Thermal

الدكتور

جميل الاصفر

Subject 16.6..19 بسم الله Date No.

thermal

first part

1. thermo

Ch.1 Basic concepts.

Energy, E, $e = \frac{E}{m}$; kJ/kg , $w = \frac{W}{m}$, $q = \frac{Q}{m}$

Work W heat Q

* $\Delta E = Q_{net} - W_{net} = E_2 - E_1$; U : internal energy ; kJ

$K.E = \frac{1}{2} \vec{v}^2$ $P.E = g.Z$ Potential

- $e = u + K.E + P.E$

- enthalpy, $h = u + p v = u + \frac{P}{\rho}$; $\forall = \frac{1}{\rho} = \frac{\forall}{m}$ specific volume (m^3/kg)

ρ = density (kg/m^3)

- Flow work (energy) = $P\forall$; entropy

- intensive | extensive. E

لا تعتمد على كمية mass

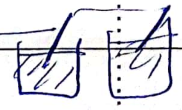
- pure substance: fixed chemical composition. but exist in wherever one phase

- state postulate: two independ intensive properties to specify the state of a substance. Thermo dynamic

- Z^{th} (zeroth low) of T/D :

↳ If two bodies are in thermodynamic equilibrium. with a third body, then they are in thermo/D eq. with eash other

ميزان حرارة



- 1^{st} (first low) of T/D :

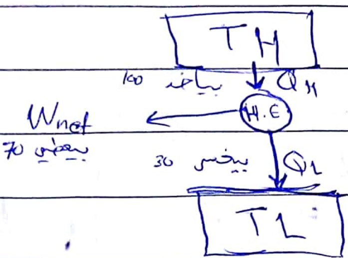
↳ Conservation of energy, Energy never created no destroyed.

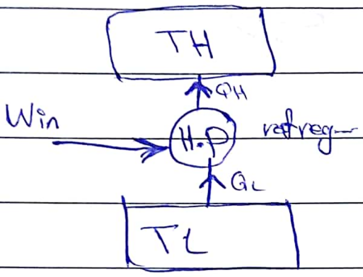
$\Delta E = E_2 - E_1 = Q - W$

●● 2^{nd} (second law) of T/D.

process بحدد اتجاه الـ

↳ I specifis that certain process. occur in certain direction.





الكون إما
← يميل للفوضى والاضطراب
← لفقدان الطاقة

●● 3^{rd} (thirred low):

↳ At zero kelvin, the entropy of pure cryslalm is zero.

second part.

2. H-T
Heat transfer.

* Heat transfer

↳ Conduction, convention, radiation.

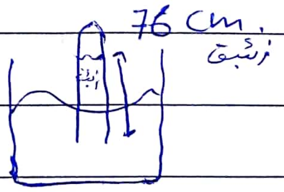
* Fluid mechanics.

↳ static fluids., cauter of pressure. $\rho = \frac{m}{V}$

Fluid in motion: Continuity ; $\dot{m} = \frac{dm}{dt} = \rho A V$

Bernalli's eq-n.

barameter

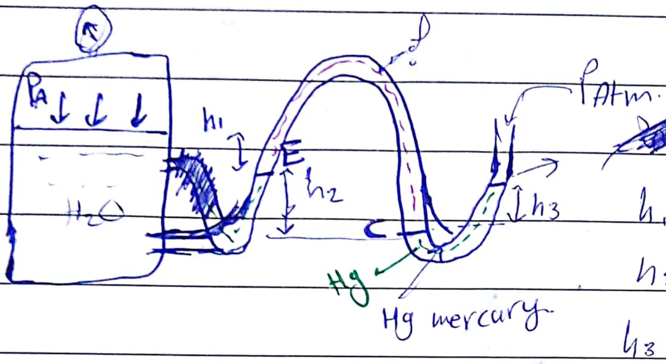


- Momentum $= mV$

(2.55 - 2.66) five problems.

Mano meter · units !

2-34 U-tube. Calculations !



$h_1 = 0.2$ m

$h_2 = 0.3$ m

$h_3 = 0.46$ m.

$\rho_{Hg} = 13600$ kg/m³

$\rho_w = 1000$ kg/m³

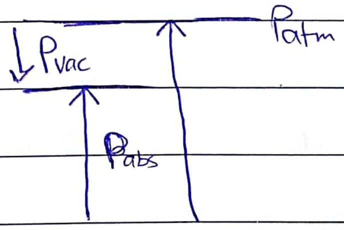
$\rho_o = 850$

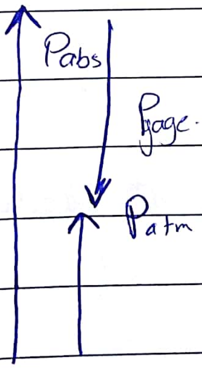
$P_{A\,gage} = P_A - P_{atm}$

same level & same fluid.

$$P_{Atm} + \rho_{Hg}\, g h_3 - \rho_o g h_2 - \rho_w g h_1 = P_A$$

- $P_{vac} = P_{atm} - P_{abs}$
- $P_{gage} = P_{abs} - P_{atm}$





موضوع الدرس ________ اليوم ________ التاريخ / /

17.6.018 بسم الله

thermal 7

$$*\ \boxed{\Delta E = E_2 - E_1 = Q_{net} - W_{net}}$$

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

= For closed system.

but for open system (controlled volume)

أنظمة قياس درجة الحرارة..

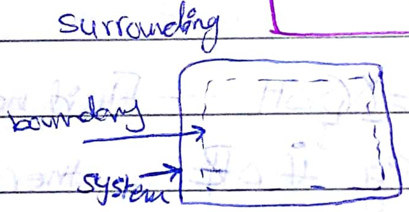
$x = \frac{5}{9}(x-32) \leftarrow \overset{\circ}{C} = F$ متى $\leftarrow$ $* \ \overset{\circ}{C} = \frac{5}{9}(F-32)$

at −40

$R = F + 460$

$K = \overset{\circ}{C} + 273.15$

$K = \frac{5}{9} R^{\circ}$



→ gage

vacume.

→ 1 atm = 14.7 psi

→ independent properties

prussere & tempretur

نسأل عن saturation

(phase change) والـ

$$● \ P_g = \frac{F}{A} = \frac{mg}{A} = \frac{AZ\rho g}{A}$$

$$P_B = P_{atm}$$

$$P_B = P_{atm} + \rho Z g.$$

$$= \int_{V_1}^{V_2} P\,dV$$

→ Work = $W_b + W_{other}$

$$W = \int f.d = \int P.\underbrace{A\ d}_{V} = \int P.\Delta V \rightarrow \text{for closed system.}$$

$$= \int P.V = P.\Delta V$$

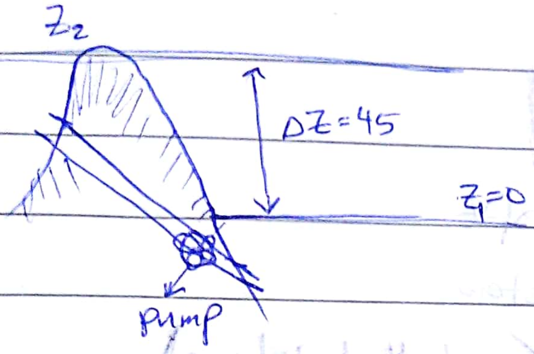
$W_{electrical}$ = $I V \Delta t$

shaft = $I\theta$ = $\tau \omega \Delta t$

$W_{sp} = \frac{1}{2}K(x_2^2 - x_1^2)$

$\boxed{● \ \text{spring} = -kx}$

$\boxed{3.66}$



$$P_{mech} \xrightarrow{\text{motor}} P_{ela} \xrightarrow{\text{pump}} P_{hyd}$$

$$\Rightarrow \eta_{motor} = \frac{P_{\cancel{ele}mech}}{P_{\cancel{mech}\,ela}} = \frac{20}{25} = 80\%$$

$$\Rightarrow \eta_{pump} = \frac{P_{hyd}}{P_{ela}} = \frac{13.24}{20} = 66\%$$

[illegible]

$P_{mech} = 20\ kW$ $\quad P_{elec} = 25\ kW$ $\quad \dot{V} = 0.3\ m^3/s$ $\quad \rho = 1000\ kg/m^3$?

$$\boxed{P_{loss} = P_{mech} - P_{hyd}}$$

$P_{hyd} = \gamma Q \Delta H$ --- Fluid mechanics.

$= \rho g \dot{V} \Delta Z$ ... thermal science

$= (1000)(9.8)(0.03)(45)$

$= 13243.5\ W$

$$\frac{P_{hyd}}{P_{ele}} = \eta_o = \eta_{ov} = 0.66(0.8) = 52\%$$

⑤

موضوع الدرس ______ اليوم ______ التاريخ / /

18.6..19 بسم الله

"(جزاك الله يا مرسي

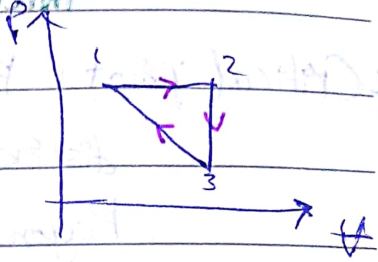
Ch2 Procese

التناهي

evabrotion, Condensation, melting, freezing, sublmation

(i) isobaric process ↴

constant **pressure** process $P_2 = P_1$ (1→2)



(ii) isometric process ↴

constant **volume** process 2→3

(iii) isothermal ↴ (3→1)

cosntant **tempreture** $T_3 = T_1$

(iv) adiabatic process ↴

No **heat** transfer $q = 0$ (isolated sys.)

(v) isentropic ↴ $S_1 = S_2$

Constant **entropy** process. (adiabatic + reversible).

(vi) isenthalpic ↴ $h_1 = h_2$

constant **enthalpy** process

⇒ Continuum / simple compressible substance

fixed chemical composition without holes, uniform material & may exist in more phase.

$$\underset{\text{fluids}}{S.G} = \frac{\rho}{\rho_w}$$

⑥

ALFAJER

Ch.4 properties of pure substance.

* Triple point : The point at which the substance may exist in **three phases** (solid, liquid, gas) at equil.

* Critical point : the point at which there is no further distinction between liquid & gaseous states. Beyond which the substance is called supercritical fluid.

19.6.19

بسم الله

table A-1(a)

* $\boxed{PV = mRT}$ → for Ideal gas.

C_p : specific **heat** at constant P $\Delta h = C_p \Delta T$

C_v . specific heat at constant V. $\Delta U = C_v \Delta T$

$$\Rightarrow K = \frac{C_p}{C_v} , \quad C_p - C_v = R \quad \#$$

T	P
T_1	P_1
T_x	P_x
T_2	P_2

linear interpolation.

$$\frac{T_x - T_1}{T_2 - T_1} = \frac{P_x - P_1}{P_2 - P_1}$$

23.6..19

بسم الله

At $P < P_{initial}$ (compressed table)

$h = h_f @ T$

Real Gas → $P\forall = ZRT$ z: compressibility factor

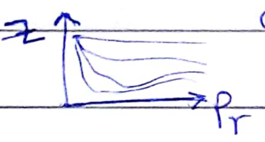


Chart (4-51) بيطلع القيم من

Equation of state $PV = mRT$

$h = C_pT$, $u = C_vT$

$X = \frac{m_g}{m_f + m_g}$ (in kg)

quality factor $(^4$

section $\boxed{4\text{-}8}$ X

⇒ Prob (3rd)

29, 30, 32, 92, 60, 63, 101

⇒ Compressed

الضغط أعلى

⇒ super heated

الحرارة أعلى

Thermal 24.6..19 $y = y_f + x\, y_{fg}$

4-28 10kg of 134a fill a 1.3589 m³ rigid container at an initial temperature -40°C

ⓐ is heated until the R-134 exist as saturated vapor, Find P_2 & T_2?

ⓑ If heated countinued, final pressure is 200kpa, find T_f, Q & W?

Sol :-

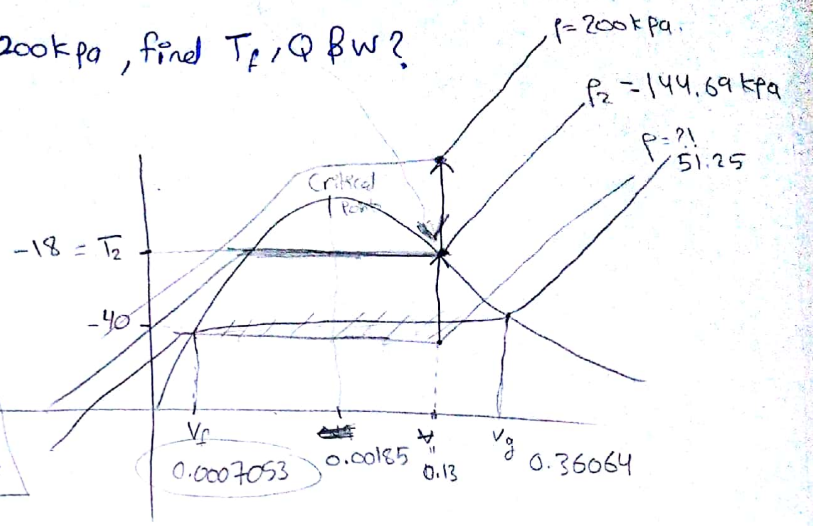
$m = 10\,kg$

$\forall = 1.3589\ m^3$

$\dot{\forall} = 0.13589\ m^3/kg$

$T_1 = -40°C$

We find v_g & v_f at -40 then compare it with our volume & critical volume



ⓐ $$X = \frac{\forall_1 - v_f}{v_g - \forall_f}$$

$$X = \frac{0.13 - \cancel{0.36}\ 0.00070}{0.36 - 0.0007} \approx \boxed{0.34}$$

$$\forall_{cr} = \frac{0.19\ m^3/kmol}{102.3\ kg/kmol} = \boxed{0.00186}$$

** $\forall_1 = \forall_g$

rigid body means constant volume

So $\forall_1$ to all system ⇐

$U_1 = U_f + X U_{fg}$.

$U_1 = -0.036 + 0.34(207.4)$.

