1st law as a rate equation

In any interval dt

$$dU = \delta Q - \delta W \quad (\delta W \rightarrow P\,dV)$$

divide by dt:

$$\frac{dU}{dt} = \dot{Q} - \underbrace{P\frac{dV}{dt}}_{\dot{W}}$$

$\dot{Q}$: rate of heat addition

$\dot{W}$: rate of work done

$$\dot{Q} = m c_p \frac{dT}{dt} \text{ if isobaric}$$

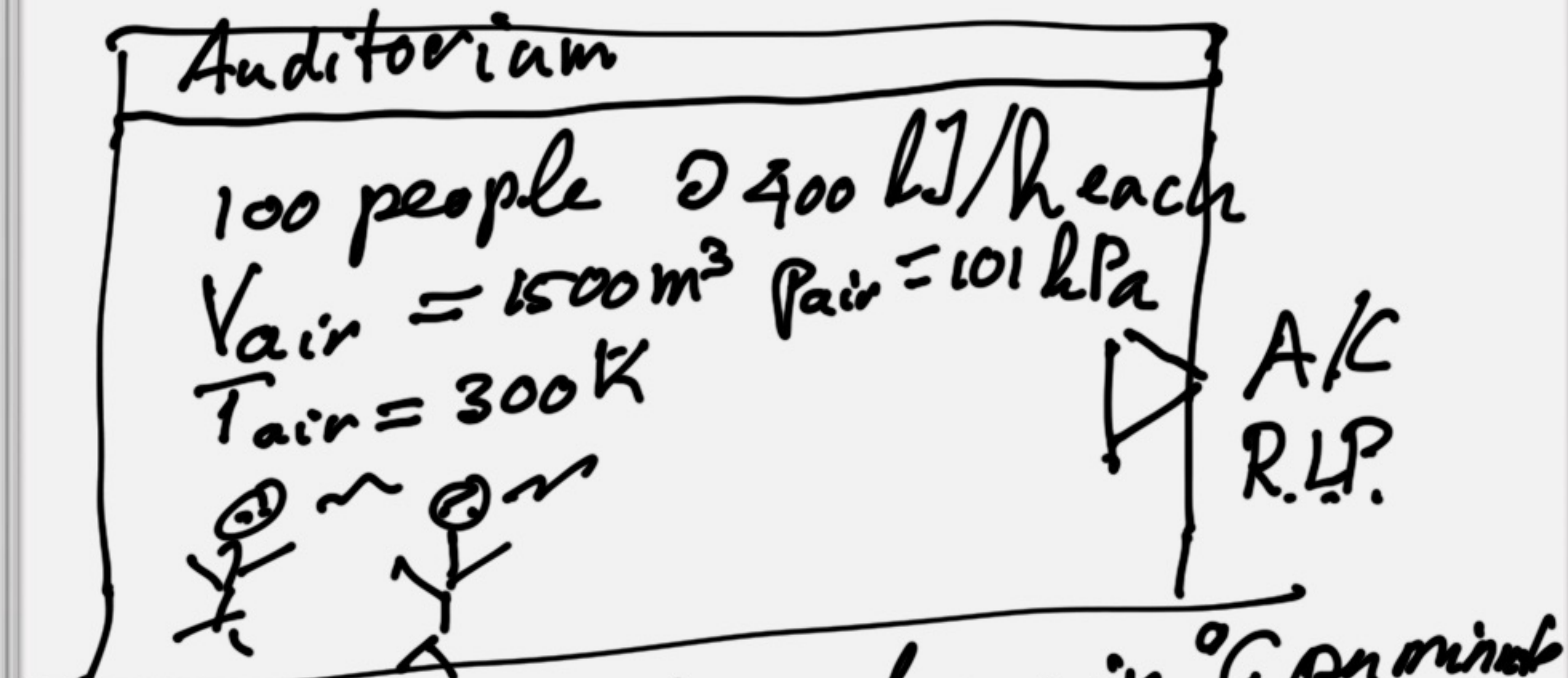
$$\dot{Q} = m c_v \frac{dT}{dt} \text{ if isochoric.}$$

