2^2}{2} = \rho \frac{(4)^2}{2} + [1962]$$

solving for $V_2 \Rightarrow$ $V_2^2 = \left(\frac{1000 * 16}{2} + 1962\right) / 500$

$\boxed{V_2^2 = 19.924 \text{ m/s}} \Rightarrow \boxed{V_2 = 4.46 \text{ m/s}}$

Q62 Kerosene at 20°C flows through a contraction section as shown. A pressure gage connected between the upstream pipe and throat section shows a pressure difference of 20 kPa. The gasoline velocity in the throat section is 10 m/s. What is the velocity (m/s) in the upstream pipe? $\rho_{Kerosene} = 814 \text{ kg/m}^3$



Hint: $Z_1 = Z_2$: Horizontal

$P_1 - P_2 = 20$ kPa
so $P_2 - P_1 = -20$ kPa

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

$$\rho \frac{V_1^2}{2} = (P_2 + \gamma Z_2) - (P_1 + \gamma Z_1) + \rho \frac{V_2^2}{2}$$

$$\rho \frac{V_1^2}{2} = 20 * 10^3 + 814 \frac{(10)^2}{2}$$

$$V_1^2 = \frac{-20 * 10^3 + 40700}{407}$$

$$V_1^2 = 50.86 \text{ (m/s)}^2$$

$$\boxed{V_1 = \sqrt{50.86} = 7.13 \text{ m/s}}$$

* Applications of the Bernoulli equations:

→ Velocity measurment devices:

(1) stagnation tube "Total head tube":-

* it's an open ended tube directed upstream inaflow and connected to apressure sensor.

$$P_0 + \rho \frac{V_0^2}{2} = P_1 + \rho \frac{V_1^2}{2}$$

$$* \; P_0 = \gamma d$$

$$* \; P_1 = \gamma (\partial + d)$$

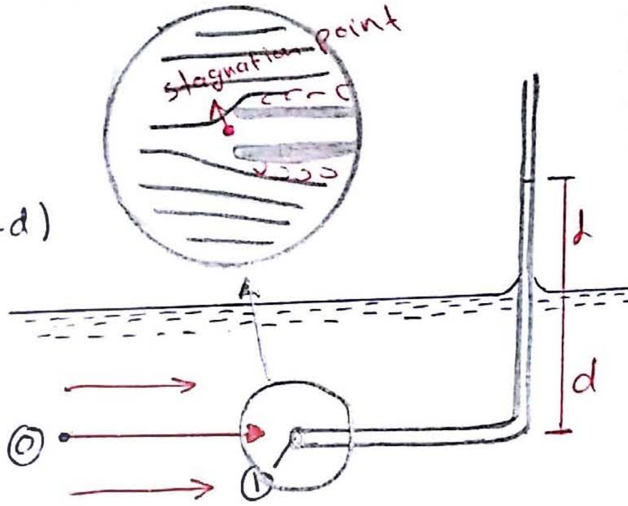
سبب ارتفاع السائل نتيجة الحركة

$$V_0^2 = \frac{2}{\rho}(P_1 - P_0)$$

$$V_0^2 = \frac{2}{\rho}(\gamma(\partial + d) - \gamma d)$$

$$\boxed{V_0 = \sqrt{2g\partial}}$$

→ stagnation tube equation



(2) pitot-Static tube:-

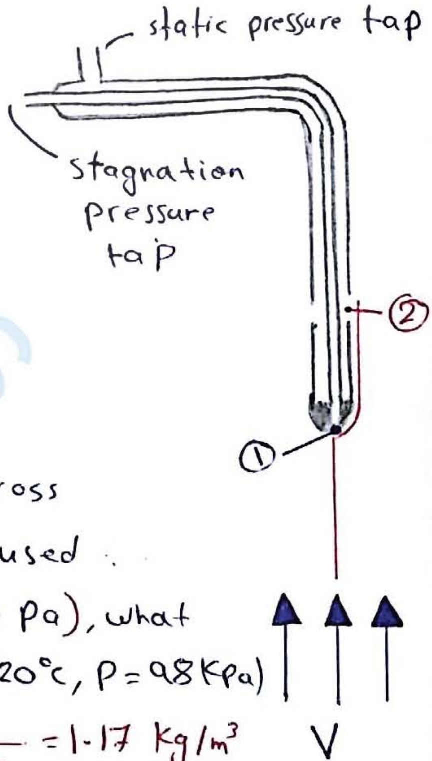
the tube which based on same princible of stagnation tube, but it's much more versatile than the stagnation tube.

$$P_1 + \gamma Z_1 + \underbrace{\cancel{\frac{\rho V_1^2}{2}}}_{zero} = P_2 + \gamma Z_2 + \frac{\rho V_2^2}{2}$$

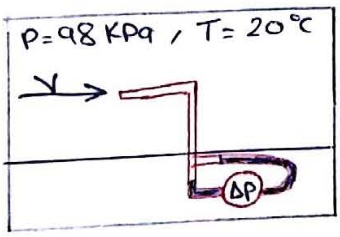
$$V_2 = \left[\frac{2}{\rho}(P_{z,1} - P_{z,2})\right]^{1/2}$$

$$\boxed{V = \sqrt{\frac{2\Delta P}{\rho}}}$$

→ pitot-static tube equation



example 4-9: adifferential pressure gage is connected across the taps of apitot-static tube, when it's used in wind tunnel test; the gage → ($\Delta P = 730$ Pa), what is the air velocity in the Tunnel? ($T = 20°C$, $P = 98$ KPa)



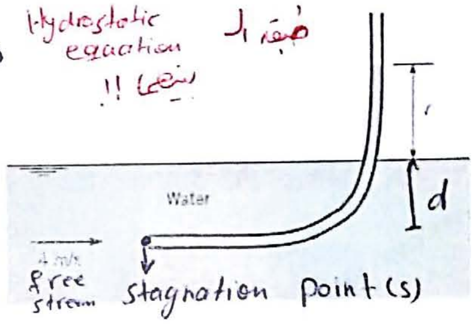
*Sol:

$$\rho = \frac{P}{RT} = \frac{98 \times 10^3}{287 \times 293} = 1.17 \text{ kg/m}^3$$

$$V = \sqrt{\frac{2\Delta P}{\rho}} = \sqrt{\frac{2 \times 730}{1.17}} = 35.3 \text{ m/s}$$

Q64 A glass tube is inserted into a flowing stream of water with one opening directed upstream and the other
end vertical. If the water velocity is 4 m/s, how high will the water rise in the vertical leg relative to the
level of the water surface of the stream?

[stagnation tube & water surface] $\Rightarrow$ Hydrostatic equation طبق ال
!! ننتبه



free stream stagnation point (s)

$$P_{stagnation} = \gamma(\ell + d)$$

$\Rightarrow$ now, apply Bernoulli between $\underline{\underline{S}}$ and free-stream.

$$\frac{P_s}{\gamma} + \frac{\cancel{V_s^2}}{2g} + \cancel{Z_s} = \frac{P_{free}}{\gamma} + \frac{V_{free}^2}{2g} + \cancel{Z_{free}}$$

0 Hor = 0 zero $\Rightarrow$ Hor

$$P_{free} = \gamma d$$

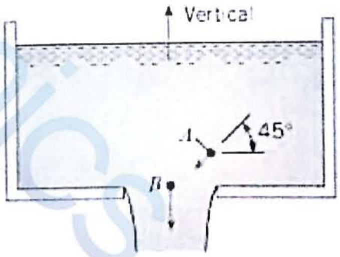
$$\frac{\gamma(\ell + d)}{\gamma} = \frac{\gamma d}{\gamma} + \frac{(4)^2}{2g} \Rightarrow \ell + d = d + \frac{16}{19.62}$$

$$\boxed{\ell = \frac{16}{19.62} = 0.81549 \text{ m}}$$

سيرتفع الماء في الأنبوب بهذه القيمة !!

