ElCoM
ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة ElCoM الاكاديمية

دفتر لمادة:

حراريات وموائع

جزيل الشكر للطالبة:

صفاء

Subject :

* Ch.1 :- Introduction and over view :-

* 1.1 :- Thermal - fluid sciences

Thermo dynamics — Heat Transfer — Fluid Mechanics

- 1.2 :- Thermodynamics :- Defiend as the sciences of energy

- 1st law of Thermodynamics (conservation of energy) حفظ الطاقة
- 2nd " " " (Direction of Heat transfer)

- 1.3 :- Heat Transfer :- methods of Heat transfer

- conduction توصيل (in solid)
- convection تحميل (in fluid) liquid or gas
- radiation إشعاع (In space)

* 1.4 :- Fluid Mechanics :- Defined as the science that deals with behavior of fluid at rest (fluied statics) or motion (fluid dynamics)

* 1.5 :- Dimensions and units :-

→ Any Physical quantity can be characterized by dimension

→ The magnitudes assigned to the dimensions are called (un

→ Primary dimensions → Mass (m)
→ Length (L)
→ Time (t)
→ Temprute (T) (θ)

→ secondary dimensions or (derived dimensions):-
→ velocity (V)
→ energy (E)
→ volume (V)
→ density (ρ)
→ Force (F)

* Units → SI (International system)
→ English system (USCS)

* Dimensions	SI	English System
Mass	kg	Pound mass (Ib) or (Libra)
length	meter (m)	foot (ft)
Time	second (s)	second (s)
Temprutur	kelvin (k) or Degree celisus (°C)	Fahreheit (°F)

* Note : 1 ft → 0.3048 m / 1 Ib → 0.45359 kg

▸ Subject : .... / /

→ Derives units:-

	SI	English
* velocity (V) = $\frac{\text{lengths}}{\text{time}}$ =	$\frac{m}{s}$,	$\frac{ft}{s}$

* force = mass * acc => F = $\boxed{kg.\frac{m}{s^2} = (N) \text{ (newton)}}$, English: $lbm.\frac{ft}{s^2}$

* Work (W) = Force * distance = $\boxed{kg.\frac{m}{s^2}.m = (N.m)}$, BTU
  = Joule (J)

* Power = $\frac{\text{work}}{\text{time}}$ = $\frac{N.m}{S}$ (watt)

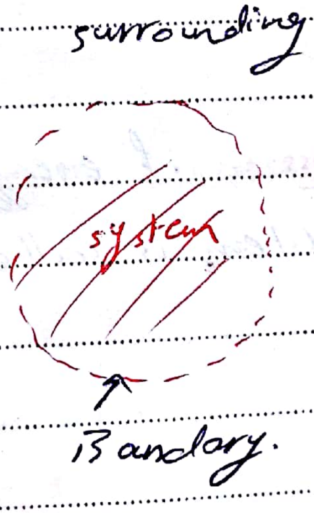
* 2.1 :- system and control volums:-

- system :- A system is defind as a quantity of matter or a region in a space ~~to~~ chosen for study.

- Surrounding :- is defind as the mass or regoin outside the system.

- Boundary :- is defind as the real or imaginary serface that separtes the system from its surrounding.
  فاصل

=> Boundary → real
→ imaginary
→ fixed ثابت
→ movable



* Types of systems:-

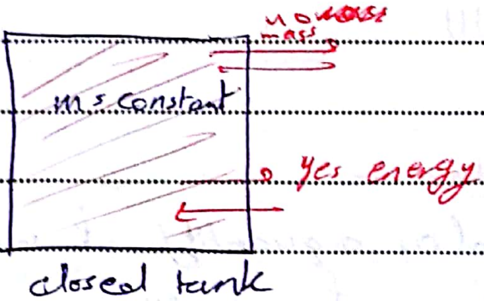
[1] closed system (control mass)

[2] open system (control volume)

* closed system:- a system where no mass transfer or cross the Boundaring ~~which~~ while energy in forms of heat and work can transfer.

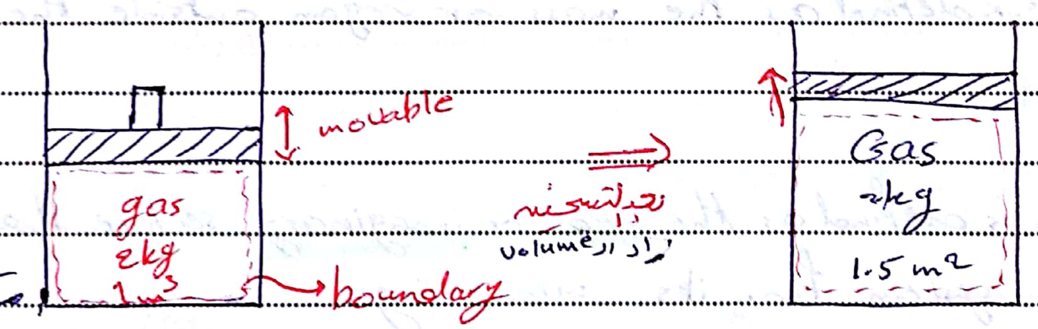
* Example:-

[1]



(closed system)

[2]



Piston cylinder

*special case:- if energy is not allowed to cross the boundary, then the system is called "isolated system"

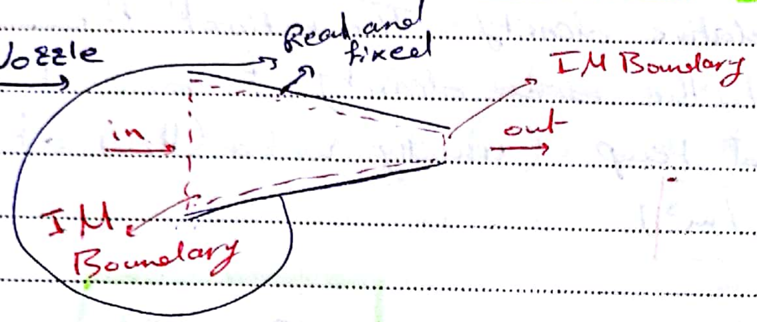
Subject : .... التاريخ

*** open system :-** "control volum" or control surface

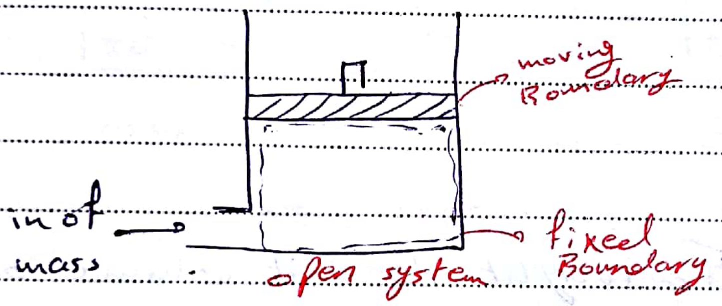
→ a system where mass and energy transfer &or cross the boundaring.

* Example :- [1] Nozzle, compressor, pump, turbime.
محولة حركة الى حركة
على شكل شلال ماء.

[1] Nozzle



[2]



* 2.2:- Properties of system:-

→ Any charateristic of a system is called a property (Temp, Pressure, volume, density, mass, enthalpy (energy))

⇒ properties

- **Intensive** :- independent of mass (Temp, density, pressure)
- **Extensive** :- depend on mass or size (mass, volume, energy)

* Extensive properties per unit mass are called "specific properties"

→ Ex :- specific volume $v = \frac{V}{m} = \frac{m^3}{kg} = \frac{1}{\rho}$ (density)

*2.3 :- Density and specific Gravity (S.G) :

⇒ specific gravity ~~and~~ relative density :- The ratio of the density of a substance to the ~~dete~~ density of some standard substance at a specified temp (usually water (H_2O) at 4 C°, $\boxed{\rho_{H_2O} = 1000\ kg/m^3}$)

→ $S.G = \frac{\rho_{sub}}{\rho_{H_2O}}$ = unit less , Example :- $\boxed{S.G_{Hg} = 13.6}$

→ $\boxed{\rho_{\text{هواء}} = 1\ kg/m^3}$

* specific weight (γ) غاما :- The weight per unit volume of the substance , $\gamma = \rho \cdot g$

→ gravitational accelration = 9.8 m/s^2

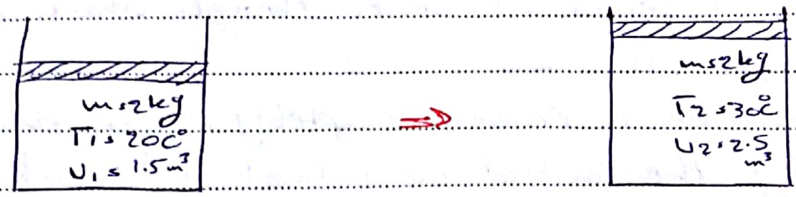
→ $\gamma = \frac{kg}{m^3} \cdot \frac{m}{s^2} = (N/m^3)$

* 2.4 :- State and Equilibrium :-

* $\boxed{\text{State}}$:- system not undergoing any change of properties.

EX//

Ex

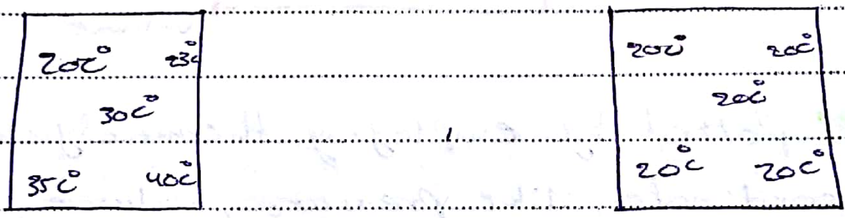


closed system

state 1 state 2

* Equilibrium:- a state of balance; there are no unbalanced potentials or driving forces with the system.

Ex



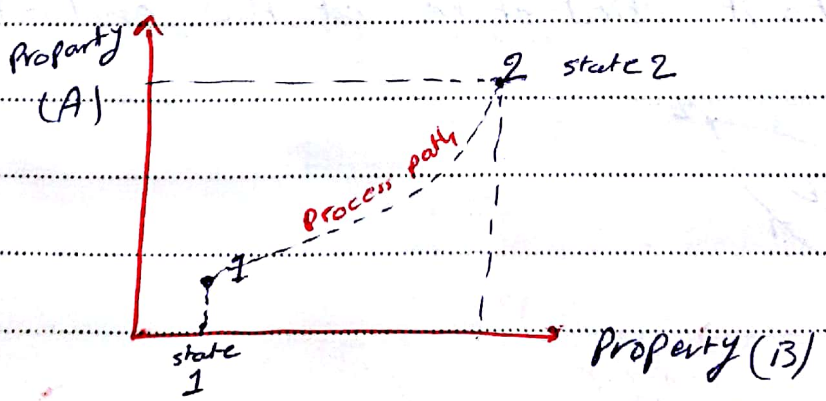
درجات حرارة مختلفة في نفس الغرفة

non equilibrium Equilibrium

* Example of equilibrium:- Thermal equil, Mechanical equil, chemical equil.

* 2.5:- Processes and cycles:-

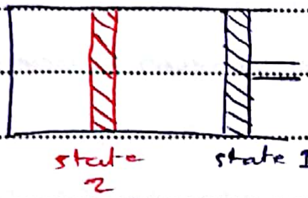
- Process: Any change that a system undergoing from one equilibrium state to another state.

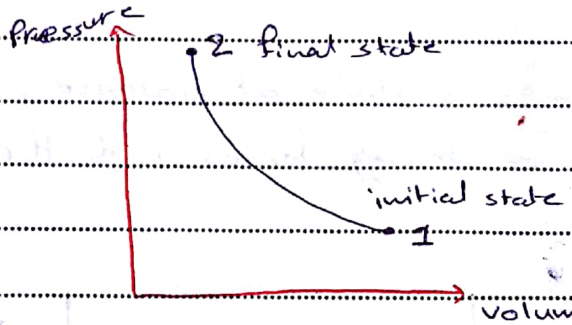


► Subject : .... / /

Process path:- A series of stats through which a system pass during a process

⇒ to describe a process completely, one should specify the initial and final states of process as well as the path it follows, and the interactions with the surrounding.





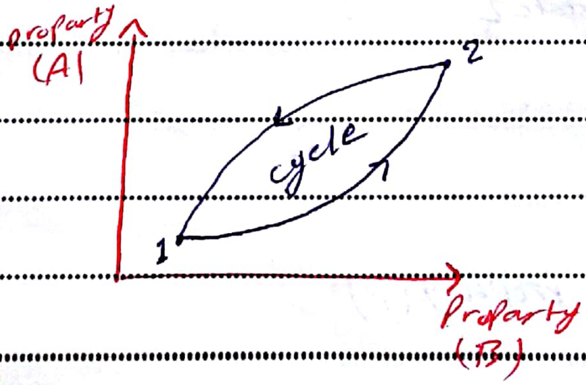
"Process diagram"

* **Process diagram:-** plotted by employing thermodynamics properties as coordinates, like pressure, volume, temperature

* During a process, a specific system property may remain constant (iso)

1. iso thermal Process:- Temp remain constant.
2. iso baric Process :- Pressure remain constant.
3. iso metric process :- Volume remain constant.

* **cycle:-** system returns to it intial state at the end of the Process.



Scanned by CamScanner

▸ Subject : .... / /

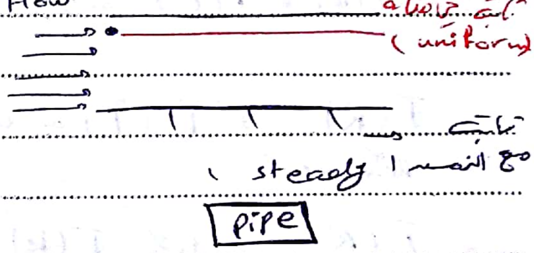
*example :- otto cycle / Diesel cycle / Refiegeration cycle.

* The steady - flow process :-

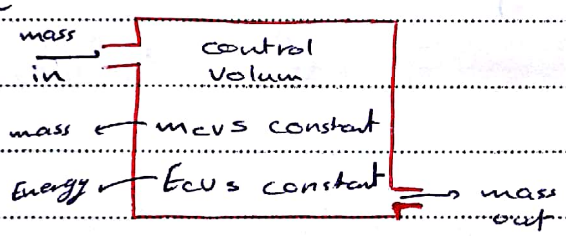
- steady :- No change with time (oppsite unsteady, transitent) حالة إنتقالية
ثابت

- uniform :- No change with location over a specific region
منتظم

Ex [1] :- flow

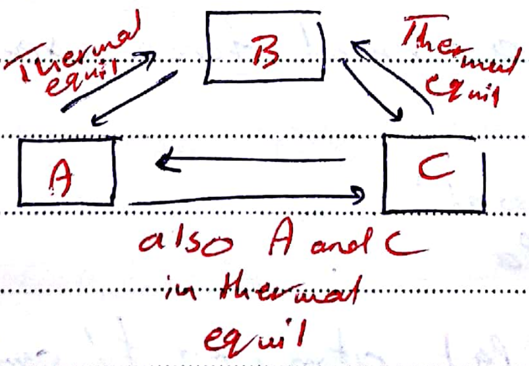


* Ex [2] :-



* 2-6 :- Temperature and The zeroth law of Thermodynamics :-

=> zeroth law :- if two bodies are in thermal equilibrium with a third body, they are also in thermal equilibrium with each other.



Subject :

* Temperature scales :-

S.I. unit	English
celsius scale	faherenhiet scale
kelvin scale	Rankine scale

absolute temp

→ $T(k) = T(C^\circ) + 273.15$

→ $T(R) = T(\mathring{F}) + 459.67$
Rankine

→ $T(R) = 1.8\ T(k)$

→ $T(F^\circ) = 1.8\ T(C^\circ) + 32$

* Note :- $\Delta T(k) = \Delta T(C^\circ)$

$\Delta T(R) = \Delta T(\mathring{F})$

* Temperature Devieses :-

1. Thermometer
2. RTD
3. Thermistor
4. Thermo couple

* 2.7 : Pressure :-

* Pressure defined as :- a normal force exerted by a fluid per unit area.

→ $\boxed{P = \frac{F}{A}} = \frac{N}{m^2}$ (Passal) Pa

→ Pressure units :- (Passal (Pa), atm, kg f / cm², bar) SI units

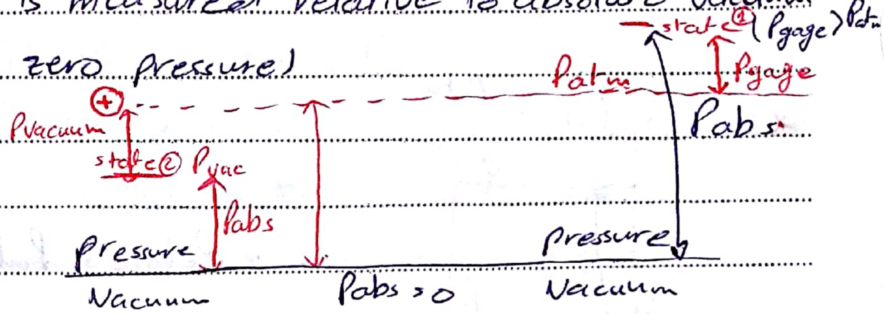
▸ Subject : .... / /

→ In english units (Ibf/in², (psi)) (pound per square in)

1 bar → 100 kpa

1 atm → 101.325 kpa

* Absolute pressure: it is measured relative to absolute vacuum pressure (i.e absolute zero pressure)

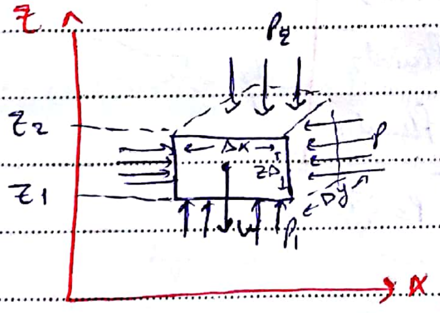


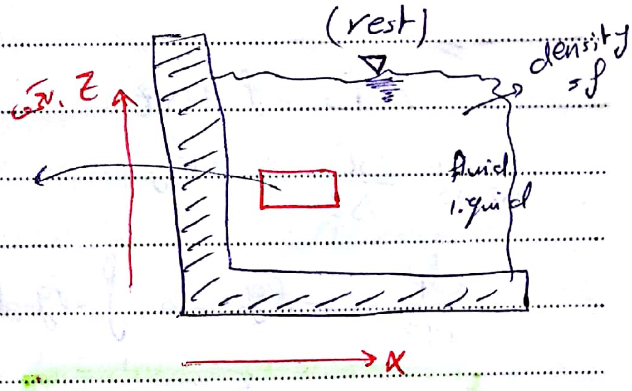
* Pgage = Pabs − Patm

* Pvac = Patm − Pabs (negative sign)

* pressure measuring devices are calibrated to read zero in atmosphere.

