hi 3002]

CM.

$_1W_2 = 0$ isochoric $V_2 = V_1$

$_1W_2 = P(V_2 - V_1)$ isobaric $P_2 = P_1$

$_1W_2 = \frac{P_1 + P_2}{2}(V_2 - V_1)$ springs

$_1W_2 = PV \ln\frac{V_2}{V_1}$ polytropic $n = 1$

$P_1V_1 = P_2V_2$

$_1W_2 = \frac{P_2V_2 - P_1V_1}{1 - n}$ polytropic $n \neq 1$

$P_1V_1^n = P_2V_2^n$

CV : C? S.E.E

~~1st law~~ reversible

1st law $q + h_1 + \frac{1}{2}Vel_1^2 + gZ_1$

$= w + h_2 + \frac{1}{2}Vel_2^2 + gZ_2$

2nd law (reversible)

$$\delta q = Tds = dh - v\,dP$$

$$q = \int_1^2 \delta q = h_2 - h_1 - \int_1^2 v\,dP$$

C.M.: $w = \int_1^2 P\,dv$

$$w = -\int_1^2 v\,dP + \frac{1}{2}Vel_1^2 - \frac{1}{2}Vel_2^2 + gZ_1 - gZ_2$$

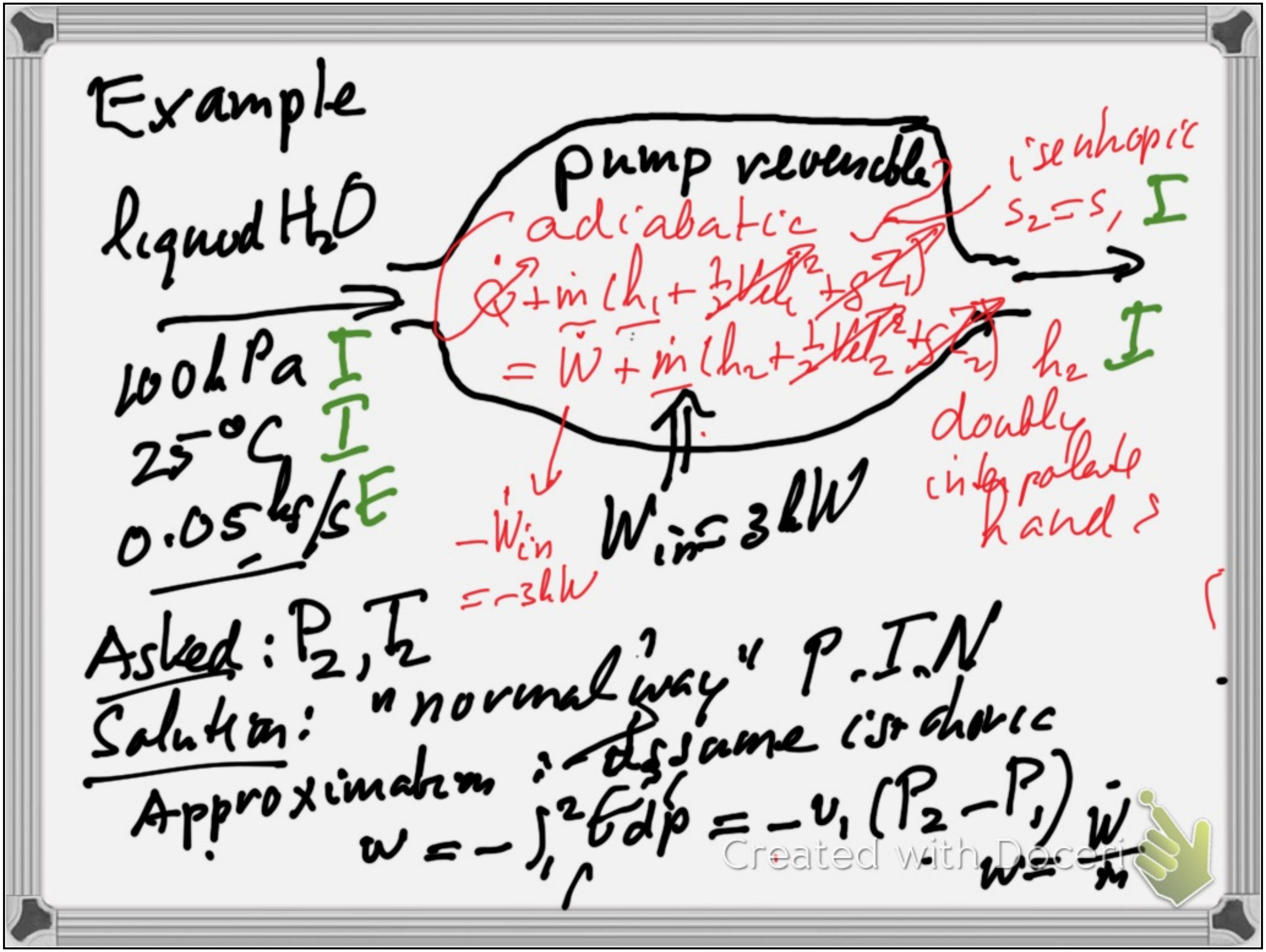
S.E.E. and reversible CV

$$-\int_1^2 v\,dP = 0 \quad \text{if isobaric } P_2 = P_1$$

$$= v(P_2 - P_1) \quad \text{if isochoric } v_2 = v_1$$

$$= -P_1 v_1 \ln\frac{P_2}{P_1} \quad \text{if polytropic } n = 1 \qquad P_1 v_1 = P_2 v_2$$

$$= \frac{n(P_2 v_2 - P_1 v_1)}{1-n} \quad \text{if polytropic } n \neq 1$$


Example
liquid H2O
100kPa I
25°C I
0.05 kg/s E
pump reversible
adiabatic
isentropic
s2=s1 I
= W + m (h2 +
h2 I
doubly
interpolate
hand?
-Win
=-3kW
Win=3kW
Asked: P2, T2
Solution: "normal way" P.I.N
Approximation: assume isochoric
w = - ∫ v dp = - v1 (P2 - P1)
w = W/m
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$$w = \frac{3\,kW}{0.05\,kg/s} = \frac{m^3}{kg}\frac{1}{997}(P_2 - 100\,kPa)$$

