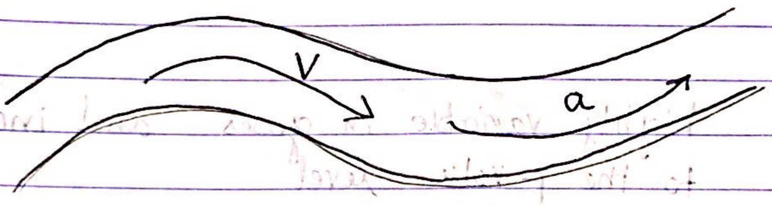
1.7

- In fluid mechanics we deal with the flow of a field as a function of position ~~&~~ time.

and since we are using Eulerian method of description. It is very suitable for us to know position as a function of time for the fluid flow

▸ Velocity field: Sometimes we need to find the velocity function of a fluid to solve problems related to it (It is the most important fluid properties)

$$V(x, y, z, t) = u\hat{i} + v\hat{j} + w\hat{k}$$



▸ Acceleration field: It is the derivative of V and it's really complicated where a:

$$a = \frac{dV}{dt} = \frac{\partial V}{\partial t} + u\frac{\partial V}{\partial x} + v\frac{\partial V}{\partial y} + w\frac{\partial V}{\partial z}$$

1.8

Thermodynamics Properties of a fluid:

- Pressure P
- Density ρ
- Temprature T
- Internal energy $\hat{u}$
- Enthalpy $h = \hat{u} + \frac{P}{\rho}$
- Entropy s
- specific heat C_p, C_v

} Important when Work heat & energy balances are treated.

- Coefficient of viscosity μ } friction
- Thermal conductivity k } and heat Related

Explanation of properties :-

Pressure: stress at a point in a static fluid
Differences in pressure ⟶ Derives a fluid flow.
$P_{atm} = 101.3 \text{ KPa} = 1 \text{ atm}$.

Temprature: Scales : Rankine , Kelvin
$R = °F + 459.69$
$K = °C + 273.16$

Density : highly variable in gases and increases propotiona
to the level
Constant in liquids

$\rho_{water} = 1000 \text{ Kg/m}^3$

Heavist liquid is mercury $\rho = 13580 \text{ Kg/m}^3$
lightest gas is hydrogin $\rho = 0.0838 \text{ Kg/m}^3$

Specific weight : $\gamma = \rho g = \frac{\text{Weight}}{V}$ ⟶ volume

Specific Gravity: $SG_{gas} = \frac{\rho_{gas}}{\rho_{air}} = \frac{\rho_{gas}}{1.205 \text{ Kg/m}^3}$

$SG_{liq} = \frac{\rho_{liq}}{\rho_{water}} = \frac{\rho_{liq}}{1000 \text{ Kg/m}^3}$

State Relations for Gases:

- All gases at High tempretures and low pressures are considered ideal gases and so we can apply the perfect gas - law:

$p = \rho R T$ $\qquad R = c_p - c_v = \text{gas constant}$

Memorize ?

N_0

$= 8314 \ J(Kmol \cdot K)$

$R = \frac{\Lambda}{M_{gas}} \Rightarrow R_{air} = \frac{49700}{28.97} = 287 \ \frac{m^2}{s^2 \cdot K}$

- Some Rules for approximation:-

$K = \frac{C_p}{C_v}$ $\qquad C_v = \frac{R}{K-1}$

$C_p = \frac{KR}{K-1}$

1.9 : Viscosity & other secondary Properties

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

- τ ← shear stress
- μ ← viscosity
- $\frac{du}{dy}$ ← velocity as a function of y.

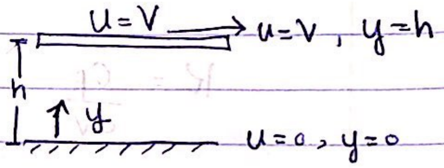
- Raynolds number

$$R_e = \frac{\text{Inertial forces}}{\text{viscous forces}} = \frac{\rho V L}{\mu}$$

- ρ ← كثافة
- L ← مسافة
- μ ← Viscosity

- flow between plates

$$\tau = \mu \frac{V}{h}$$



- Variation of viscosity with Temprature

we use approximation to find μ if you don't have tables

Power law : $\frac{\mu}{\mu_0} = \left(\frac{T}{T_0}\right)^n$ where: $n = 0.7$

μ_0 = viscosity at T_0 (273 K)