* variation of pressure with depth:





Subject :

volume density

$\uparrow \sum F_z = 0$ $\qquad$ $W = mass\cdot acc.$

$-P_2(\Delta x \cdot \Delta y) + P_1(\Delta x \cdot \Delta y) + -W = 0$ $\qquad$ $W = m \cdot g$

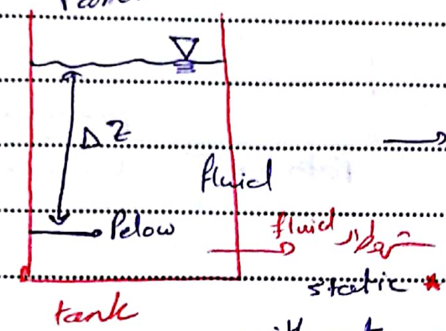
$-P_2(\Delta x \cdot \Delta y) + P_1(\Delta x \cdot \Delta y) - \rho \Delta x \Delta y \Delta z \cdot g = 0$ $\qquad$ $= \rho(\Delta x \Delta y \Delta z) \cdot g$

3D (حجم)

$-P_2 + P_1 - \rho \Delta z g = 0 \longrightarrow \boxed{P_2 - P_1 = -\rho \Delta z g} = \Delta P$

direction

* P_{above} P_{atm}



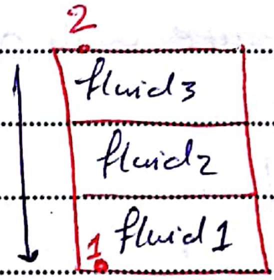
$\longrightarrow P_{elow} = P_{atm} + \rho g |\Delta z|$

static *

without *
variable
~~density~~ (constant density)

* The pressure of a fluid at rest increases with depth (increasing linearly)

$\longrightarrow$ For ~~variable~~ variation of density with elevation



$P = ??$

$\Delta P = -\rho g \Delta z$

$\lim_{\Delta z \to 0} \frac{\Delta P}{\Delta z} = -\rho g$

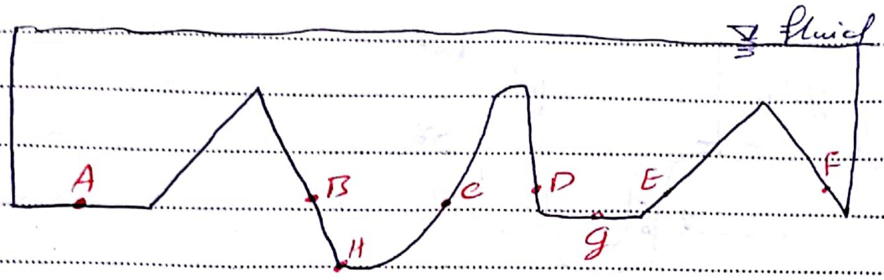
$\frac{dP}{dz} = -\rho g \rightarrow \int_1^2 -\rho g \, dz = \int dP$

$$\boxed{\Delta P = -\int_1^2 \rho g \cdot dz}$$

Scanned by CamScanner

Subject :

*



→ $P_A = P_B = P_C = P_D = P_E = P_F \neq P_g \neq P_H$

*Note :- pressure in a fluide at rest is independent of the shape or cross-sectional area of the container, it changes with vertical direction, constant in othe direction.

*2.8:- Pressure measurment devices :-

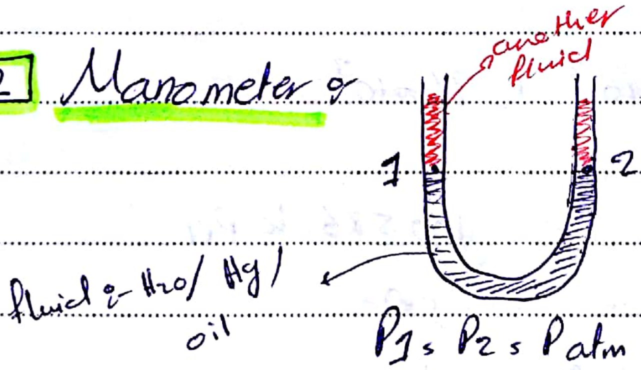
1 The Barometer :- is used to measure the atmospheric pressure (barometric prusser)

1 atm → 760 mm Hg
1 torr → 760 mm Hg

→ $\boxed{P_{atm} = \rho_{Hg}\, g\, .\, \Delta Z}$

→ $\boxed{\Delta Z_{water} = 10.3\ m}$

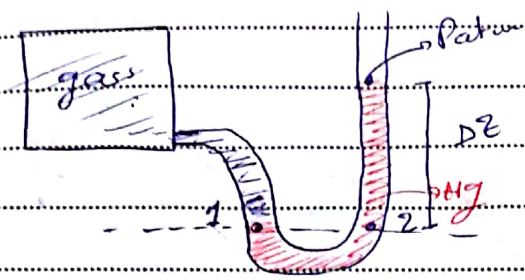
2 Manometer :



$P_1 = P_2 = P_{atm}$

The manometer is used to mesure small pressure difference and consists of a glass or plastic with U-tube contaning one or more fluids, like Hg, H2o, oil, etc —

*** Example :**



$P_1 = P_2$

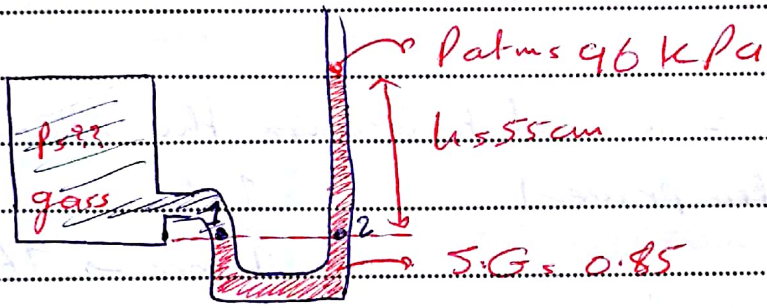
$P_1 = P_{gage}$ of gas

$P_2 = \rho_{Hg} \cdot g \cdot \Delta Z$

$P_{gage_{gas}} = \rho_{Hg} \cdot g \cdot \Delta Z$

$$\boxed{P_{abs\,gas} = P_{atm} + P_{gage}}$$

*** Ex :**



→ Determain the absolute pressure in tank ?

→ $P_1 = P_2$

P_1 = Pressure tank

$P_2 = \rho g h + P_{atm}$

$P_2 = 0.85 * 1000 * 9.81 * 55 * 10^{-2} + 96 * 10^3$

$P_2 = 4.586 * 10^3 + 96 * 10^3$

$= 100.586 * 10^3$ Pa or 100.586 kPa

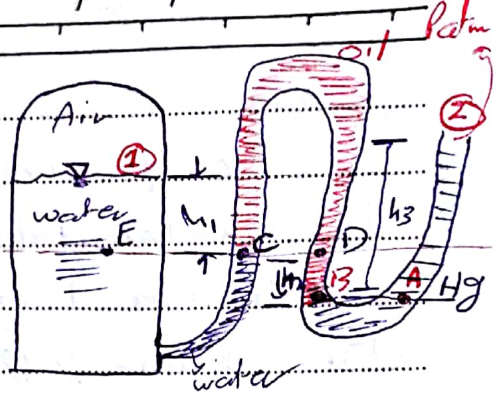
$P_1 = P_2 = 100.586$ kPa → atm = 0

اذا بدي gage بطرح ال atm

STARS NOTEBOOK

Subject : ② و ① بنوخذ نقطتين عند الفتحتين مثل + Note: دايمًا عشان احلها بنوخذ النقاط الي فيها discontinuity

***Ex:** water tank pressurized by air
$P_{atm} = 85.6$ kPa, if $h_1 = 0.1$ m,
$h_2 = 0.2$ m, $h_3 = 0.35$ m, $\rho_{H_2O} = 1000$ kg/m³
$\rho_{oil} = 850$ kg/m³, $\rho_{Hg} = 13600$ kg/m³



→ Determain the air pressure in ~~total~~ the tube?

→ sol: $P_A = P_B$ —— ①
$P_C = P_D = P_E$ —— ②

→ $P_A = P_2 + \rho_{Hg}\, g\, h_3$ —— ③

$P_E = P_1 + \rho_{H_2O}\, g\, h_1$ —— ④

$P_B = P_D + \rho_{oil}\, g\, h_2$ —— ⑤

→ sub. eq (3) and eq (5) in eq (1):
$P_A = P_B$
$P_2 + \rho_{Hg}\, g\, h_3 = P_D + \rho_{oil}\, g\, h_2$ —— eq (6)

→ sub eq (4) in eq (6)
$P_2 + \rho_{Hg}\, g\, h_3 = P_1 + \rho_{H_2O}\, g\, h_1 + \rho_{oil}\, g\, h_2$
Patm =

→ $P_1 = P_2 + \rho_{Hg}\, g\, h_3 - \rho_{H_2O}\, g\, h_1 - \rho_{oil}\, g\, h_2$
$= 85.6 \times 10^3 + 13600 \times 9.81 \times 0.35 - 1000 \times 9.8 \times 0.1 - 850 \times 9.81 \times 0.2$
$P_1 = 129.6 \times 10^3$ Pa or 129.6 kPa
absolute

Scanned by CamScanner

→ other pressure measurements devices:-

1. Bourdon tube (gage)
2. Pressure transducers
3. Strain- gages pressure tranducers
4. Piezoelectric transducers

* Ch.3 :- Energy transfer and Energy Analysis:-

* 3.1 :- Introduction :-

→ Conservation of energy : Energy can't be created or destroyed during a Process, it can only change from one form to another

* 3.2 :- Forms of Energy :

* Thermal, kinetic, Potentials, nuclear, electrical, chemical, mechanical, magnetic

– The sum of these forms (E) "Total Energy" (kJ)

→ $e = \frac{E}{m}$ $\boxed{\left(\frac{kJ}{kg}\right)}$

Energy Per unit mass

* kinetic Energy (K.E) = $\boxed{\frac{mV^2}{2}}$ or k.e = $\frac{V^2}{2}$ $\left(\frac{kJ}{kg}\right)$

Scanned by CamScanner

▸ Subject :

* Potential energy (P.E) = $\boxed{mgZ}$ (Z → elevation) or P.e = g.Z

(*) The total Energy of a system is divided into two groups:-

[1] Macroscopic form of Energy :- These form are considered with respect to some outside reference from such as kinetic and potential Energys

[2] Microscopic form of Energy :- These form are related to the molecular structure of the system and the degree of the molecular activity, and they are independent of outside reference frames.

- The sum of all the microscopic forms of energy is called the internal energy of a system $\boxed{(U)}$

→ $\boxed{E = U + K.E + K.P \quad (kJ)}$

Per unit mass:

→ $e = u + k.e + k.p \quad \left(\frac{kJ}{kg}\right)$

→ The most closed systems are stationary system → ~~K.P~~ k.E, P.E remain constant. ~~ΔP.E~~

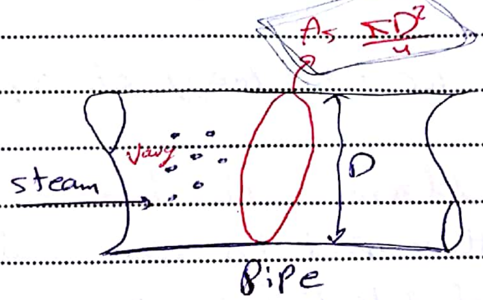
↳ $\Delta P.E = 0$,

↳ $\Delta K.E = 0$

$$\boxed{\Delta E = \Delta U}$$

– open system (control volume)

↳ Mass flow rate



الدفعة

kg/s $= \dot{m} = \rho \dot{V}$ → Volume flow rat

$\dot{m} = \rho V_{avg} A$

↳ Energy flow rate $\boxed{(\dot{E}) = \dot{m} e}$ → Energy per unit mass

(kJ/s) (watt)

* Mechanical Energy: The form of energy that can be converted to mechanical work completely and directly by an ideal mechanical devices, such as ideal turbine.

→ Kinetic and potential energies are familiar form of mechanical energy.

* The mechanical energy of a fluid can ~~be~~ expressed on a unit mass:

$$e_{mech} = \underbrace{\frac{V^2}{2}}_{\text{kinatic}} + \underbrace{gz}_{\text{potinial}} + \underbrace{\frac{P}{\rho}}_{\text{Pressure energy}}$$

→ Pressure $= \frac{N}{m^2} = \frac{N \cdot m}{m^3} = \frac{J}{m^3}$ // $\frac{\text{Pressure}}{\text{dinsity}} = \frac{J/m^3}{kg/m^3}$

Subject : ....

$$\boxed{\rightarrow \dot{E} = \dot{m}\, e_{mech} = \dot{m}\left(\frac{P}{\rho} + \frac{V^2}{2} + gz\right)}$$

* The mechanical energy changed of a fluid during incompresible (ρ = constant)

$$\rightarrow \Delta e_{mech} = \frac{P_2 - P_1}{\rho} + \frac{V_2^2 - V_1^2}{2} + g(z_2 - z_1) \quad (kJ/kg)$$

→ rate of energy :- $\dot{E} = \dot{m}\, \Delta e_{mech} = \dot{m}\left(\frac{\Delta P}{\rho} + \frac{\Delta V^2}{2} + g\Delta z\right)$ (kW)

* 3.3 :- Energy Transfer by heat :-

* Heat :- The form of energy that is transfer between two systems or (system and it's surrounding) depends on temprecture difference. (Q)

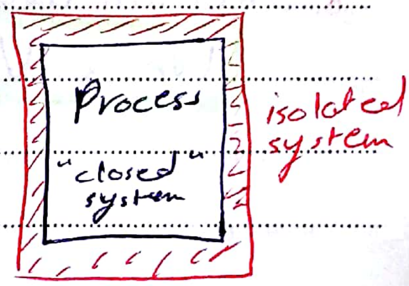
* Heat per unit mass (q) → $q = \frac{Q}{m}$ (kJ/kg), rate of Heat transfer ($\dot{Q}$) (kJ/s)

إزا كانت تتغير بالنسبة للزمن

$Q = \int_{t_1}^{t_2} \dot{Q}\, dt$, where $\dot{Q}$ remains constant during process.

$$\boxed{Q = \dot{Q}\, \Delta t}$$

* Adiabatic process :- A process during which there is not heat transfer between the system and surrounding.



* 3.4 :- Energy Transfer by work :-

* Work :- is the energy transfer associated with a force acting through a distance. (Ex:- rising piston, rotating shaft)

→ work per unit mass (w)

$w = \frac{W}{m}$ $\left(\frac{kJ}{kg}\right)$

→ Power $\dot{W} = \frac{W}{t}$ (kW)

change per unit time ← $W = \int_{t_1}^{t_2} \dot{W} dt$, if $\dot{W}$ constant $\boxed{W = \dot{W} \Delta t}$

* Heat and Work are directional quantites (Magnitued and direction)

عالي → Heat transfer to a system and work done by a system are $\boxed{\text{positive}}$

ع → Heat transfer from a system and work done on a system are $\boxed{\text{negative.}}$

* Electrical work (We) :-

$\boxed{W_e = V N}$, V :- Potenial diff ⇒ voltage

N :- electrical charge.

Subject : / /

→ electrical power $\dot{W}_e$:- $\dot{W}_e = VI$ (k watt)

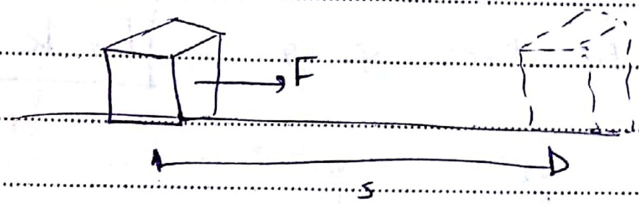
change with time → $W_e = \int_{t_1}^{t_2} IV\,dt$

if I :- constant → $\boxed{W_e = VI\Delta t}$ (kJ)

* 3.5 :- Mechanical forms of work :-

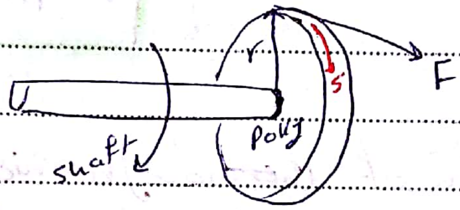
work (force acting through a distance)

$W = F.S$ → if (F) is constant



if F is variable → $W = \int_1^2 F\,ds$

* Shaft work :-



$T = F.r$, $S = 2\pi r n$ → # of revelution

Torque · ~~revelution~~ distance

→ $W = F.S$

$W_{shaft} = \frac{T}{r} \cdot 2\pi r n = \boxed{T 2\pi n}$ (kJ)

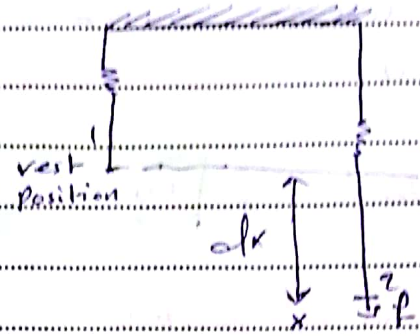
→ power of shaft → $\dot{W}_{shaft} = \boxed{2\pi \dot{n} T}$ (kW)

$\dot{n}$: revelution per unit time (Angular ~~speed~~ velocity)

Subject :

* Spring Work :

$dW_{spring} = F \cdot ds$



→ for linear spring → $\boxed{F = k x}$ → distance

stiffens of spring (N/m)

→ $\int_{w_1}^{w_2} dw = \int k x \, dx$ → $W_{spring} = \frac{1}{2} k x^2 \Big|_{x_1}^{x_2}$

$$\boxed{W_{spring} = \frac{1}{2} k (x_2^2 - x_1^2)} \text{ (kJ)}$$

*3.6 :- The first law of Thermodynamics :- (conservation of energy)

→ Energy
- → work
- → heat
- → Total of energy

* Energy balance :- $\left(\text{Total energy entry the system}\right) - \left(\text{Total energy leaving the system}\right) = \left(\text{change in the total energy of the system}\right)$

↳ net of energy transfer by Heat, work, mass of energy

↳ internal energy, potential energy, kinetic energy

$$\boxed{E_{in} - E_{out} = \Delta E_{system}}$$

Subject :

* ~~change~~ Energy change of the system ΔE_{sys}

→ $\boxed{\Delta E_{sys} = E_{\substack{final \\ state}} - E_{\substack{initial \\ state}}}$

$\Delta E_{sys} = \Delta U + \Delta K.E + \Delta P.E$

$\Delta U = m(U_2 - U_1)$ $\Delta K.E = \frac{m}{2}(V_2^2 - V_1^2)$ $\Delta P.E = mg(Z_f - Z_i)$

→ $E_{in} - E_{out} = \Delta E_{system}$

$$\boxed{(Q_{in} - Q_{out}) + (W_{in} - W_{out}) + (E_{\substack{mass \\ in}} - E_{\substack{mass \\ out}}) = \Delta E_{sys} \quad (kJ)}$$

→ Energy per unit mass :- $e_{in} - e_{out} = \Delta e_{system}$ (kJ/kg)

→ rate of form 1^{st} law of thermodynamics :-

$$\dot{E}_{in} - \dot{E}_{out} = \frac{dE_{sys}}{dt} \quad (kW)$$

*Note :- for a closed system undergoing a cycle, initial state and final state are identical → $\Delta E_{sys} = 0$ → $E_{in} = E_{out}$

→ $W_{net,out} = Q_{net,in}$

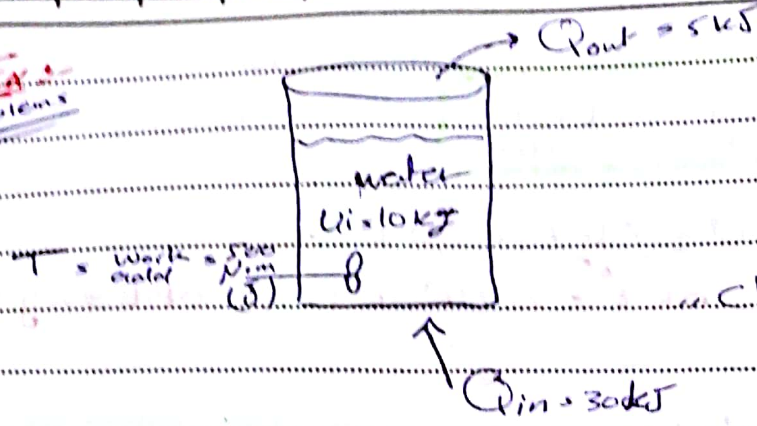
$\dot{W}_{net,out} = \dot{Q}_{net,in}$

*3.7 :- Energy conservation efficiency :-

$$\eta = \frac{\text{Desired output}}{\text{Required input}} = \text{cofficient of performance (COP)}$$

► Subject :

***Ex: Problems**



Closed system

→ Determine the final energy of the system if the initial energy is 10 kJ?