$$v: A\text{-}4: \; v = \frac{1}{\rho} = \frac{m^3}{997\,kg}$$

$$P_2 = 100\,kPa + 997\frac{kg}{m^3}\,\frac{3\,kJ/s}{0.05\,kg/s}$$

$$= \underline{\underline{6{,}082\,kPa}}$$

Temperature?, $\dot{m}h_1 = \dot{W} + \dot{m}h_2$

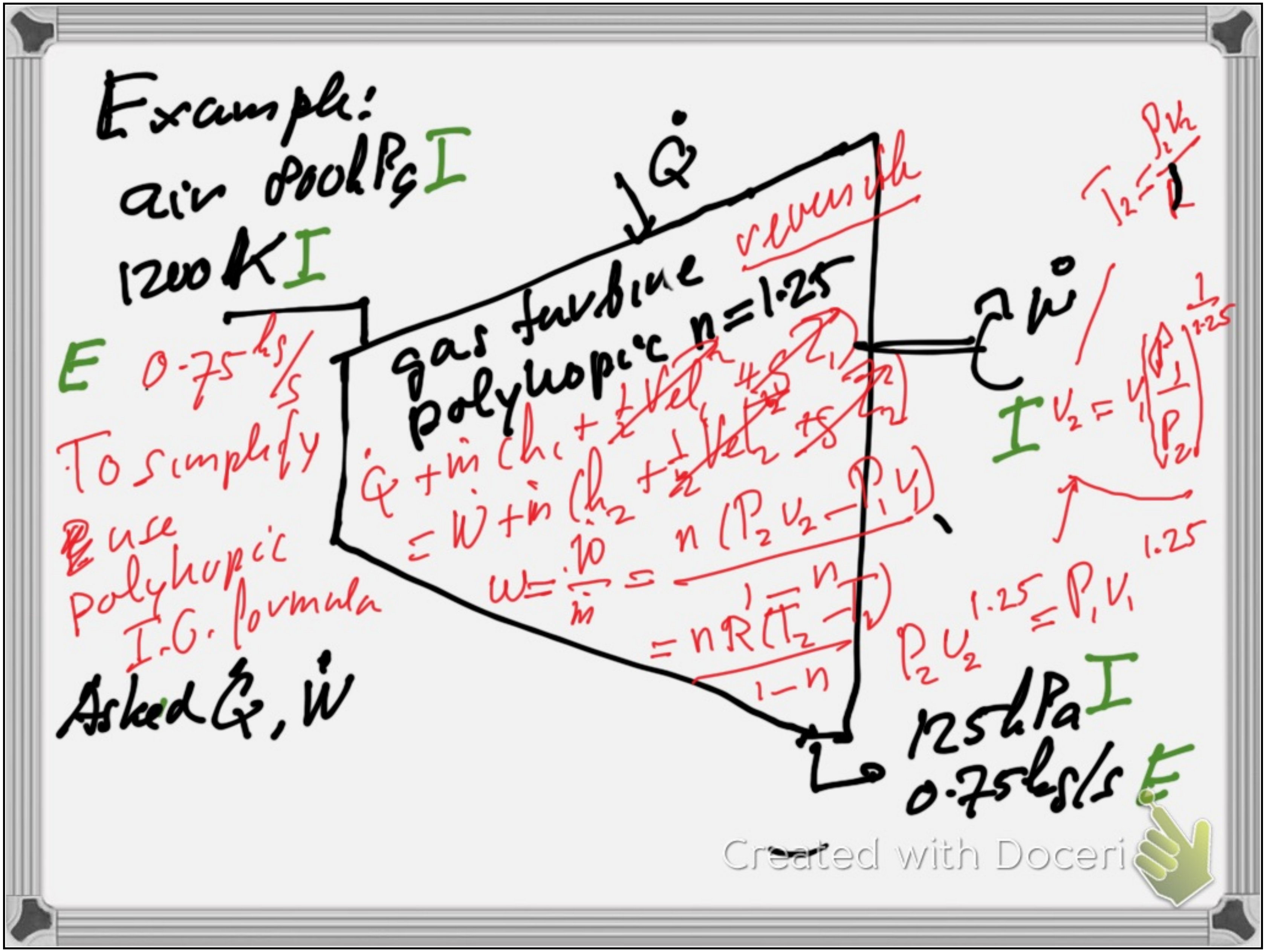
$$\dot{W} = \dot{m}(h_2 - h_1)$$

If isobaric (simple liquid) → $25°$

$$3\,kW \rightarrow \dot{W} = \dot{m}c_p(T_2 - T_1)$$

$$c_{p_{A4}} = 4.18\frac{kJ}{kg\,K}$$

→ $T_2 = 26.43°C$ Temperature is OK.
But temperature difference is bad
Best (from 1st law and double
interpolation $T_2 = 25.113$


Example:
air 800kPa I
1200K I
E 0.75 kg/s
To simplify use polytropic I.G. formula
Asked Q̇, Ẇ
gas turbine
polytropic n=1.25
reversible
Q̇
Ẇ
125kPa I
0.75kg/s E
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$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^n = \left(\frac{T_2}{T_1}\right)^{\frac{n}{n-1}} \qquad \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$

$T_2 = 827.89\,K$ $\quad T_1 = 1200\,K$

$\rightarrow \dot{W} = \dot{m}\,\frac{nR(T_2 - T_1)}{1-n} = 400.5\,kW$

$\rightarrow$ 1st law A-7.1 $\quad 1200\,K \quad h_1 = 1277.81\ \frac{kJ}{kg}$

$827\,K \quad h_2 = 852.95$ "

