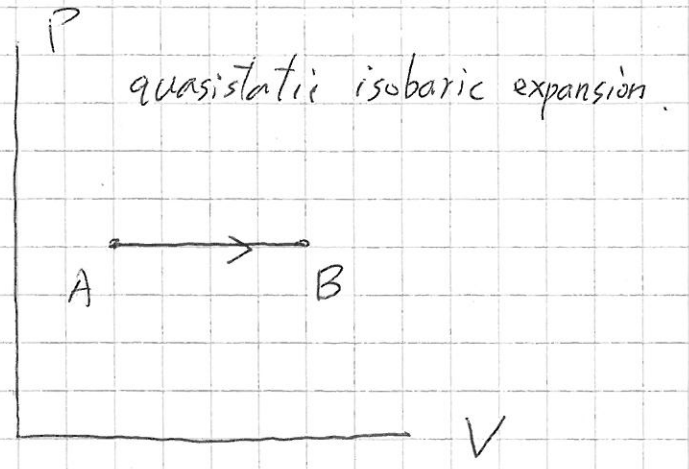
Phys 344

Lecture 4. Heat and Work

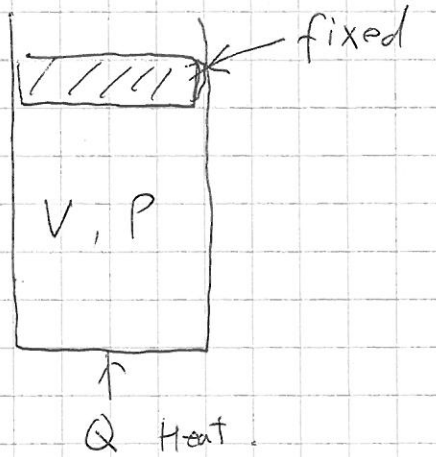
Ref. 1.5

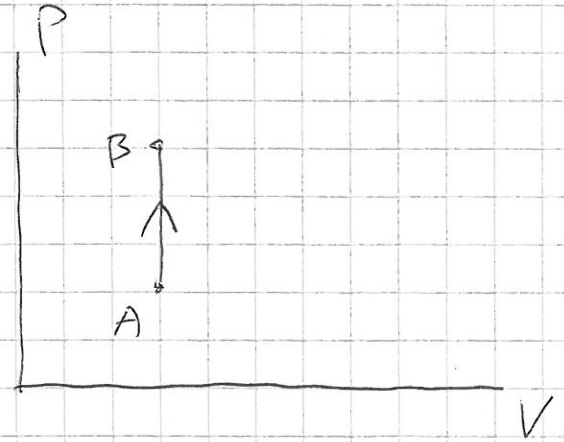
- Some examples of physical process (ideal gas).

— Isobaric process (constant pressure).



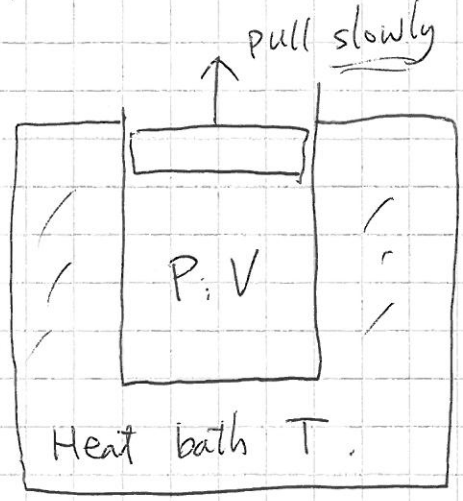
— Isochoric (constant volume).

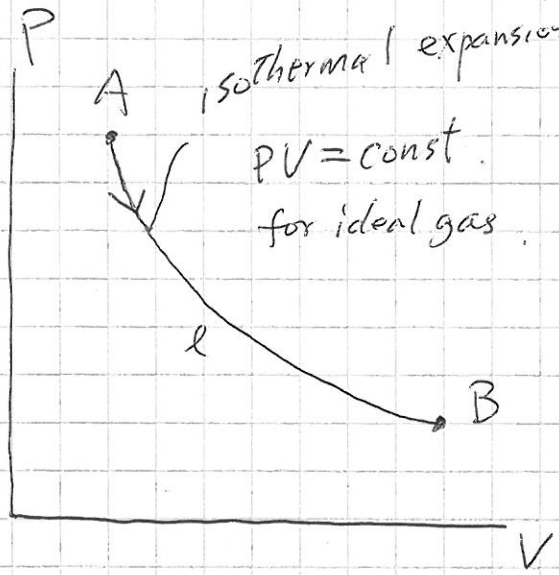




- Isothermal process (constant temperature)