Also, for I.Gs

$$du = c_v \, dT$$

$$\frac{du}{dt} = c_v \frac{dT}{dt}$$

$$\frac{dU}{dt} = m c_v \frac{dT}{dt}$$



Asked: temperature change in °C per minute

Solution $\frac{dU_{air}}{dt} = \dot{Q} - \dot{W}_{air}$ → sealed, then $\frac{dV}{dt} = 0 \Rightarrow \dot{W}$

$$m_{air}\, c_{v_{air}} \frac{dT_{air}}{dt} = 400 \frac{kJ}{h\ \text{people}} \quad 100\ \text{people}$$

$$P_{air} V_{air} = m_{air} R_{air} T_{air}$$

$$101\ kPa \ 1500\ m^3 = m_{air}\ 0.287 \frac{kJ}{kg\,K}\ 300\,K$$

$$m_{air} = 1759.6\ kg$$

$$1759.6\ kg\ \ 0.717 \frac{kJ}{kg\,K} \frac{dT_{air}}{dt} =$$

$$= 40{,}000 \frac{kJ}{h} \frac{1\,h}{60\,min}$$

$$\frac{dT_{air}}{dt} \simeq 0.53\ K/min = 0.53\ {}^{\circ}C/min$$

Note: More reasonable assumption: isobaric, then $\dot{Q} = m c_p \frac{dT}{dt}$

$\rightarrow$ then. $\frac{dT_{air}}{dt} = \ldots$

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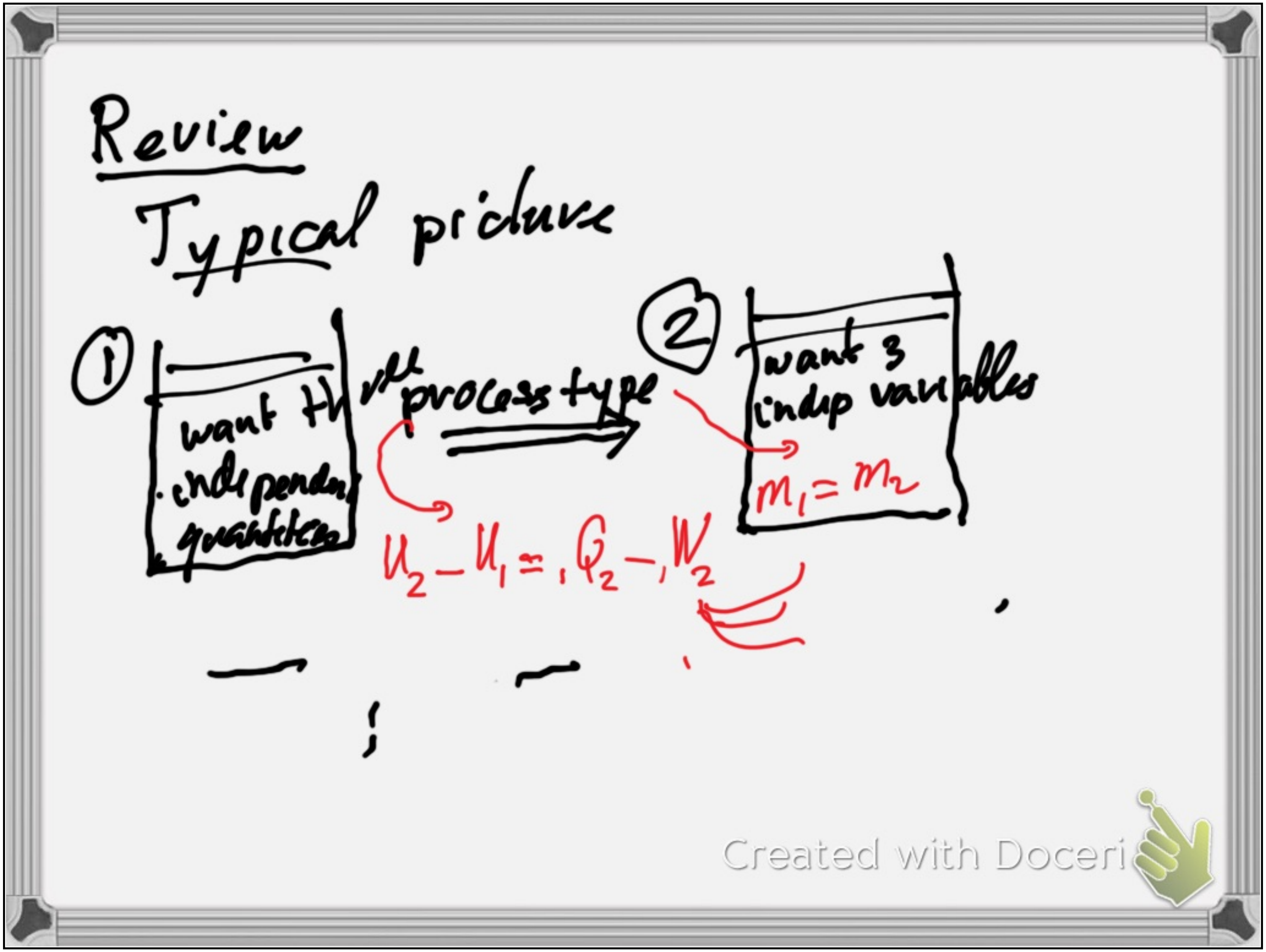
Review
Typical picture
1
want three independent quantities
process type
2
want 3 indep variables
m1 = m2
U2 − U1 = 1Q2 − 1W2