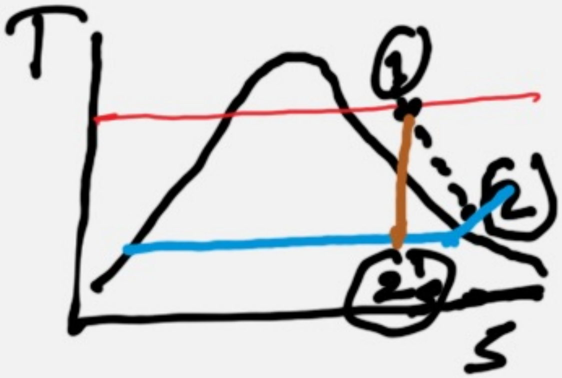
$\dot{Q} = 81.84\,kW$

Efficiencies

Turbine: $\eta_{turbine} = \dfrac{w}{w_s} \le 1$ → s: ideal

Both assumed adiabatic

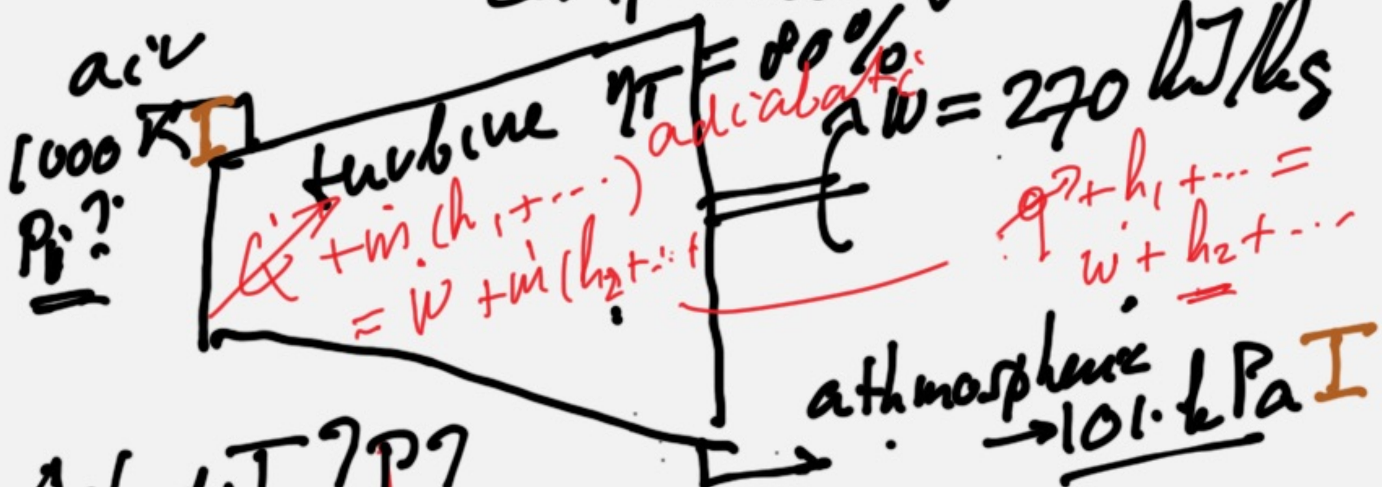
Ideal turbine has the same entrance conditions and same exit pressure



Compressor

$$\eta_{comp} = \frac{w_s}{w} < 1$$

Examples: Do ideal turbine or compressor first



Asked: T_2? P_1?

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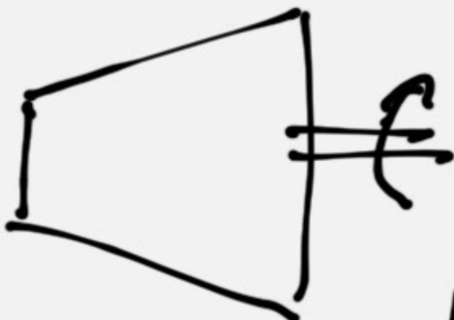
do ideal first