Bernoulli equation in irrotational flow

Q99 Water (ρ = 1000 kg/m3) flows from the large orifice at the bottom of the tank as shown. Assume that the flow is irrotational. Point *B* is at zero elevation, and point *A* is at 30 cm elevation. If *VA* = 3 m/s at an angle of 45° with the horizontal and if *VB* = 36 m/s vertically downward, what is the value of *pA* - *pB*?



apply Bernoulli equation between $\underline{\underline{A}}$ & $\underline{\underline{B}}$

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

$$P_A - P_B = \gamma\left[\frac{V_B^2 - V_A^2}{2g} + Z_B - Z_A\right]$$

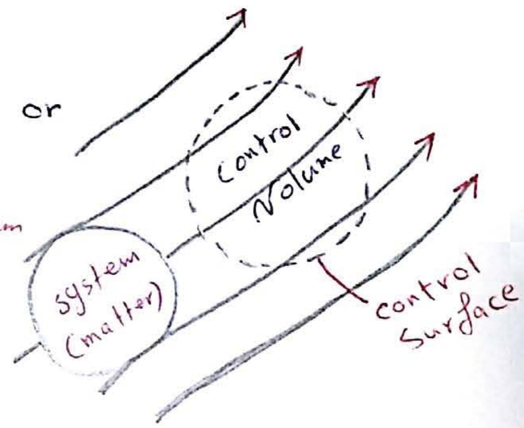
$$P_A - P_B = 9810\left[\frac{36^2 - 3^2}{19.62} - 0.3\right]$$

$$\boxed{P_A - P_B = }$$

* Ch * 5 : Control Volume approach and continuity equation:

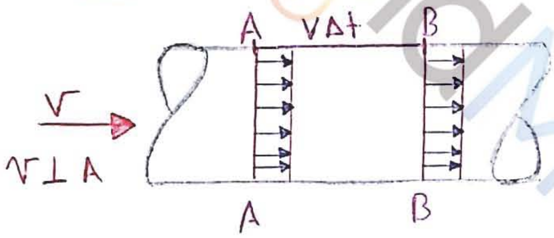
→ **Control volume:** Volume located in space and through which matter can pass and the selection of the control volume position and shape is problem-dependent; the control volume is enclosed by the control surface.

* Control surface can be stationary or moveable.
* control surface separate the system from it's surronding.



note: check extensive and intensive properties which mentioned before!!

* **flow in pipes:** Discharge "Volumetric flow rate" [Q]

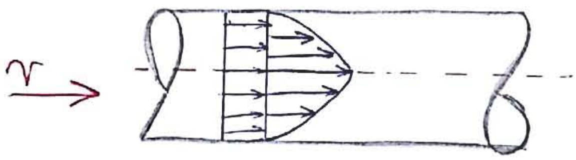


: the volume of fluid passing section A-A = $\frac{V}{\Delta t}$

$Q = \frac{V}{\Delta t}$ (m^3/s , L^3/s , ft^3/s ....)

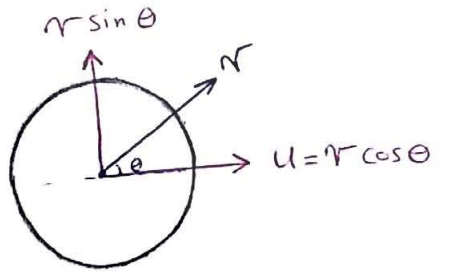
$\boxed{Q = VA}$ uniform velocity distribution discharge.

* for variable velocity distribution:



$Q = \int v \cdot dA$

mean (avg) velocity $= \frac{Q}{A} = \int \frac{Q}{A} = \frac{\int V dA}{A}$



$Q = \int V \cdot dA$

$= V \cos \theta \, dA$

$= u \cdot dA$

θ: the angle between the outward norm of the surface and the velocity vector

* **mass flow Rate:** $\dot{m} = \rho Q = \rho V A$ (kg/s , slug/s , lbm/s ...)

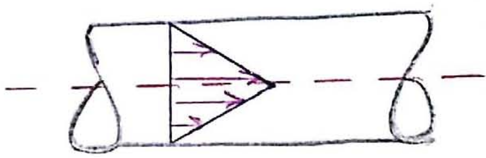
* also; @ variable velocity distribution: $\dot{m} = \int \rho V \, dA$

- example: for the hypothetical velocity in the pipe shown; $\frac{v}{v_{max}} = \left(1 - \frac{r}{R}\right)$

determine $\frac{\bar{V}}{v_{max}}$??

$A = \pi r^2$

$dA = 2\pi r\, dr \Rightarrow \bar{V} = \frac{\int V\, dA}{A} = \frac{\int V_{max}\left(1 - \frac{r}{R}\right) 2\pi r\, dr}{\pi R^2}$



$= \frac{2\pi}{\pi R^2} \int \left(V_{max} - \frac{V_{max} r}{R}\right) r\, dr$

$= \frac{2\cancel{\pi}}{\cancel{\pi} R^2} \int \left(V r - \frac{V_{max} r^2}{R}\right) dr$

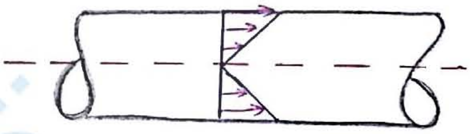
$= \frac{2}{R^2} \left[\frac{V_{max} r^2}{2} - \frac{V r^3}{3R} \Big|_0^R \right] = \frac{2 V_{max}}{R^2} \left(\frac{R^2}{2} - \frac{R^3}{3R} \right)$

$\bar{V} = \frac{2 V_{max}}{R^2} \left(\frac{3 \times R^2}{3 \times 2} - \frac{2 \times R^2}{2 \times 3} \right) = \frac{2 V_{max}}{\cancel{R^2}} \times \frac{\cancel{R^2}}{6} = \frac{1}{3} V_{max}$

$$\boxed{\frac{\bar{V}}{V_{max}} = \frac{1}{3}}$$

* example: for the hypothetical velocity in the pipe, determine $\frac{\bar{V}}{V_{max}}$??

$V = ar + b$



@ $r = 0 \Rightarrow V = 0 \Rightarrow b = 0$

@ $r = R \Rightarrow V = V_{max} \Rightarrow a = \frac{V_{max}}{R}$

$V = V_{max} \frac{r}{R} \Rightarrow \frac{V}{V_{max}} = \frac{r}{R}$

$\Rightarrow \bar{V} = \frac{\int V\, dA}{A} = \frac{\int V_{max} \frac{r}{R} \times 2\pi r\, dr}{\pi R^2} = \frac{2\pi V_{max}}{\pi R^2} \int_0^R \frac{r^2}{R}$

$\bar{V} = \frac{2 V_{max}}{R^2} \frac{r^3}{3R} \Big|_0^R = \frac{2 V_{max}}{R^2} \times \frac{R^3}{3R} = \frac{2}{3} V_{max}$

$$\boxed{\frac{\bar{V}}{V_{max}} = \frac{2}{3}}$$

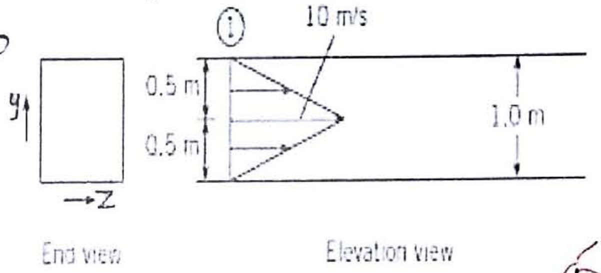
(فوقه وتحت)

* لاحظوا أنه اقتران السرعة متماثل حول خط المركز، لذلك بإمكانك حساب Q على أحد الجانبين وضربها بـ ②

الفكرة كيوت ^_^ *

Q16 Air enters this square duct at section 1 with the velocity distribution as shown. Note that the velocity varies
in the y direction only (for a given value of y, the velocity is the same for all values of z).

a. What is the volume rate of flow?
b. What is the mean velocity in the duct?
c. What is the mass rate of flow if the mass density of the air is 1.2 kg/m3?



$\rightarrow V = ay + b \Rightarrow 10 @ y = 0.5,\ 0 @ y = 0$

$\Rightarrow 10 = a(0.5) + b \Rightarrow a = 20$

$\Rightarrow 0 = a(0) + b \Rightarrow \boxed{b = 0}$

$V = 20y$

always 1m

$A = y \times (1)$

$dA = dy$

y 1m

(1m)

هذا البعد يتغير

ⓐ $Q = \int V\,dA = \int_0^{0.5} 20y\,dy$

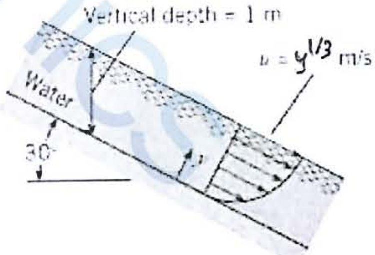
$= \frac{20}{2} y^2 \Big|_0^{0.5} = \frac{20}{2} \times (0.5)^2 = 2.5\ m^3/s$ (للنصف الأسفل)

So $\boxed{Q = 2 \times 2.5 = 5\ m^3/s}$

Ⓑ $V_{mean} = \bar{V} = \frac{Q}{A} = \frac{5}{1 \times 1} = \boxed{5\ m/s}$

Ⓒ $\dot{m} = \rho Q = 1.2 \times 5 = \boxed{6\ kg/s}$

Q18 The rectangular channel shown is 1.5 m wide. What is the discharge in the channel?