ⓑ go to super heated table $\boxed{A-13}$

where P = 0.2 MPa & $\forall$ = 0.13589 will find the T.

make inter polation

T	$\forall$	u
60	0.13206	279.38
T_2	0.13589	X
70	0.13641	~~[illegible]~~ 287.75

$$\frac{T_2 - 60}{70 - 60} = \frac{0.135 - 0.132}{0.136 - 0.132}$$

$$\frac{0.1358 - 0.132}{0.1364 - 0.1320} = \frac{X - 279.38}{287.7 - 279.3}$$

$T_2 = \boxed{68.8}$ // $U_2 = \boxed{286.73}$

$Q = \cancel{W} + U(m)$

$= 10(U_3 - U_1)$

$= 10(286.7 - 77.69)$

$= 2090.4$

$\Delta E = Q - W = \Delta U + \cancel{\Delta k} + \cancel{\Delta P}$

$= 0$ closed system.

$\boxed{4\text{-}39}$ 25.6..19 بسم الله

water $P_1 = 200$ kPa, $T_1 = 300°C$ is contained in a piston-cylinder device fitted with stops, water is allowed to cool until the piston rests on stops (lower) where it exist as saturated steam. If cooling continuous until final pressure (P_3) reaches 100 kPa, T_2, P_2, T_3, ΔU, W, Q??, $q = \frac{Q}{m}$ على mass

T-$\forall$ & P-V diagrams!

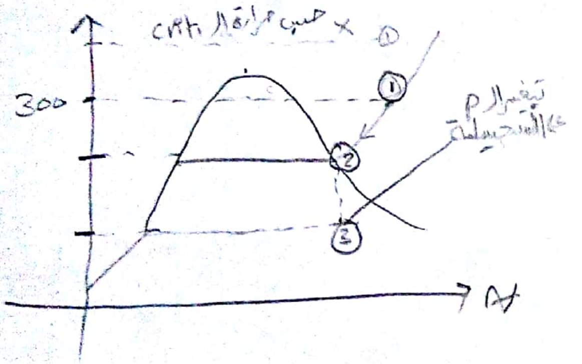
سؤال امتحان

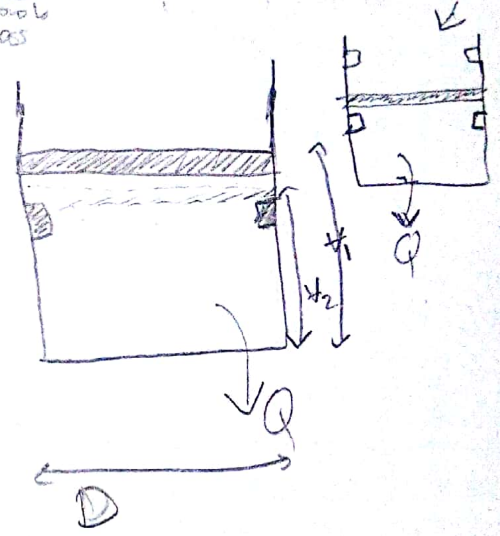
أحياناً بكون عندي two stops يعني 3 مراحل
cons. V
cons. P
cons. V

constant pressure then constant volume

لأنه [illegible] حتكون سالبة

Sol:





State 1

super heated. $P_1 = 200$ kPa, $T_1 = 300°C$

super heated $\forall_1 = 1.31623\ m^3/kg$ $u_1 = 2808.8$ kJ/kg

(1→2)
State 2 (cooling process) isobaric cooling process.

saturated vapor $\forall_2 = 0.8857\ m^3/kg$, $u_2 = u_g = 2529.1$ kJ/kg

(2→3)
State 3 (isometric cooling process); constant volume

Saturated mix $\forall_3 = \forall_2$

$T_3 = 99.61°C$ $\cancel{\forall_g}$

$x = \frac{\forall_2 - \forall_f}{} = \frac{0.88 - 0.00104}{} = 0.5236$ ①

$u_3 = u_{f_3} + x_3 u_{fg_3}$

$= 417.4 + 0.52(208$

$= 1508.6$ kJ/kg.

$W_{13} = \int_1^3 P\,dV = \int_1^2 P\,dV + \int_2^3 P$

constant volume = 0

$= P_1(V_2 - V_1)$

$= 200(0.88 - 1.316)$

$= -86.09$ kJ/kg.

(work done on a system

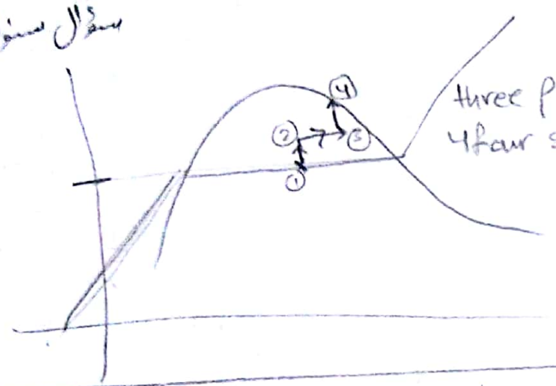
$${}_1q_3 - {}_1W_3 = \Delta e_3 = \Delta u + \cancel{\Delta P} + \cancel{\Delta K}$$

$$q_{13} = -86.09 + (158.6 - 2808.2)$$

$$= -1386.\ \text{kJ/kg}$$

heat transfer from system. #

سؤال سنوات



three processes
4four states..

iso thermal. ↓

Ch.5 Energy Analysis of closed system.

$$\Rightarrow \Delta E = Q - W \quad ; \quad W = W_b + W_{other}$$

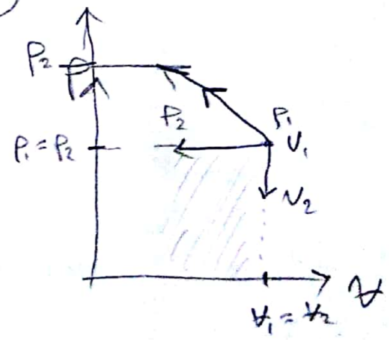
$W_b \rightarrow$ ① isometric , ${}_1W_2 = \int P\,dV = 0$

$V_2 = V_1$

② isobaric $\rightarrow W_{12} = \int P\,dV = P_1 (V_2 - V_1)$

$P_2 = P_1$

and these.



For Ideal gas.

③ isothermal, $PV = P_1 V_1 = P V_2 = R T_1 = C$

$T_2 = T_1$

$$P = \frac{C}{V} \rightarrow {}_1W_{2T} = \int_{V_1}^{V_2} \frac{C}{V}\,dV$$

$$= C \ln V \Big]_{V_1}^{V_2}$$

$$= P_1 V_1 \ln \frac{V_2}{V_1} = R_x T_1 \ln \frac{P_1}{P_2} \quad \ldots (5\text{-}10)$$

11

26.6.19 بسم الله

just for Ideal gases

(iii) isobaric ; $T_1 = T_2$; $P_1\forall_1 = P_2\forall_2 = c = RT$

$$ {}_1W_2 = \int_{\forall_1}^{\forall_2} \frac{c}{\forall}\, d\forall = P\forall \ln\frac{V_2}{\forall_1} = RT_1 \ln\frac{P_1}{P_2} $$

(iv) adiabatic & reversible (isentropic) $s_1 = s_2$, $q = 0$

$P\forall = RT$; $\boxed{P\forall^k = c} = P_1\forall^k = P_2\forall_2^k$

$\boxed{P = \forall^{-k} c}$

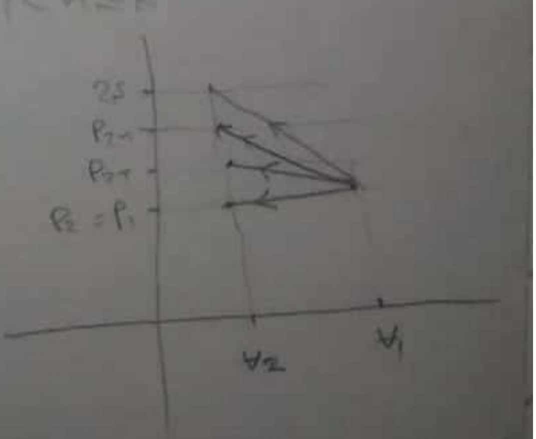
$$ {}_1W_2 = c\int_{\forall_1}^{\forall_2} \forall^{-k}\, d\forall = c\left[\frac{\forall^{-k+1}}{-k+1}\right]_{\forall_1}^{\forall_2} = \frac{c}{1-k}\left[P_2\forall_2^k\forall_2^{1-k} - P_1\forall_1^k\forall_1^{1-k}\right] $$

$$ = \frac{P_2\forall_2 - P_1\forall_1}{1-k} = \frac{R(T_2 - T_1)}{1-k} $$

(v) polytropic $\boxed{P\forall^n = Const.}$ more realistic process

$1 < n \le k$

$$ {}_1W_2 = \frac{P_2\forall_2 - P_1\forall_1}{1-n} = \frac{R}{1-n}(T_2 - T_1) $$



Prob.

5.32

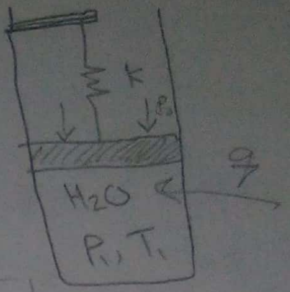
$H_2O, P_1 = 200\,kPa, T_1 = 200°C, V = 0.4\,m^3$

then ~~$P_2 = 250\,kPa$~~ ; ~~$V_2 = 0.6\,m^3$~~ 0.6108 m^3

شيلها 300 kpa

انتبه! total مو

specific = 0.6



الضغط الداخلي

$$\boxed{P_1 = P_0 + \frac{m_p g}{A}}$$

الضغط الخارجي

P_{atm}

$$m = \frac{V_1}{v_2} = \frac{0.4\,m^3}{1.08049\,m^3/kg} = 0.3702\,kg$$

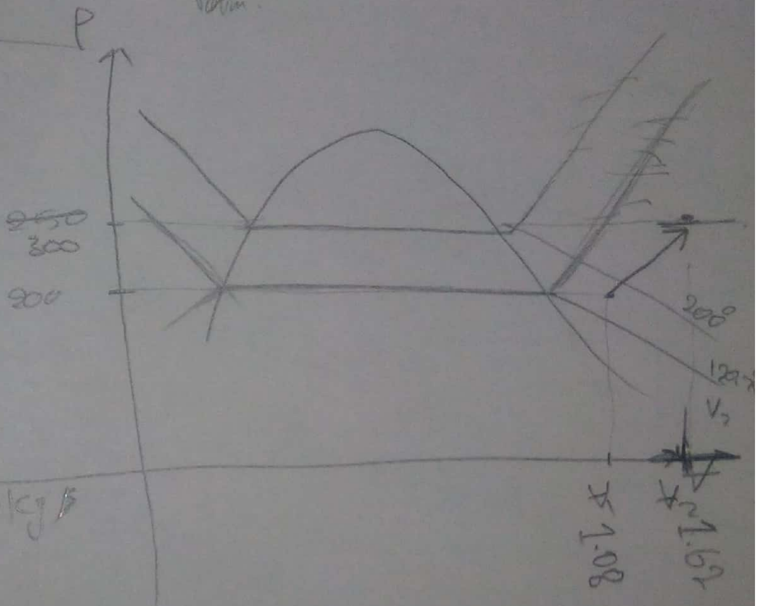
$u_1 = 2654.6\,kJ/kg$

$$v_2 = \frac{V_2}{m} = \frac{0.6}{0.3702} = 1.62075\,m^3/kg$$

$W = W_b + W_{sp}$

$$= \frac{P_1 + P_2}{2}(V_2 - V_1)$$

$$\left(\frac{200+300}{2}\right)(0.6108 - 0.4) = 50\,kJ$$



$T_2 \simeq 800°$

$u_2 = 3664.3\,kJ/kg.$

$Q - W = \Delta U + \cancel{\Delta K} + \cancel{\Delta P}$

$Q - 50 = (0.61)(3664.3 - 2654).$

$\frac{V}{v_{spec}} = 0.37$

13

④

30.6..19 بسم الله

Quiz

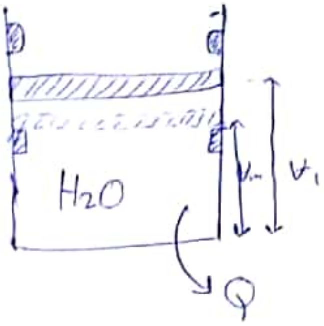
Prob (5-4) 5th edition (with doctor edit)

Piston-cylinder with two stops

$P_1 = 1000\ kPa$ $T_1 = 400°$ → Super heated steam

$\forall_{stop} = 0.4\ \forall_1$ $P_f = 500\ kPa$

$m = 0.5\ kg$ | T_f? Q? W?