"Insulated" means ${}_1Q_2=0$

"Isolated" means ${}_1Q_2=0$ and ${}_1W_2=0$

$$u = u_f + x(u_g - u_f)$$
$$h = h_f + x(h_g - h_f)$$
} in 2 Phase

$x=0 \rightarrow$ pure SAT liquid

$x=1 \rightarrow$ pure SAT vapor

No C.L. table $\rightarrow$ use SAT liquid at the correct temperature

I.G. $u = u(T)$ $h = h(T)$ $c_v = c_v(T)$ $c_p = c_p(T)$

Try 1st: is it in A.8 or A.7.1

If not $u_2 - u_1 = c_{v\,ave}(T_2 - T_1)$

$h_2 - h_1 = c_{p\,ave}(T_2 - T_1)$

$c_{v\,ave}, c_{p\,ave}$: best : use table A.8

worse : use table A.5 (25°C)

(noble gases : use either)

$c_p - c_v = R$

$u = E$ if $KE, PE = 0$

solids, simple liquids:

$$ {}_1Q_2 = m\,C_{(p)}\,(T_2 - T_1) $$

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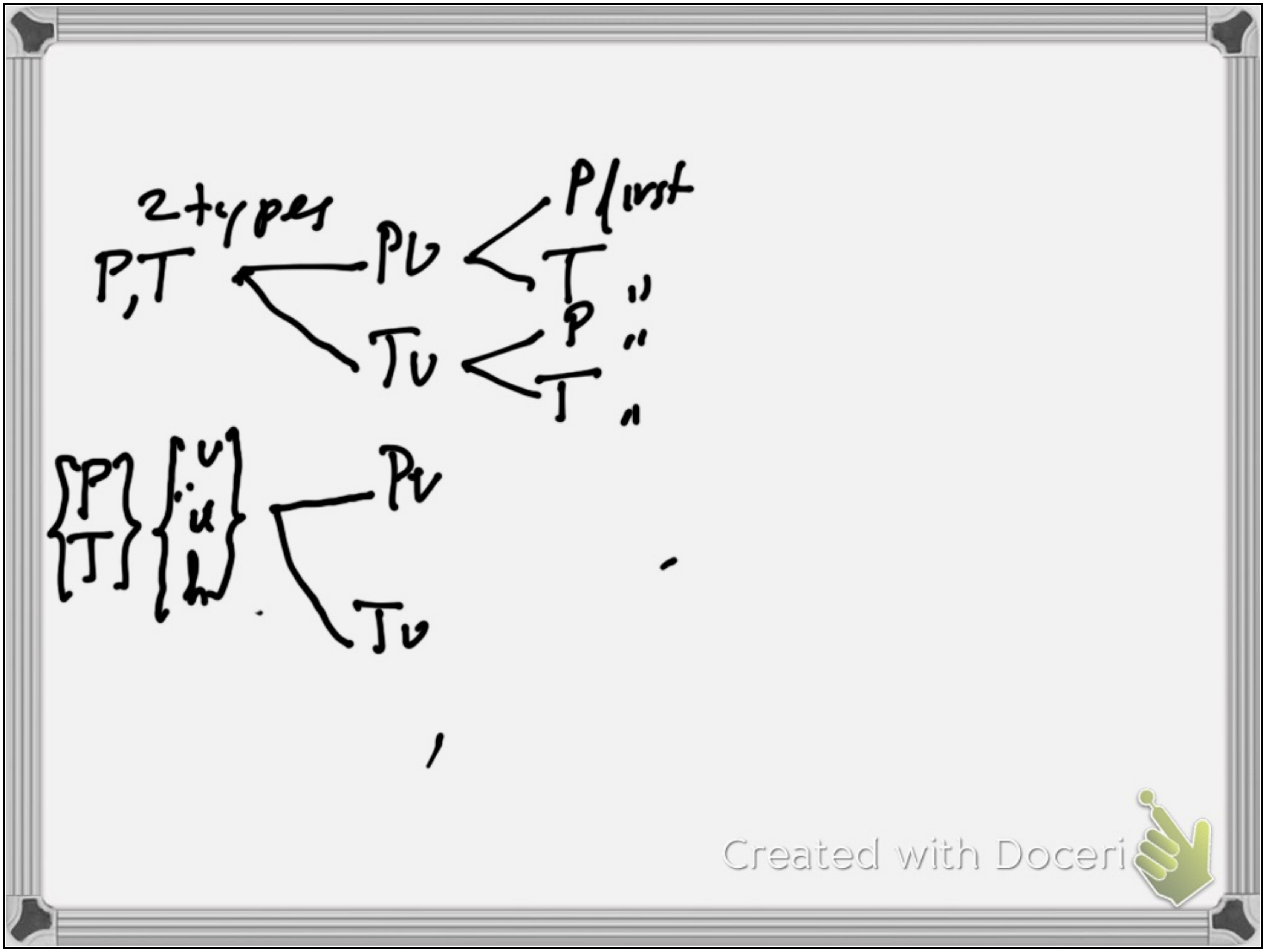