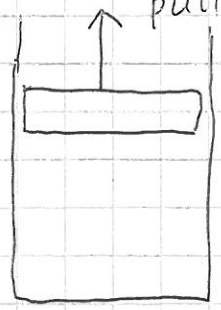
— quasistatic

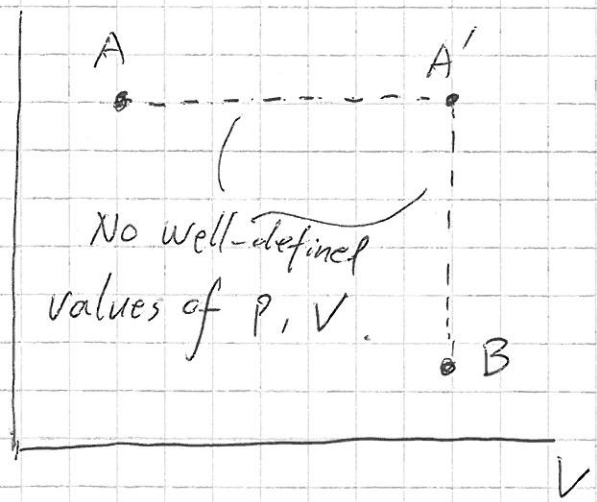




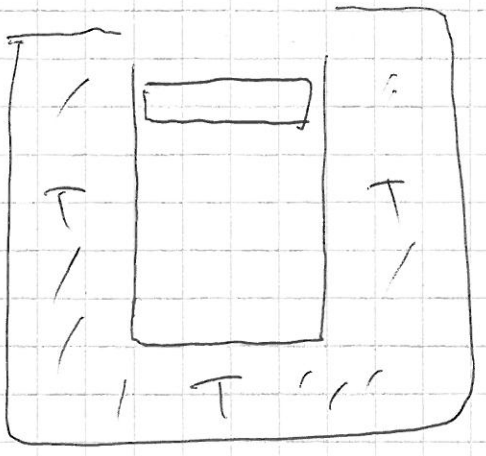
$T_A = T_B = T_e$.

— non-quasistatic





Then inverse into heat bath T.



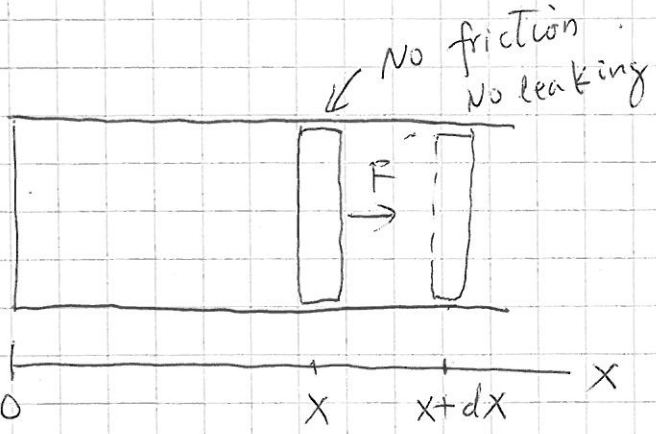
∴ dashed line represents nonquasistatic.

Solid line represents quasistatic.

comment on Textbook p.21.

- Quasistatic expansion (compression) — Mechanical work.

piston moves from x to $x+dx$



— Work done by the system

$$dW' = F \cdot dx$$
$$= P \cdot A \cdot dx$$
$$= P \cdot dV$$

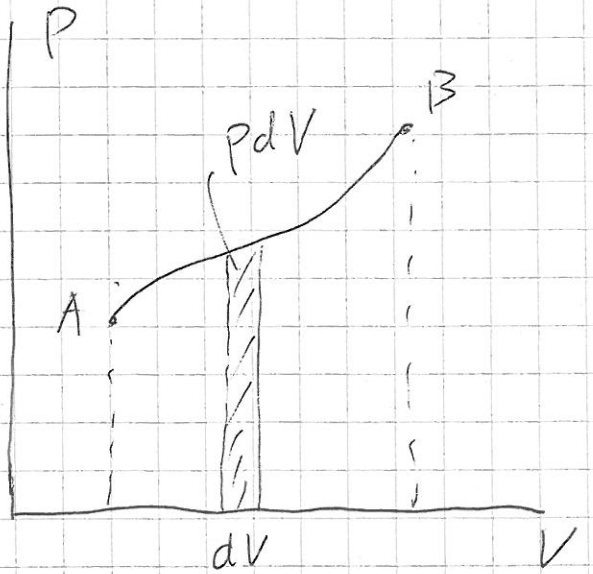
— Work done on the system

$$dW = -P\,dV$$ — True for expansion ($dV > 0$) and compression ($dV < 0$)

Total work done on the system during process ℓ (quasistatic from A to B).