→ sol:
$$E_{in} - E_{out} = \Delta E_{sys} \rightarrow U_f - U_i$$
$$(Q_{in} - Q_{out}) + (W_{in} - W_{out}) = \Delta U$$
$$(30\times10^3 - 5\times10^3) + (500 - 0) = U_f - 10\times10^3$$
$$U_f = 35500 \text{ J} \quad \underline{\text{or}} \quad 35.5 \text{ kJ}$$

Scanned by CamScanner

* Ch. 4. :- Properties of pure substances:-

*** 4.1 :- pure of substance:-** a substance that has fixed chemical composition through its structure (water, nitrogen, helium, etc.).

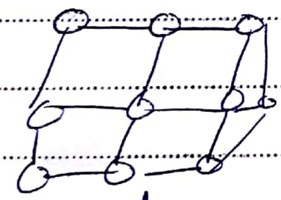
* A mixture of differient chiemical elemints may also be a pure substances as long as it is homogenous. (Air is a mixture of several gases, because it has a uniform climical composition).

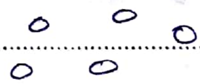
* A mixture of oil and water are not a pure substance.

* 4.2 :- phase of pure substance :-

*** phase :-** is adentifeed as a having a distanct molecular arrengment that is homogenous throghout and sepreated from the others by easily identifiable boundary surface.

[1] solid   [2] liquid   [3] gas





solid fixed

liquid moleals free to relat and to translate

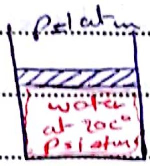
gass molecals free with high energy

→ intermoleculer bonds is stronger is solid and weaknest at gas.

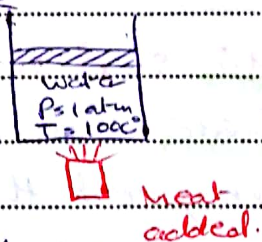
* 4.3 : Phase change Process of Pure substance :-

* To understand the phase change process, consider a cylinder filled with water and piston to cover the cylinder.

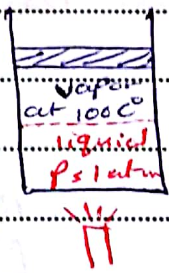
* **state 1** :- compressed liquid (subcooled liquid) :-
At 20°C and 1 atm water exists in the liquid phase mean it is not about to vaproize.



* **state 2** :- (saturated liquid) :- specific volume increase at constant pressure, and a liquid that is about to vaporize.



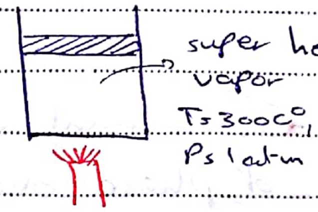
* **state 3** :- saturated liquid vapor mixture (mixture) :-
The Tempretuere remain constant at T=100°c while boiling and Phase changing take place.



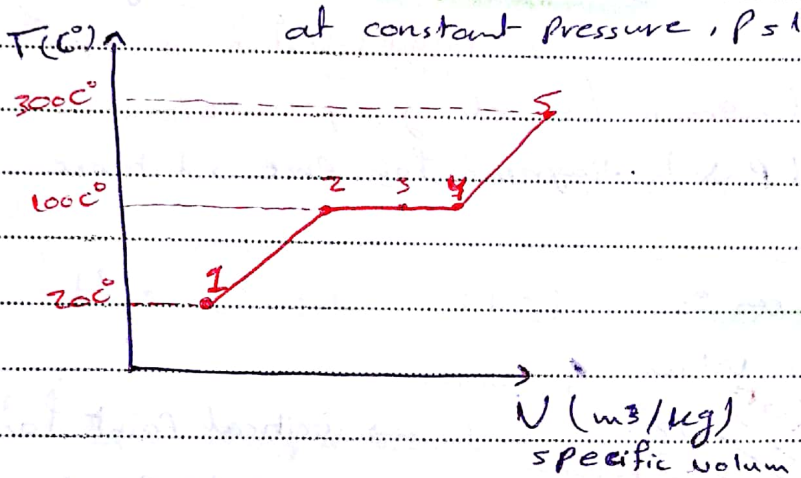
→ saturated vapor :-
* **state 4** :- Heating is still and the vaporization will continue until the last drop of liquid is vaporited, at this stage the cylinder contains only vapor at 100°c and 1 atm, Any cooling process will cause some vapor

to condense to water.
التكاثف

* state 5 : super heated vapor : a vapor which is not about to condence.



→ at constant pressure, P=1atm



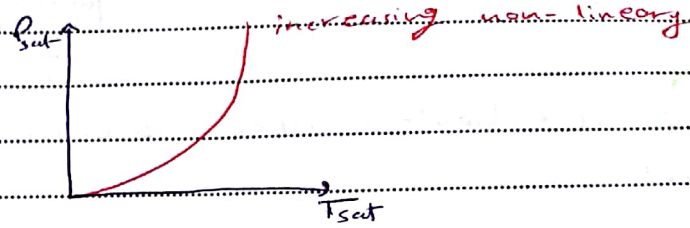
* The temp. at which apure substance change phase is called saturated temperature (T_{sat})

* The pressure at which a pure substance change a phase is called saturated pressure (P_{sat})

Subject : .... / /

* During phase change temp and pressure are dependant on each other.

$T_{sat} = f(P_{sat})$



* The amount of energy absorbed or relased during process of phase change is called (latent heat) $\Delta h = h_{fg} = h_g - h_f$

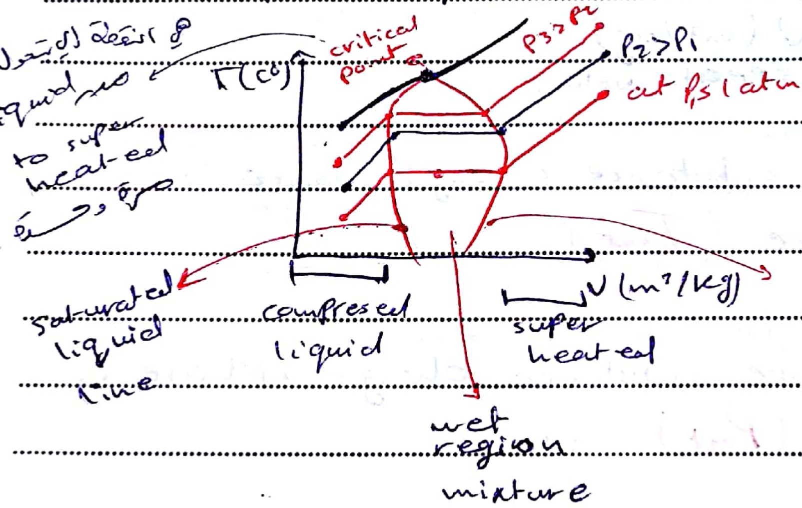
latent heated of vaporization — gas — fluid.

* 4.4 : Property diagrams for change phase:-

(T - V) and (P-V) diagrams for pure substance.

[1] The T-V diagram :

Temp. — specific Volum



→ critical point for water

$T_{cr} = 373.95 C^{o}$

$P_{cr} = 22.06$ MPa

Table A-1 for critical properties of pure substance.

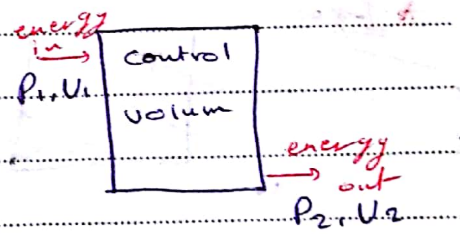
2 The P-V diagram :-

Pressure   specific volume

* 4.5 :- Property Tables A-4 , A-5 → for water :-

1 Enthalpy :- A combination property
"heat content"

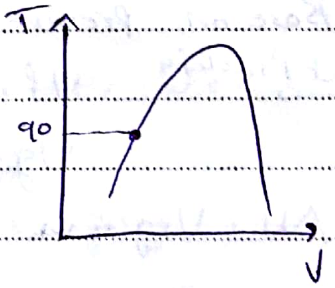
$$\boxed{H = U + PV} \quad (kJ)$$

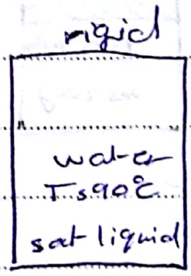


per unit mass → $h = u + Pv$ (kJ/kg)

* v_f = specific volume of sat liquid
v_g = " " " " vapor
v_{fg} = difference between v_g and v_f
volum ال يعني

* Ex :- A rigid tank contains 50 kg of saturated liquid water at 90°C.
Find the pressure in the tank and the volume of tank?





→ from Table of water property : (A-4) , (A-5)

specific volum

T	P_{sat}	v_f	v_g	v_{fg}
90°	$\boxed{}$ 70.183 kPa			

$v_f = 0.001036 \ m^3/kg$

اختار القيمة لأنه معطى بالسؤال fluid

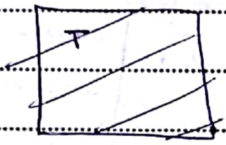
$U_{tank} = 0.001036 * 50$

$= 0.0518 \ m^3$

$1 \ m^3 \rightarrow 1000 \ L$

$\rightarrow V_{tank} = 51.8 \ L$

*Ex:



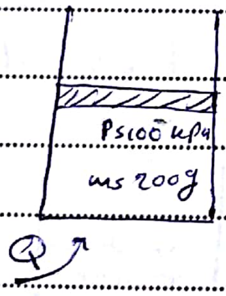
*Ex: A mass of 200g of saturated liquid water is completely vaporized at a constant pressure of 100kPa.

→ find: (1) The volume of change

(2) The amount of energy transfered to the water.

→ (1) to find volume of change: بيطلع V liquid

بيطلع V vapore بنطرحهم



→ Base on pressure 100 kPa from table A-5

at P=100kPa

$v_f = 0.001043 \ m^3/kg$

$v_g = 1.6941 \ m^3/kg$

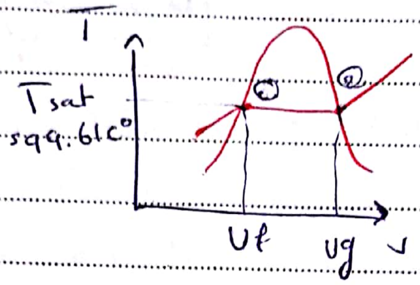
$\Delta V = v_{fg} * m = 1.6931 * 200 * 10^{-3}$

$= 0.3386 \ m^3$

نتعوا لكل
ال مش

(b) $h_{fg} = 2257.5 \ kJ/kg$

$\rightarrow Q = m h_{fg} = 200 \times 10^{-3} \times 2257.5 = 451.5 \ kJ$



1-b saturated liquid - vapor mixture (wet region)

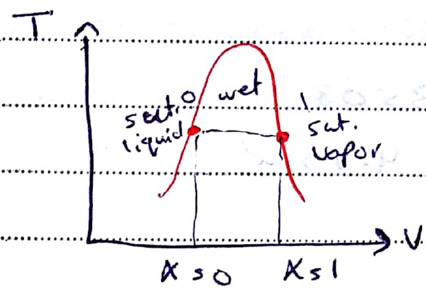
* Quality (x) = The ratio of the mass of vapor to the total mass of mixture.

$$\boxed{x = \frac{m_{vapor}}{m_{total}}}$$

تتراوح قيمتها بين 0-1

لأنها ratio

$0 < x < 1$



$\boxed{\frac{f}{g}}$ هون اعتبرناه

Homogenous mixture

$\rightarrow$ $\boxed{m_{total} = m_f + m_g}$

$\boxed{V_{avg} = V_f + V_g}$, $V = mv$

$m_t v_{avg} = m_f v_f + m_g v_g$

$m_t v_{avg} = (m_t - m_g) v_f + m_g v_g$

$m_t v_{avg} = m_t v_f - m_g v_f + m_g v_g$

$\rightarrow m_t V_{avg} = m_t V_f + m_g (V_g - V_f)$ $\rightarrow x$

Divided by (m_t) $\rightarrow V_{avg} = V_f + \boxed{\frac{m_g}{m_t}} V_{fg}$

$$\boxed{V_{avg} = V_f + x V_{fg}}$$

$\boxed{V = m \forall}$ mass, specific volume

$\rightarrow$ similar analysis gives:

* $U_{avg} = U_f + x U_{fg}$
* $h_{avg} = h_f + x h_{fg}$

Ex:- A rigid tank contains 10 kg of water at 90°C. if 8 kg is in a liquid form and the rest is in vapor ~~vol~~ form. Determine the pressure in the tank and the volume of the tank?

Vapor $m = 2kg$
liquid $m = 8kg$

$T = 90C°$

$\rightarrow$ From table A-4 at $T = 90°C$

$P_{sat} = 70.183$ kPa

$\boxed{m_t V_{avg} = m_f V_f + m_g V_g}$

$10 * V_{avg} = 8 * 0.001036 + 2 * 2.3503$

$V_{avg} = 0.473 \ m^3/kg$, $V = 4.73 \ m^3$

$x = \frac{2}{10} = 0.2$

$V_{avg} = V_f + x V_{fg}$

Subject :

V_{avg} total mass

Ex :- An 80 L vessel contains 4 kg of Refrigerant R134-a at pressure of 160 kPa, Determine (1) the temp., (2) the quality (3) the enthalpy (4) the volume occupied by the vapor phase.

→ from ~~table~~ table A-12 at $P = 160$ kPa :-

$\boxed{1}$ $T_{sat} = -15.6\ C^{o}$

$\boxed{2}$ $x = \dfrac{v_{avg} - v_f}{v_{fg}} \rightarrow x = \dfrac{\frac{80 \times 10^{-3}}{4} - 0.0007435}{(0.12355 - 0.0007435)} = 0.157$

إذا طلعت أكبر من ١ في الحسبة يعني غلط اكيد

$\boxed{3}$ $h_{avg} = h_f + x h_{fg}$

$h_{avg} = 31.18 + 0.157 \times 209.96$

$= 64.1$ kJ/kg

$\boxed{4}$ $V_g \rightarrow$ from $x \rightarrow$ mass of vapor $\rightarrow m_g = 0.157 \times 4$

$= 0.628$ kg

$V_g = m_g v_g = 0.628 \times 0.12355$

$V_g = 0.0775894\ m^3$

Scanned by CamScanner

Subject :

② Super heated vapor :-

→ compared to sat- vapor.

- lower pressure ($P < P_{sat}$) at given Temp. → super heated
- higer temp ($T > T_{sat}$) at given Pressure → " "
- higer specific volume ($\upsilon > \upsilon_g$) at given Temp. and/or Pressure
- higer internal energy ($u > u_g$) at give T and P
- higer enthalpies ($h > h_g$) at given T and P

③ Compressed liquid :-

→ compared to sat- liquid.

- higer pressure ($P > P_{sat}$) at given Temp
- lower temp. ($T < T_{sat}$) at give Pressure.
- lower specific volume ($\upsilon < \upsilon_f$) at given Temp or Pressure
- lower internal energy ($u < u_f$) at given T or P.
- lower enthalpies ($h < h_f$) at given T or P

* Note :- When no data avilable in compressed liquid table for water $y \cong y_f$ at T for u_f and υ_f → نعتبر saturated liquid.

for h → $\boxed{h \cong h_f @T + \upsilon_f @T \, (P - P_{sat} @T)}$

Important

* Ex :- Determine the missing properties and phase descriptions in the following table for water. →

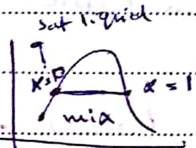
Scanned by CamScanner

* الـ عـليم $\boxed{1}$ الها اعطي

#	T C°	P kPa	U (kJ/kg)	X	Phase
1	120.21	$\boxed{200}$	1719.26	$\boxed{0.6}$	mixture
2	$\boxed{125}$	232.23	$\boxed{1600}$	0.535	mixture
3	395.2 ~~179.88~~	1MPa $\boxed{1000}$	$\boxed{2950}$	ما في لازم / super heated	super heated ~~vapor~~ لانه u>ug
4	$\boxed{75}$	$\boxed{500}$	313.99	ما بنقدر نوجدها لأنها does not exist بالجدول	compressed liquid
5	172.94	$\boxed{850}$	uf = 731	$\boxed{0.0}$	sat. liquid

* state 1 :- → x = 0.6 → mixture دوغري

sat liquid



sat. vapor

→ T → من الجدول

A5 _ at constant pressure

$$\rightarrow U_{avg} = U_f + X\,U_{fg}$$

$$= 504.5 + 0.6 * 2024.6$$

$$= 1719.26 \text{ kJ/kg}$$

* state 2 :- table A4

→ U = 1600 عرفنا انها mixture لانه

حال تتحقق بين Uf and Ug بالجدول

$$\rightarrow U_{avg} = U_f + X\,U_{fg}$$

$$1600 = 524.83 + X * 2009.5$$

$$\rightarrow X = 0.535$$

* stat 3 :- → table A-5

لانه U>Ug بنروح ع table A-6

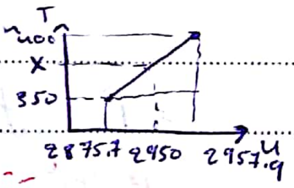
ع P = 1 MPa وبندور ع قيمة

ال U = 2950

@ T = 350 C° → U = 2875.7

T = 400 C° → 2957.9

interplation →



تشابه مثلثات

$$\frac{400-350}{2957.9-2875.7} = \frac{X-350}{2950-2875}$$

$$\boxed{X = 395.2\,C^{\circ}}$$

Subject : / /

* stat 4 :- from table A-4 :-

$P_{sat} = 38.597$ but $P > P_{sat}$ → compressed liquid

→ from table A-~~7~~ → ~~[illegible]~~ ميصير جدول ما يلزم تهمنا باكل

Note :- from table A-7 at P = 500 kPa does not exist so we back to table A-5 or A-4

بناءً على البحث إلى قبل

→ table A-4 @ 75°C → $u_f = 313.99$ kJ/kg

* stat 5 :- from table A-5

* 4.6 :- The Ideal - Gas Equation of state.

→ related to P, V and T of a substance

$$P v = R T$$

P: absolute pressure (kPa)

v: specific volume (m^3/kg)

T: Temp (K)

R: Gas constant (kJ/kg.K)

Air → 0.287

He → 2.0769

Ar → 0.2081

N → 0.2968

or $P = \rho R T$, $PV = mRT$

ρ: density of substance (kg/m^3)

m: mass (kg)

$$\rightarrow R = \frac{R_u}{M}$$

R_u → universal gas constant

M: Molar Mass (kg/kmol)

$R_u = 8.314$ kJ/kmol.K

Scanned by CamScanner

*H.W 4.43

▸ Subject :

→ if constant mass → $PV = mRT \rightarrow \frac{PV}{T} = \underset{\text{constant}}{mR} = \text{constant}$

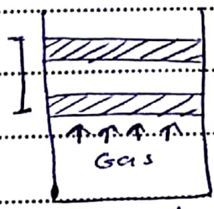
$$\boxed{\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}}$$

Scanned by CamScanner

Subject : Ch. 5.