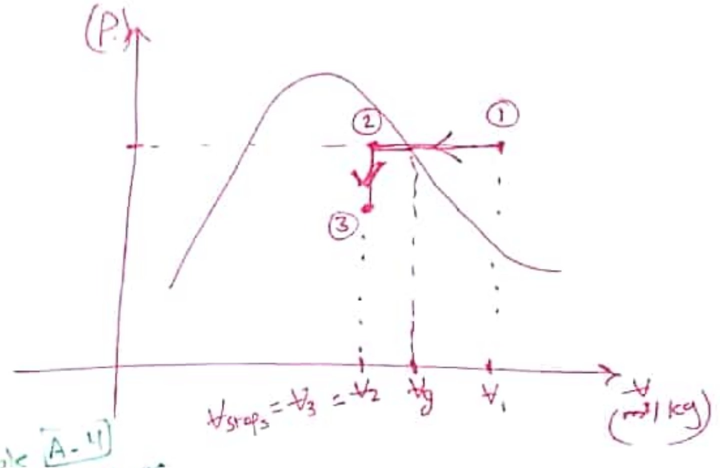
Solution:

from A-6

$\forall_1 = 0.30661\ m^3/kg$

$u_1 = 2957.9\ kJ/kg$

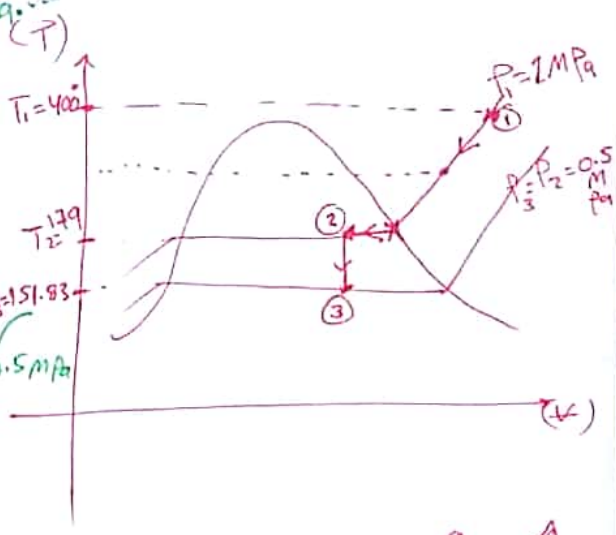
$\forall_3 = \forall_{stops} = 0.4\ \forall_1 \rightarrow 0.12264\ m^3/kg = \forall_2$



$P_2 = P_1 = 1000\ kPa$, $T_1 = 400°$

$\forall_1 = \forall_{stops}$ $\forall_g$ at ~~st~~ 1000 kPa in table A-4 we find $T_2 = 179....$

$P_f = 500\ kPa$, $\boxed{\forall_{g_2} = 0.193436\ m^3/kg}$



Tsat @ P=0.5MPa

$u_3 = ?$

$$X_3 = \frac{\forall_3 - \forall_{f_3}}{\forall_{g_3} - \forall_{f_3}} = \frac{0.12264 - 0.001093}{0.3748 - 0.001093}$$

$\boxed{X = 0.334}$

$u_3 = u_{3f} + X_3 u_{fg}$

$639.54 + 0.334 * 1921.2 = 1275.45\ kJ/kg$

$Q - W = m\Delta u + \cancel{\Delta K} + \cancel{\Delta P.E}$

$W = 1000(0.122644 - 0.30661)$

$\boxed{W = -183.86\ kJ/kg}$ $\Delta u = 1275.45$

#

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1.7..19

بسم الله

$\boxed{\text{insulated } q=0}$

$\boxed{5.31}$

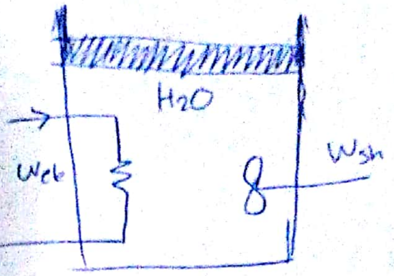
$V_1 = 5L = 0.005 m^3$

$q=0$, $\boxed{\text{State ① : sat liq}}$

$P_1 = 175$ kPa , $x_1 = 0$

$v_1 = v_f = 0.00105\cancel{7}$ m³/kg

$u_1 = u_f = 486.82$ kJ/kg



$\boxed{\text{State②}}$ Mixture

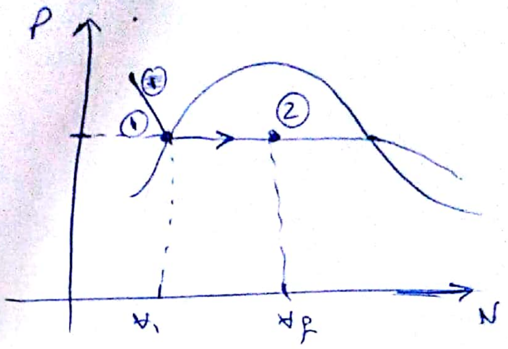
$x_2 = 50 = 0.5$

$T_2 = T_1 = 116.04°$

$P_2 = P_1 = 175$ kPa

$v_2 = (1-x_2)v_f + x_2 v_g = 0.5023$ m³/kg

$u_2 = u_f + 0.5u_{fg} = 1505.7$ kJ/kg.



$$\cancel{q} - w = \Delta u + \cancel{\Delta k} + \cancel{\Delta p}$$

$$\boxed{\Delta u = -w}$$

$w = w_b + w_{other}$ $= P(v_2 - v_1)$

$w_b = P_1(\cancel{v}_2 - v_1)$

$= 175(0.5023 - 0.001)$

$= 87.7$ kJ/kg

$\Delta u = -[w_b + w_{sh} + w_{ele}]$

قسمنا على m
عشان نا كلهم
kJ/kg

Done on system

$1505.7 - 486.82 = -[\cdot 87.71 - \frac{400}{m} + \cancel{IV\Delta t} W_{ele}]$

$$-1018.8 = 87.71 - \frac{400}{4.7} - \frac{(8)(V)(45)(60)}{(1000)(4.73)}$$

$W_{ele} = IV\Delta t$ [J] ×60 [s]

÷1000 [kJ]

مم انتبه التحويلات!

÷mass [kJ/kg]

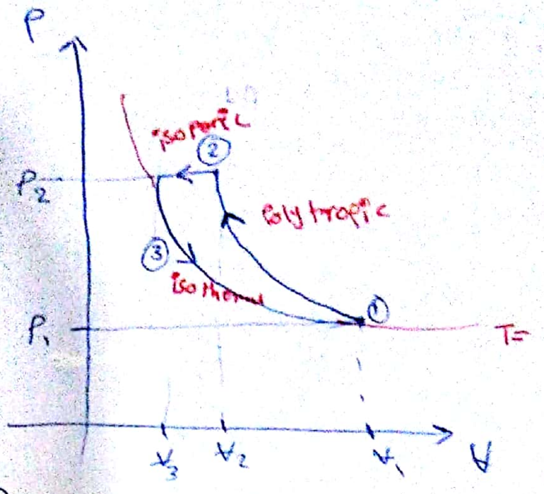
$$\boxed{m = \frac{V_1}{v} = \frac{0.005}{0.001057} = 4.73 kg}$$

$$\frac{360 \times 60\,V}{4730} = 1018.8 + 87.71 - \frac{400}{4.73}$$

$$\boxed{V \cong 224 V}$$

\#

5-21   2.7.19   بسم الله



1 → 2 Poly tropic

الضغط عالي جدا عليه
constant pressure

2 → 3 iso baric / (isometric → isentropic)

3 → 1 iso thermal

$r = \frac{V_1}{V_2} = 8$ $n = 1.2$ $P_1 = 100\,kPa$

$T_1 = 25°$

$m = 1\,kg$ $N_2(g)$

P_2 ? T_2 ? P_3 ? T_3 ?

Soluation

ideal gas

$R = 0.2968$ from A-1

Warning! in kelfin

$PV = mRT$

$(100\,kPa)(V_1) = 0.2968(25+273)$

$\boxed{V_1 = 0.8845\,kg}$

$V_2 = \frac{V_1}{8} = 0.1106\,kg$

$P_1 V_1^n = C \rightarrow (100)(0.884)^{1.2} = 86.305$

$C = P_2 V_2^n$

$86.305 = P_2 (0.1106)^{1.2}$

$\boxed{P_2 = 1212.07\,kPa}$

$P_3 = P_2 = 1212.07$

$P_2 V_2 = mRT_2$

$(1212.07)(0.1106) = (0.2968)\ T_2$

$\boxed{T_2 = 451.67\,K}$

178.67°

$P_3 = P_2 = 1212.07\,kPa$

$P_1 V_1 = P_3 V_3 \rightarrow (100)(0.884) = (1212.07) V_3$

$V_3 = 0.073\ m^3/kg$

another way ↓   1 → 2

$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^n = 8^{1.2} = 12.12 \rightarrow P_2 = 1212\,kPa$

$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)\left(\frac{V_2}{V_1}\right) = \left(\frac{V_1}{V_2}\right)^n \left(\frac{V_2}{V_1}\right) = r^n \left(\frac{V_1}{V_2}\right)^{-1} = r^{n-1}$

$\left(\frac{V_1}{V_2}\right)^{n-1} = 1.515$

$T_2 = (298.15) * (1.515) = 451.6\,K = 178°$

تابع →

work

سالب ← لأنه (الحجم) قل!

$W = {}_1W_2 + {}_2W_3 + {}_3W_1$ isobaric isothermal

polytropic

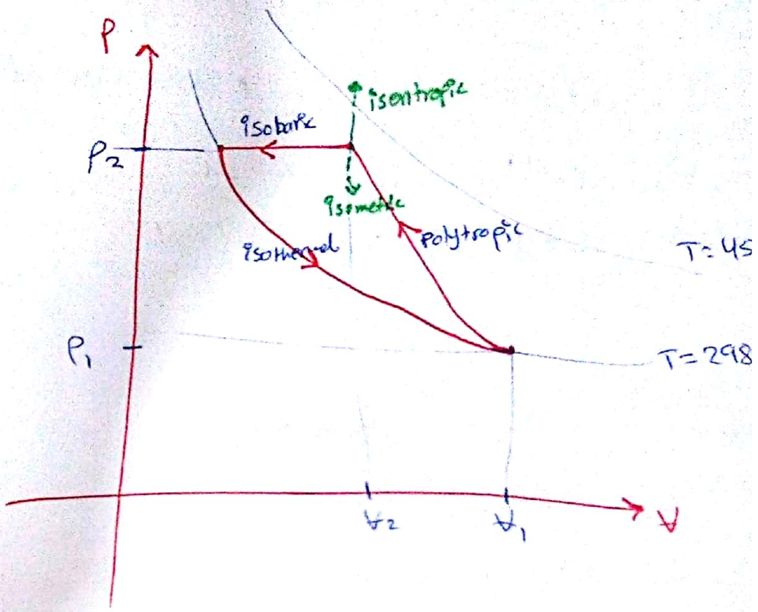
$$= \frac{R(T_2-T_1)}{1-n} + P_2(V_3-V_2) + RT \ln \frac{V_1}{V_3}$$

OR $R(T_3-T_2)$

$$q - W_1 = \underset{Cv(T_2-T_1)}{\Delta U} + \cancel{\Delta K} + \cancel{\Delta P} = 0$$

ii) cycle دورة

$$\boxed{q = W}$$



3.7..19

بسم الله

حب الله ♡

closed system

$$\Delta E = \Delta U + \cancel{\Delta K}^{\text{zero}} + \cancel{\Delta P.E}^{\text{zero}}$$

$$\boxed{Q - W = \Delta U}$$

refeed

Ideal gas \boxed{from doctor}

Process	Q(kJ)	W(kJ)	ΔU(kJ)	process type
1 → 2	−50	−50	0	$T_1 = T_2$ isothermal
2 → 3	+70	(70−70) 0	+70	isometric $\forall_2 = \forall_3$
3 → 1	0	+70	−70	adiabatic Q=0
cycle 1→2→3→1	+20 (70−50)	+20 (70−50)	0	▨

No heat transfer

ΔU يساوي صفر

لأنه cycle = 0 (closed!)

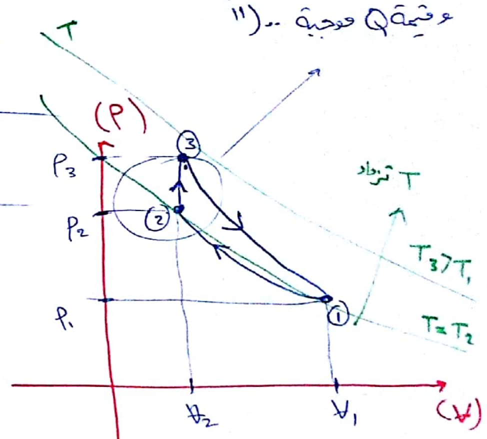
T=45

T=298

→ ∀

طلعنا لفوق لأنه ازدادت الحرارة

وقيمة Q موجبة .. ")



work = (−)

So work done on system

(compression)

\boxed{4.84} 5th edition.

\boxed{CO_2(g)}

Ideal gas @ $P_1\forall_1 = RT_1$

$$P_1\forall_1 = \dot{m}RT_1 \rightarrow \forall_1 = \frac{2 * 0.1889 * 500}{3000}$$

$$\forall_1 = 0.063\ m^3/s = 63\ liter/s$$

$$\forall_2 = \dot{m}RT_2$$

$$= \frac{2 * 0.1889(450)}{3000} = 56.7\ lit/s$$

Z (from chart) = 0.97

18

متى بروح لا (chart) ؟

لو ما تحققت الشروط التالية:

$P_{cr} > 0.1$

$T_{cr} > 2$

وأنا معي

$P_{cr} = 7.39$ ✓

$T_{cr} = 304.2K$ ✓

Done

Scanned by CamScanner

9.7..19 بسم الله

Ch.6

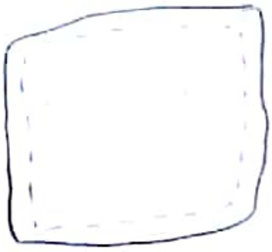
First law: Energy analysis of control volumes / open systems)

(i) conservative of mass: $m_1 + \sum m_{(in)} - \sum m_{(ex)} = m_2$

OR

$$\left.\frac{dM}{dt}\right|_{sys} = \sum m_{in} - \sum m_{ex}$$

مثل
- المضخة
- جرة الغاز
-



$h = u + P\forall$

$P\forall = \frac{P}{\rho}$ (flow work)

$\boxed{M_{system}}$

(ii) conservation of energy: $\boxed{\theta = h + \frac{V^2}{2} + gz}$

$$\Delta E = Q - W = m_2\left(u_2 + \frac{V_2^2}{2} + g z_2\right) - m\left(u + \frac{V_1^2}{2} + g z_1\right) + \sum m_{ex}\left(h_j + \frac{V_j^2}{2} + g z_j\right) - \sum m_{in}\left(h_i + \frac{V_i^2}{2} + g z_j\right)$$

(SSSF)

Steady flow devices:

(pump, turbine, expansion valve, ...

$\sum \dot m_{in} = \sum m_{ex}$ ...(1)

single input - single output = $\dot m_{in} = \dot m_{e} = \dot m$

$$\Delta E = \dot Q_{net} - \dot W_{net} = \dot m(\Delta h + \Delta K.E + \Delta P.E).$$

17 19

$V = \sqrt{2gh}$

ex.6-2

سرعة المي الطالعة من خزان
تتناسب مع حجم المي اللي جواه
كل م قل طول المي بتقل سرعته

ex. 6-3

لما بعملية التبخر بستخدم v_f
لما عند المخرج بستخدم v_g لانه صار gas.