$u \equiv V = y^{1/3}$

$Q = \int_A V\,dA$

$A = \text{width} \times \text{depth}$

$A = 1.5 \times y$

خذ البعد المائل

$y = 1 \times \cos 30 = 0.866\ m$

$Q = \int_0^{0.866} y^{1/3} \times 1.5\,dy$

$Q = 1.5 \left[\frac{y^{4/3}}{4/3} \right]_0^{0.866}$

$Q = 1.5 \frac{(0.866)^{4/3}}{4/3}$

$\boxed{Q = 0.9286\ m^3/s}$

* Reynolds transport theorem: Lagrangian approach $\longrightarrow$ Eulerian approach

* this theorem is derived by considering the rate of change of an extensive property of a system as it passes through the control volume.

$$\Rightarrow \underbrace{\left.\frac{dB}{dt}\right|_{sys}}_{\text{Lagrangian approach}} = \underbrace{\frac{d}{dt}\int_{C.V} b\rho\, d\forall + \int_{C.S} b\rho V\cdot dA}_{\text{Eulerian approach}}$$

B: any extensive prop.

b: the corresponding intensive property.

← تكمن فكرة هذه النظرية في اختيار (C.V) مناسب ومراقبة مداخله ومخارجه (C.S) وبناءً عليه يكون التغير الحاصل في الخاصية (B) مساوية للتغيرات السابقة (في المعادلة) على (C.V) وال (C.S) !!

← تعتبر هذه النظرية من أهم وأقوى النظريات المستخدمة في ميكانيكا الموائع والديناميكا الحرارية وانتقال الحرارة !!

→ Let us now, use (mass) as "B" so, $B = \text{mass}$, $b = \frac{\text{mass}}{\text{mass}} = 1$

$$\left.\frac{dm}{dt}\right|_{sys} = \frac{d}{dt}\int_{C.V}\rho\, d\forall + \int_{C.S}\rho V\cdot dA \quad , \text{now } \left.\frac{dm}{dt}\right|_{sys} = 0 \quad \text{so:}$$

$$\frac{d}{dt}\int_{C.V}\rho\, d\forall + \int_{C.S}\rho V\cdot dA = 0.0$$

$$\boxed{\frac{d}{dt} m_{C.V} + \sum_{C.S}\dot{m}_{out} - \sum_{C.S}\dot{m}_{in} = 0.0}$$ the continuity equation ^ ^

from continuity equation:

① $\frac{dm_{C.V}}{dt} > 0.0 \rightarrow \sum \dot{m}_{in} > \sum \dot{m}_{out}$ "filling"

② $\frac{dm_{C.V}}{dt} = 0.0 \rightarrow \sum \dot{m}_{in} = \sum \dot{m}_{out}$ "Stead state cond."

③ $\frac{dm_{C.V}}{dt} < 0.0 \rightarrow \sum \dot{m}_{in} < \sum \dot{m}_{out}$ "emptying"

⇒ @ steady-state conditions: $\sum \dot{m}_{in} = \sum \dot{m}_{out}$ and assuming Incompressible flow. ($\rho = ct$)

$$\rho \dot{m}_{in} = \rho \dot{m}_{out}$$

$$Q_{in} = Q_{out}$$

$$V_1 A_1 = V_2 A_2$$

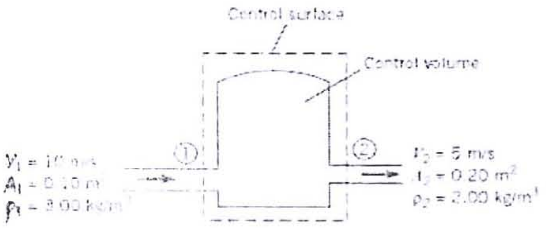
Conceptual proplem, doesn't need nums and calculations

it's need operfect comprehension only!!

Control volume approache

Q37 Gas flows into and out of the chamber as shown. For the conditions shown, which of the following statement(s) are true of the application of the control volume equation to the continuity principle?

a. Bsys = 0
b. dBsys$/dt$ = 0
c. $\sum_{cs} b\rho V \cdot A = 0$
d. $d/dt \int_{cv} \rho d\forall = 0$
e. $b = 0$



Sol:

$\dot{m}_{input} = \rho_{in} V_{in} A_{in}$

$= 3 * 10 * 0.1 = 3 \text{ Kg/s}$

$\dot{m}_{output} = \rho_{out} V_{out} A_{out}$

$= 2 * 5 * 0.2 = 2 \text{ Kg/s}$

=> mass flow Rate not equal!!

So; the flow is unsteady!!

a) $B_{sys} = 0$; false, there is matter (property)

b) $\frac{dB_{sys}}{dt} = 0$; True; the matter will go on and out without change.

c) $\sum_{C.S} b\rho V \cdot A = 0$; false; mass flow rate in not equal to $\dot{m}_{out}$

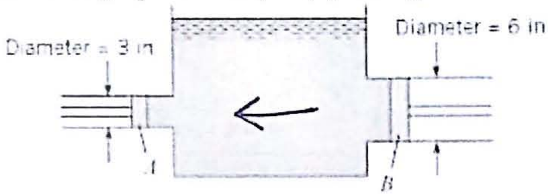
d) $\frac{d}{dt} \int_{C.V} \rho d\forall = 0$; false; the Volume will change in control Volume

e) $b = 0$; fals; equal to 1 $(\frac{m}{m} = 1)$

Continuity equation

Q44 Both pistons are moving to the left, but piston *A* has a speed twice as great as that of piston *B*. Then the
water level in the tank is (a) rising, (b) not moving up or down, or (c) falling?

apply Reynolds transport theorems



$$\text{zero} \leftarrow \left.\frac{dB}{dt}\right|_{sys} = \frac{\partial}{\partial t}\int_{c.v} \rho b \, d\forall + \int_{c.s} \rho b \, V \cdot dA$$

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

$$\frac{\partial}{\partial t}\int_{c.v} \rho \, d\forall = \sum \dot{m}_{in} - \sum \dot{m}_{out}$$

$$\dot{m}_{in} = \rho A_{in} V_{in} \quad @ \underline{\underline{B}}$$

$$= \rho \frac{\pi}{4}(6)^2 V_B$$

$$\dot{m}_{out} = \rho A_{out} V_{out} \quad @ A$$

$$= \rho \frac{\pi}{4}(3)^2 (2V_B)$$

$$\frac{\partial}{\partial t}\int_{c.v} \rho \, d\forall = \rho \left[\frac{\pi}{4}(6)^2 \times V_B - \frac{\pi}{4}(3)^2 \times 2 \times V_B\right]$$

$$\frac{\partial}{\partial t}\int_{c.v} \rho \, d\forall = \rho \times 14.13 \, V_B$$

$$\cancel{\rho} \frac{\partial \forall}{\partial t} = \cancel{\rho} \times 14.13 \, V_B$$

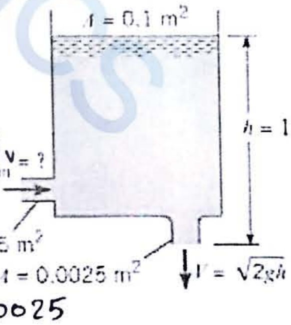
$$A \frac{\partial h}{\partial t} = 14.13 V_B \Rightarrow \frac{\partial h}{\partial t} = \frac{14.13 V_B}{A_{Tank}}$$

this value is positive, so it's <u>Rising</u>

مساحة المقطع ثابت دائماً؟

Q49 tank has a hole in the bottom with a cross-sectional area of 0.0025 m2 and an inlet line on the side with a cross-sectional area of 0.0025 m2, as shown. The cross-sectional area of the tank is 0.1 m2. The velocity of the liquid flowing out the bottom hole is $V = \sqrt{2gh}$ where *h* is the height of the water surface in the tank a bove the outlet. At a certain time the surface level in the tank is 1 m and rising at the rate of 0.1 cm/s. The liquid is incompressible. Find the velocity of the liquid through the inlet