* Chapter 5. : Energy analysis of closed system:

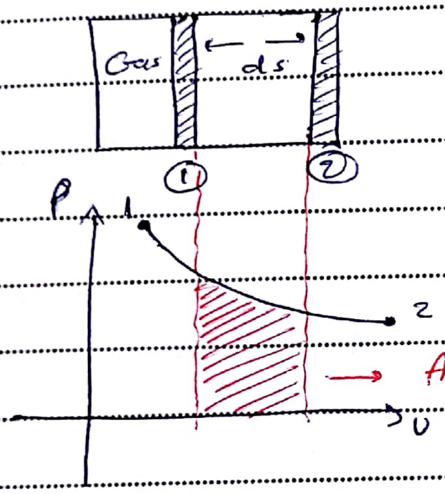
* Moving Boundary work:-



$\delta w_b = P\,dv \rightarrow w_b = \int_1^2 P\,dv$

$\delta w_A = P A\, ds$

Remark → $\boxed{F = P A}$



for change (P) or constant (P)

→ Area under curve represent work (KJ)

→ $P = f(v)$ " from P-v diagram "

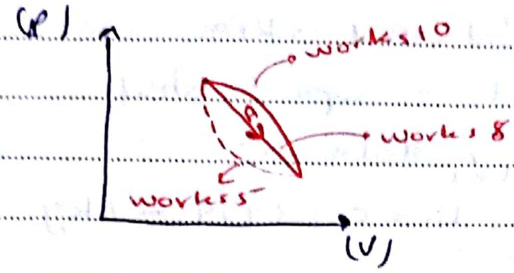
→ The total Area under the Process ~~curve~~ 1 → 2 is obtain by adding in differential areas.

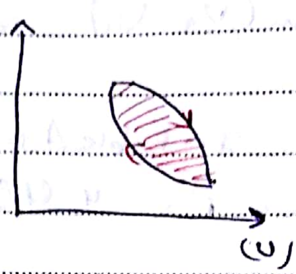
* Note that:-

1) The Boundry work done during process depends on the Path followed as well as end state.

2) The Net work during cycle the difference between the work done by the system, done ~~by~~ on system.

Subject : / /





[1] Expansion :- ^{+}wb (work done by system)
↓
piston cylinder

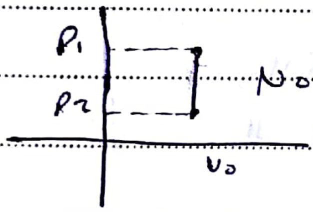
[2] compression :- $-wb$ (work done on system)

V constant

***Ex:** Rigid tank air $P_1 = 500\,kPa$, $t_1 = 150\,C^\circ$
$P_2 = 400\,kPa$, $t_2 = 65\,C^\circ$

find the Boundary work done during process?

→ $wb = \int_1^2 P\,dv$, no change in volume work done = zero

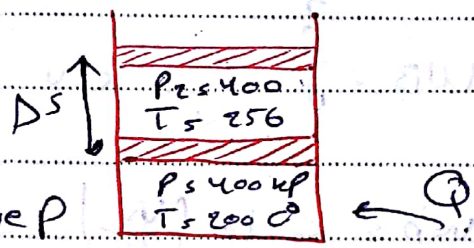


No Area

***Ex:** piston cylinder 5kg of steam , find the work done by system during process?

→ $wb = \int_1^2 P\,dV$ → $wb = PV\Big|_1^2$

→ from table give S.V "A-4" → give P



Mass

Subject :

$W_b = P_m (V_2 - V_1)$ at $t = 200$ $P_{sat} = 1554.9$ kPa

$P < P_{sat}$:- super heated

go table A-6 ← super heated ← state الـ :-

state (1) → $P = 0.4$ MPa, $t = 200$ C°, $V_1 = 0.53434$ m³/kg

state (2) → The steam is superheated $P < P_{sat}$

from table A-6

$P_2 = 0.4$ MPa, $t = 250$, $V_2 = 0.59520$ m³/kg

$W_b = 400 \times 10^3 (0.59520 - 0.53434) \times 5$

$W_b = 121.72 \times 10^3$ J

*نراجع قوانين الـ ideal gas

← إذا الـ سؤال عطانا Air ← بنعتبرها ideal gas ← بنطبق عليها قوانين ideal

*Ex :- Piston cylinder $V_1 = 0.4$ m³ of Air $P_1 = 100$ kPa, $T_1 = 80°$ compressed to 0.1 m³ (V_2) at constant temprature determine work boundary "isothermal system"

→ $W_B = \int_1^2 P\,dV$ → حالة air بنعوض

الـ Volume من قوانين idealgas

→ from ideal gas :- $PV = \underbrace{mRT}_{\text{(constants)}}$

then $\boxed{P = \frac{C}{V}}$ $C = P_1V_1 = mRT$

→ $W_B = \int_1^2 \frac{C}{V} dV = C \ln V \Big|_1^2 = C \ln \left[\frac{V_2}{V_1}\right]$

$W_b = C \ln\left(\frac{V_2}{V_1}\right)$ → $W_b = RmT \ln\left(\frac{V_2}{V_1}\right)$

↳ Remark :- $RmT = P_1V_1 = P_2V_2$

use this ↙ ↳ unknown

Subject :

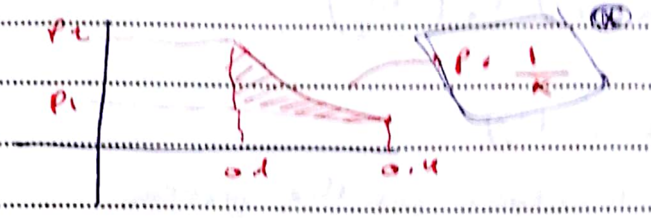
$W_b = P_1 V_1 \ln\left(\frac{V_2}{V_1}\right)$

$= (0.4)(100 \times 10^3) \ln\left(\frac{0.1}{0.4}\right)$

$= -55.5$ kJ

work done on the system

Non linear [illegible] Area under the curve [illegible]
curve



→ in ideal gas only suppose that $PV = mRT$

But during actual process of expansion of gas, pressure, volume are often related by:

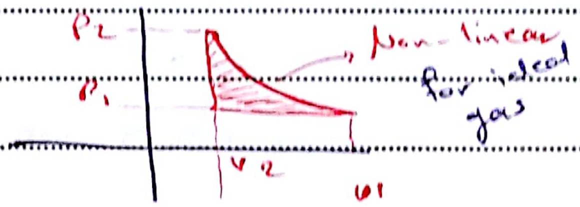
$\boxed{PV^{n} = C}$ where n: degree of polytropic

C: constant

→ Polytropic process:

(P) ثابت، (V) متغير أو (P) متغير، (V) ثابتة

متى نستخدمها؟ $\boxed{P = CV^{-n}}$



→ work boundry:

$W_b = \int_1^2 P\,dV$, $W_b = \int_1^2 CV^{-n}\,dV$

$W_b = C\,\frac{V_2^{-n+1} - V_1^{-n+1}}{-n+1}$ → $\underbrace{CV_2^{-n}}_{P_2}\,V_2^{1}$

$$\boxed{W_b = \frac{P_2V_2 - P_1V_1}{-n+1}}$$ → $\underbrace{CV_2^{-n}}_{P_2} \cdot V_2$

$= \frac{mRT_2 - mRT_1}{-n+1}$ $\boxed{P = CV^{-n}}$

Scanned by CamScanner

closeal system

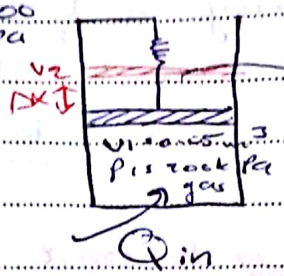
***Ex :-** $V_1 = 0.05\ m^3$ of gas at $P_1 = 200$ kPa

$K_{spring} = 150\ kN/m$

after Qin the volum is double

$V_2 = 2V_1$

$A_{piston} = 0.25\ m^2$



الـ spring ما بأثر بقوة ع الـ piston حتى يصير ...

Determine :- ① The final pressure inside the cylinder?

② The total work done by gas?

③ work done against the spring to compressed it?

→ ① $F_s = k\Delta x$, $\boxed{\Delta V = A\,\Delta x}$ → $\Delta V = 0.25 \times \Delta x$

$(0.1 - 0.05) = 0.25 \times \Delta x$

$\boxed{\Delta x = 0.2\ m}$

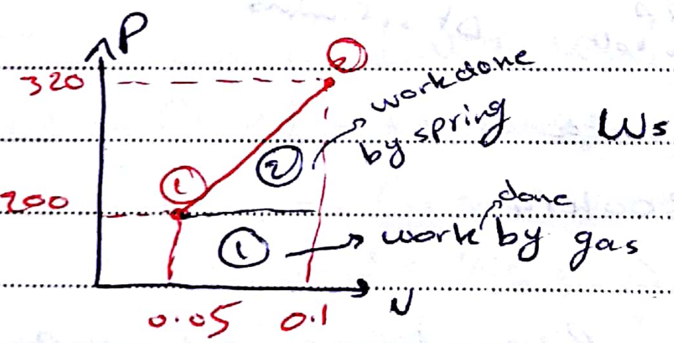
→ $F_s = k\,\Delta x$

$= 150 \times 10^3 \times 0.2 = \boxed{30\ kN}$

→ $P_s = \dfrac{F_s}{A} = \dfrac{30 \times 10^3}{0.25} = \boxed{120\ kPa}$

$P_{inside\ cylinder} = P_s + P_{gas} = 120k + 200k = \boxed{320\ kPa}$

②



$W = \int_1^2 P\,dv$

$W_{total} = W_{gas} + W_{spring}$

, $W_{trapizoial} = \frac{1}{2}(320 + 200) \times 10^3 \times (0.1 - 0.05)$

شبه منحرف

$= \boxed{13\ kJ}$

Scanned by CamScanner

Subject: $E_{in} - E_{out} = \Delta E$
$(Q_{in} - Q_{out}) - (W_{out} - W_{in}) = \Delta u + \Delta k.e + \Delta p.e$

③ $W_{spring} = \frac{1}{2} k (x_2^2 - x_1^2)$

$= \frac{1}{2} \times 150 \times 10^3 (0.2^2 - 0)$

$= \boxed{3\ kJ}$

*** 5.2 :- Energy baulance for closed system :-**

→ from ch. 3 :- $E_{in} - E_{out} = \Delta E$ (kJ)

$E_{in} - E_{out}$: net of energy transfer by heat, work, mass of energy

ΔE: change in internal, kinatic, potential.

per unit mass → $e_{in} - e_{out} = \Delta e$ (kJ/kg)

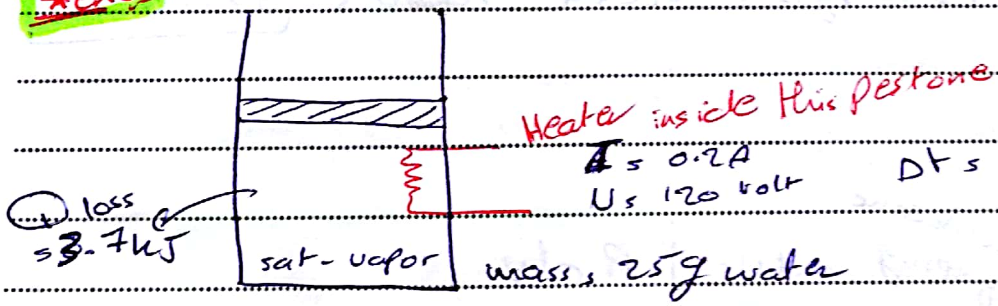
rate → $\dot{E}_{in} - \dot{E}_{out} = \frac{dE}{dt}$

→ for closed system under goes a cycle :-

$E_{in} - E_{out} = 0$ → $Q_{in,net} - W_{net,out} = 0$

$$\boxed{(Q_{in} - Q_{out}) - (W_{out} - W_{in}) = 0}$$

*** Ex :-**



at constant pressure = 300 kPa

→ Piston cylinder $m = 25\ g$, $P = 300\ kPa$, sat-vapor.

$I = 0.2\ A$, $V = 120$ volt for $t = 5$ mins, heat loss $= 3.7\ kJ$

Subject :

→ final :- ⓐ Show that for a closed system the (total) boundary work and the change in the internal energy (ΔU) in the first law relation can be combined into one term (ΔH) for constant pressure?

ⓑ determine the final Temp. of the system?

→ Sol :- ⓐ $Q_{net\,in} - W_{net\,out} = \Delta U + \cancel{\Delta KE}^{zero} + \cancel{\Delta PE}^{zero}$

$Q_{net\,in} - (W_{Boundary} + W_{electrical}) = \Delta U$

$Q_{net\,in} - (P_o(V_2 - V_1) + W_e) = \Delta U$

$Q_{net} - P_o(V_2 - V_1) + W_e = \Delta U$

$Q_{net} - W_e = \Delta U + P_o \underbrace{(V_2 - V_1)}_{(\Delta V)}$

$Q_{net} - W_e = \Delta U + P_o \Delta V$

$\boxed{Q_{net} - W_e = \Delta H} \rightarrow H_2 - H_1$ (kJ)

for constant pressure.

ⓑ state 1 :- @ $P = 300$ kPa and sat. vapor → $h_g = 2724.9$ kJ/kg

from table A-5 @ $P = 300$ kPa

→ $W_e = IV\Delta t = 0.2 * 120 * 5 * 60 = 7.2$ kJ

$Q_{net\,in} - W_{net\,out} = \Delta U$

$(Q_{in} - Q_{out}) - (W_{out} - W_{in}) = \Delta U$

$(0 - Q_{out}) - (W_{boundary} - W_{electrical}) = \Delta U$

$- Q_{out} - P_o(V_2 - V_1) + W_e = \Delta U$

$- Q_{out} + W_e = \Delta H$ per unit mass بدل ما هو لازم نحولها

$-3.7 * 10^3 + 7.2 * 10^3 = \cancel{2724.9 * 25}\ 25 * 10^{-3} (h_2 - 2724$

$h_2 = 2864.9$ kJ/kg

→

S T A R S N O T E B O O K

Subject :

→ from table A-5 @ P = 300 kPa

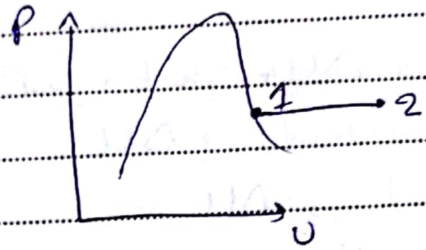
$h_f = 561.43$ kJ/kg

$h_g = 2724.9$ kJ/kg

state ② super heated → from table A-6 @ P = 300 kPa

$h = 2864.9$

→ $T = 200°C$ at $P = 0.3$ MPa



for constant pressure

***5-3:- specific heat:** الحرارة النوعية

→ Energy required to rise the Temprature of a unit mass of a substance by one degree.

↳ Two kinds of specific heat:

① specific heat at constant volum (CV)

② " " " " pressur (CP)

$\boxed{CP > CV}$

internal energy

→ $\boxed{CV = \frac{du}{dT}}\Big|$ at constant volum

→ $h = u + Pv$

$\boxed{dh = du + Pdv + vdP}$

→ $\boxed{CP = \frac{dh}{dT}}\Big|$ at C.pressur

→ unit = $\frac{kJ}{kg \cdot C°}$ or $\frac{kJ}{kg \cdot k}$

for CV

Subject :

* 5-4 :- Internal Energy, enthalpy, specific heats of Ideal gas :-

per unit mass → $Pv = RT$, $u = u(T)$, $h = u + Pv$

→ $\boxed{h = u + RT}$

$\Delta h = \int c_p(T)\,dT$
$\Delta u = \int c_v(T)\,dT$
$\Delta h = c_{p,avg}\,\Delta T$
$\Delta u = c_{v,avg}\,\Delta T$

→ The differential changes in the internal energy and enthalpy h of an ideal gas

$$\int_1^2 du = \int_1^2 C_v(T)\,dT \rightarrow \Delta u = \int_1^2 C_v(T)\,dT$$

$$\rightarrow \int_1^2 dh = \int_1^2 C_p\,dT \rightarrow \Delta h = \int_1^2 C_p(T)\,dT$$

→ for small T intervals → $\boxed{\Delta u = C_{v\,avg}(\Delta T)}$

$\boxed{\Delta h = C_{p\,avg}(\Delta T)}$

→ $\left.\begin{matrix} C_{v\,avg} \\ C_{p\,avg} \end{matrix}\right\}$ → at $\boxed{\dfrac{T_1 + T_2}{2}}$ from Table (A-2) 15

from → $h = u + RT$

$dh = du + R\,dT$

$C_p\,\cancel{dT} = C_v\,\cancel{dT} + R\,\cancel{dT}$

$\boxed{C_p = C_v + R}$

S T A R S N O T E B O O K

Subject : .... / /

→ specific heat ratio (k) = $\boxed{\frac{C_p}{C_v}}$

for Air $\boxed{k = 1.4}$

* 5-5:- Specific heat, u and h for solid and liquid:-

→ $C_v = C_p = C$ from table (A-3)

$\int_1^2 du = \int_1^2 C\, dT$ → $\Delta u = \int_1^2 C(T)\, dT$ → $\Delta u = C_{avg} \Delta T$ at $\frac{T_1 + T_2}{2}$

→ $h = u + Pv$ zero for solid and liquid

$dh = du + \cancel{P dv} + v dP$

$dh = du + v dP$

$\boxed{\Delta h = \Delta u + v \Delta P}$ ⟹ $\Delta h = C_{avg} \Delta T + v \Delta P$

→ for solid :- $\Delta P = \text{Zero}$ → $\boxed{\Delta h = C_{avg} \Delta T}$

→ for liquid :-
- → constant (P) → $\Delta h = C_{avg} \Delta T$
- → constant (T) → $\Delta h = v \Delta P$

Subject: Ch.6.

Open system.

* Ch.6:- Mass and energy analysis of control volum:-

* 6-1:- Conservation of mass:-

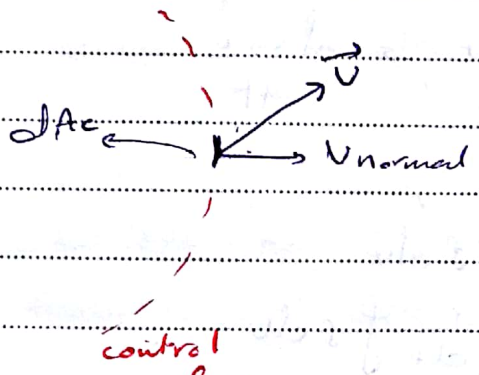
→ for closed system required that the mass of the system remains constant during process.

→ for control volum (~~control volum~~ open system) mass can cross boundaries, so mass in and mass out need to be tracked.