2 types
P,T
PV
TV
P first
T
P
T
Pv
Tv
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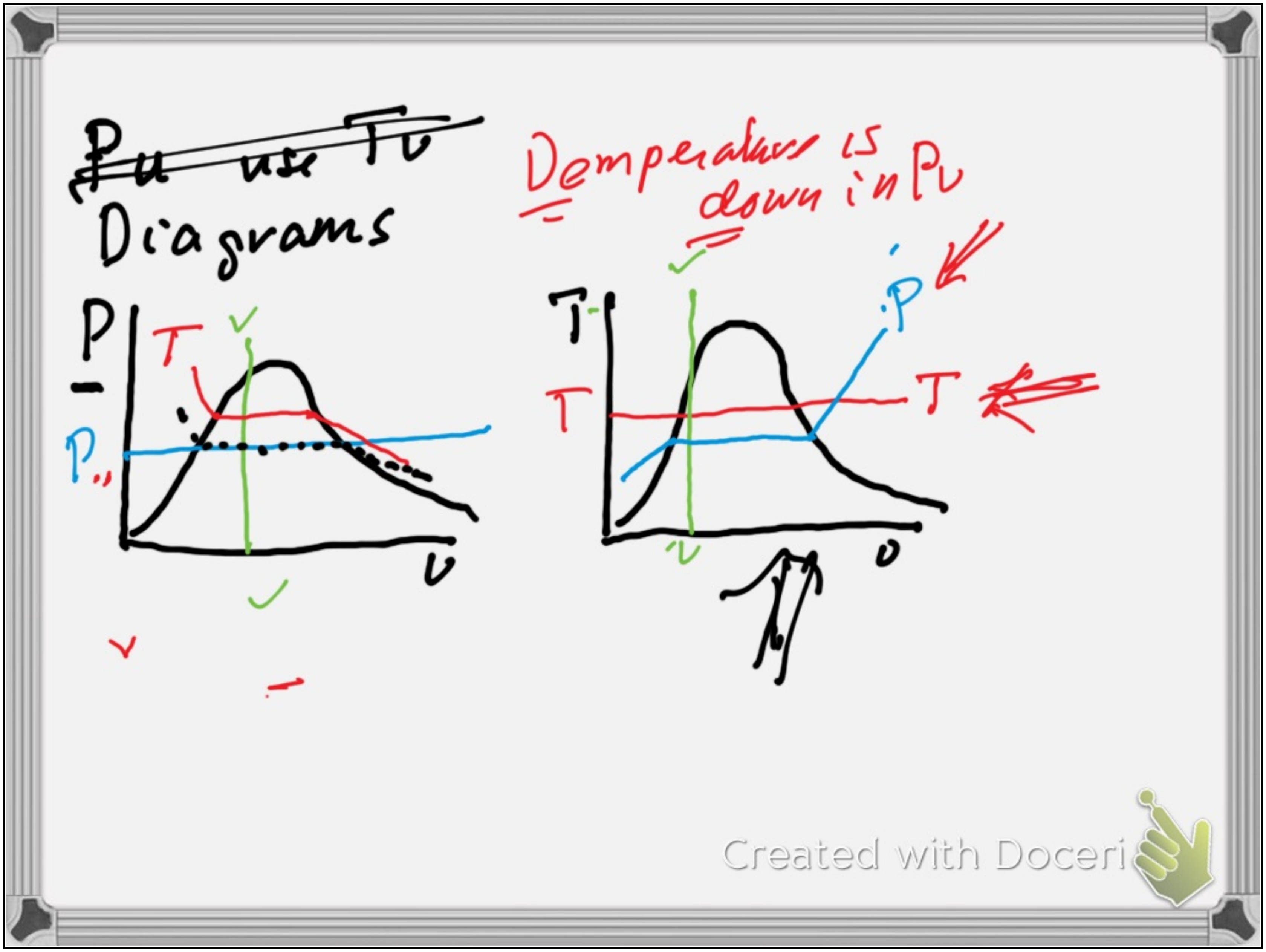
Diagrams
P
T
v
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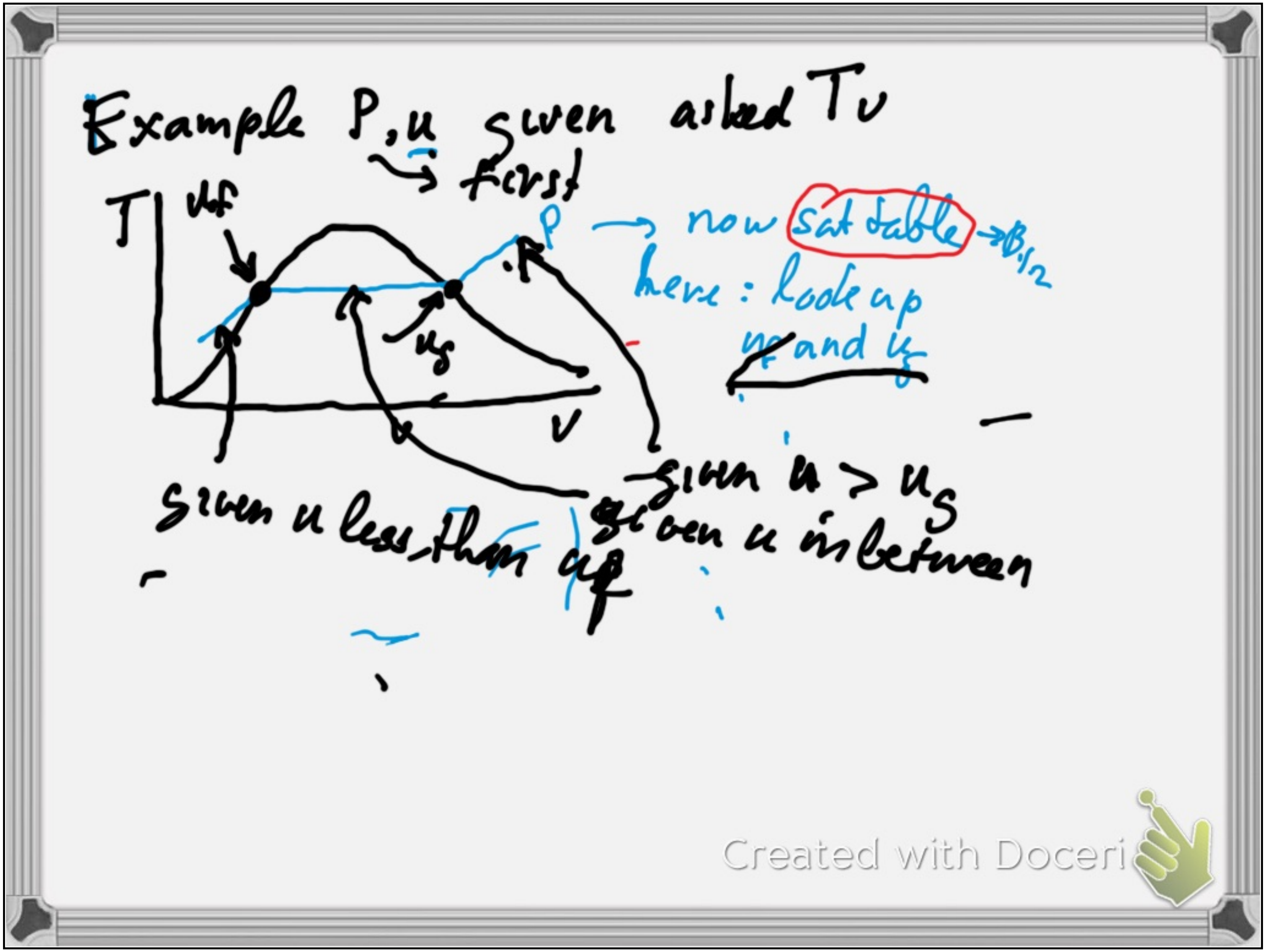
Example P, u given asked T v
first
T
uf
ug
v
P → now sat table → P1,2