* apply Reynolds transport theorem:



$$\frac{\partial}{\partial t}\int_{c.v} \rho \, d\forall = \sum \dot{m}_{in} - \sum \dot{m}_{out}$$

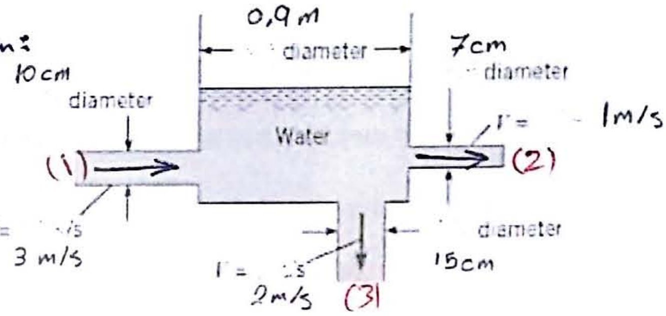
$$\cancel{\rho} \frac{\partial h}{\partial t} \times A = \cancel{\rho}\left([V_{in} \times 0.0025] - [\sqrt{2gh} \times 0.0025]\right)$$

take $h = 1\,m \Rightarrow \frac{\partial h}{\partial t} A = 0.0025 V_{in} - \sqrt{2 \times 9.81 \times 1} \times 0.0025$

$$0.01107 + 0.1 \times 10^{-2} \times 0.1 = 0.0025 V_{in}$$

$$\boxed{V_{in} = 4.47 \, m/s}$$

Q61 Is the tank in the figure filling or emptying? At what rate is the water level rising or falling in the tank?



* apply Reynolds transport theorem:

$$\frac{\partial}{\partial t}\int_{c.v} \rho \, d\forall = \sum \dot{m}_{in} - \sum \dot{m}_{out}$$

$$\frac{\partial V}{\partial t} * \cancel{\rho} = \cancel{\rho}\left[0.02355 - 0.0391715\right]$$

$$\frac{\partial h}{\partial t} * A_{tant} = -0.0156215$$

$$\boxed{\frac{dh}{dt} = -0.02456 \ m/s}$$

falling (-)

* هبوط في مستوى سطح الماء

$$\dot{m}_{in\,(1)} = V_1 A_1 \rho = 3 * \frac{\pi}{4} * 0.1^2 * \rho = \boxed{0.02355\rho}$$

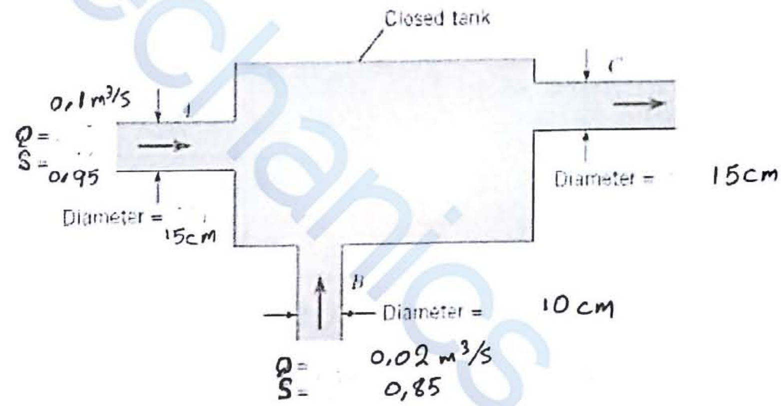
$$\dot{m}_{out\,(2)} = V_2 A_2 \rho = 1 * \frac{\pi}{4} * 0.07^2 * \rho = \boxed{3.8465 * 10^{-3}\rho}$$

$$\dot{m}_{out\,(3)} = V_3 A_3 \rho = 2 * \frac{\pi}{4} * 0.15^2 * \rho = \boxed{0.035325\rho}$$

$$\sum \dot{m}_{out} = \dot{m}_{out\,(2)} + \dot{m}_{out\,(3)} = \boxed{0.0391715\rho}$$

Q66 Assuming that complete mixing occurs between the two inflows before the mixture discharges from the pipe at *C*, find the mass rate of flow, the velocity, and the specific gravity of the mixture in the pipe at *C*.

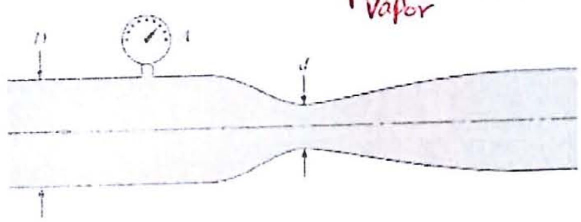
$\boxed{ans: S = 0.925}$



Cavitation

Q96 When gage *A* indicates a pressure of 120 kPa gage, then cavitation just starts to occur in the venturi meter.
If *D* = 40 cm and *d* = 10 cm, what is the water discharge in the system for this condition of incipient
cavitation? The atmospheric pressure is 100 kPa gage, and the water temperature is 10°C. Neglect
gravitational effects

$P_{Vapor} = 1230$ Pa (abs)



* Cavitation will occur when the pressure reaches vapor pressure of the flowing fluid "check 1st"

→ apply Bernoulli equation:

$$P_A + \frac{\rho V_A^2}{2} + \underbrace{\cancel{Z_A}}_{Hor} = P_B + \frac{\rho V_B^2}{2} + \underbrace{\cancel{Z_B}}_{Hor}$$

$$P_A + \frac{\rho V_A^2}{2} = P_B + \frac{\rho V_B^2}{2} \quad , \quad V_A = \frac{Q}{A_A} = \frac{Q}{\frac{\pi}{4}(0.4)^2}$$

$$V_{throat} = \frac{Q}{A_{throat}} = \frac{Q}{\frac{\pi}{4} * 0.1^2}$$

$$\frac{\rho Q^2}{2}\left[\frac{1}{\left[\frac{\pi}{4} * (0.1)^2\right]^2} - \frac{1}{\left[\frac{\pi}{4} * (0.4)^2\right]^2}\right] = 220\,000 - 1230$$

220 000 ↑ abs pressure = ($P_{gauge} + P_{atm}$)

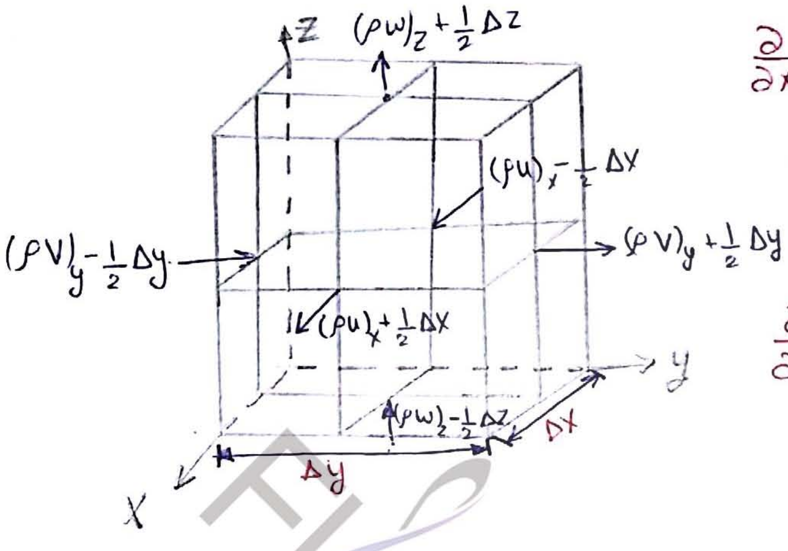
1230 ↑ abs pressure

solving for Q:

$$\boxed{Q = 0.165 \ m^3/s}$$

* Differential form of the continuity equations: "3D"

→ this equation is derived by applying the integral form of the continuity equation to a small control volume and taking the limit as the volume approaches zero!!



$$\frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}(\rho w) + \frac{\partial \rho}{\partial t} = 0.0$$

* check full derivative from text-book

* If the flow is steady:

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

* If the flow is incompressible:

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

* for steady and unsteady:

$$\nabla \cdot V = 0$$

$$\nabla = \frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}$$

* example:

→ the expression ($V = 10x\hat{i} - 10y\hat{j}$) is said to represent the velocity for a two-dimensional flow (planar) incompressible flow, check to see if the continuity equation satisfied

Sol: two dimensional, incompressible so; equation reduced to:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \overset{??}{=} 0.0 \quad \text{check}$$

$u = 10x \rightarrow \frac{\partial u}{\partial x} = 10$

$v = -10y \rightarrow \frac{\partial v}{\partial y} = -10$

$$10 + -10 \overset{??}{=} 0.0$$

$$0 = 0$$

So, it's satisfied!!