* Mass and volume flow rates:-

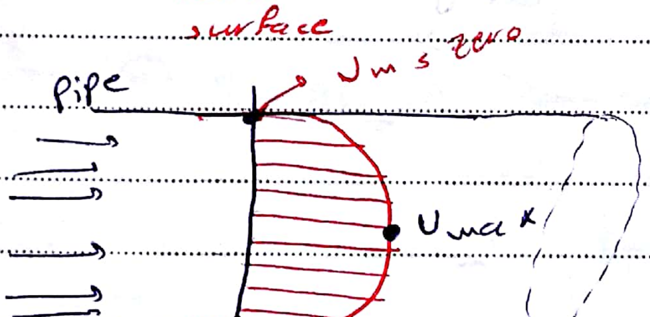
↳ mass flow rate:- the amount of the mass flowing ($\dot{m}$) through a cross section per unit time (kg/s)

($\dot{V}$) → the amount of the volum flowing through — (m^3/s)



$$\int_{A_c} \delta \dot{m} = \int\int_{A_c} V_n \, dA_c \rightarrow \dot{m} = \int\int_{A_c} V_n \, dA_c$$

(kg/s)



→ Average velocity

$$V_{avg} = \frac{1}{A_c} \int_{A_c} V_n \, dA_c$$

$$\boxed{\dot{m} = \rho V_{avg} A_c}$$

$= \int V_{avg} A$

Subject : specific v

* Volum flow rate ($\dot{V}$) → $\dot{V} = \int V_n \, dA$ (m^3/s)

→ in general :- $\boxed{\dot{V} = V_{avg} A_c}$

→ mass = density * volume

rate $\boxed{\dot{m} = \rho * \dot{V}}$ or $\dot{m} = \frac{\dot{V}}{v} = \frac{m^3/s}{m^3/kg} = \boxed{kg/s}$

$= \frac{1}{v} \dot{V}$

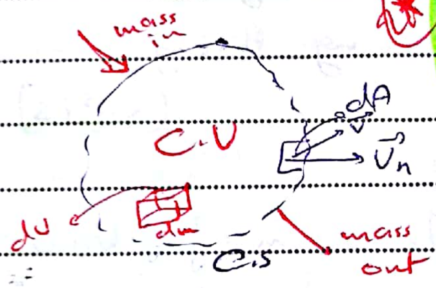
specific volum

zero at steady state

→ conservation of mass principle :-

(Total mass entery the C.V during Δt) − (Total mass leaving The C.V during Δt) = (net change of mass within the control volum during Δt)

* $\boxed{\dot{m}_{in} - \dot{m}_{out} = \Delta m_{C.V}}$ mass balance



rate → $\dot{m}_{in} - \dot{m}_{out} = \frac{dm_{cv}}{dt}$

→ total mass within C.V → $m_{cv} = \int \rho \, dv$

rate of change of mass within the C.V → $\frac{dm_{cv}}{dt} = \frac{d}{dt} \int_{C.V} \rho \, dv$

→ from mass balance :

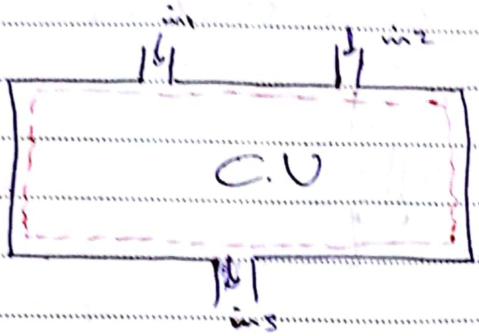
$$\sum_{in} \dot{m} - \sum_{out} \dot{m} = \frac{dm_{cv}}{dt}$$

→ special case : if the system is steady state

$\frac{dm_{cv}}{dt} = zero$, $\sum_{in} \dot{m} = \sum_{out} \dot{m}$

$\rho \dot{V}_1 = \rho \dot{V}_2$

$\rho_1 V_1 A_1 = \rho_2 V_2 A_2$

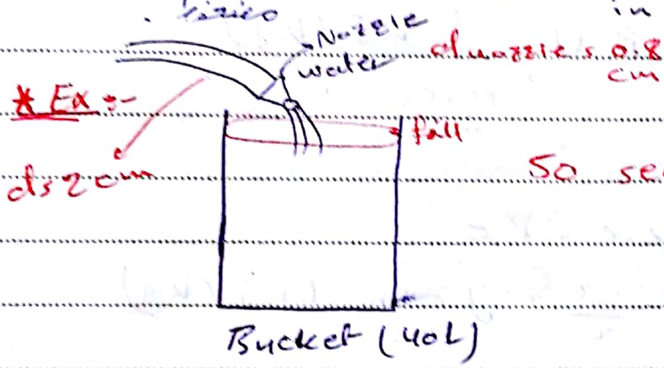


$\dot{m}_1 + \dot{m}_2 = \dot{m}_3$

→ in compressible flow $\sum_{in} \dot{m} = \sum_{out} \dot{m}$, $\sum_{in} \dot{V} = \sum_{out} \dot{V}$
غير انضغاطي

→ compressible flow $\sum_{in} \dot{m} = \sum_{out} \dot{m}$, $\sum_{in} \dot{V} \neq \sum_{out} \dot{V}$
انضغاطي

* Ex :-



50 sec to fill the Bucket

① determain the volum and mass flow rate of the water through the pipe?

→ ② the avarge velocity of water at the nozzle exist?

sol:- ① $\dot{V} = \frac{V}{t} = \frac{40}{50} = \boxed{0.8}$ L/sec or $0.8 * 10^{-3}$ m³/s

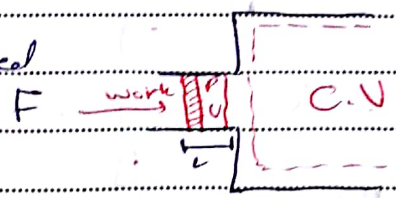
→ $\dot{m} = \rho \dot{V} = 1000 * 0.8 * 10^{-3} = 0.8$ kg/s

② $\dot{V} = V_{avg} A_{nozzle}$ → $0.8 * 10^{-3} = V_{avg} * \frac{\pi}{4} (d_{nozzle})^2 = 15.9$ m/s

$(0.8 * 10^{-2})^2$

* 6.2: Flow work and energy of a flowing fluid:

→ flow work:- is the energy needed to push a fluid into or out of a control volume.



→ $F = PA$ (pressure, Area) , $W_{flow} = F \cdot L$ ⇒ $W_{flow} = PAL$

3* $\boxed{W_{flow} = PV}$ volum (kJ)

= flow energy

rate (per unit mass) ⇒ $W_{flow} = P \cdot v$ (kJ/kg)

specific volum

* Total energy (e) = $u + k.e + P.e$

$= u + \frac{V^2}{2} + gz$ (kJ/kg)

→ Add flow energy to total energy of a flowing fluid:

total energy, flow energy

$\theta = Pv + e$

$\theta = Pv + u + \frac{V^2}{2} + gz$

4* $\boxed{\theta = h + \frac{V^2}{2} + gz}$

* Energy transport by mass → $E_{mass} = \theta m = m(h + k.e + P.e)$ (mass of energy) (kJ)

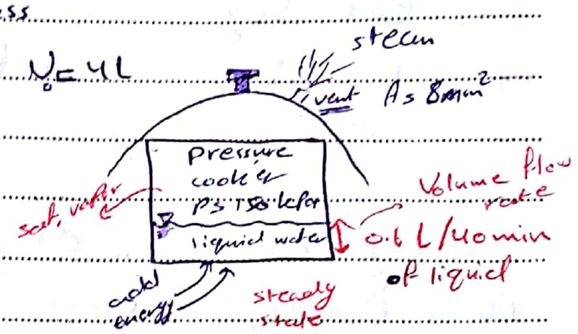
rate of energy transport → $\boxed{\dot{E}_{mass} = \theta \dot{m} = \dot{m}(h + k.e + P.e)}$

(kJ/s) (K watt)

Subject : .... θ = u + k.e

* θ = h + K.E + P.E
↳ total energy of flow per unit mass

*** Ex:-**



→ Determine:- ① mass flow rate of the steam exist and velocity?

② The total energy and flow energy of the steam per unit mass?

③ The rate at which energy leaves the cooker by the steam?

→ ① mass balance:- $\dot m_{in} - \dot m_{out} = \frac{dm}{dt}$ → zero (steady state)

$\boxed{\dot m_{in} = \dot m_{out}}$

$\dot V_f = \frac{0.6\times10^{-3}}{40\times60} = \boxed{25\times10^{-8}\ m^3/s}$ ⇒ $\dot m_f = \rho_f \dot V_f$

$\dot m_f = \frac{\dot V_f}{v_f}$

→ $\dot m_f = \frac{25\times10^{-8}}{0.001053}$ → from tables at P = 150 kPa

$= 2.37\times10^{-4}$ kg/s

$v_f = 0.001053$ m³/kg

$v_g = 1.1594$ m³/kg

→ $\dot m_g = 2.37\times10^{-4}$ kg/s

→ $\dot m_g = \rho_2 V_2 A_2$

$2.37\times10^{-4} = \frac{V_2 A_2}{v_g}$ → $V_2 = ??$

$2.37\times10^{-4} = \frac{V_2 \times 8\times10^{-6}}{1.1594}$ ⇒ $\boxed{V_2 = 34.3\ m/s}$

leaving

(2) $\theta = h + \overset{\text{zero}}{\cancel{ke}} + \overset{\text{zero}}{\cancel{pe}}$

$\theta = h_g$ → from the table

for the steam

$h_g = 2693.1 \text{ kJ/kg}$

$\theta = \underbrace{PV}_{\text{flow energy}} + u + \cancel{ke} + \cancel{pe}$

$PV = \theta - u_g$

$= 2693.1 - 2519.2 \text{ kJ/kg}$

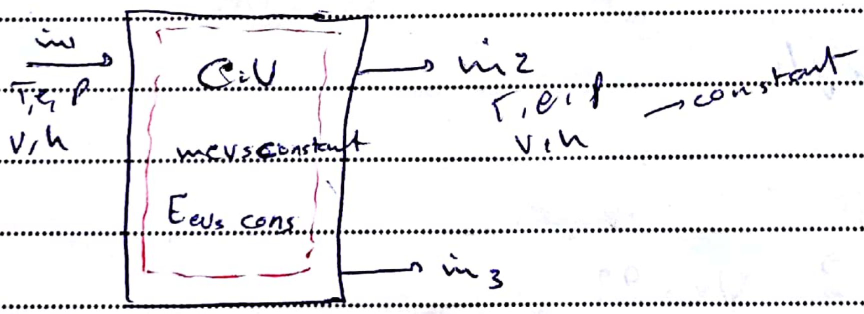
$= \boxed{173.9 \text{ kJ/kg}}$

(3) $\dot{E}_{steam} = \dot{m}\theta$

$= 2.37 \times 10^{-4} \times 2693.1 = 0.638 \text{ kW}$

*** 6.3 :- Energy ~~anal~~ analysis of steady flow systems:**

→ under S.S conditions, the mass, energy contents of a control volume remain constant, the fluid properties at an inlet or exist remain constants



(1) mass balance:-
$\sum_{in} \dot{m} = \sum_{out} \dot{m} \rightarrow$ S.S $\longrightarrow$ $\dot{Q}_{in} + \dot{W}_{in} + \sum_{in} E_{mass} = \dot{Q}_{out} + \dot{W}_{out} + \sum E_{out}$

Subject (2) energy balance:- $\dot{E}_{in} = \dot{E}_{out}$ $\dot{Q}_{in} + \dot{W}_{in} + \dot{m}_{in}(h + ke + pe) = \dot{Q}_{out} + \dot{W}_{out} + \dot{m}_{out}(h + ke + pe)$

→ The mass balance for S.S.F:-

$$\sum_{in} \dot{m} - \sum_{out} \dot{m} = \cancel{\frac{dm}{dt}}\Big|_{CV}^{\text{zero}} \rightarrow \boxed{\sum_{in} \dot{m} = \sum_{out} \dot{m}}$$

$$\rho_1 V_1 A_1 = \rho_2 A_2 V_2$$

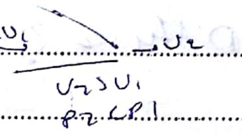
→ Energy balance:-

$$\sum \dot{E}_{in} - \dot{E}_{out} = \cancel{\frac{de}{dt}}^{\text{zero}} \rightarrow \boxed{\dot{E}_{in} = \dot{E}_{out}}$$

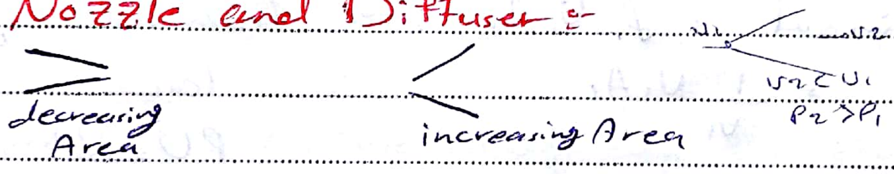
$$\dot{Q}_{in} + \dot{W}_{in} + \sum_{in} \dot{m}\theta = \dot{Q}_{out} + \dot{W}_{out} + \sum_{out} \dot{m}\theta$$

(kW)

* 6-4:- steady flow devices:-



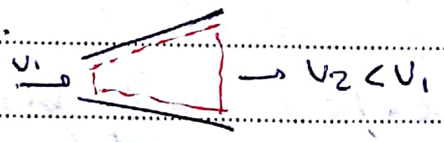
1 Nozzle and Diffuser:-



* Nozzle:- is adivce that used to increas the velocity of fluid

$V_2 > V_1$

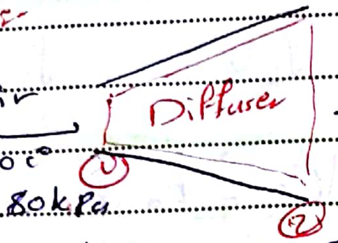
* Diffuser:- a divce that used to increas the pressure of a fluid by slowing it down.



▸ Subject : energy الـ losses صافي

* Nozzle and Diffuser are adiabatic $(\dot{Q}=0)$, $(\Delta k.e \neq 0)$, $(\Delta P.e = 0)$, $(\Delta U = 0)$

* Ex :-



Air →

$T = 10°C$

$P_1 = 80\,kPa$

$A_1 = 0.4\,m^2$

$U_1 = 200\,m/s$

→ U_2 is very small ≈ 0

$T_2 = ?$

$\dot{m} = ?$

S.S.F

→ Determine ① The mass flow rate of Air ?

② The Temprature of Air leaving the Diffuser ?

→ ① $\dot{m}_{in} = \dot{m}_{out} = \rho_1 U_1 A_1$ → from ideal gas law

$= \frac{1}{v_1} U_1 A_1$

$PV = RT$

$= \frac{1}{1.015} * 200 * 0.4$

$80 * 10^3 \, v = 287 * (10 + 273)$

$\boxed{= 78.8\ kg/s}$

*وليس حجم نوعي حجم

$v = 1.015\ m^3/kg$

→ ② $\dot{E}_{in} = \dot{E}_{out}$

$\cancel{\dot{Q}_{in}} + \cancel{\dot{W}_{in}} + \sum_{in} \dot{m}\theta = \cancel{\dot{Q}_{out}} + \cancel{\dot{W}_{out}} + \sum_{out} \dot{m}\theta$

$\sum_{in} \cancel{\dot{m}} (h_1 + k.e_1 + \cancel{P.e}) = \sum_{out} \cancel{\dot{m}} (h_2 + \cancel{k.e} + \cancel{P.e})$

Scanned by CamScanner

▸ Subject : .... / /

$\rightarrow h_2 = h_1 + k.e$

$h_2 = h_1 + \frac{V_1^2}{2}$ $\longrightarrow$ h_1 at $T = 10c°$ from table A-21 for air

$T = 283\,k$

$= 283.14 + \frac{(200)^2}{2} \times 10^{-3}$

$h_1 = 283.14\ kJ/kg$

$\boxed{h_2 = 303.14\ kJ/kg}$ $\longrightarrow$ from table A-21 at $h = 303.14$

$\longrightarrow T = 303\,k$

$T_2 = 30\,C°$

* **Ex :-**

$\dot{Q}_{loss} = 25\,kw$

$\longrightarrow$ Nozzle $\longrightarrow$ $T_2 = 300\,C°$

steam

$T_1 = 400\,C°$ ① S.S.C → condition ② $P_2 = 200\,kPa$

$P_1 = 800\,kPa$ S.S. f → flow

$V_1 = 10\,m/s$

$A_{nozzle} = 800\,cm^2$

→ Determain :- ① The velocity and ~~the~~ volum flow rate of the steam at exist

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

$\rho_1 V_1 A_1 = \rho_2 V_2 A_2$

$\frac{V_1 A_1}{\vartheta_{specific,1}} = \frac{V_2 A_2}{\vartheta_2}$

$\longrightarrow \dot{E}_{in} - \dot{E}_{out} = \frac{dE}{dt}$

$\cancel{\dot{Q}_{in}}^{zero} + \cancel{\dot{W}_{in}}^{zero} + \dot{m}_{in}\theta = \dot{Q}_{out} + \cancel{\dot{W}_{out}}^{zero} + \dot{m}_{out}\theta$ zero

$\dot{m}_{in}(h_1 + k.e + \cancel{p.e}^{zero}) = \dot{m}_{out}(h_2 + k.e + \cancel{p.e}) + \dot{Q}$

$\dot{m}_{in}(h_1 + \frac{V_1^2}{2}) = \dot{Q}_{out} + \dot{m}_{out}(h_2 + \frac{V_2^2}{2})$

Nozzle

Subject : →

sat. vapor

→ from table A-5 at $P = 800\,kPa$, $T > T_{sat}$ → superheated

go to table A-6 @ $P = 0.8\,MPa$, $T = 400\,C°$ → $h_1 = 3267.7\,kJ/kg$, $v_1 = 0.38429\,m^3/kg$

→ from table A-5 at $P = 200\,kPa$, $T > T_{sat}$ → superheated

go to table A-6 @ $P = 0.2\,MPa$, $T = 300\,C°$ → $h_2 = 3072.1\,kJ/kg$, $v_2 = 1.31623\,m^3/kg$

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

$$\rightarrow \frac{V_1 A_1}{v_1} = \frac{V_2 A_2}{v_2}$$

$$\dot{m} = \frac{10 \times 800 \times 10^{-4}}{0.38429} = 2.082\,kg/s$$

بنعوض بالمعادلة

$$2.082\left(3267.7 \times 10^3 + \frac{10^2}{2}\right) = 25 \times 10^3 + 2.082\left(3072.1 \times 10^3 + \frac{V_2^2}{2}\right)$$

$$\boxed{V_2 = 606\,m/s}$$

$$\rightarrow \dot{V}_2 = V_2 A_2 = \dot{m}_2 = \frac{\dot{V}_2}{v_2} \rightarrow \boxed{\dot{V}_2 = 2.74\,m^3/s}$$

* 2 Turbines and Compressors:

* Turbine :- a device that use to drive the electric generator. $\dot{Q} \approx 0$, $\Delta P.e \approx 0$, $\Delta K.e \neq 0$

Scanned by CamScanner

▸ Subject : .... / /

* compressor :- a device that used to increase the pressure up to high pressure. (for gas only)

↓

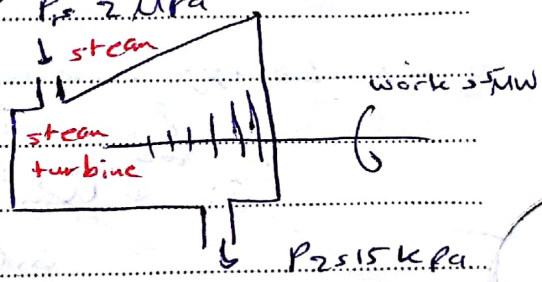
Pumps :- similar to compressor but for liquid only

$\Delta P.e \neq 0$, $\Delta k \neq 0$, $\dot{Q} = 0$

*** Ex :-** Adiabatic steam tourbine without power 5MW.

$V_1 = 50\,m/s$ / $T_1 = 400\,°C$ / $P_1 = 2\,MPa$

$Z_1 = 10\,m$



→ find :- ① Δh?