ليه بنقسم ع 1000 ال $k + \Delta PE$ عشان نحول الوحدة
بتكون قيمهم صغيرة وبنهملهم .

$$\dot{m} = \rho A \bar{V} = \frac{A_{ex} \bar{V}_{ex}}{v_g}$$

θ: total energy of a flowing fluid

$$\theta = h + \frac{V^2}{2000} + \frac{gz}{1000}$$

بسم الله

هل لك سرٌ عند الله..!

10.7..19

ex.6-3

Find ⓐ flow energy in kw ⓑ $Q=?$

ⓐ $173.9 \text{ kg/kg} * 2.37\times10^{-4} \text{ kg/s} = -0.041 \text{ kw}$

ⓑ $Q - \overset{0}{\cancel{W}} = \dot{m}\,\Delta\theta = \dot{m}(\Delta h + \overset{0}{\cancel{\Delta k}} + \overset{0}{\cancel{\Delta p}})$

work مافي
rigid body

$$\boxed{\dot{Q} = \dot{m}\, h_{fg}}$$

$$\frac{q}{r} = h_{fg} = 2226 \text{ kg/kg}$$

ex.6-5

حله كامل + ما تنسى اشارة السالب

بال $\frac{q}{r}$ ، عشان يعني!

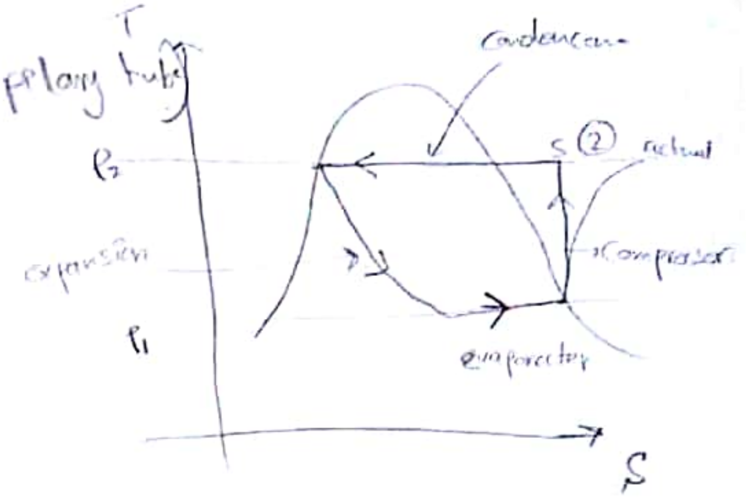
14.7..19

بسم الله

Throttle or expansion valve (capilary tube)

isenthalpic process, $h_2 = h_1$

$P_2 < P_1$ & $T_2 < T_1$



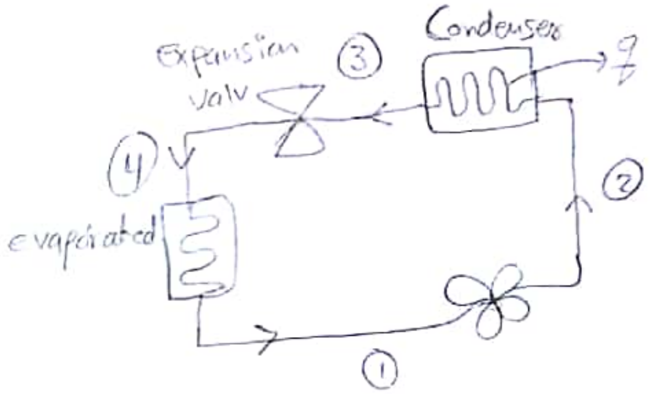
مع حل

$\boxed{ex.6\text{-}8}$

$\cancel{q} - \cancel{W} = \Delta h + \cancel{\Delta k} + \cancel{\Delta P}$

$\Delta h = 0$

$\boxed{h_2 = h_1}$



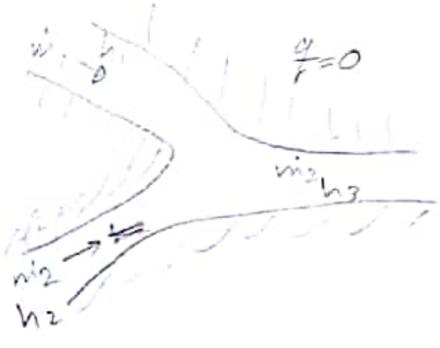
refrigerator cycle.

Mixing chambre

=) زي حنفية المي

$\boxed{ex.6\text{-}9}$

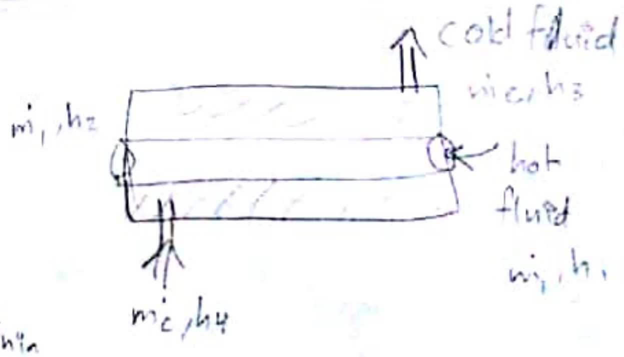
مع حل



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

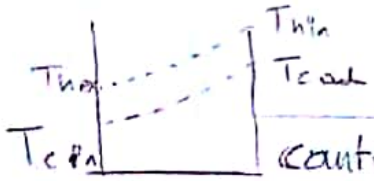
$\dot{m}_1 h_1 + \dot{m}_2 h_2 = (\dot{m}_1 + \dot{m}_2)(h_3)$

Heat exchanger



$-\dot{m}_h(h_2 - h_1) = \dot{m}_c(h_4 - h_3)$

Parallel flow



counter flow.

15.7..19

بسم الله

Turbine

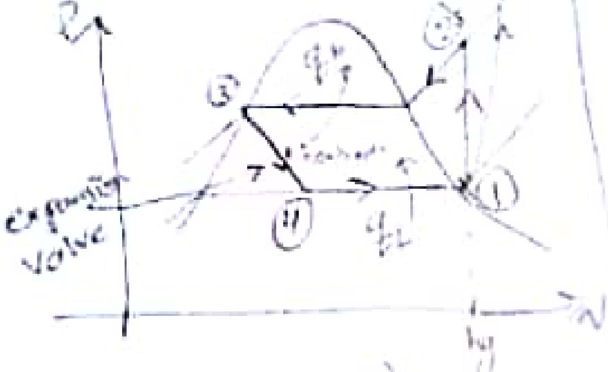
work producing device

$$q - w = \Delta h + \Delta K.E + \Delta P.E$$

velocity.

$$-W_{out} = \dot{m}(h_{out} - h_{in}) + \frac{1}{2}(\bar{V}_2^2 - \bar{V}_1^2)$$

Compressor



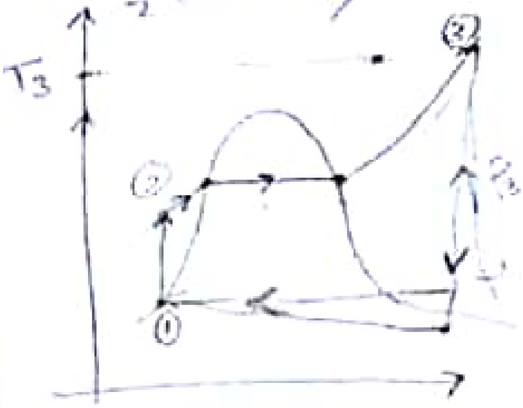
H.P)ice

Heat pump or cooling

$\boxed{h_2 = w + h_1}$

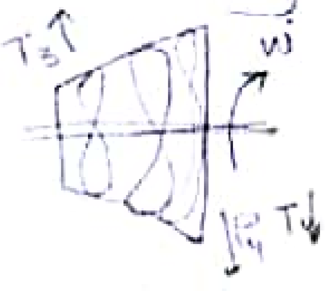
$\cancel{q} - w = \Delta h + \cancel{\Delta K} + \cancel{\Delta P}$

$\boxed{w = h_2 - h_1}$

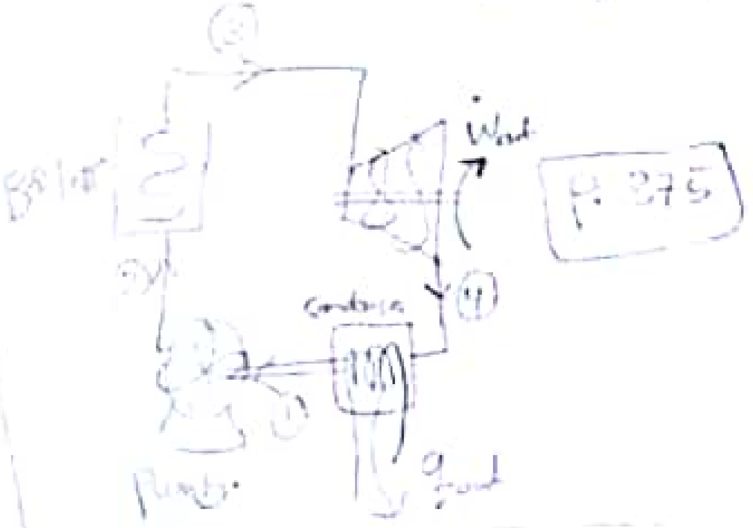


T_2, P_2

for cycle



rotor, blades



P. 375

ال pump عكس ال compressor

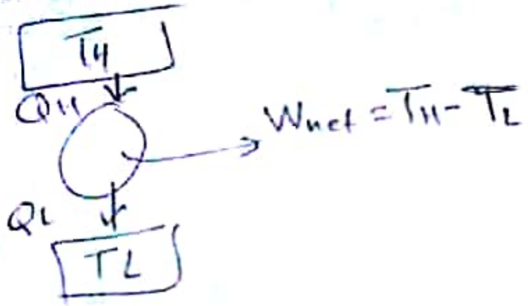
gas مع

liq مع

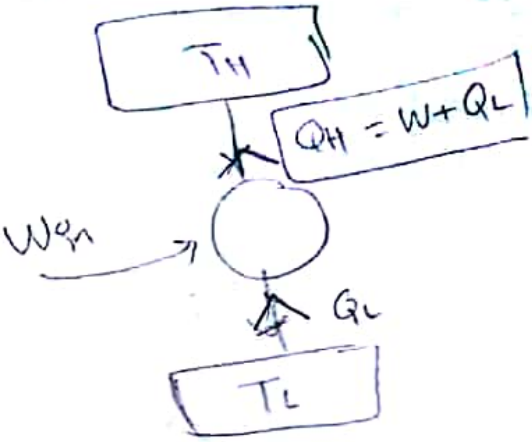
23

①

Ch.7



kelvin- Planck Statement



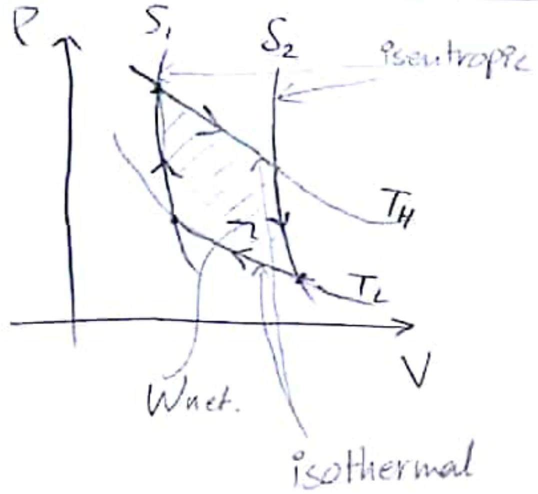
Heat-pumb
Clausius statmat

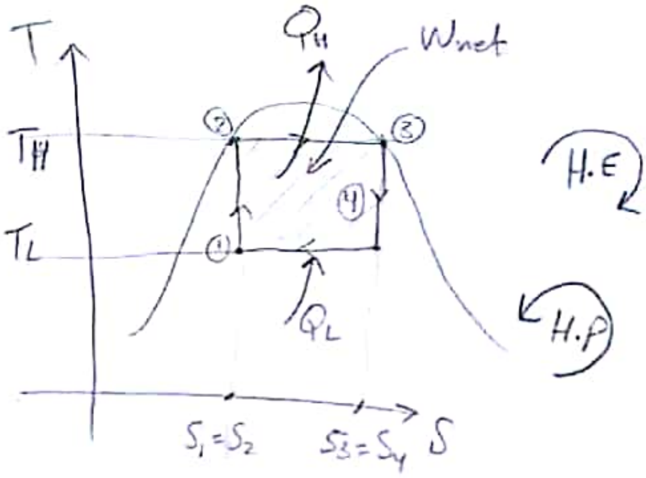
16.7..19

الثلاثاء

Carnot cycle.

for ideal gas





$$\eta_{max} = \eta_{Carnot} = \frac{Q_H - Q_L}{Q_H} = 1 - \frac{Q_L}{Q_H} = 1 - \frac{T_L}{T_H} \quad \text{(reversable)}$$

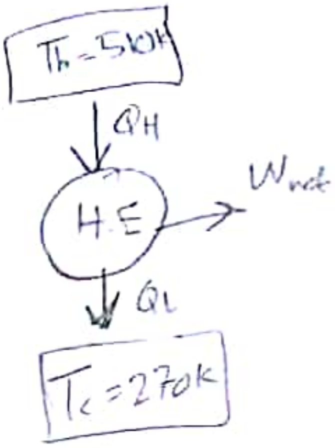
لو أقل من [illegible] irreversible

لو أكبر impossible

17.7..19

QW1 Quiz

$\boxed{7.72}$



$$Q_H = W_{net} + Q_L$$

$$= 4.1 + 15{,}000 \frac{kJ}{hr} \times \frac{1\,hr}{3600\,S}$$

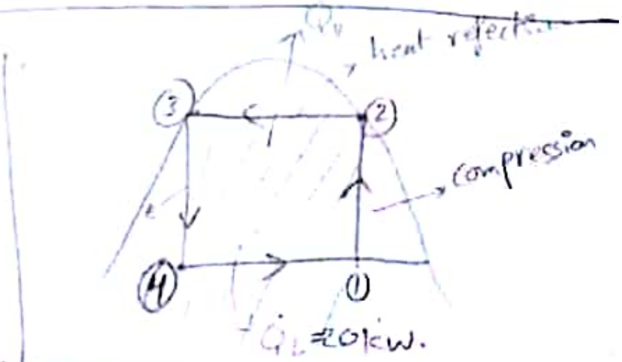
$$= 4.1 + 4.167 = 8.267\ kW$$

$$\eta_{max} = 1 - \frac{T_L}{T_H} = 1 - \frac{270}{510} = 47.059\,\%$$

$$\eta_{th} = \frac{W}{Q_H} = \frac{4.1}{8.26} = 49.63\,\% \quad \text{Not valid}$$

$$\eta_{max} = \eta_{Carnot} = \frac{W_{net}}{Q_H} = \frac{Q_H - Q_L}{Q_H} = 1 - \frac{Q_L}{Q_H} = 1 - \frac{T_L}{T_H}$$

$$\eta_{th} < \eta_{max}; \quad \eta_{th} = \frac{W_{net}}{Q_H}$$



$\boxed{7.114}$ problem.