إضافي

→ check if it's irrotational:

$$\Omega = \frac{1}{2}\begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 10x & -10y & 0 \end{bmatrix} = \frac{1}{2}[0-0] = 0.0$$

So it's irrotational too!!

* ركّز عَ القوانين منيح ^ *

* Chapter ※6: Momentum princible: مبدأ الزخم ... الزخم: كمية الحركة = السرعة × الكتلة

← لاشتقاق علاقات الزخم ، سنطبق قانون نيوتن الثاني ($F_n = m a_n$) باستخدام (Reynolds Trans. the.)

← ببساطة: التغير في زخم الجسم يساوي القوة التي تؤثر على الجسم نفسه ...

$$\left.\frac{dB}{dt}\right|_{sys} = \frac{\partial}{\partial t}\int_{C.V} \rho b \, d\forall + \int_{C.S} \rho b V \cdot dA$$

$B = m\vec{V}$ (زخم)

$b = \frac{m\vec{V}}{m} = \vec{V}$ (momentum per unit mass)

$$\left.\frac{d\, m\vec{V}}{dt}\right|_{sys} = \frac{\partial}{\partial t}\int_{C.V} V \rho \, d\forall + \int_{C.S} \rho \vec{V}\vec{V} \cdot dA \Rightarrow \underbrace{m\frac{d\vec{V}}{dt} = ma = \sum Force}_{\text{Newton's } 2^{nd} \text{ law}}$$

$$\sum F = \frac{\partial}{\partial t}\int_{C.V} \vec{V} \rho \, d\forall + \int_{C.S} \rho \vec{V}\vec{V} \cdot dA \Rightarrow$$

$\vec{V}, \vec{V}$: will be same if control Volume non accelerated

[The net force acting on the fluid within contro volume] = [Rate of accumulation of momentum within control volume] + [Net out flow of momentum from the control volume through the control surface]

$$\underbrace{\sum F}_{\sum F_b \;,\; \sum F_s} = \frac{d}{dt}\int_{C.V} \vec{V} \rho \, d\forall + \underbrace{\int_{C.S} \rho \vec{V}\vec{V} \cdot dA}_{\sum \dot{m}_{out} V_{out} - \sum \dot{m}_{in} V_{in}}$$

$\cdot$ → dot product:

$\sum F_b$ → * Body force: gravitational, electric — لا تحتاج لتلامس مع الجسم حتى تؤثر فيه

$\sum F_s$ → * shear force — تحتاج أنه تلامس الجسم حتى تؤثر فيه

* Momentum in cartesian coordinates:

$$\sum F_x = \frac{d}{dt}\int_{C.V} \rho \vec{V} \, d\forall + \sum \dot{m}_{out_x} V_{out_x} - \sum \dot{m}_{in_x} V_{in_x}$$

$$\sum F_y = \frac{d}{dt}\int_{C.V} \rho \vec{V} \, d\forall + \sum \dot{m}_{out_y} V_{out_y} - \sum \dot{m}_{in_y} V_{in_y}$$

$$\sum F_z = \frac{d}{dt}\int_{C.V} \rho \vec{V} \, d\forall + \sum \dot{m}_{out_z} V_{out_z} - \sum \dot{m}_{in_z} V_{in_z}$$

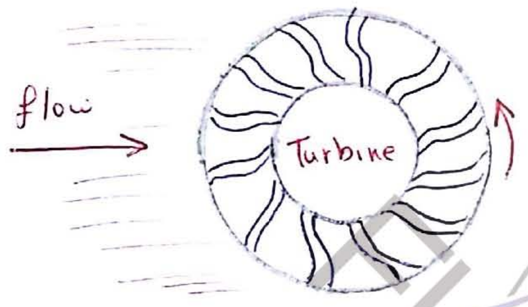
* ملاحظة: أغلب الحالات التي ندرسها تكون (steady state) وهذا يعني أنه الزخم لا يتغير مع تغير الزمن في ال (Control volume) ، ولهذا السبب خانة الحد:

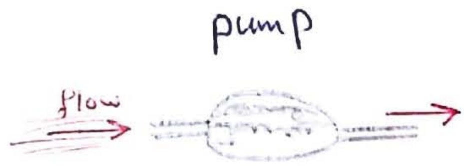
$$\frac{d}{dt}\int_{C.V} \rho \vec{V} \, d\forall = 0.0$$

* Mechanical components "fittings":

*الهدف من دراسة الزخم هو تحديد القوى اللازمة لتثبيت أي قطعة ميكانيكية عند التصميم أو دراسة تأثير الموائع على هذه القطع ----

① Vanes: structural component that may be used to change the direction of flow, its used either to subtract energy from flow (Turbines) or add energy to the flow (pumps).

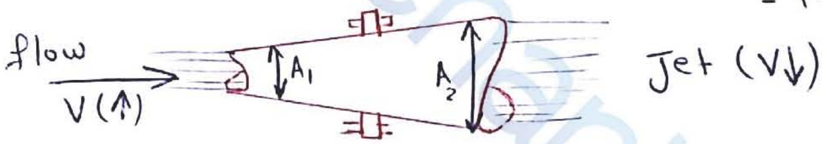




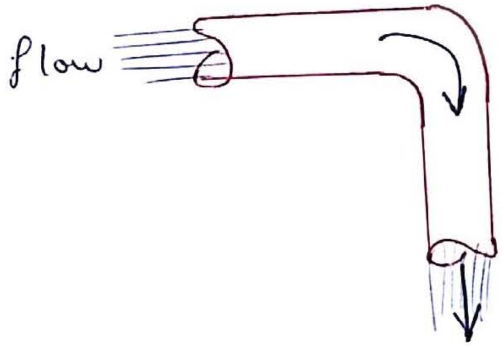
② Nozzle: mechanical component use to increase velocity of flow by reducing the flow area.

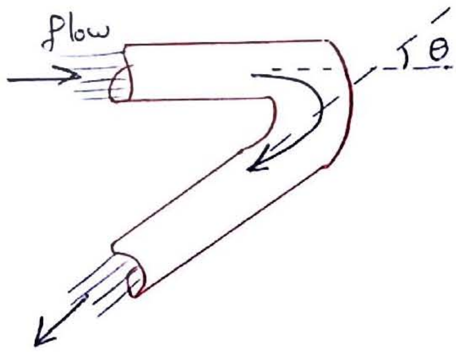
③ diffuser: mechanical component use to decrease flow velocity by increasing the flow area.

(Nozzle) عكس ال



④ Bends: mechanical component use mainly for change direction of flow usually it's found between two pipes, every one has a different direction





* كيف نحل أسئلة الزخم ؟!

١- اختر (control volume) مناسب

٢- ارسم مخططين ، واحد للقوى (forces diagram) وآخر للزخم (Momentum diagram) ---

٣- حلل الوزن ، رد الفعل ، القوى الناتجة عن الضغط مراعياً الاتجاهات ، وعينها على ال (force diagram)

٣- حدد السرعات الداخلة والخارجة ، والتدفق الكتلي الداخل والخارج مراعياً الاتجاهات ، ثم عينها على ال (momentum diagram)

٤- استخدم علاقات الزخم ، واحسب المطلوب .