② $\Delta k.e$?

③ $\Delta P.e$?

④ Work done per unit mass of steam?

⑤ Mass flowrate?

$P_2 = 15\,kPa$

$x_2 = 0.9$

$V_2 = 180\,m/s$

$Z_2 = 6\,m$

①

→ Δh → tables جي (مجوا)

from table A-5 @ $P = 2\,MPa$, $T = 400\,C°$ → superheated

go to table A-6 @ $P = 2\,MPa$, $T = 400\,C°$ → $h_1 = 3248.4\,kJ/kg$

→ $h_2 = h_f + x\,h_{fg}$ → x لانه مخلوط (mixture يعني)

from table A-5 @ $P = 15\,kPa$ → $h_f = 225.94\,kJ/kg$

$h_{fg} = 2372.3\,kJ/kg$

Scanned by CamScanner

Subject :

$\rightarrow h_2 = 225.94 + 0.9 \times 2372.2$

$h_2 = 2361.01$ kJ/kg

$\rightarrow \Delta h = h_2 - h_1 = -887.39$ kJ/kg

(2) $\Delta k.e = \frac{V_2^2}{2} - \frac{V_1^2}{2} = \frac{180^2}{2} - \frac{50^2}{2} = 14.95$ kJ/kg

(3) $\Delta P.e = g(z_2 - z_1) = 9.81(6-10) = \cancel{-0.04}$ kJ/kg

-39.24

$\rightarrow$ Energy balance :-

$\dot{E}_{in} = \dot{E}_{out}$

$\overset{zero}{\cancel{\dot{Q}_{in}}} + \overset{zero}{\cancel{\dot{W}_{in}}} + \dot{m}_{in}\theta = \overset{zero}{\cancel{\dot{Q}_{out}}} + \dot{W}_{out} + \dot{m}_{out}\theta$

$\dot{m}(h_1 + \frac{V_1^2}{2} + gz_1) = \dot{W}_{out} + \dot{m}(h_2 + \frac{V_2^2}{2} + gz_2)$

(kJ/kg)

kJ/s $\quad \dot{W}_{out} = -\dot{m}_{out}(h_2 + \frac{V_2^2}{2} + gz_2) + \dot{m}_{in}(h_1 + \frac{V_1^2}{2} + gz_1)$

kW/kg/s $\leftarrow \frac{\dot{W}_{out}}{\dot{m}} = -\frac{\cancel{\dot{m}}}{\cancel{\dot{m}}}(h_1 - h_2 + \frac{V_1^2}{2} - \frac{V_2^2}{2} + gz_1 - gz_2)$

= kJ/kg $\quad W_{out} = (887.39 - 14.95 + 0.04)$

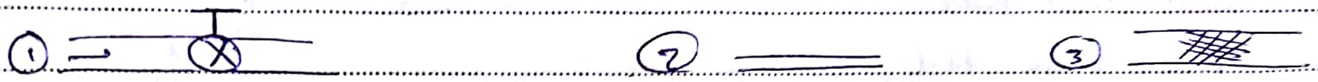
$W_{out} = 872.39$ kJ/kg

(4) $\rightarrow \dot{m} = \frac{\dot{W}_{out}}{W_{out}} = \frac{5 \times 10^6}{872.39} = \boxed{5.03 \text{ kg/s}}$

3 Throttling Valves :-

→ Device that cuse large pressure drops in the fluid, ($\dot{w} \approx 0$), ($\dot{Q} \approx 0$), ($\Delta P.e \approx 0$) ($\Delta k.e \approx 0$), temprutre drop or temp. rise → usid in AC cycle, refrigration cycle "isenthalpic" ($h_1 \approx h_2$)

another naie



① A djustable Valve ② A capillary tube ③ A Porous plog

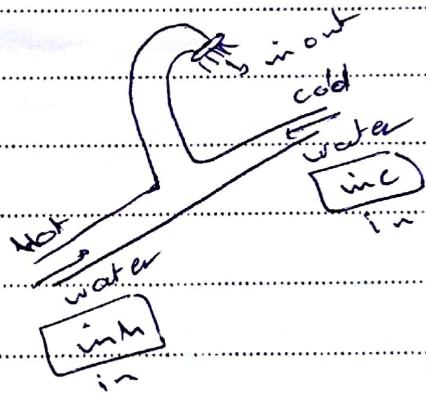
→ mass balance :- $\boxed{\dot{m}_{in} = \dot{m}_{out}}$

→ energy balance :- $\dot{E}_{in} = \dot{E}_{out}$

$\boxed{h_1 = h_2}$

$P_1V_1 + U_1 = P_2V_2 + U_2$

4 @ Mixing chamber :- (خلاط)



$q \approx 0$

$W \approx 0$

$\Delta k.e \approx 0$

$\Delta P.e \approx 0$

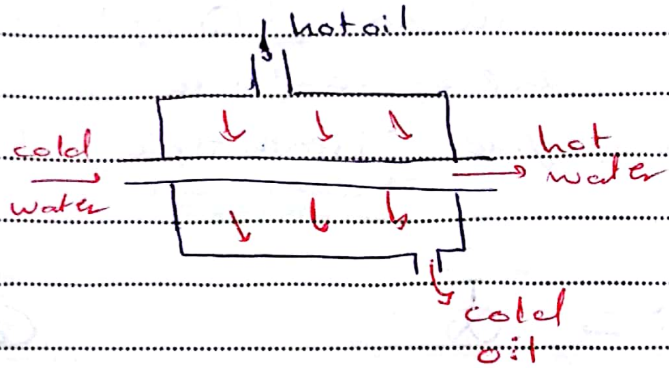
H.W: ① Ex 6-8 ③ 6-10

② Ex 6-9

Subject :

4 (b) Heat exchanger :- → no mix between 2 fluids

→ used to exchange heat between two fluids without mixing.



* Types of H.E:-

① shell and tube
② cross flow H.E

$(W = 0), (k.e = 0), (\Delta P.e = 0), (\dot{Q} = 0)$ Ideal

for

Subject : Ch.7

* Ch.7 :- The second law of thermo dynamics:-

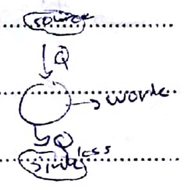
→ The first law is only concerned with the conservation of energy of systems.

→ The second law has been introduced to deal with process direction, energy quality as well as quantity and the therotical limitation of thermal system.

* 7-2 :- Thermal Energy Reservious:-

→ A larg body with large thermal capacity (mass * Thermal capacity) can supply or absorbed energy without change Temperature.

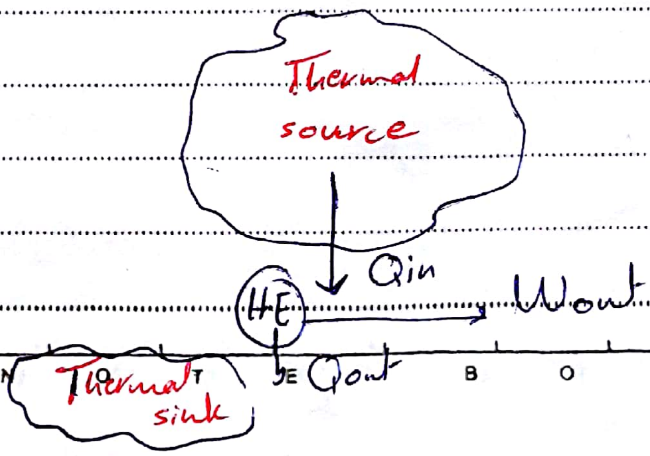
→ Ex :- Oceans, seas, rivers, atmospheric air, Industrial furnace.
الأفران الصناعية



Thermal Reservious →
- source :- supply energy
  مطلقة
- sink :- absorb energy
  ماصة طاقة

* 7.3 :- Heat engines (H.E) devices:-

→ H.E :- is a special devices use to convert heat to work.



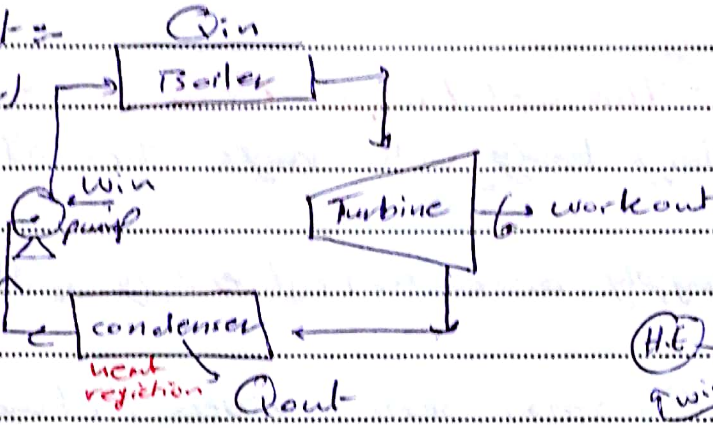
1) Qin: from high temp source (solar energy, nuclear reactors)

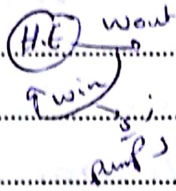
2) Work out $\boxed{W_{out} = Q_{in} - Q_{out}}$ (1)

3) Qout to surrounding (Thermal sink)

4) operate on cycle

* steam power plant:-
working fluid (water)





→ first law → $W_{net,out} = Q_{net,in}$

$$W_{out} - W_{in} = Q_{in} - Q_{out}$$

→ Thermal efficiency (η_{th}) $= \dfrac{\text{net work output}}{\text{total heat input}}$

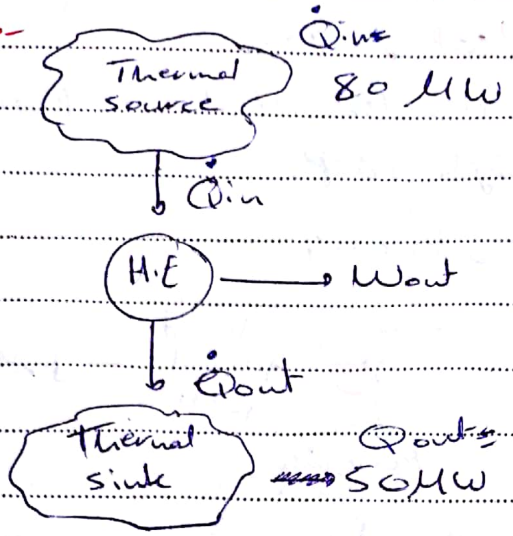
$$= \frac{W_{net,out}}{Q_{in}}$$

$$= \frac{Q_{in} - Q_{out}}{Q_{in}}$$

$$= \boxed{1 - \frac{Q_{out}}{Q_{in}}}$$

$$\Rightarrow \boxed{\eta_{th} < 1}$$

Ex :-



→ Determain net power output and thermal efficiency ?

$\eta = \frac{W_{out}}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$

→ $\dot{W}_{net} = \dot{Q}_{in} - \dot{Q}_{out} = 80 - 50 = \boxed{30\,MW} = W_{out}$

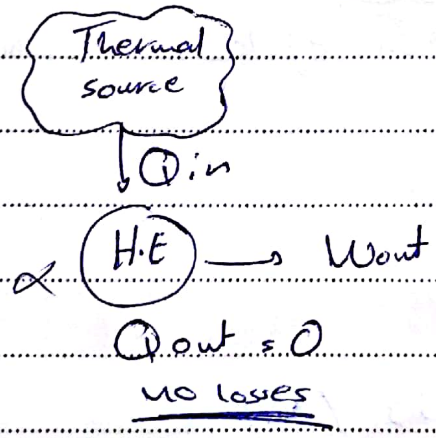
→ $\eta_{HE} = 1 - \frac{Q_{out}}{Q_{in}} = 1 - \frac{50M}{80M} = 0.375$

$= \boxed{37.5\%}$

→ The second law of Thermodynamics (kelvin planck statment) :-

it is impossible for any device that Operates on a cycle to recive heat from a single reservior and produce a net amount of work, it is impossible to have H.E with $\eta = 100\%$

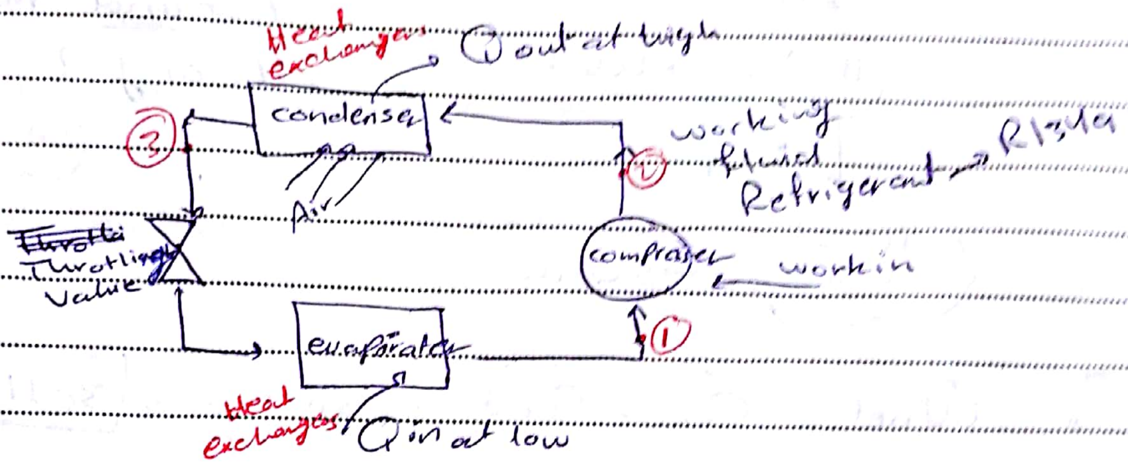
نفس الطاقة الداخلة = ال work ذاكرة



Subject :

* 7.4 :- Refrigerators and Heat Pumps :-

↳ special device used to transfer of heat from lower temp. medium to a high temp.



→ $COP_R = \dfrac{\text{Desired output}}{\text{Required input}} = \dfrac{Q_L}{W_{in}} = \boxed{\dfrac{Q_L}{Q_H - Q_L} > 1}$

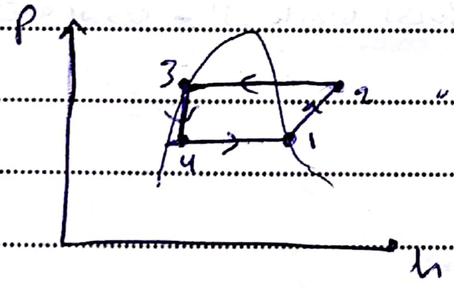
Refrigeration

$W_{in} = Q_H - Q_L$

→ $COP_H = \dfrac{Q_H}{W_{in}} = \boxed{\dfrac{Q_H}{Q_H - Q_L} > 1}$

Heat pump

→ $\boxed{COP_H = COP_R + 1}$



"ideal refrigeration cycle"

* Ex: 7.3 / 7.4

suggested: 21 / 39 / 42 / 43 / 53 / 101

* second law of Thermodynamics (Clausius statement) :-
→ it impossible to construct a device that operate in a cycle and produces no effect other than the heat transfer from low temp body to a higher temp. body.

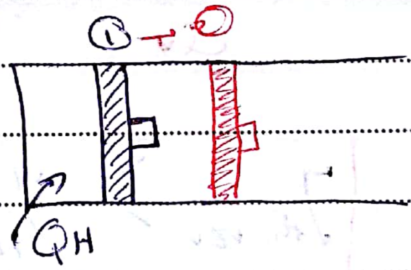
* 7-5 :- Reversible (ideal) and Irreversible Processes :-

→ **Reversible Process** :- Process that can be reversed without leaving any trace on the surrounding

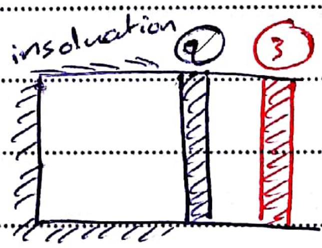
→ **Irreversible Process** :- not reversable, it will leave change on the surrounding
→ Ex :- Friction, Mixing with two fluids.

* 7-6 :- Carnot cycle :-
→ it is a theoretical cycle consist of four reversible process.

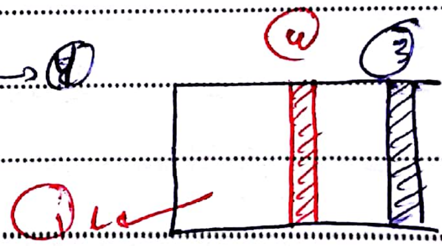
1. Reversible isothermal expansion
① → ②



2. Rversible adiabatic expansion
② → ③

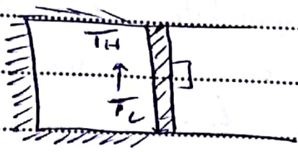


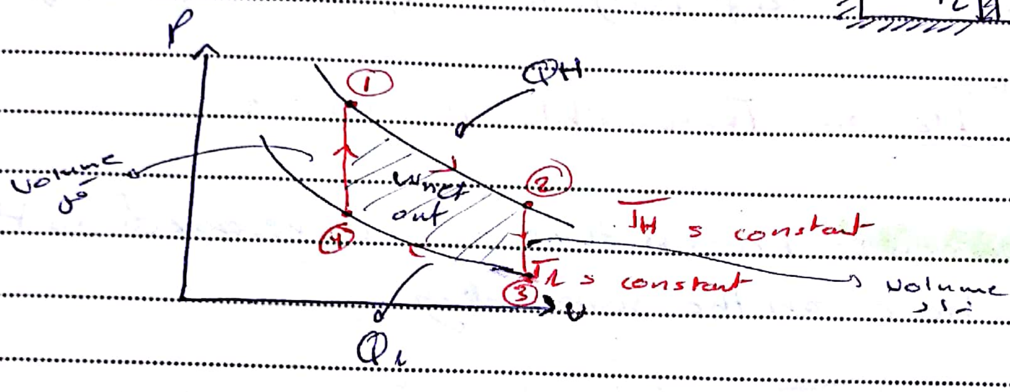
3. Reversible isothermal compression ③ → ④



Subject :

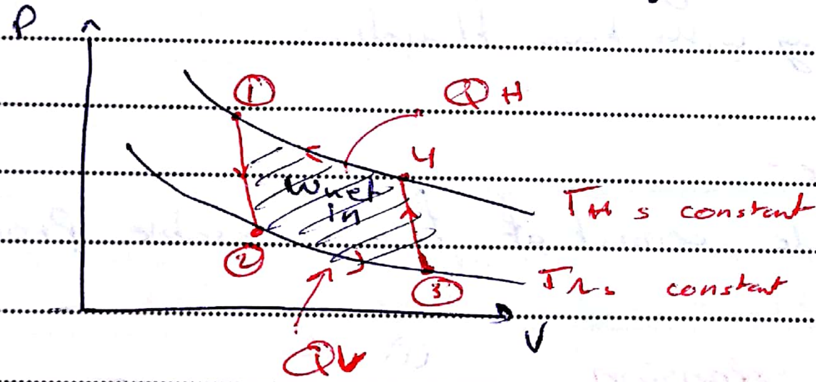
4 Reversible Adiabatic compression 4 → 1





(Heat Pump)

→ The reversed carnot cycle :



(Refrigeration cycle)

$$\boxed{\eta_{th,rev} > \eta_{th,irr}}$$

* 7-8 :- Thermodynamic Temp scale :- (kelvin-scale)

$\eta_{th,rev} = g(T_H, T_L)$, $\frac{Q_H}{Q_L} = f(T_H, T_L)$

→ for carnot cycle $\eta_{th} = 1 - \frac{Q_L}{Q_H}$, $\boxed{\eta_{th,rev} = 1 - \frac{T_L}{T_H}}$

→ Refergration and heat pump :-

$$COP_{R,rev} = \frac{Q_L}{Q_H - Q_L} = \frac{1}{\frac{Q_H}{Q_L} - 1} = \frac{1}{\frac{T_H}{T_L} - 1}$$

$$COP_{H,rev} = \frac{Q_H}{Q_H - Q_L} = \frac{1}{1 - \frac{Q_L}{Q_H}} = \frac{1}{1 - \frac{T_L}{T_H}}$$

Scanned by CamScanner

* Ch. 11 : fluid statics :-

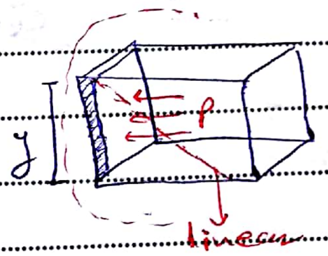
Fluid Mechanics

- fluid statics — "fluid at rest"
- fluid dynamic — "fluid at motion"

used to determine the force acting on floating or submesured bodies and the forces developed by devices such as Hydrdlic pressure and car Jacks, water dams and liquid stronge tank.