Memorize? NO

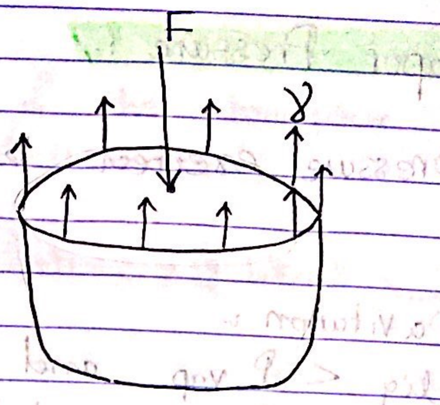
Sutherland law: $\frac{\mu}{\mu_0} = \frac{\left(\frac{T}{T_0}\right)^{\frac{3}{2}} (T_0 + S)}{T + S}$ where $S = 110$ K

Surface Tension :-

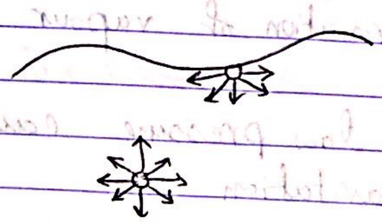
$F_{\text{surface Tension}} = \gamma L$ ← surface Tension

↑ L is the circumference

$L = 2\pi R$



$P = \frac{F}{A} \rightsquigarrow F = PA$



now for equilibrium :-

$F = F_{\text{surface Tension}}$

surface tension

• هو حالة من التوتر التي توجد على السطح للسائل. وذلك بسبب عدم تساوي القوى المؤثرة ونتيجة لذلك نستطيع ان نكسر الحتط.

$PA = \gamma \, 2\pi R$

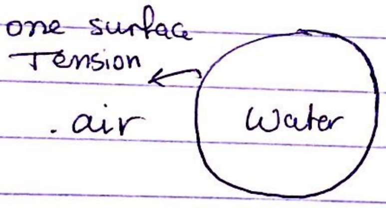
$P\pi R^2 = \gamma \, 2\pi R$

$\Delta P = \frac{2\gamma}{R}$ ← لكرة من الماء

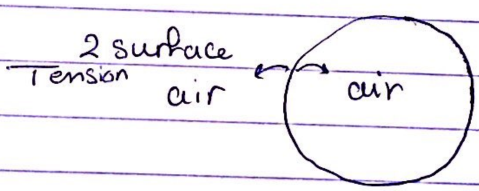
فرق الضغط (ΔP)

نصف القطر للقطرة (R)

now, $\Delta P_{bubble} = 2 \Delta P_{droplet} = \frac{4\gamma}{R}$



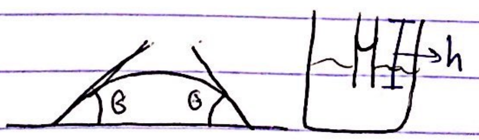
Droplet



Bubble

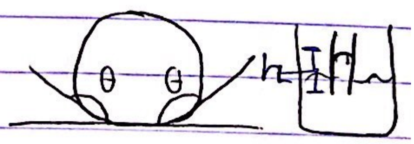
Wetting and nonwetting fluids:

water (wetting)



$\theta < 90^\circ$

mercury (nonwetting)

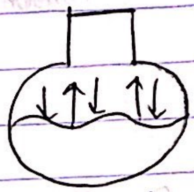


$\theta > 90^\circ$

Capillary Action ⇒ $h = \frac{2\gamma \cos\theta}{\rho g R}$

Vapor Pressure :-

pressure exerted by a vapor over a liquid



Cavitation :-
$P_{liq} < P_{vap}$ and then formation of vapour bubbles

• عند تبخر الجزيئات تظل محبوسة وبالتالي تضغط ضغط يسمى Vapor pressure

→ So low pressure causes cavitation

$$C_a = \frac{P_a - P_v}{\frac{1}{2}\rho V^2}$$

(P_v → Vap. pressure; V → velocity)

Note: The lower portion of the atmosphere is called the troposphere (until 11 km up)

$$P = P_{atm}\left(1 - \frac{BZ}{T_0}\right)^{g/RB}$$: توزيع الضغط في هذه الطبقة

where : $\frac{g}{RB} = 5.26$ for air

$T_0 = 288.16\ K^{\circ}$, $B = 0.0065\ K/m$

Memorize ? NO