٥- قد يتطلب السؤال استخدام معادلات التدفق الحجمي (Q) لحساب سرعة أو ($\dot{m}$) وهكذا ---

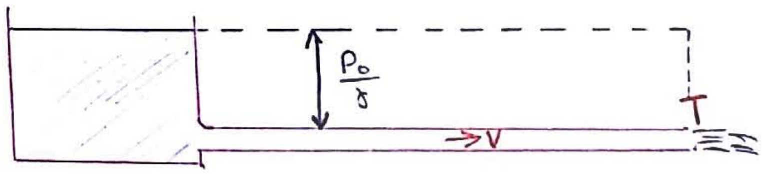
* يوجد في هذا التلخيص الكثير من الأسئلة المتعلقة بموضوع الزخم ---

سأترك لك بعض الأسئلة فارغة ... جرب الحل بنفسك ، ستحقق استفادة أكبر ... ^_^

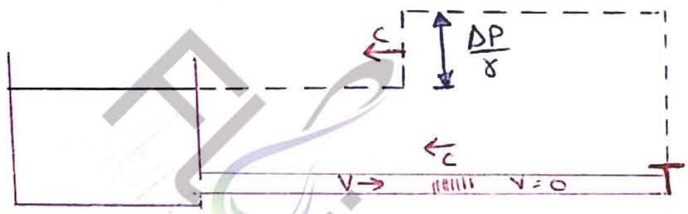
* Water Hammer :

* Whenever a valve is closed in a pipe, a positive pressure wave is created upstream of the valve and travels up the pipe at speed of sound!! In this context a positive pressure wave is created as one for which the pressure is greater than the existing steady-state pressure.

→ this pressure wave may be great enough to cause a pipe failure.

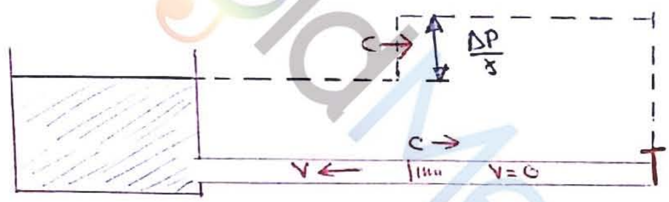


$t = 0 \; , \; P = P_o \; , \; V \rightarrow$



* هنا يحدث انغلاق مفاجئ للصمام ، وينتج موجة نتيجة لذلك تتجه نحو الخزان بسرعة الصوت بحيث يكون سرعة المائع قبلها = صفراً أما بعدها فهي تمتلك نفس السرعة الابتدائية

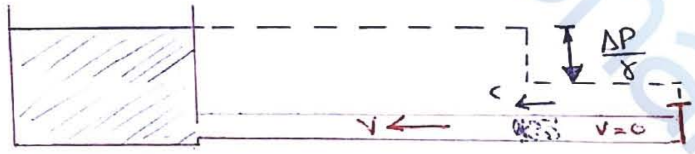
$[0 < t < L/c]$



* بعد وصول الموجة الى الخزان وبداية عودتها تسبب زيادة في الضغط بمقدار ΔP ، أما ما قبلها فهو يبقى بنفس الضغط الابتدائي (P_o)..

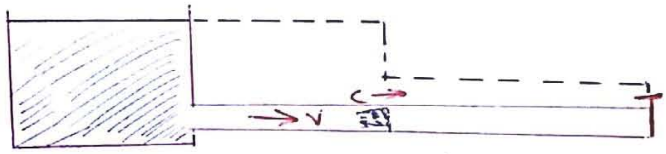
← هذا يحدث في زمن قدره $[L/c < t < 2L/c]$

ونتيجة لفرق الضغط ، فان السائل يعود الى الخزان مرة أخرى.



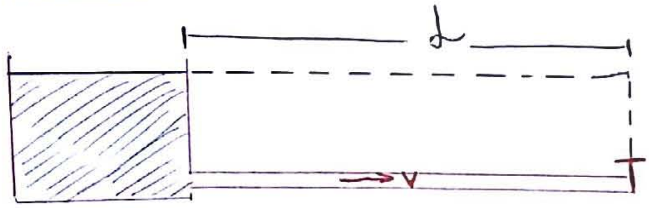
* بعد وصول الموجة الى الصمام ، فانها تعود الى الخزان مرة أخرى مسببة انخفاض في الضغط ، بحيث تكون الموجة مع اتجاه السائل سيران باتجاه الخزان وهذه المرحلة تشبه (B)

$[2L/c < t < 3L/c]$



* هنا تعود الموجة للمرة الأخيرة لم تحقق وبهذا يكون الضغط قد تساوى ...

$[3L/c < t < 4L/c]$



$t = 4L/c$

* Time to complete an cycle $= \frac{4L}{c}$

* Time critical $= \frac{2L}{c}$

$t_{closing} < t_{cr}$ → water Hammer exist //

$t_{closing} > t_{cr}$ → Watter Hammer not exist

* $\Delta P = \rho V c$

ρ: density ; V: Velocity of flowing fluid ; c: speed of sound-wave

* $c = \sqrt{\frac{E_v}{\rho}}$

* water Hammer can be avoided by:

1- installing an accumulator near the valve.

2- prevent sudden closing of the valve.

3- use safty Relief valve.

* example: arigid pipe leading from areservoir is 900 m long, and water is flowing through it with ($V=1.5\,m/s$); if the initial pressure at downstream end is 280 KPa, what maximum pressure will develop at the downstream end when arapidacting valve at that end is closed in 1s ?? ($\rho=1000\ kg/m^3$, $E_v=2.2*10^9$ Pa)

Sol: * check whether water hammer existed by calculating t_{cr}

$$t_{cr}=\frac{2L}{C}=\frac{2*900}{1483}=1.21\,s \quad , \quad C=\sqrt{\frac{E_v}{\rho}}=\sqrt{\frac{2.2*10^9}{1000}}=1483\,m/s$$

$t_{cr} > t_{closing}$, so water Hammer existed

$$\Delta P=\rho V C$$

$$P_{max}-P_o=1000*1.5*1483=2224.5\ KPa$$

$$P_{max}=280*10^3+2224.5*10^3=\boxed{2504\ KPa}$$

* example: estimate the maximumm water hammer pressure that is generated in arigid pipe if the initial water velocity ($=4\,m/s$) and the pipe is (10 Km) long with avalve at the downstream end that is closed in 10 s ??

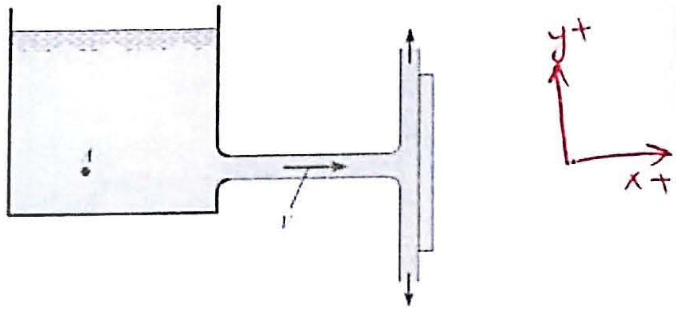
Sol: * check:
$$C=\sqrt{\frac{E_v}{\rho}}=\sqrt{\frac{2.2*10^9}{1000}}=1483\ m/s$$

$$t_{cr}=\frac{2L}{C}=\frac{2*10*10^3}{1483}=13.48\,s > t_{closing}$$, so water hammer exist

$$\Delta P=\rho V C=1000*4*1483=5,933\ KPa$$

Chapter 6 : jets

Q10 A horizontal water jet at 20C impinges on a vertical-perpendicular plate. The discharge is 0.05 m3/s. If the external force required to hold the plate in place is 900 N, what is the velocity of the water?



$Q = 0.05\ m^3/s$

Momentum equation (x-direction)

momentem out @ x-axis = 0

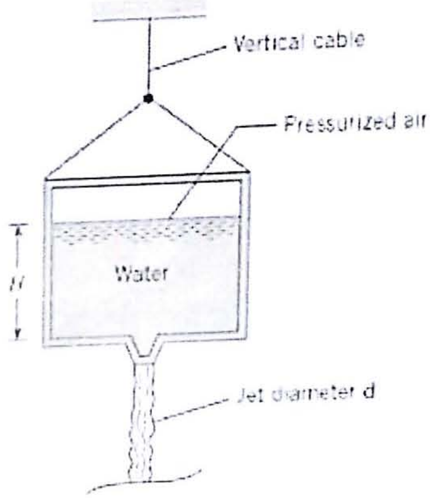
$$\sum F_x = \sum \dot{m}_{out_x} V_{out_x} - \sum \dot{m}_{in} V_{in_x}$$

$$+F_x = +\sum \dot{m}_{in_x} V_{in_x}$$

$$900 = \rho Q V_{in_x}$$

$$V_{in_x} = \frac{900}{\rho Q} = \frac{900}{1000 \times 0.05} = \boxed{18\ m/s}$$