$$W_{net} = (T_H - T_L)(S_{fg}) * \dot{m}$$

$$5 = (1.2T_L - T_L)(0.22)\,S_{fg} = T_L S_{fg}(0.2)(0.22)$$

$$T_L = \frac{5}{(0.044)S_{fg}}$$

$\boxed{350K}$

①

$\boxed{26}$

open sys.

$${}_3Q_2 - W_3 = \Delta h + \cancel{\Delta k} + \cancel{\Delta P}$$

$$\dot{Q}_H - \cancel{\dot{W}_{23}} = -h_{fg}\,\dot{m} = \frac{25}{0.22} = 113.6\ kJ/kg$$

$$\dot{Q}_H = \dot{W}_{net} + 0.2 = 5\,kW$$

$$\dot{Q}_H = 25\,kW$$

$$Q_{H_1} = ? = COP)_{HP} = \frac{\dot{Q}_H}{\dot{W}_{in}}$$

$$\left(\frac{T_H}{T_L} - 1\right)$$

Scanned by CamScanner

21.7.19   بسم الله

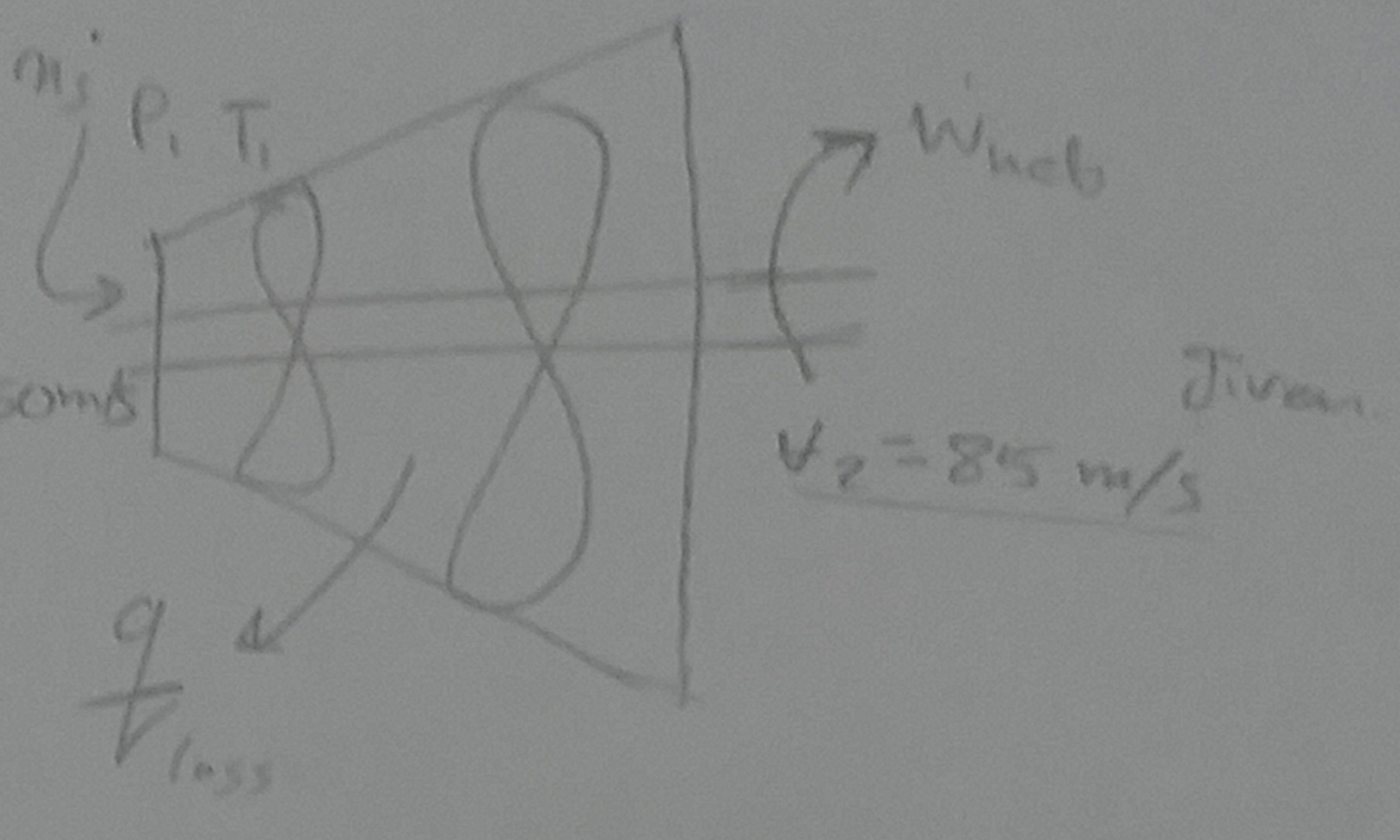
دولة الشيماء ♡

$\boxed{6.39}$ Steam (from tables) $\dot{m}_s = \frac{20{,}000\,kg}{hr} \cdot \frac{1\,hr}{3600\,s} = 5.56\,kg/s$

$\boxed{A\text{-}6}$ $P_1 = 7\,MPa$, $T_1 = 500^{\circ}$

$h_1 = 3411.4\ kJ/kg$

$v_1 = 0.048157\ m^3/kg$



$P_2 = 40\,kPa$ $x_2 = 1$

$h_2 = h_{g_2} = 2636.1\ kJ/kg$

$v_2 = v_{g_2} = 3.9933\ m^3/kg$

$\dot{Q} - \dot{W} = \dot{m}_s(\Delta h + \cancel{ke} + \cancel{\Delta p})$

$= (5.56)(2636.1 - \overset{3411}{\cancel{4000}})$ ✓ غلط

ملحوظ

$\cancel{V_2}$

$\cancel{V_2}$

adiabatic $q = 0$

$w = \Delta h$.

V<100

velocity

ملحوظ

$Q = 4000 - 4309$

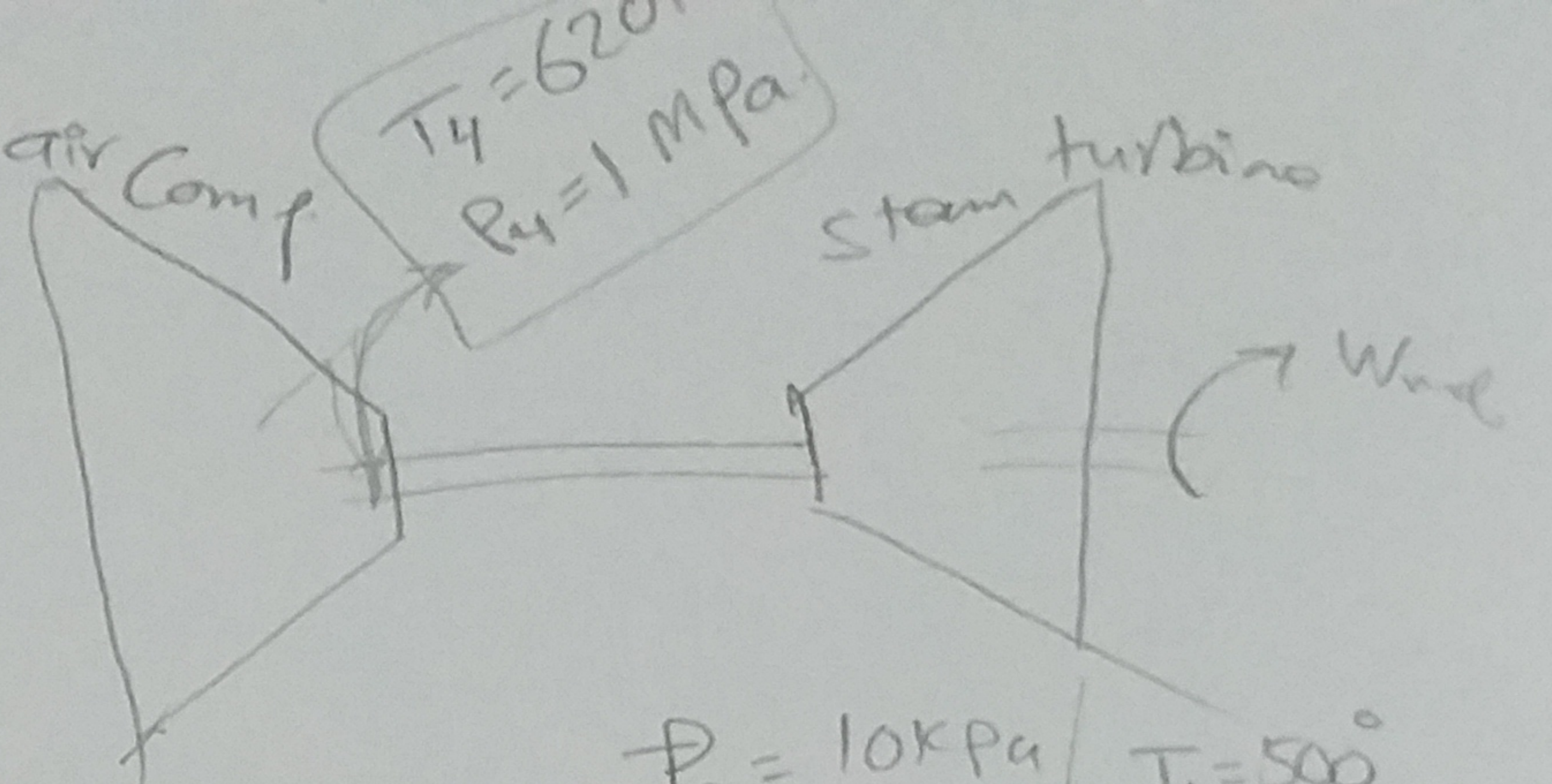
$= -309\ kW$

$\dot{m} = \rho_1 A_1 \vec{V}_1 = \frac{\vec{A}_1 \vec{V}}{v}$ → $A_1 = \frac{\dot{m} v}{V} = \frac{5.56 \cdot 0.048}{50} = 48\,cm^2$

عمودي

$A_2 = \frac{5.56 \cdot 3.9933}{85} = 2600\,cm^2$

6-145



$W_{net} = \dot{m}_s w_s - \dot{m}_a w_a$

$\dot{m}_s = 25$ kg/s

$\dot{m}_a = 10$ kg/s

$P_2 = 10$ kPa

$h_2 = 2392.5$ kJ/kg

$x_2 = 0.92$

$T_1 = 500°$

$P_1 = 12.5$ MPa

$h_1 = 3343.6$ kJ/kg

$\left(\frac{T_4}{T_3}\right) = \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}}$

a: Air S: Steam.

Comp

$$\cancel{\dot{Q}} - \dot{W} = \dot{m}_a \overset{\Delta h.}{\left(C_p (T_4 - T_3)\right)}$$

$$-\dot{W} = 10.05\,(620 - 295) = 3.25 \text{ kW}$$

Tur [illegible]

$$\cancel{\dot{Q}} - \dot{W} = \dot{m}_s(h_2 - h_1) = 25\,(2392.5 - 3343.6) = 23 \text{ MW}$$