→ Remark from chapter (2) :

$\boxed{P_{gage} = \rho g \Delta h}$ → not constant (P) "depends on (h)"

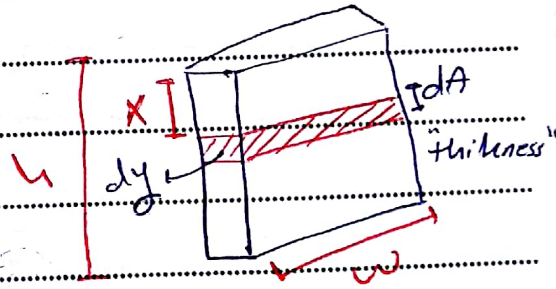


→ Force → Normal force

$\boxed{P = \frac{F}{A}}$ "Normal force"

→ to find the (P) related to Area by using integration :

الطول x العرض
$y * w$



$$F = \int_A \rho g y \, dA = \int_A P \, dA$$

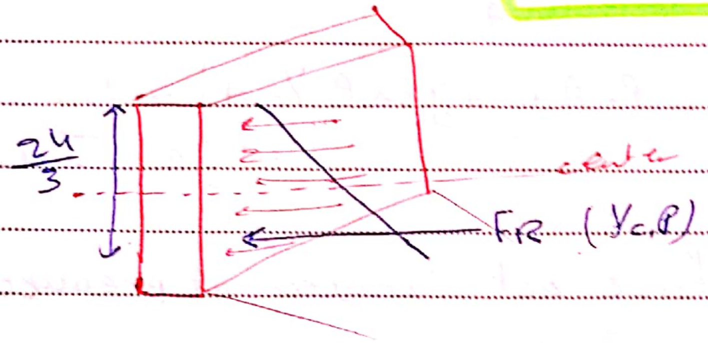
$$F = \rho g \int y \, dA \rightarrow F = \rho g \int_0^h y \cdot \underbrace{w}_{\text{constant}} \, dy$$

$$F = \frac{\rho g w y^2}{2} \Big|_0^h = \boxed{\frac{\rho g w h (h)}{2}}$$

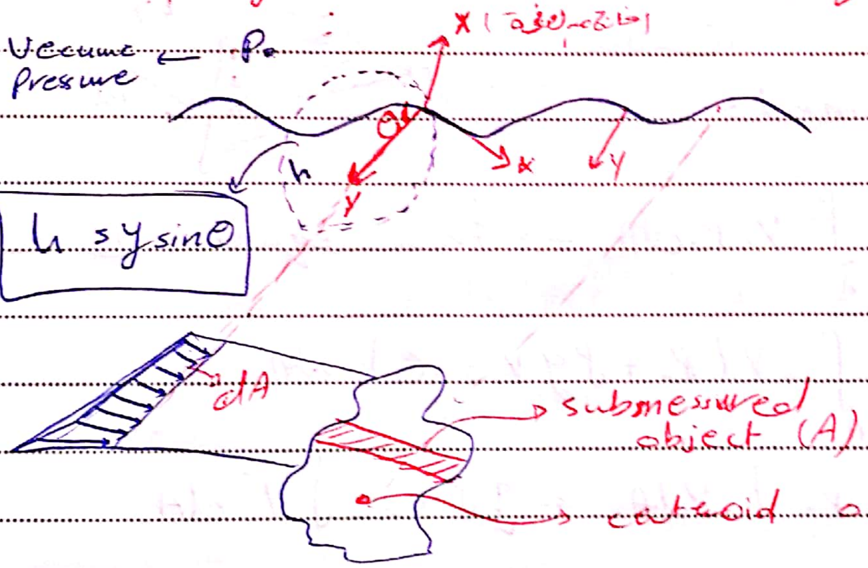
→ $F_R = \rho g \frac{h}{2}(A)$

→ But :- $\rho g h = P$ ⟶ $\boxed{\rho g \frac{h}{2} = P_{avg}}$

then :- Resoltant force $(F_R) = P_{avg} * A$



→ H.2 :- Hydroulic force on submerged Plane surface :-



$\boxed{h = y \sin\theta}$

$P_0 = atm$

→ Presure at any point on Plane :-

$P = P_0 + \rho g h = P_0 + \rho g y \sin\theta$ ---- $\boxed{1}$

→ to find resultoint force (Hydroulic force (F_R)) :-

$$F_R = \int (P_0 + \rho g y \sin\theta)\, dA$$

S T A R S N O T E B O O K

Scanned by CamScanner

$\rightarrow F_R = \int_A P_\circ \, dA + \int_A \rho g y \sin\theta \, dA$

$F_R = P_\circ A + \rho g \sin\theta \int_A y \, dA$ → first moment of Area

$y_c = \frac{1}{A} \int_A y \, dA \rightarrow y_c A = \int_A y \, dA$

"centroid"

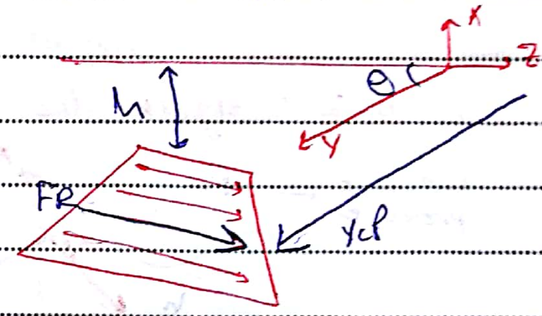
$\rightarrow$ then :- $\boxed{F_R = P_\circ A + \rho g \sin\theta \, y_c A}$ رح تتغير بتغير الزاوية

"استثنا لما بكون 0° و 90°

$\rightarrow$ when does the force act "center of pressure"

عشان يكون ال "static fluid"

لازم يكون كل القوة المؤثرة ع الجسم متساوية متعاكسة



By using moment :-

$\sum M = 0$

$y_{cp} F_R = \int_A y \cdot P \cdot dA \rightarrow$ from equation (1)

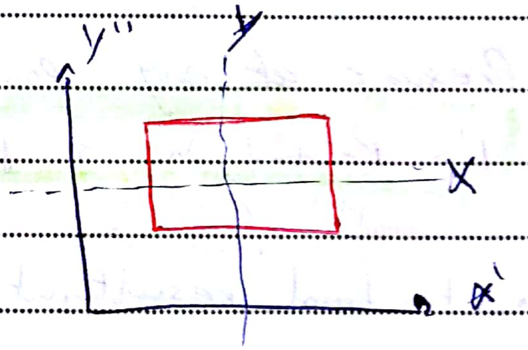
$y_{cp} F_R = \int_A y (P_\circ + \rho g y \sin\theta) \, dA$

$y_{cp} * F_R = P_\circ \int y \, dA + g \rho \sin\theta \int y^2 \, dA$

$\rightarrow$ Remark :-

$I_y = \frac{1}{12} a b^3$

$I_x = \frac{1}{12} b a^3$



Parallel axies theory [illegible] (Any Axis) [illegible] *

$$\boxed{I_A = I_{centroid} + Ad^2}$$

Y_{cP} $F_R = P_0\, Y_c A + \rho g \sin\theta \, (I_{xx} + A Y_c^2)$ "centroid"

$Y_{cP} = Y_c + \dfrac{I_{x,c}}{(Y_c + P_0/\rho g \sin\theta)\, A}$

$F_R = P_0 A + \rho g \sin\theta \cdot Y_c A$

Rectangular [illegible]

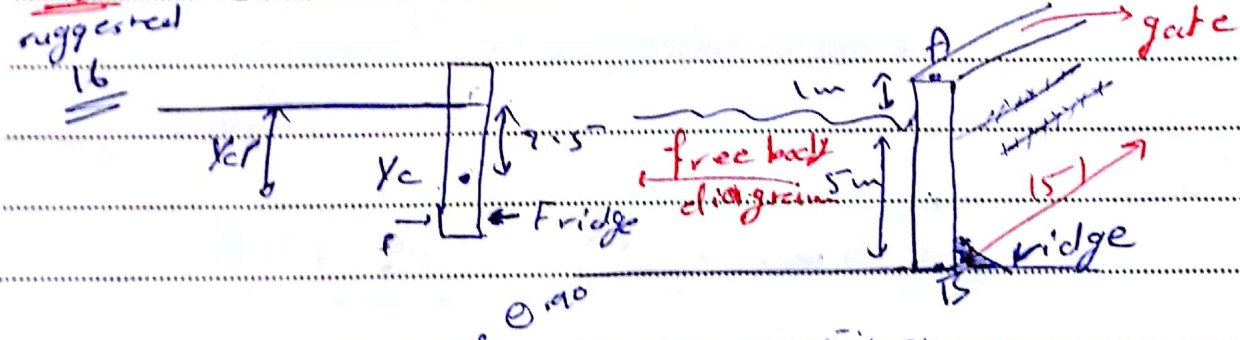
$\rightarrow Y_{cP} = \dfrac{h}{2} + \dfrac{\frac{1}{12} w h^3}{\frac{h}{2}(wh)}$

$\rightarrow Y_{cP} = \dfrac{h}{2} + \dfrac{2}{12} h \rightarrow \boxed{Y_{cP} = \dfrac{2}{3} h}$

centroid Bellow (Y_{cP}) دايماً تحته *

*Ex: determine the force exerted on plane by ridge?

suggested 16



$\theta = 90$

$F_R = \rho g \sin\theta \; Y_c A$ المسافة بين سطح المائع و centroid

$= 1000 \times 9.81 \times (2.5)\,(5 \times 5) \rightarrow F_R = 613.125 \times 10^3\ N$

Subject : (5)

$\rightarrow Y_{CP} = \frac{2}{3} h = \frac{10}{3} = 3.333\ m$

$\Sigma M_B = 0$

$\rightarrow F_R \times (3.33 + 1) - F \times 6 = 0$

$\frac{613.125 \times 10^3 (4.333)}{6} = F$

$F = 442.47 \times 10^3\ N$

OR $\boxed{F = 442.47\ kN}$

$\rightarrow$ suggested :- 15 / 16 / 25 / 42 / 45 / 52

Subject : Ch.12.

*Ch.12.:- Bernoulli eq and Energy equations:-

*12.1:- The Bernoulli equation is concerned with the conservation of kinetic, potential and flow energies of a fluid steam and their conversion to each other in the regions of flow. Where net viscous forces are negligible.
اللزوجة

$$\boxed{\underbrace{\frac{P}{\rho}}_{\text{flow energy}} + \underbrace{\frac{U^2}{2}}_{\text{kinetic energy}} + \underbrace{gZ}_{\text{potential energy}} = \text{constant}}$$ (along stream line)

(kJ/kg)

→ limitations on the use of the Bernoulli equ:-

1- steady state (not change with time)

2- Viscous (friction): effects are negligible.
اللزوجة

3- Incompressable flow → (ρ= constant)

4- flow is irrotational and there is no vorticity.

صيغة ثانية ② →

$$\boxed{\underbrace{\frac{P}{\rho g}}_{\text{pressure head}} + \underbrace{\frac{U^2}{2g}}_{\text{velocity head}} + \underbrace{Z}_{\text{elevation head}} = \text{constant}}$$ (m)

③ →

$$\boxed{\underbrace{P}_{\text{static Pressure}} + \underbrace{\frac{\rho U^2}{2}}_{\text{dynamic Pressure}} + \underbrace{\rho g Z}_{\text{hydrostatic pressure}} = \text{constant}}$$ (Pa)

④ sum of static and dynamic Pressurs → stagnations Pressure

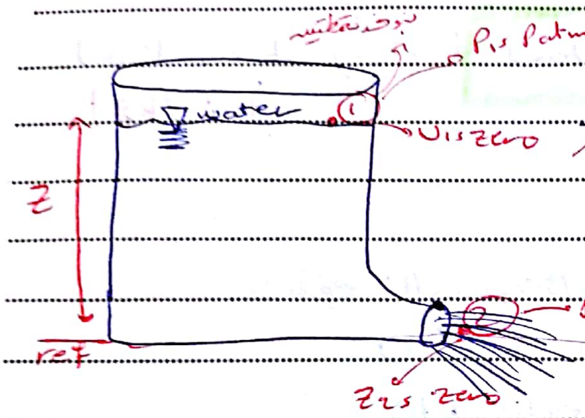
$$\boxed{P_{stag} = P + \frac{\rho U^2}{2}}$$

Scanned by CamScanner

★ stagnation pressure :- represent the pressure at a point where the fluid is brought to a complete stop $\rightarrow \boxed{V = 0}$

★ **Applications of the Bernoulli equ:-**

1- Water discharge from a large tank :-

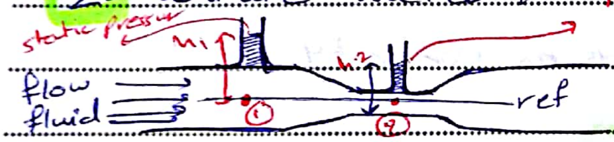


$$\cancel{\frac{P_1}{\rho g}} + \cancel{\frac{V_1^2}{2g}} + Z_1 = \cancel{\frac{P_2}{\rho g}} + \frac{V_2^2}{2g} + \cancel{Z_2}$$

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

$$\boxed{V_2 = \sqrt{2 Z_1 g}}$$ Torricelli equation

2- Venture meter :- piezo meter (measure static pressure)



from mass balance

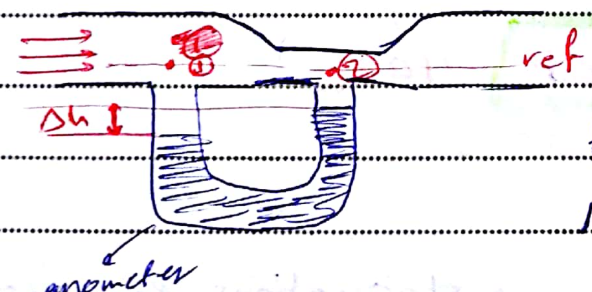
$\dot{m}_{in} = \dot{m}_{out}$

$\rho A_1 V_1 = \rho V_2 A_2$

Incompressible flow نشيلها لأن

then $A_1 V_1 = A_2 V_2$

, Area علاقة عكسية بين velocity



$P_1 = \rho g h_1$

$P_2 = \rho g h_2$

$$\rightarrow \frac{P_1}{\rho g} + \frac{U_1^2}{2g} + \cancel{Z_1} = \frac{P_2}{\rho g} + \frac{U_2^2}{2g} + \cancel{Z_2}$$

they are in the same ref

→ from mass balance:-

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

$\rho_1 U_1 A_1 = \rho_2 U_2 A_2$

$U_1 A_1 = U_2 A_2$

$$\boxed{U_1 = U_2 \frac{A_2}{A_1}}$$

$$\rightarrow \frac{P_1}{\rho \cancel{g}} + \frac{U_2^2 \left(\frac{A_2}{A_1}\right)^2}{2\cancel{g}} = \frac{P_2}{\rho \cancel{g}} + \frac{U_2^2}{2\cancel{g}}$$

$$\frac{P_1}{\rho} - \frac{P_2}{\rho} = \frac{U_2^2}{2} - \frac{U_2^2}{2}\left(\frac{A_2}{A_1}\right)^2$$

$$\frac{2(P_1 - P_2)}{\rho} = U_2^2\left(1 - \frac{A_2^2}{A_1^2}\right)$$

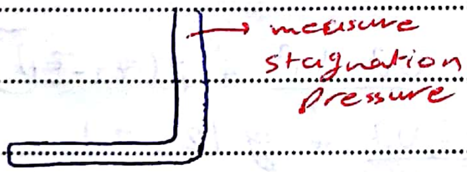
$$\rightarrow \boxed{U_2 = \sqrt{\frac{2(P_1 - P_2)}{\rho\left(1 - \frac{A_2^2}{A_1^2}\right)}}}$$

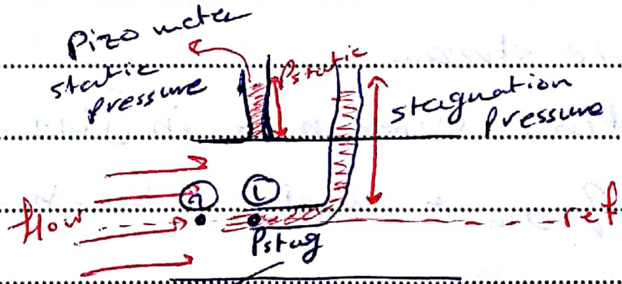
→ flow rate

$\dot{m}_1 = \rho U_1 A_1$

$\dot{m}_2 = \rho U_2 A_2$

3- Pitot tube:-





velocity zero ال stagnation point

$$\frac{P_1}{\rho g} + \cancel{\frac{U_1}{2g}} + \cancel{Z_1} = \frac{P_2}{\rho g} + \frac{U_2}{2g} + \cancel{Z_2}$$

$$V_2 = \sqrt{\frac{2(P_1 - P_2)}{\rho}} = \sqrt{\frac{2(P_{stag} - P_{static})}{\rho}}$$

4- Spraying water into the air :-

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

→ if $V_1 \neq 0$

$$\rightarrow \boxed{Z_2 = \frac{P_1 - P_2}{\rho g} + \frac{V_1^2}{2g}}$$

→ if $V_1 = 0$

$$\boxed{Z_2 = \frac{P_1 - P_2}{\rho g}}$$

note :- to know the value of V_1 → from mass flow rate or volum flow rate if we have the cross sectional Area $\boxed{A_1}$

* 12-20 :- Energy analysis of steady flow :-

$$\rightarrow \dot{Q}_{net\,in} + \dot{W}_{net\,in} = \sum_{out} \dot{m}\left(h + \frac{V^2}{2} + gz\right) - \sum_{in} \dot{m}\left(h + \frac{V^2}{2} + gz\right)$$

→ for single stream

$$\dot{Q}_{net\,in} + \dot{W}_{net\,in} = \dot{m}\left[(h_2 - h_1) + \frac{V_2^2 - V_1^2}{2} + g(z_2 - z_1)\right]$$

divided by $\dot{m}$ →

$$q_{net\,in} + w_{net\,in} = h_2 - h_1 + \frac{V_2^2 - V_1^2}{2} + g(z_2 - z_1)$$

enthalpy eq →

$$h = PV + u \rightarrow h = \frac{P}{\rho} + u$$

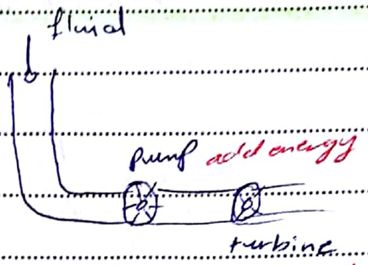
$$\underbrace{w_{net\,in} + \frac{P_1}{\rho_1} + \frac{V_1^2}{2} + g z_1}_{\text{Mechanical energy input}} = \underbrace{\frac{P_2}{\rho_2} + \frac{V_2^2}{2} + g z_2}_{\text{Mechanical energy output}} + \underbrace{(u_2 - u_1 - q_{net\,in})}_{\text{Mechanical energy loss}}$$

Subject :

→ $e_{mech,loss} = u_2 - u_1 - q_{net\,in}$

→ $W_{net\,in} = W_{in} - W_{out}$

shaft pump — shaft Turbine



① # → $\frac{P_1}{\rho_1} + \frac{V_1^2}{2} + gZ_1 + W_{pump} = \frac{P_2}{\rho_2} + \frac{V_2^2}{2} + gZ_2 + W_{turbine} + e_{mechanical\,loss}$

② # → $\dot{m}\left(\frac{P_1}{\rho_1} + \frac{V_1^2}{2} + gZ_1\right) + \dot{W}_{pump} = \dot{m}\left(\frac{P_2}{\rho_2} + \frac{V_2^2}{2} + gZ_2\right) + \dot{W}_{turbine} + \dot{E}_{mech,loss}$ (KW)

③ # → $\frac{P_1}{\rho_1 g} + \frac{V_1^2}{2g} + Z_1 + h_{pump} = \frac{P_2}{\rho_2 g} + \frac{V_2^2}{2g} + Z + h_{turb} + h_L$

$h_{pump} \rightarrow \frac{W_{pump}}{g}$

(head pump) أقصى ارتفاع بيوصله ال fluid مستفيد ال pump

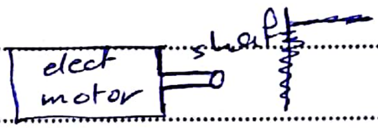
$$\boxed{h_{pump} = \frac{\dot{W}_{pump}}{\dot{m} g}}$$ → useful head pump delivered

$$\boxed{h_{turb} = \frac{\dot{W}_{turb}}{\dot{m} g}}$$ → extracted head turbine removed

$$\boxed{h_L = \frac{\dot{E}_{mech,loss}}{\dot{m} g}}$$ head loss → irreversible head loss between two points due to all components of piping system.