Q15 A tank of water (15°C) with a total weight of 200 N (water plus the container) is suspended by a vertical cable. Pressurized air drives a water jet ($d = 12$ mm) out the bottom of the tank such that the tension in the vertical cable is 10 N. If $H = 425$ mm, find the required air pressure in units of atmospheres (gage). Assume the flow of water is irrotational.



$$A_2 = \frac{\pi d^2}{4}$$

$$= \frac{\pi (0.012\,m)^2}{4}$$

$$= 1.131 * 10^{-4}\,m^2$$

$$\Sigma F = \dot{m}_o V_o$$

$$-T + W = \dot{m} v_2$$

$$(-10 + 200)\,N = \rho A_2 v_2^2$$

$$190\,N = (999\,Kg/m^3)(1.131 * 10^{-4}\,m^2)\,v_2^2$$

$$v_2 = 41.01\,m/s$$

$$P_{air} + \frac{\rho v_1^2}{2} + \rho g z_1 = P_2 + \frac{\rho v_2^2}{2} + \rho g z_2$$

Let $v_1 \approx 0$, $P_2 = 0$ gage and $\Delta z = 0.425\,m$.

$$P_{air} = \frac{\rho v_2^2}{2} - \rho g \Delta z$$

$$= \frac{(999\,Kg/m^3)(41.01\,m/s)^2}{2} - (999\,Kg/m^3)(9.81\,m/s^2)(0.425)$$

$$= (835{,}900\,Pa)\left(\frac{1.0\,atm}{101.3\,KPa}\right)$$

$$\boxed{P_{air} = 8.25\,atm}$$

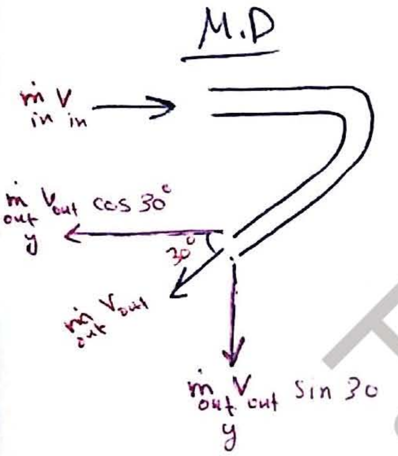
vanes

6.20 Determine the external reactions in the x- and y-directions needed to hold this fixed vane, which turns the oil jet in a horizontal plane. Here $V1$ is 18 m/s, $V2$ = 17 m/s, and Q = 0.15 m3/s.

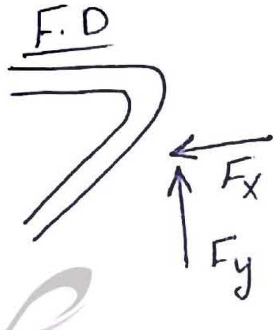
S.G = 0.9

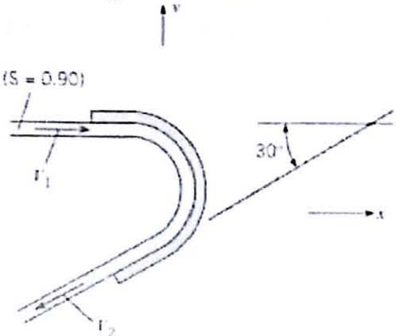
سؤال اضافي ... *6.21 Solve Prob. 6.20 for V1 = 30m/s, V2 = 25/s, and Q = 0.05 m3/s.*

M.D



F.D





$$\dot m = \rho Q = 0.9 \times 1000 \times 0.15$$
$$= 135 \text{ Kg/s}$$

$V_{in} = 18$ m/s

$V_{out} = 17$ m/s

$$\sum F_x = \sum \dot m_{out} V_{out_x} - \sum \dot m_{in} V_{in_x}$$

$$-F_x = [135 \times (-17 \times \cos 30°)] - [135 \times 18]$$

$$-F_x = -1987.53 - 2430$$

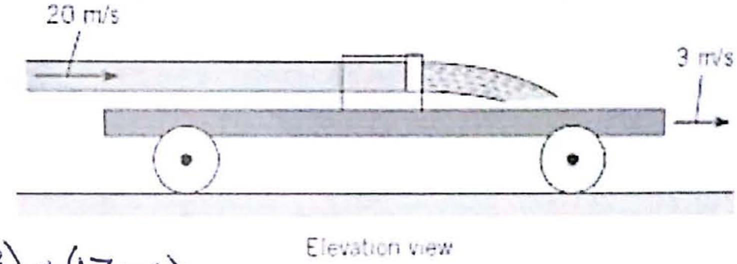
$$\boxed{F_x = 4.417 \text{ KN}}$$ بنفس الاتجاه المفروض ←

$$\sum F_y = \sum \dot m_{out} V_{out_y} - \cancel{\sum \dot m_{in} V_{in_y}} \to \text{Zero}$$

$$F_y = 135 \times (-17 \times \sin 30)$$

$$\boxed{F_y = -1.1475 \text{ KN}}$$ عكس الاتجاه المفروض ↓

Q30 A vane on this moving cart deflects a 10 cm water (ρ = 1000 kg/m3) jet as shown. The initial speed of the water in the jet is 20 m/s, and the cart moves at a speed of 3 m/s. If the vane splits the jet so that half goes one way and half the other, what force is exerted on the vane by the jet?



$F_x = \dot{m}_2 v_{2x} - \dot{m}_1 v_1$

$\dot{m} = \rho A V = (1000\ Kg/m^3) * (\frac{\pi}{4}(0.1m)^2) * (17 m/s)$

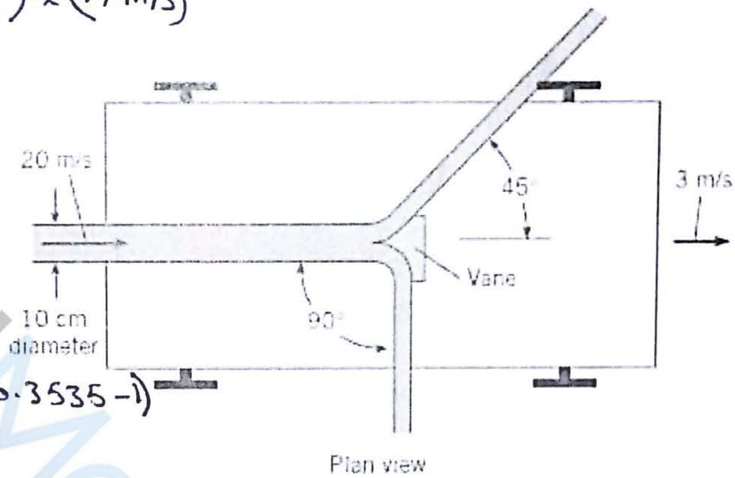
$= 133.5\ Kg/s$

$F_x = (\frac{\dot{m}}{2} v \cos 45° - \dot{m} v)$

$= \dot{m} v (\frac{\cos 45°}{2} - 1)$

$= (133.5\ Kg/s) * (17\ m/s) * (0.3535 - 1)$

$= -1470\ N$



* تذكر موضوع السرعة النسبية: "Relative Velocity"

$V = 20 - 3 = 17\ m/s$

وذلك لأنه الجسمانه يتحركانه بنفس الاتجاه ...

واذا كانا يتحركانه بعكس الاتجاه اجمع السرعة ...