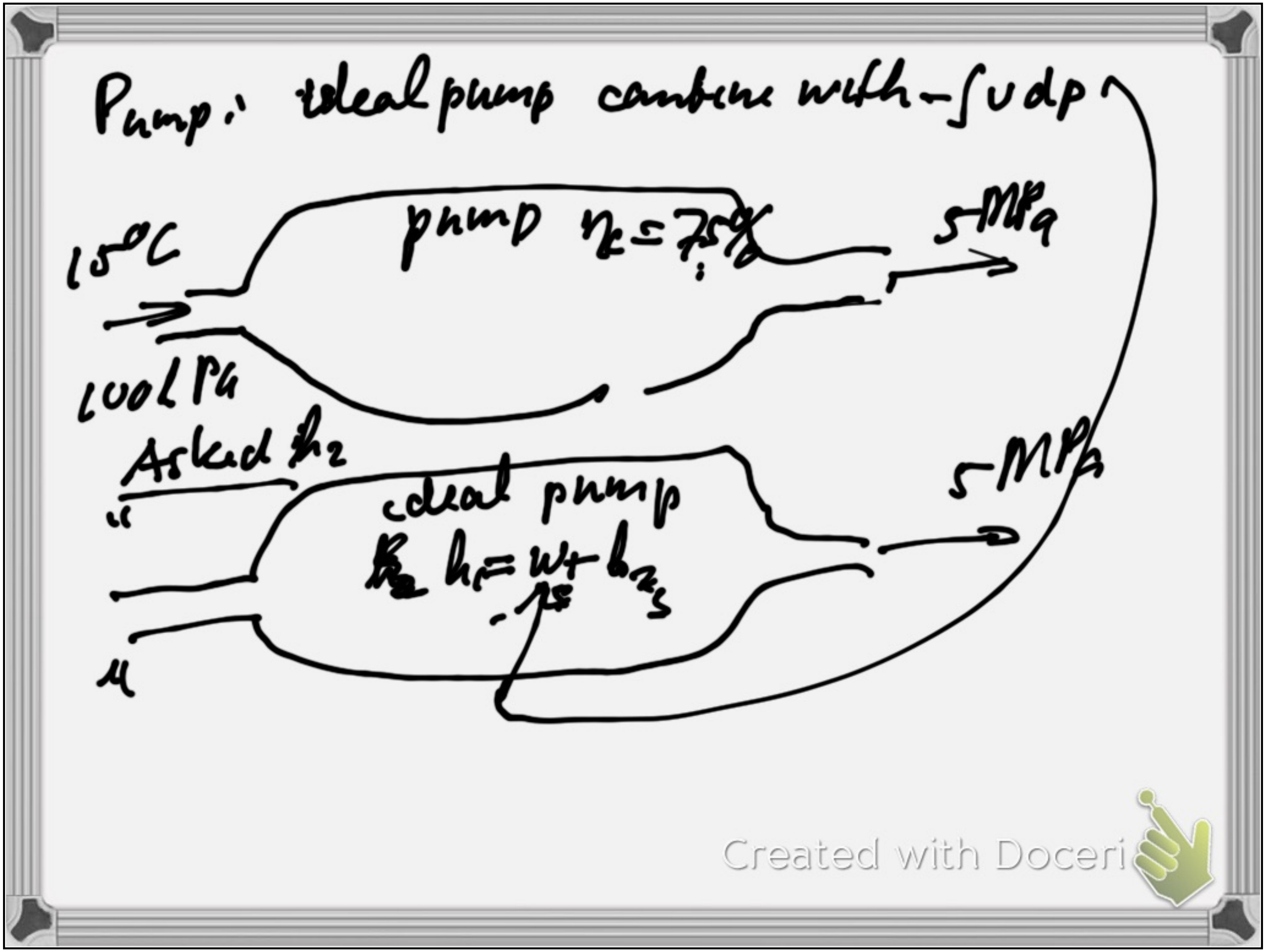
$w_s = \frac{w}{\eta_T}$ → 270 kJ/kg

$h_1 = w_s + h_{2s}$

→ h_{2s} → T_{2s} →

$s^o_{T_{2s}} - s^o_{T_1} - R\ln\frac{P_2}{P_1} = s_{2s} - s_1$

→ P_1 →


Pump: ideal pump combine with -∫vdp
15°C
100kPa
Asked h2
pump η = 75%
5MPa
ideal pump
h1 = w + h2s
5MPa
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