$$W_{net} = 23 \text{ MW} - 3.25 \text{ kW}$$

CP Δh

If $\dot{W}_{net} = 0$ $\dot{m}_a (1.005)(620 - 295) = \dot{m}_s (h_2 - h_1)$

7.95 $H.P_{max}$; $\frac{q}{t} = \frac{55000 \text{ kJ}}{3600} = 15.27$ kW

$W_{in} = 4.8$ kW

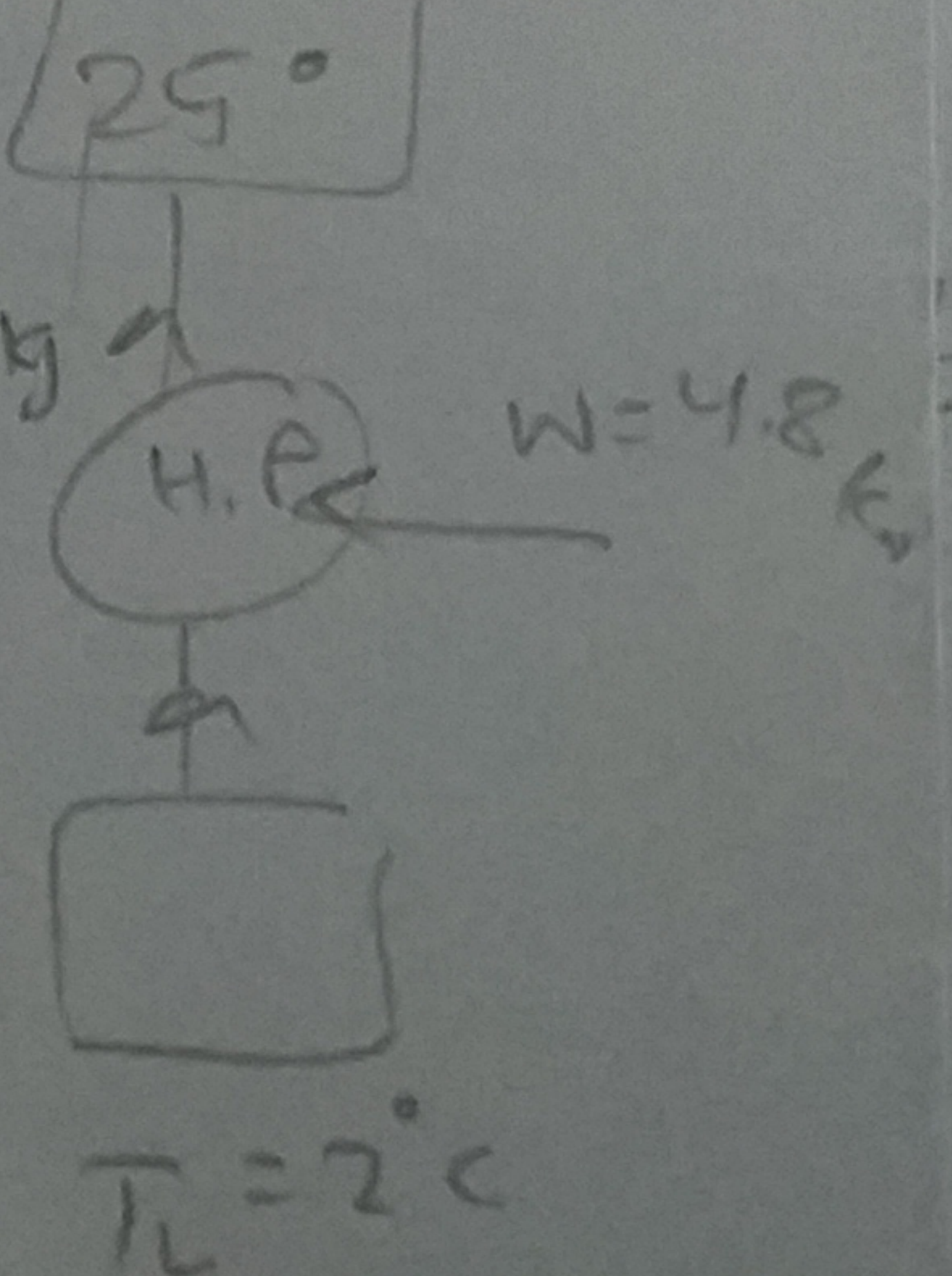
$Q = 1320000$ kJ

$$\frac{Q_H}{W} = COP = \frac{1}{1 - \frac{T_L}{T_H}} = 12.9$$

$$\frac{1320000}{12.9} = W = 102325.5 \text{ kJ}$$

$$\boxed{W = Pt}$$

$$t = \frac{102325.5}{4.8 * 3600} = 5.9 \text{ H}$$



$$\frac{4.8 * 5.9 * 11}{100} = 3.11 \$$$

$$15.27 * 24 * 11 = 40.31 \$$$

24-7-19

بسم الله

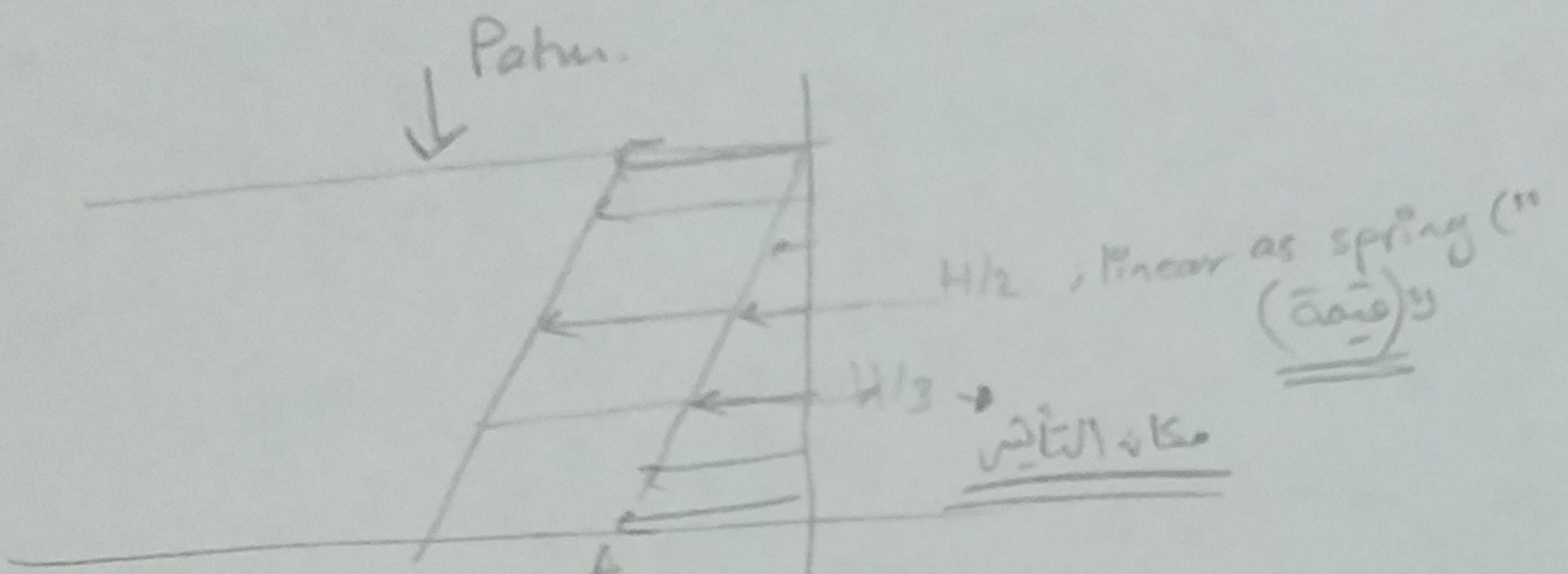
Fluids Mechanics / statics , fluid flow

↓
Dams
سدود

Ch.2 }
Ch.3 } mamiometers

Center of pressure , moment of force ?

Fluids: liquids or gases , it can't resist shear stress



$P_A = P_{atm} + \rho_f g h$

$\longleftarrow$

قيمة $\boxed{\bar{P} = P_{atm} + \rho g H/2}$

$F_p = \bar{P}A = [P_{atm} + \rho g H/2]A$

$A = L \times H \quad 1\,m^2$

$h_{c.p}$ point of action is slightly lower than $\bar{h}$, OR $\bar{y}$

$\circlearrowleft + \quad \Sigma M = 0 \quad \text{--- (1)}$

fluid flow

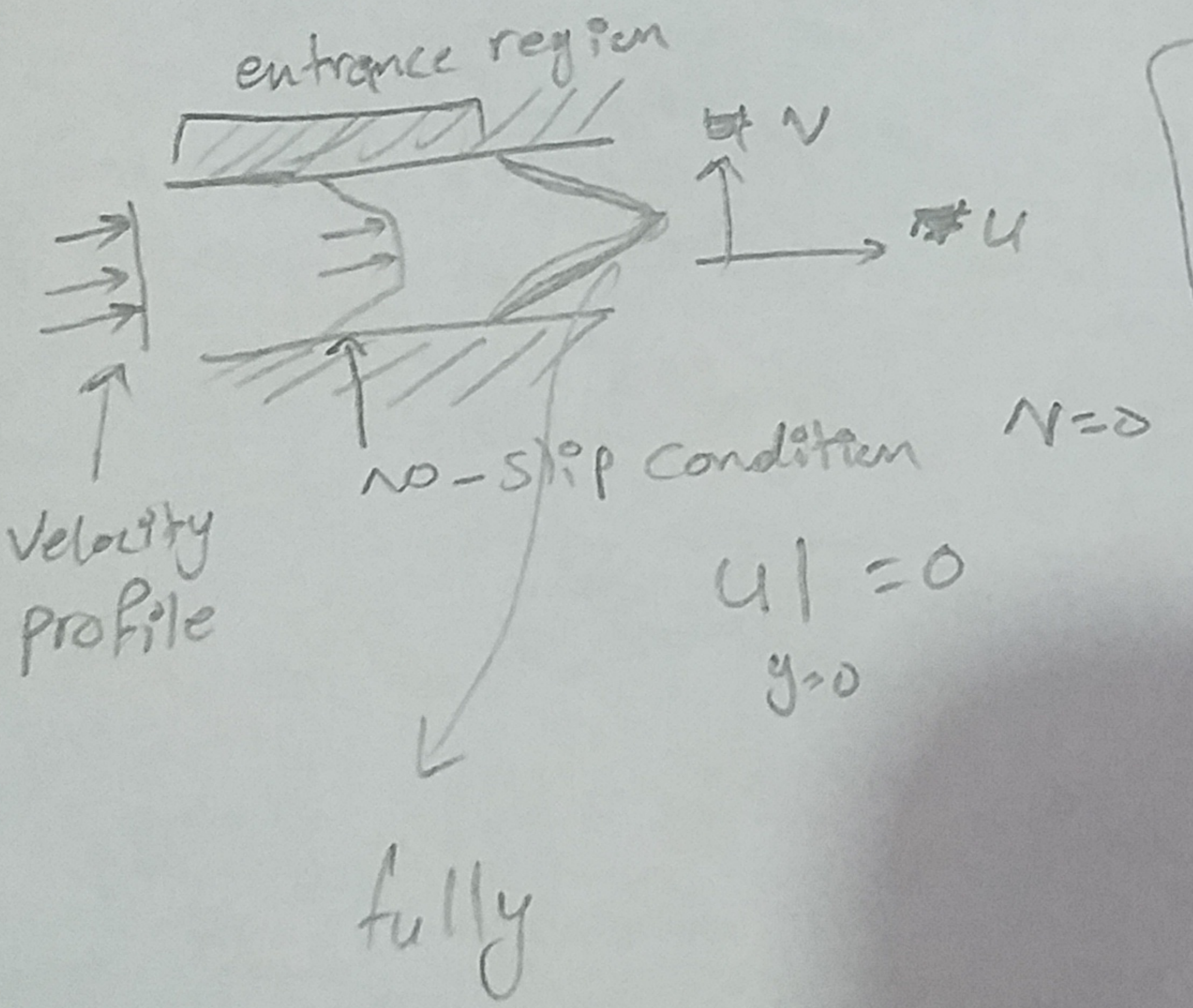
continuity

Bernoulli eq
↓
modified Bernoulli
↓
energy eq

momentum eq

Read Ch 10

① internal & external flow
② Compressible & in
③ rotational & irro
④ Viscous & inviscid flow
⑤ Newtonian & Non-Newtonaion fluid
⑥ laminar & turbelent flow.



$V=0$

$u|_{y=0}=0$

internal flow

math قوة

$\vec{\nabla}\times\vec{V}=0\Rightarrow$ irrotational

$\vec{\nabla}f$

$V=u\hat{i}+v\hat{j}+w\hat{k}$ m/s

in قيمة x axis

Reynolds Experiment

Re 72300

laming أقل

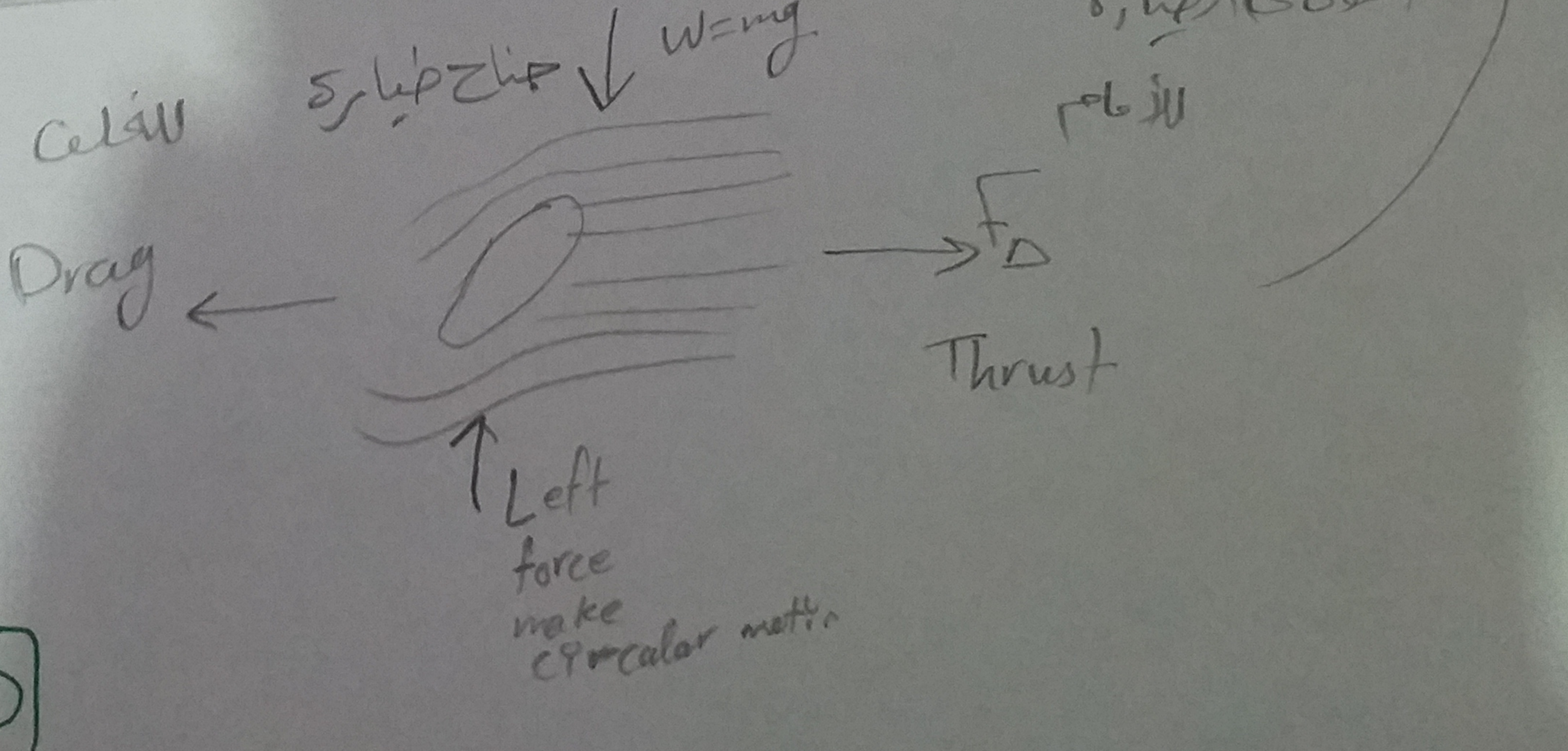
turbelent 10^4 أكبر من

$f=(64/Re)$ ....