→ Mechanical efficiancy :-

$$\boxed{\eta_{pump} = \frac{\dot{W}_{pump}}{\dot{W}_{shaft,in}}}$$ $\dot{W}_{pump} \rightarrow \dot{m} g h_{pump}$



$$\boxed{\eta_{turb} = \frac{\dot{W}_{shaft\,out}}{\dot{W}_{turbine}}}$$ $\dot{W}_{shaft\,out} \rightarrow$ power of shaft; $\dot{W}_{turbine} \rightarrow$ extracted power ($\dot{m} g h_{turb}$)

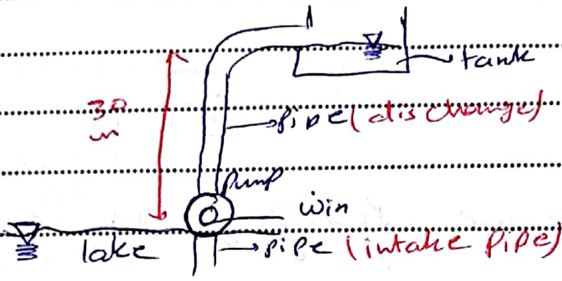
Scanned by CamScanner

Subject : ....

$\boxed{\eta_{motor} = \dfrac{\dot{W}_{shaft,out}}{\dot{W}_{elect,in}}}$, $\boxed{\eta_{gen} = \dfrac{\dot{W}_{elect,out}}{\dot{W}_{shaft,in}}}$

*Ex :-

بنضخ الـ
lake من الـ
to الـ
tank



→ $\eta_{pump} = 78\%$

$\dot{W}_{shaft} = 5\,kW$

$D_{pipe,intake} = 7\,cm$

$D_{pipe,discharge} = 5\,cm$, assume that $h_{mechanical,loss} = 0$

→ Determain : ⓐ The maximum flow rate $(\dot{m}, \dot{V})$?

ⓑ The pressure differance across the pump? ΔP.

→ sol :- ⓐ $\eta_{pump} = \dfrac{\dot{W}_{pump}}{\dot{W}_{shaft,in}}$

$0.78 * 5k = \dot{W}_{pump}$

$\dot{W}_{pump} = 3.9\,kW$

$\dot{m} g h_{pump} = 3.9k$

$\dot{m} * 9.81 * 30 = 3.9k \rightarrow \dot{m} = 13.25\,kg/s$

$\dot{V} = \dfrac{\dot{m}}{\rho_{water}} = 13.25 * 10^{-3}\,m^3/s$

▸ Subject :

$$\dot{m}\left(\frac{P_1}{\rho_1}+\frac{V_1^2}{2}+g\cancel{z_1}\right)+\dot{W}_{pump} = \dot{m}\left(\frac{P_2}{\rho_2}+\frac{V_2^2}{2}+g\cancel{z_2}\right)+\cancel{W_{turb}}+\cancel{E}$$

3.9 kW

$\rightarrow V_1 = \frac{\dot{V}}{A_1} = \frac{\dot{V}}{\frac{\pi}{4}(7\times10^{-2})^2}$ / $V_2 = \frac{\dot{V}}{A_2} = \frac{\dot{V}}{\frac{\pi}{4}(5\times10^{-2})^2}$

$\boxed{V_1 = 3.44\ m/s}$ $\boxed{V_2 = 6.74\ m/s}$

→ to find ΔP = ?

incompressible نعوض ρ لأنه

$$P_2 - P_1 = \rho\left[\frac{V_1^2 - V_2^2}{2}\right] + \frac{\dot{W}_{pump}}{\dot{V}}$$

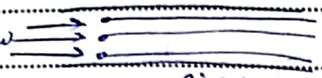
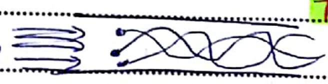
$$\Delta P = 1000\left[\frac{3.44^2 - 6.74^2}{2}\right] + \frac{3900}{13.25\times10^{-3}} = 277.5\times10^3\ Pa$$

$= 277.5\ kPa$

Scanned by CamScanner

Subject : Ch.14..

* Ch.14 : Internal flow :- Types of flow:-

① flow  ~~laminar~~ flow ② flow  Turbulent flow

pipe

→ laminar flow :- smooth stream lines and highly order ~~xxxx~~ motion.

→ Tubulent flow:- non smooth, it is characterized by velocity fluctuation and highly disordered motion.

→ Transition flow :- region in between laminar and turbulent.

* Reynolds Number (Re)

→ $Re = \dfrac{\text{inertia force}}{\text{viscous force}} = \boxed{\dfrac{V_{avg} * D}{\nu}}$

D → geometric diameter

ν → ~~dynamic~~ viscosity kinematic (m^2/s)

→ $Re = \dfrac{\rho V_{avg} D}{\mu}$

μ → dynamic viscosity $(kg/m.s)$

$$\boxed{\nu = \frac{\mu}{\rho}}$$

→ D = hydradic diameter (depend on geomatry)

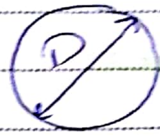
→ flow $Re < 2300$ laminar flow

$2300 < Re < 4000$ Transition flow

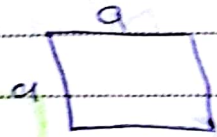
$Re > 4000$ Turbulent flow

① → circular pipe → $\boxed{D = \frac{4A_c}{P}}$ → cross sectional area
P → Parimeter (محيط)

→ $D_{pipe} = \frac{4 * \frac{\pi}{4} D^2}{\pi D} = \boxed{D}$

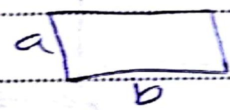


② → squre duct ⇒ $D_{duct} = \frac{4 * a^2}{4a} = \boxed{a}$



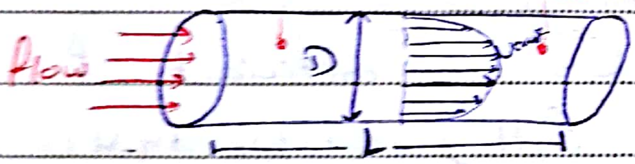
③ → rectangular duct ⇒ $D_{duct} = \frac{4 * a * b}{2a + 2b} = \frac{4 * a * b}{2(a+b)}$

$D_{duct_{Rec}} = \boxed{\frac{2ab}{a+b}}$



* sec 14-4 :- laminar flow in pipes:-

① P_1 ② P_2 $P_1 > P_2$



ΔP_{1-2} (pressure drop in pipe)

→ $\Delta P_{1-2} = P_1 - P_2$

$\boxed{\Delta P = f \frac{L}{D} \rho \frac{V_{avg}^2}{2}}$ for laminar flow

friction factor ⇒ $\boxed{f = \frac{64}{Re}}$

Subject : ....

→ Head loss (h_L) $\boxed{h_L = \frac{\Delta P}{\rho g} = \frac{fL}{Dg} \frac{V_{avg}^2}{2}}$

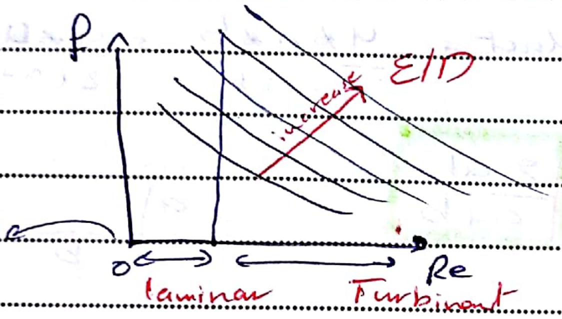
↳ Major pressure drop

★ sec 14-5 :- Turbulent flow in pipes :-

$\Delta P_{1-2} = f \frac{L}{D} \rho \frac{V_{avg}^2}{2}$

→ roughness of surface (in book table 14-2)

→ $\boxed{\frac{1}{\sqrt{f}} = -2.0 \log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\sqrt{f}}\right)}$ implicit eq (cole brook eq)



Moody chart

log scale

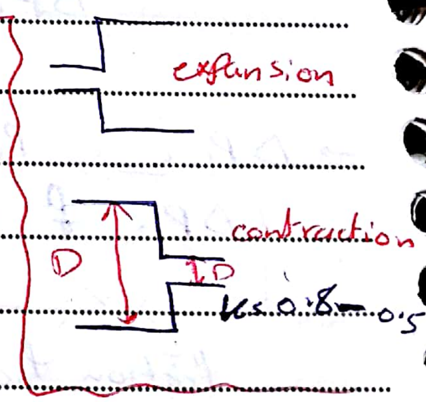
sec 14-6 :- Minor losses (In fittings) :-

→ $\boxed{h_m = K \frac{V^2}{2g}}$ where K = loss cofficiant of fitting (Table 14-4)

total pressure drop :-

$h_{total} = h_{major} + h_{minor}$

(due to friction in pipe) (due to fititings)



Subject : Ch. 16.

* Ch. 16. :- Mechanisms of Heat Transfer :

* Heat transfer :- Transfer thermal energy from higher temp region to lower temp region.

→ Three mechanisms (modes) of heat transfer :

التوصيل [1] conduction →

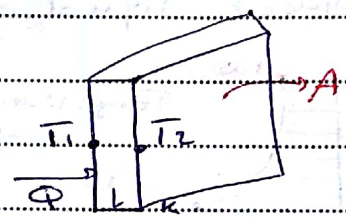
الحمل [2] convection →

الإشعاع [3] radiation →

التوصيل

[1] conduction :- Transfer of energy from more energetic particles to less energetic ones.

→ 1 Direction heat flow :-



Heat transfer rat $\propto$ $\dfrac{\text{Area (Temp. diff)}}{\text{Thickness}}$

$T_1 > T_2$

⟼ x direction

$$\boxed{Q_{cond} = -k\,A\,\frac{dT}{dX}}$$ (Fourier's law of conduction) if Q in steady state flow

Direction of flow

Temp. gradient

→ k unit → W/m.C° or k = W/m.k

from Book → Table 16-1 → Diamond → k = 2300 أعلى قيمة

→ conduction take place in solids, liquids and gases.
solids > liquids > gases.

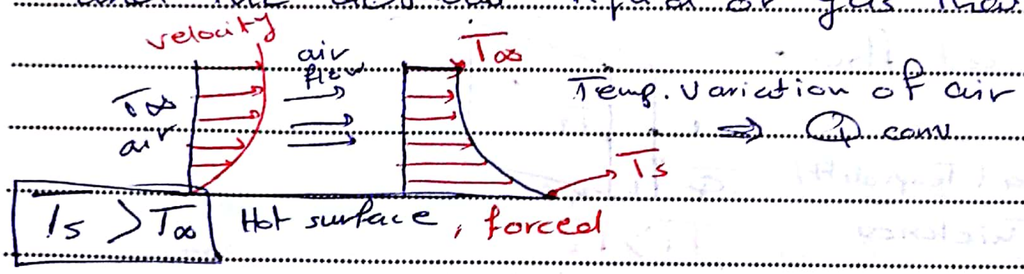
* Example 16-1 / 16-2 from Book

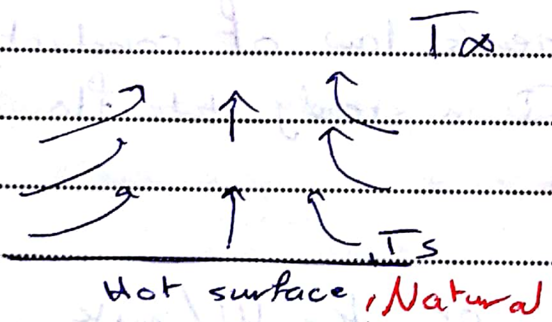
* Thermal diffusivity α :- represents how fast heat diffuses.

$$\boxed{\alpha = \frac{\text{Heat conduction}}{\text{Heat storage}} = \frac{k}{\rho C_P}} \quad (m^2/s)$$

From Table 16-4 in Book.

2- **Convection** :- energy transfer between a solid surface and the adjacent liquid or gas that is in motion.





→ convection
- → Natural :- due to density variations.
- → forced :- due to external force (fan)

▸ Subject :

→ Newton's law of cooling ⟹ $\dot{Q}_{conv} \propto A_s$ (Temp diff)

$$\boxed{\dot{Q}_{conv} = h A_s (T_s - T_\infty)}$$ at S.S

where h = heat transfer coefficient $(w/m^2 \cdot C^\circ)$

Table 16-5 from Book

3- **Radiation**: energy emitted by ~~[illegible]~~ matter in the form of electro magnatic waves.

→ stefan - Boltzman law:

$$\boxed{\dot{Q}_{\substack{rad \\ emitt}} = \underbrace{\sigma}_{constant} A_s T_s^4}$$ kelvin

stefan - Boltzman constant $\sigma = 5.67 \times 10^{-8}\ w/m^2 \cdot C^\circ$

→ $$\boxed{\dot{Q}_{rad} = \varepsilon A_s T_s^4}$$

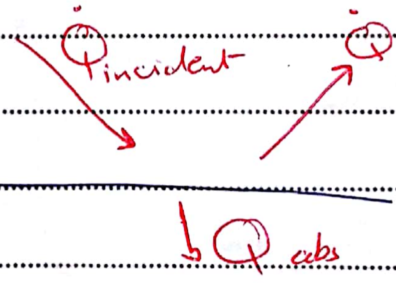
↳ emissivity $0 \le \varepsilon \le 1$ → black body

Table 16-6

إمتصاصية

* absorptivity (α): The fraction of the radiation energy incident on the surface that is absorbed by the surface.

الأشعة الممتصة
الأشعة الساقطة



Scanned by CamScanner

Subject :

$\alpha = \dfrac{\dot{Q}_{absorbed}}{\dot{Q}_{incident}}$

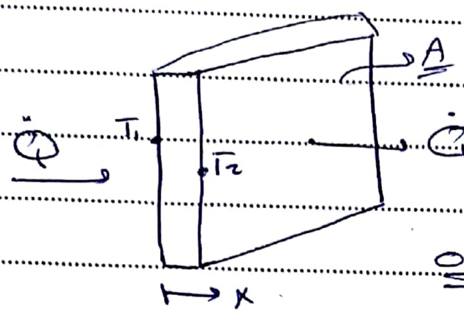
→ $\dot{Q}_{ref} = (1-\alpha)\,\dot{Q}_{incident}$

→ between two surfaces

$$\boxed{\dot{Q}_{rad} = \varepsilon \sigma A_s \left(T_s^4 - T_{sur}^4\right)}$$

→ * Example
16-5
16-6
16-7
from Book

* Ch. 17. :- steady Heat conduction:-



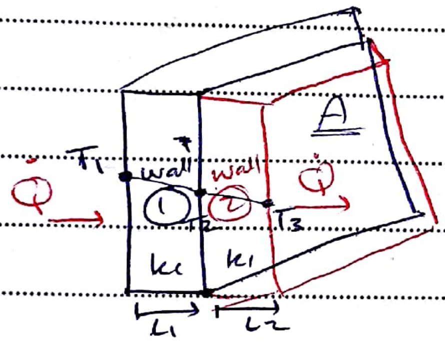
$\dot{Q}_{cond} = -kA \frac{dT}{dx}$

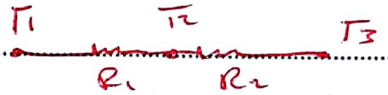
or $\dot{Q}_{cond} = \frac{\Delta T}{R_{thermal}} = \frac{\Delta T}{\boxed{\frac{\Delta x}{kA}}}$

Thermal resistans $(°C/W)$

→ $\dot{Q}_{conv} = h A_s \Delta T$

$\dot{Q}_{conv} = \frac{\Delta T}{R_{conv}}$ → $\left(\frac{1}{h_{conv} A_s}\right)$





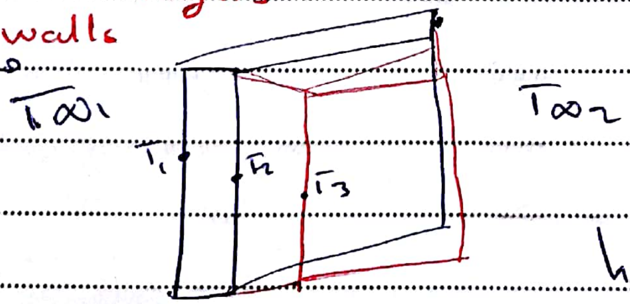
$\dot{Q}_{1-3} = \dot{Q}_{1-2} = \dot{Q}_{2-3}$

$\frac{T_3 - T_1}{R_{total}} = \frac{T_1 - T_2}{R_1} = \frac{T_2 - T_3}{R_2}$

$R_1 \to \frac{L_1}{k_1 A}$ $\quad$ $R_2 \to \frac{L_2}{k_2 A}$

→ $\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$

for multilayer walls



→ $\dot{Q}_{conv,\, T_{\infty 1}-T_1} = \dot{Q}_{conv,\, 1-2} = \dot{Q}_{conv,\, 2-3} = \dot{Q}_{conv,\, 3-T_{\infty 2}}$

$h_{\infty 1} A (T_{\infty 1} - T_1) = \frac{\Delta T_{1-2}}{R_1} = \frac{\Delta T_{2-3}}{R_2} = h_{\infty 2} A (T_3 - T_{\infty 2})$

* Examples 17-1 / 17-2 / 17-3