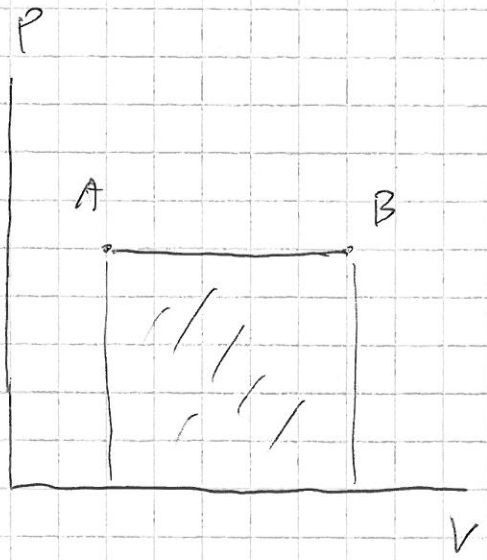
$$W = -\int_A^B P\,dV$$
(via ℓ)

(depends on path!)



$\int_A^B P\,dV$ = area under curve $P = P(V)$.

eg: Isobaric : $P_A = P_B = P = \text{const}$.



$$W = -\int_A^B P\,dV$$

$$= -P(V_B - V_A)$$

$$= -P\Delta V$$

expansion : $\Delta V > 0$. $W < 0$.

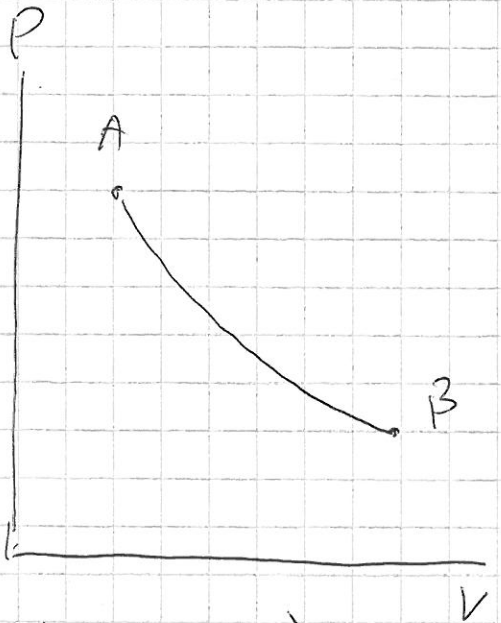
system does work to outside.

Compression : $\Delta V < 0$. $W > 0$

Outside does work on the system.

eg: <u>Isothermal</u> expansion of an ideal gas.

$$PV = \text{const} = NkT.$$



$$W = -\int_A^B P\,dV$$

$$= -\int_A^B \frac{NkT}{V}\,dV$$

$$= -NkT \ln\frac{V_B}{V_A}.$$

$\Delta U = \Delta\left(\frac{f}{2}NkT\right) = 0$. (No change in thermal energy)

$Q = \Delta U - W = NkT \ln\frac{V_B}{V_A}$. ($Q + W = 0$. i.e. $Q = -W$)

input heat = output work

- e.g. isochoric.

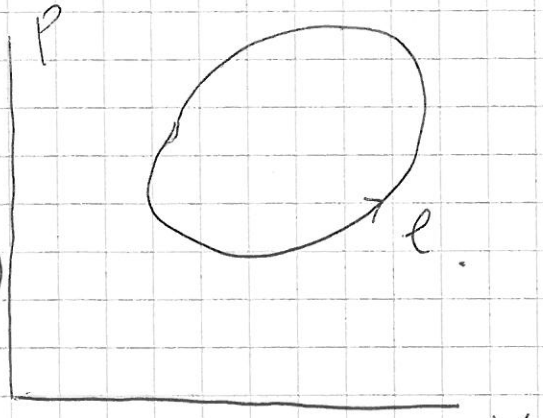
  $V = \text{const}$. $dV = 0$.

  $W = 0$.

  No displacement, No mechanical work!

- For a cyclic process, we have a closed loop

  $|W| = \text{area}$.



  CCW: $W > 0$.

  (compress work < expansion work)

  CW: $W < 0$.

  (expansion W > compression W)

- Again, since $W \neq 0$ for a loop.

  W is NOT a state property.

  (i.e., it depends on path!).

- Note: Adiabatic process — No heat exchange between system and the environment. $dQ = 0$.

  $\therefore dU = dW$

  (often fast) — be careful when it's not quasistatic!