ϵ/D turbulent

roughness

turbulent velocity perbendicul to direction of motion



$$\nu = \frac{\mu}{\rho}$$ → dynamic

kinematic

kg/ms ; $N \cdot S/m^2 = \frac{kg}{s^2} \cdot m \cdot \frac{s}{m^2}$

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

$$\tau_{max} = \mu \frac{du}{dy}\Big|_{y=0}$$

$y = 2r$

ρ constant fluids

liquids

$$h_{loss} = \Delta h_{loss} = f \frac{L}{D} \frac{V^2}{2g}$$, m.

losses.

moody diagram

تقاطع f مع ε

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equation OR moody chart بطلع القيم من

28.7..19

بسم الله

Ch.10+11+12

$$\underbrace{\text{static} + \text{elevation}}_{\text{piezometric head}} + \text{dynamic} = \text{Bernollui}$$

$$\frac{P_1}{\rho g}+Z_1+\frac{V_1^2}{2g}$$

Bernollui شروط معادلة

- un Comorissible
- irrotational
- un viscous
- steady

* No slip $\xrightarrow{\text{means}}$ $V=0$ عند الأطراف

Energy Equation.

$$h_{pump}+\frac{P_1}{\rho_1 g}+\frac{V_1^2}{2g}=\frac{P_2}{\rho_2 g}+\frac{V_2^2}{2g}+Z_2+h_{loss}+h_{pump}$$

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

$$h_{loss}=\left(f\frac{L}{D}+\Sigma K\right)\frac{V^2}{2g}$$

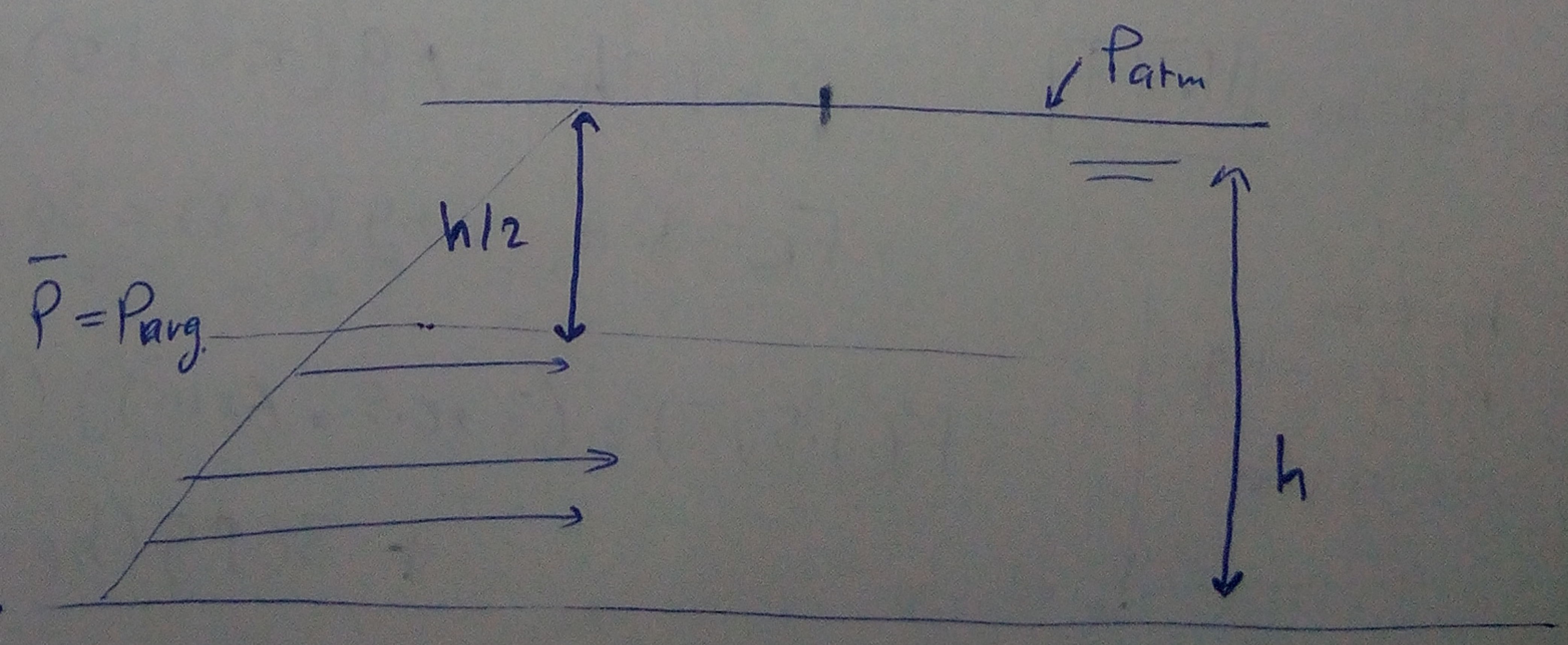
$\bar{y}=y_c=h/2$

$$\boxed{h/2=y_c\sin\theta}$$

h_{cp}

y_{cp}

$$\boxed{F_{cp}=\bar{P}A}$$



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

Figure 11.5

$$+\circlearrowleft M = \int_0^h \rho g y \, dA = \rho g b \int_0^h y^2 \, dy = (P_{atm} + \rho g h/2) A \, y_{cp}$$

$$\boxed{I = \bar{I} + Ad^2}$$ Parallel axis theorem.

$$\boxed{y_{c.p} = y_c + \frac{I_{xx,c}}{\left(y_c + \frac{P_o}{\rho g \sin\theta}\right) A}}$$

$$y_{c.p} = y_p = y_c + \frac{I_{xx,c}}{y_c A}$$ for $P_o = 0$ (11.7 b)

eq ⇒ 11.10 → 11.12 مهم

$\boxed{\text{ex. 11.1}}$ $$y_{c.p} = S + \frac{b}{2} + \frac{b^2}{\left[12\left(S + \frac{b}{2} + \frac{P_o}{\rho g \sin\theta}\right)\right]}$$

29.7..19 **Ch. 11** بسم الله

Moment of Force

$\bar{M}_o = \bar{r} \times \bar{F}$, force time the perpendicular distance between the line of the force & the point at which the moment is calculated (Pivot point)

Problem $\boxed{11.49}$

b = 6 m
m = 280 kg
AB gate

$$\bar{P} = \rho g h_c = \rho g (0.5 + 1.5) = 2 g \rho$$

$$F_R = \bar{P} A = 2 \rho g (6 \times 3) = 36 \rho g$$

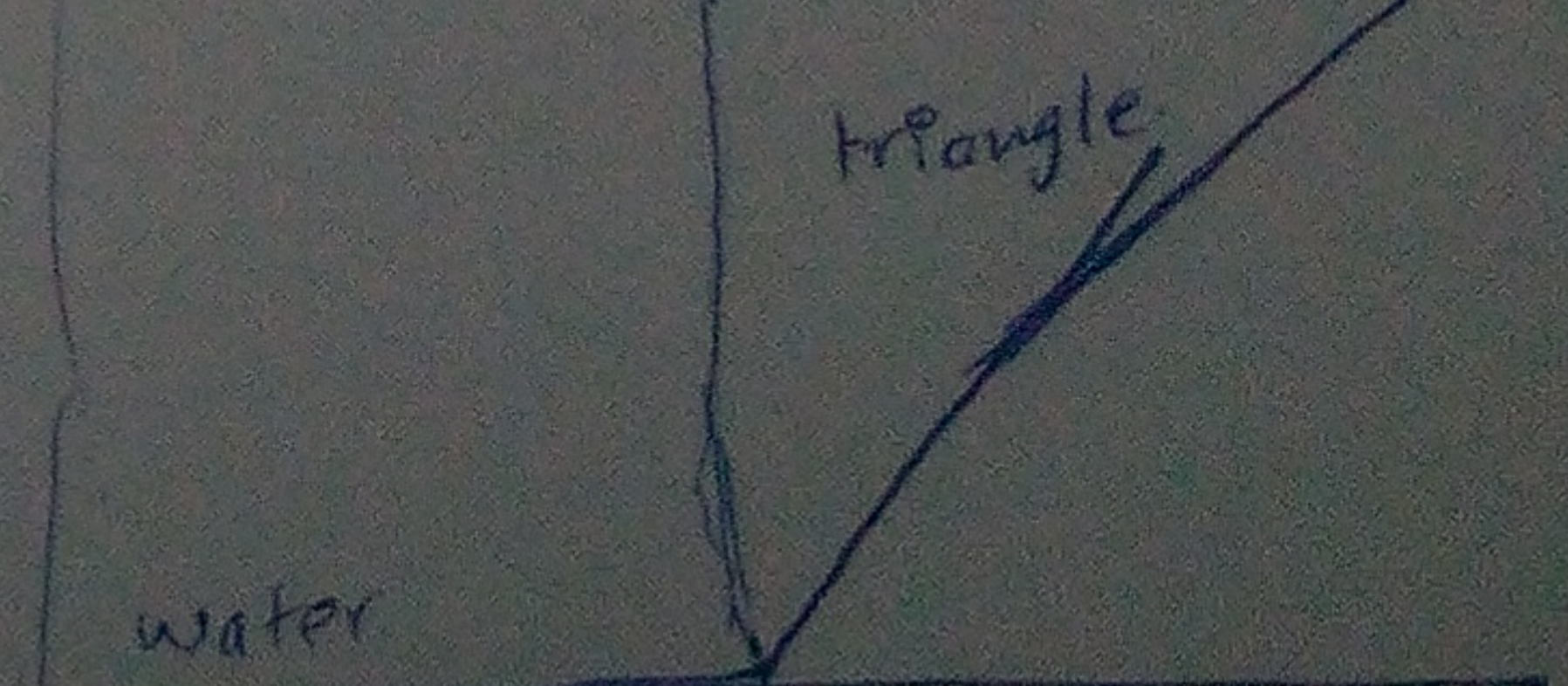
$$F(1.5\sqrt{2}) = (3 * 0.5 * 6 \times 10^3) g (1.5) + \left((3 * 1.5 * 6) \times 10^3 \times g \times 2\right) + 36 \rho g (h_p - 0.5)$$

$$h_p = h_{cp} = 0.5 + 1.5 + \frac{3^2}{12(0.5 + 1.5)}$$

$$\boxed{h_p = 2.375 \text{ m}}$$ عوّض بالعلاقة

$$1.5\sqrt{2} F = 13.5 \rho g + 54 \rho g + 36 \rho g (2.375 - 0.5)$$

$$F = \frac{135 \rho g}{1.5\sqrt{2}} = 624 \text{ kN}$$



30.7.19

نهاية عزوز ♥

بسم الله

Solve $\boxed{\text{ex } 11\text{-}8}$

Energy equation

$P_1 = P_2 = P_{atm}$

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

$$Z_1 = Z_2 + h_{loss}$$

$$h_{loss} = \left(f \frac{L}{D} + \sum_{i=1}^{5} K \right) \frac{V_{elocity}^2}{2g}$$

Velocity in pipe.

$V \neq V_1 \neq V_2$

$\boxed{\text{table A-15}}$ to find μ

f & V?

$$\bar{V} = \frac{\dot{V}}{A} = \frac{0.006}{\pi (0.05)^2} = 3.05 \text{ m/s}$$

$$Re = \frac{\rho \bar{V} D}{\mu} = \frac{10^3 \times 3.05 * 0.05}{1.307 * 10^{-3}} \simeq 117{,}000$$ So, turbelant.

خاصية للمادة $\leftarrow \frac{\varepsilon}{D}$ (from table 14-2) $= \frac{0.26 \text{ mm}}{50 \text{ mm}} = 0.0052$

from moody chart $f = 0.0315$

$$Z = 4 + \underbrace{(0.0315)\left(\frac{89}{0.05}\right)}_{\text{major}} + \underbrace{(0.5 + 2*0.3 + 0.2 + 1.06]}_{\text{minor}} \Big) \frac{(3.05)^2}{2 \times 9.81}$$

$\boxed{Z = 31.9 \text{ m}}$ #

31.7..19

بسم الله

Problem

$\boxed{14.26}$ مع تعديلات الدكتور

laminar, Newtonian, fullydevoloped

$$u(y) = u_0\left(1-\left(\frac{y}{h}\right)^2\right)$$

$$u_0 = u\Big|_{y=0} = u_0$$

$$\dot{m} = \rho A\vec{V} = \rho A u_{av}$$

$$\tau(y) = \mu\frac{du}{dy} = \mu\left(-2\frac{u_0 y}{h^2}\right)$$

$$u(y) = u_0 - \frac{u_0}{h^2}y^2$$

$$\frac{du}{dy} = 0 - \frac{2u_0}{h^2}y$$

$$\boxed{\tau(y) = -2\frac{u_0}{h^2}\mu y}$$

$$\boxed{A = 2h \times 1 = 2h\,m^2}$$

$$Au_{av} = \int 2u(y)\,dA, \quad dA = 1\,dy$$

$$u_{avg} = \frac{2}{A}\int_0^h u(y)\,dy = \frac{\cancel{2}u_0}{\cancel{2}h}\int_0^h\left(1-\left(\frac{y}{h}\right)^2\right)dy$$

$$= u_0\left(y-\frac{y^3}{3h^2}\right)\Bigg]_0^h = \frac{u_0}{h}\left(h-\frac{h^3}{3h^2}\right) = \frac{2}{3}\frac{u_0\cancel{h}}{\cancel{h}}$$