here: look up uf and ug
given u > ug
given u less than uf
given u is between
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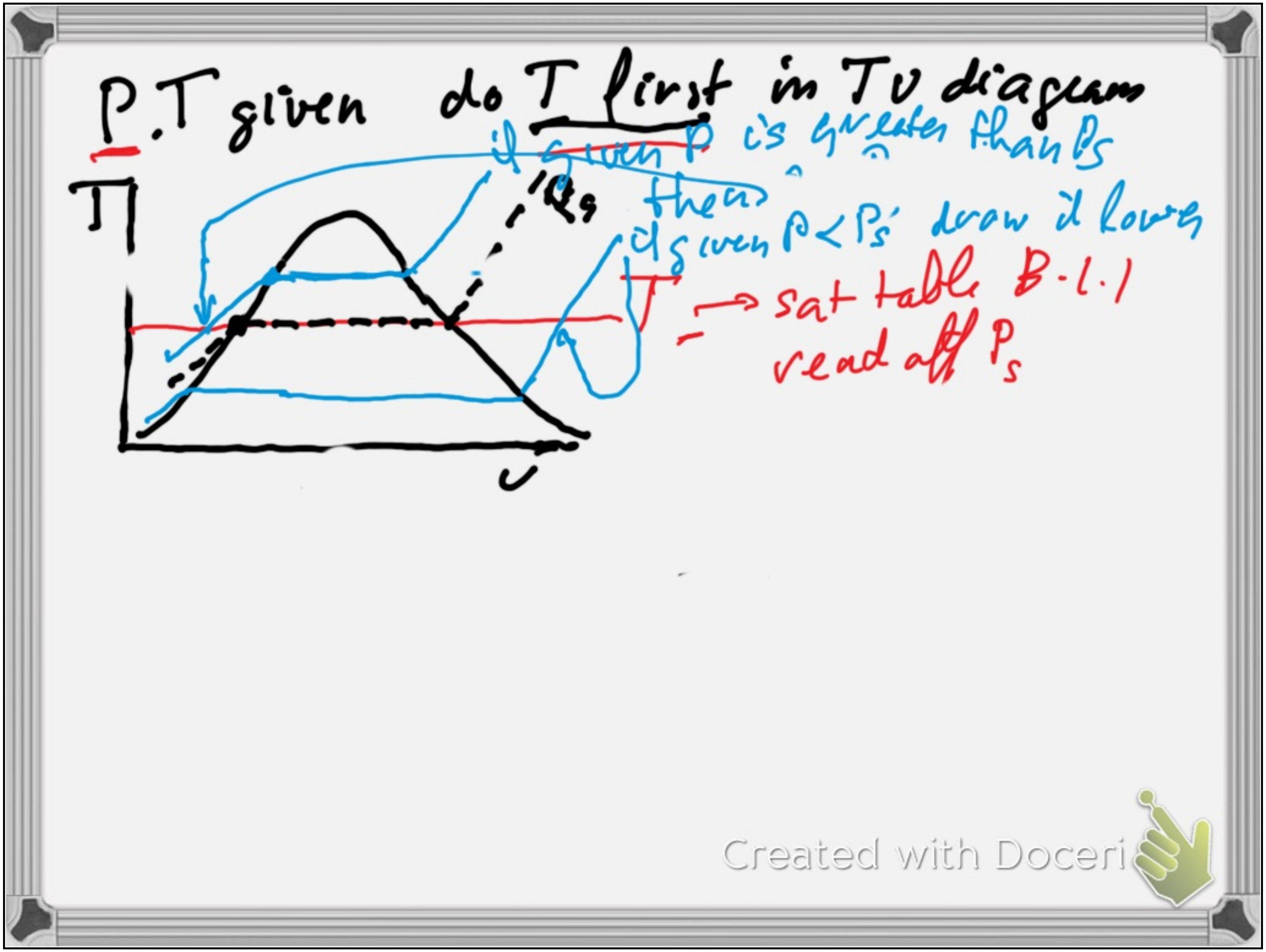
P.T given do T first in Tv diagram
if given P is greater than Ps then
if given P < Ps draw it lower
Ps
T → sat table B.1.1
read off Ps
v
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