$F_y = \dot{m}_2 v_{2y} - \dot{m} v_{3y}$

$= \frac{\dot{m}}{2} v \sin 45° - \frac{\dot{m}}{2} v$

$= \frac{\dot{m}}{2} v (\sin 45° - 1)$

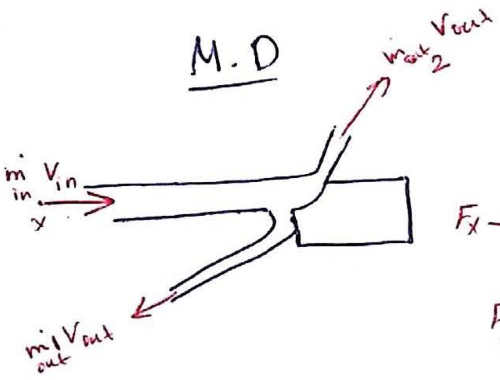
$= \frac{133.5\ Kg/s}{2} * 17 m/s * (0.707 - 1)$

$= -332\ N$

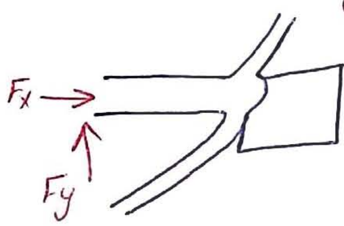
$F(\text{water on vane}) = (1470 i + 332 j) N$

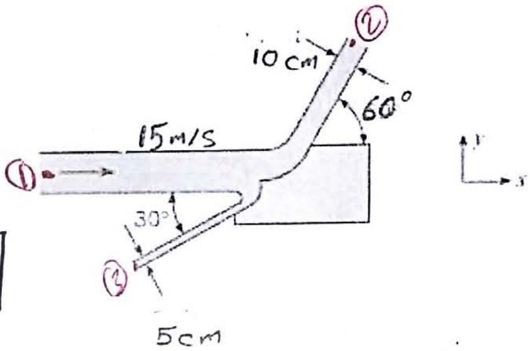
Q22 This planar water jet (15°C) is deflected by a fixed vane. What are the *x*- and *y*-components of force per unit width needed to hold the vane stationary? Neglect gravity.

M.D



F.D





$$\sum F_x = \sum \dot m_{out} V_{out_x} - \sum \dot m_{in} V_{in_x}$$

$$F_y = \sum \dot m_{out} V_{out_y} - \sum \dot m_{in} V_{in_y}$$

Complete alone ^*

① evaluate V_i's using Bernolli :

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

$$= \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + z_3$$

→ all three points at same elevation
→ all three points are atmospheric

So: $V_1 = V_2 = V_3 = 15$ m/s

$* \; Q_{total} = Q_2 + Q_3$

$$Q_2 = V_2 A_2 = 15 * \frac{\pi}{4} * 0.1^2$$
$$= 0.1177 \text{ m}^3/\text{s}$$

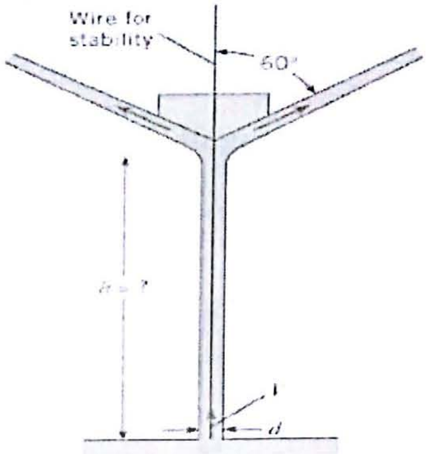
$$Q_3 = V_3 A_3 = 15 * \frac{\pi}{4} * 0.05^2$$
$$= 0.0294 \text{ m}^3/\text{s}$$

$$Q_1 = Q_2 + Q_3 = 0.1471 \text{ m}^3/\text{s}$$

$$\dot m_1 = \rho Q_1 = 147.14 \text{ Kg/s}$$
$$\dot m_2 = \rho Q_2 = 117.7 \text{ Kg/s}$$
$$\dot m_3 = \rho Q_3 = 29.4 \text{ Kg/s}$$

"Continuity equation"

Q28 A cone that is held stable by a wire is free to move in the vertical direction and has a jet of water (at 10°C) striking it from below. The cone weighs 30 N. The initial speed of the jet as it comes from the orifice is 15 m/s, and the initial jet diameter is 2 cm. Find the height to which the cone will rise and remain stationary. *note:* The wire is only for stability and should not enter into your calculations.



$$\frac{V_1^2}{2g} + 0 = \frac{V_2^2}{2g} + h$$

$$V_2^2 = (V_1)^2 - 2gh$$

$$V_2^2 = 225 - 19.62h$$

$$\Sigma F_y = \dot{m}_o V_{oy} - \dot{m}_i V_{iy}$$

$$-W = \dot{m}(V_{3y} - V_2)$$

$$-30\ N = (1000\ Kg/m^3) * (15 m/s) * (\pi * (0.01)^2) * (V_2 \sin 30° - V_2)$$

$$V_2 = 12.73\ m/s$$

$$V_2^2 = 225 - 19.62\ h$$

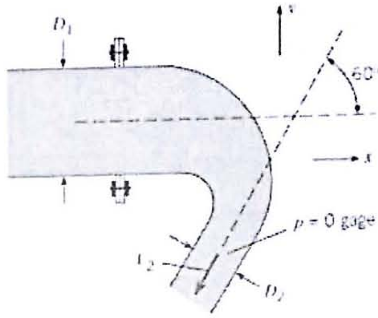
$$(12.73)^2 = 225 - 19.62\ h$$

$$\boxed{h = 3.21\ m}$$

Practice:

pipes

Q45 This bend discharges water (ρ = 1000 kg/m3) into the atmosphere. Determine the force components at the flange required to hold the bend in place. The bend lies in a horizontal plane. Assume viscous forces are negligible. The interior volume of the bend is 0.25 m3, *D*1 = 60 cm, *D*2 = 30 cm, and *V*2 = 10 m/s. The mass of the bend material is 250 kg.



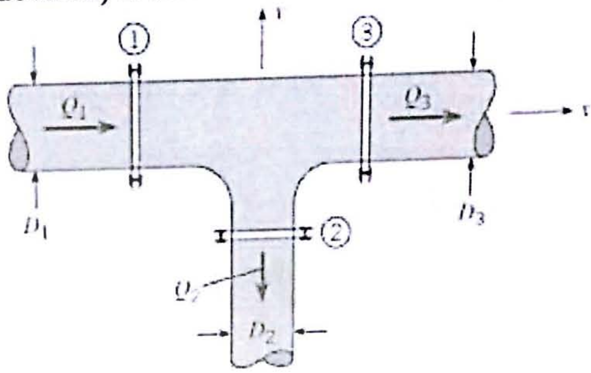
+ Solve alone, Same Idea, So easy

^ ^

Kingdom of fluid mechanics = Idea + trial + comprehension

best wishes --- ♡

Q55 For this horizontal T through which water ($\rho = 1000$ kg/m3) is flowing, the following data are given:
$Q1 = 0.25$ m3/s, $Q2 = 0.10$ m3/s, $p1 = 100$ kPa, $p2 = 70$ kPa, $p3 = 80$ kPa, $D1 = 15$ cm, $D2 = 7$ cm, and $D3 = 15$ cm. For these conditions, what external force in the *x-y* plane (through the bolts or other supporting devices) is needed to hold the T in place?



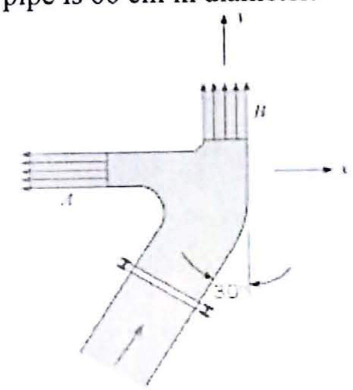
* Solve this alone

So easy; ^ ^

fluid Mechanics; try yourself !!

Nozzles

Q63 This "double" nozzle discharges water ($\rho = 1000$ kg/m3) into the atmosphere at a rate of 0.8 m3/s. If the nozzle is lying in a horizontal plane, what *x*-component of force acting through the flange bolts is required to hold the nozzle in place? *note:* Assume irrotational flow, and assume the water speed in each jet to be the same. Jet *A* is 20 cm. in diameter, jet *B* is 22 cm. in diameter, and the pipe is 60 cm in diameter.



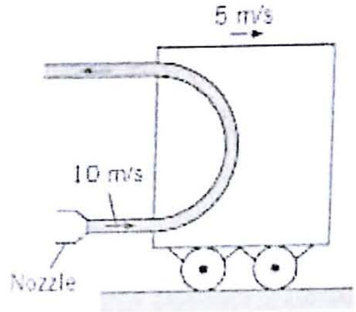
Solve this alone;
Practice !!

* you have to solve some examples & proplems ...

theire are here ... Just Do it ^ ^

Applications " nonstationary"

Q86 A cart is moving along a track at a constant velocity of 5 m/s as shown. Water (ρ = 1000 kg/m3) issues from a nozzle at 10 m/s and is deflected through 180° by a vane on the cart. The cross-sectional area of the nozzle is 0.0012 m2. Calculate the resistive force on the cart.



Solve this alone ^ ^

Fluid Mechanics -- love it ... live it

Best wishes all ...

Aboud Samee7