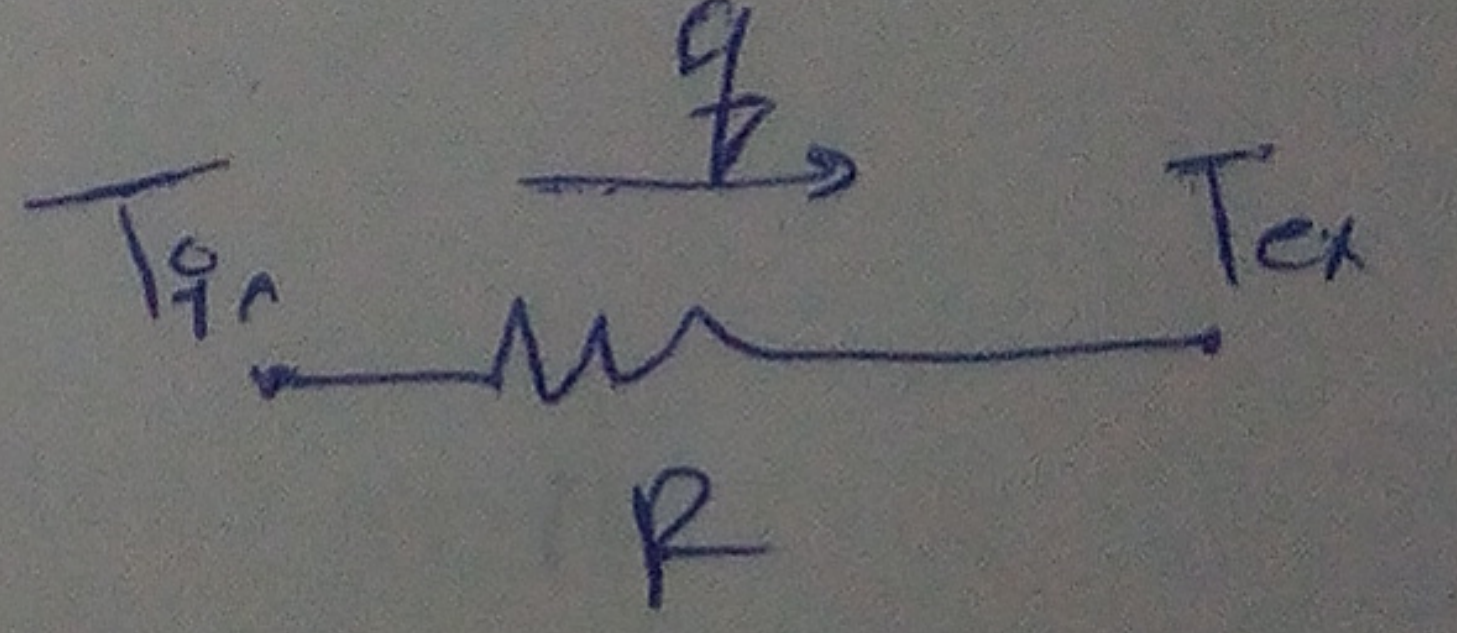
4.8..19

بسم الله

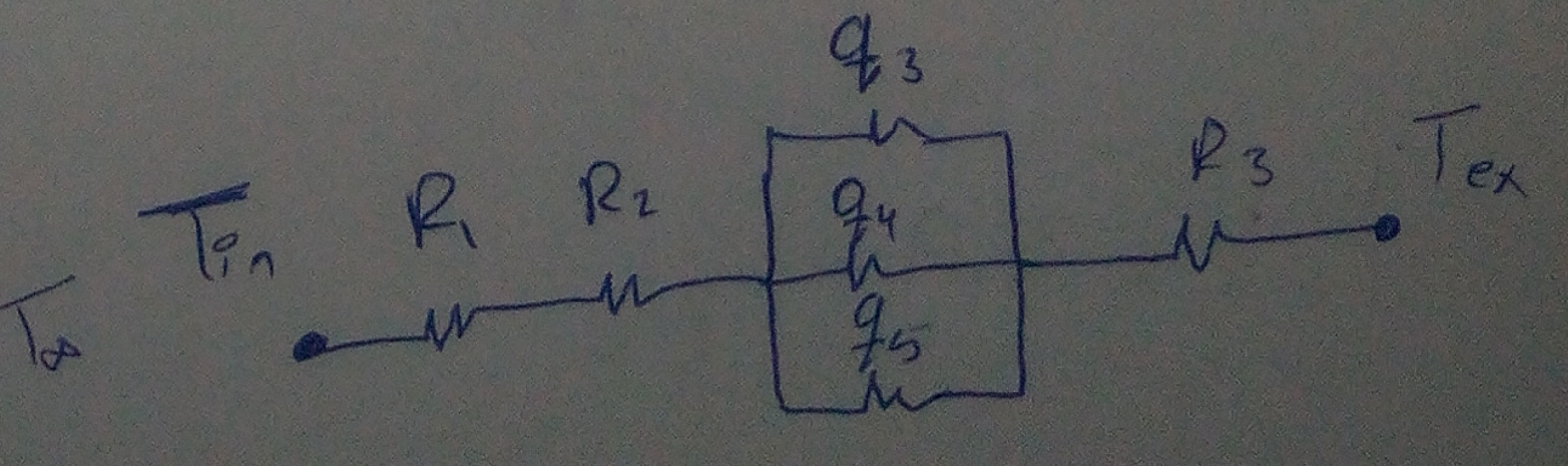
Ch.16 Heat transfer
+17

① Conduction

$$q_{cond} = -kA_c\frac{dT}{dx} \simeq -kA\frac{\Delta T}{\Delta x} = -kA\frac{\Delta T}{L}$$



$$R_1 = \frac{L_1}{k_1A_1} \leftrightarrow \frac{1}{R} = \frac{kA}{L} \rightarrow q = \frac{\Delta T}{\Sigma R} \Longleftrightarrow I = \frac{\Delta V}{\Sigma R}$$



② Convention

$$q_{conv} = hA(T_s - T_\infty)$$

↑ from table

(convective heat transfer Coeficient)

③ Radiation

$$q_{rad} = \epsilon \sigma A (T_1^4 - T_2^4)$$

$\epsilon < 1$

ϵ: emissivity $\epsilon = 1.0$ black body.

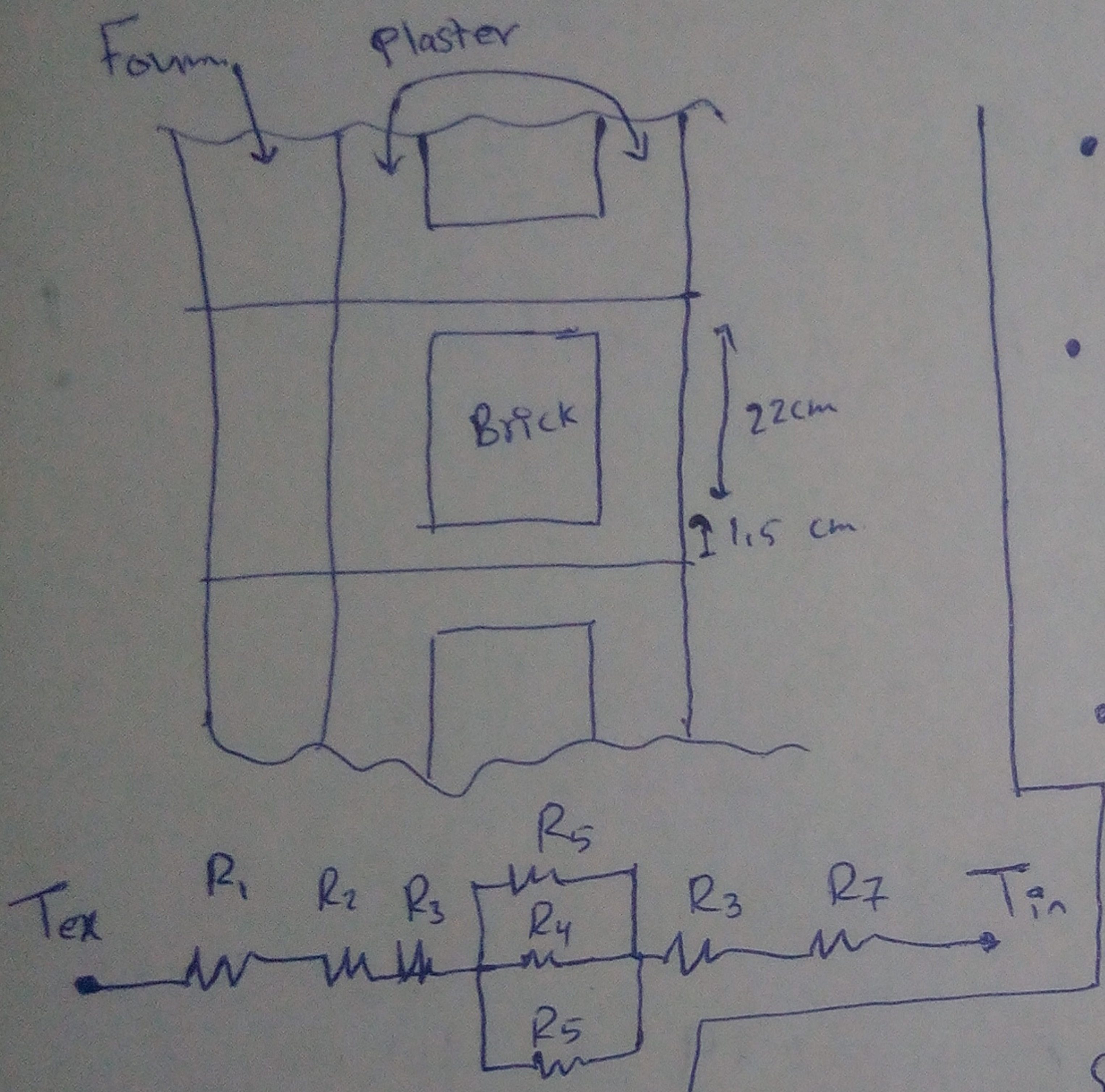
$\sigma = 5.67 \times 10^{-8}\ W/m^2.K^4$

radues for earth 6,400 km ("

بسم الله

5.8..19

Solve $\boxed{\text{ex } 17\text{-}6}$ مهم!



$R_1 = \frac{1}{h_o}$

$R_7 = \frac{1}{h_i}$

- $R_1 = \frac{1}{h_o A} = \frac{1}{10 * 0.25} = \boxed{0.4\ °C/W}$
- $R_2 = \frac{L_2}{K_2 A_2} = R_{foum} = \frac{0.03}{(0.026)(0.25)(1)}$

$\boxed{R_2 = 4.615\ °C/W}$

- $R_3 = \frac{L_3}{K_3 A_3} = \frac{0.02}{(0.22)(0.25)} = 0.363\ °C/W$
- $R_7 = \frac{1}{h_i A} = \frac{1}{25(0.25)} = 0.16\ °C/W$
- $R_4 = \frac{0.16}{(0.72)(0.22)} = 1.01\ °C/W$
- $R_5 = \frac{0.16}{(0.22)(0.015)} = 48.5\ °C/W$

parallel !

$A = 5 \times 3 = 15\ m^2$

$= 5(0.25 \times 12) = 15$

$60 \times (0.25)$

$\boxed{\#\text{Unit area} = 0.25\ m^2}$

$Q = \frac{\Delta T}{\Sigma R}$

ملاحظات

$\Delta T(K) = \Delta T(°C)$

$$\Sigma R_{parallel} = \frac{1}{\left(\frac{2 * 1}{48.5} + \frac{1}{1.01}\right)} = 0.96\ °C/W$$

$$\Sigma R = 0.4 + 4.615 + 2(0.363) + (0.96 + 0.16)$$

$$\boxed{\Sigma R = 6.87\ °C/W}$$

$$Q = \frac{\Delta T}{\Sigma R} = \frac{30}{6.87} = 4.36\ W/0.25m^2$$

$\boxed{Q_{tot} = 262\ W}$ #

6.8..19

بسم الله

Ch.18 Lumped Capacitance

$$\frac{T(t) - T_\infty}{T_i - T_\infty} = e^{\frac{-t}{\tau}} = e^{-bt} \quad \boxed{eq.\text{-}18.1}$$

$$\tau = \frac{1}{b} = \frac{t}{(F_o \cdot Bi)}$$

$$b = \frac{hA_s}{\rho C_p V} = \frac{Bi \cdot F_o}{t}$$

$$L_c = \frac{V}{A_s} \; ; \; Bi = \frac{hL_c}{k} = \frac{hV}{A_s k}$$

$$F_o = \frac{\alpha t}{L_c^2} \; ; \; \alpha = \frac{k}{\rho C_p}$$

the equations are given in final exam!

$$\Rightarrow F_o = \frac{kt}{\rho C_p L_c^2} \; ; \; Bi = \frac{hL_c}{k}$$

Solve $\boxed{ex\,18\text{-}1}$

$r = \frac{0.0010}{2}$

$L_c = \frac{0.0005}{2}$ m.

$k = 35$ W/m.K

$\rho = 8500$ kg/m^3

$C_p = 320$ J/kg.K

$h = 210$ W/m^2.K

$t = ?$

$$Bi = \frac{hL_c}{k} = \frac{210 \times 0.0005}{3 \times 35} = 0.001 < 0.1$$

$$F_o = \frac{\alpha t}{L_c^2} = \frac{k}{\rho C_p}\left(\frac{1}{L_c^2}\right)t = \frac{12 \times 10^{-5}\, t \times 9}{(0.0005)^2} = \frac{10.8 \times 10^{-5} \times 10^{8}}{25} t$$

$$= 432t$$

$$\alpha = \frac{h}{\rho C_p} = \frac{35}{8500(320)} = 1.2 \times 10^{-5} \text{ m}^2/\text{s}$$

$$b = \frac{1}{\tau} \; ; \; \tau = \frac{t}{(F_o)} = \frac{t}{(432t)(0.001)} = 23$$

$$-2 \times 2.3 = \ln(0.01) = e^{-(t/23)}$$

$$! \; \boxed{\frac{99-100}{0-100} = \frac{-1}{-100} = 0.01}$$

$$= \frac{-t}{2.3} \rightarrow \boxed{t = 10.6 \text{ S}} \; \#$$

$$\boxed{t = 4.6\tau}$$

just for know.

37 "النهاية"

Ch.1 + Ch.2 + Ch.3

just reading [concepts]

Ch.10

Concepts only!

Ch.11

مهم! ex-11.1

problems 5th (11-14)

(11-16)

مهم جداً! ← (11-49)

Ch.12

Concepts only

ch.13X

Ch.14

- examples (1, 3 مهم, 6, 8 مهم)
- equation (14-44)
- suggested prob. (43, 73, 97)

Ch.16

Concepts only!

Ch.17

examples (6)

suggested مهم problems (55, 56, 60)

Ch.18

examples (1, 2)

suggested (64)

Final material ("

Thermal & Fluid Science.

Good luck ☺