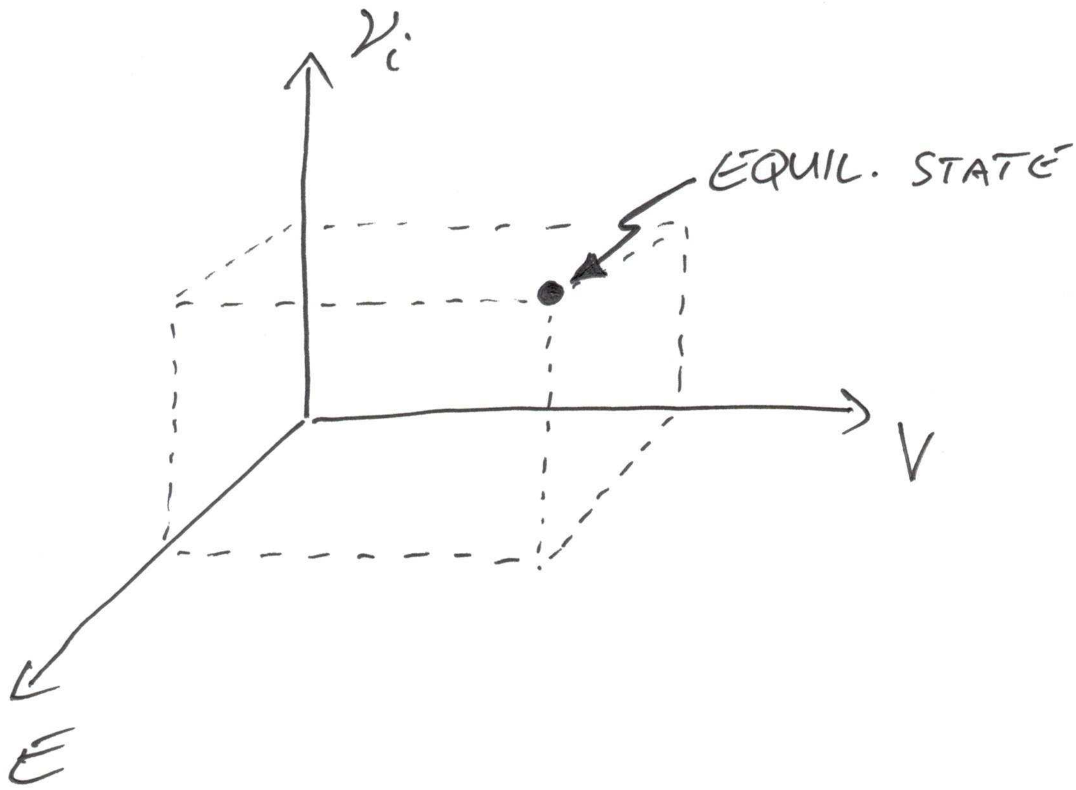
QUASISTATIC PROCESSES

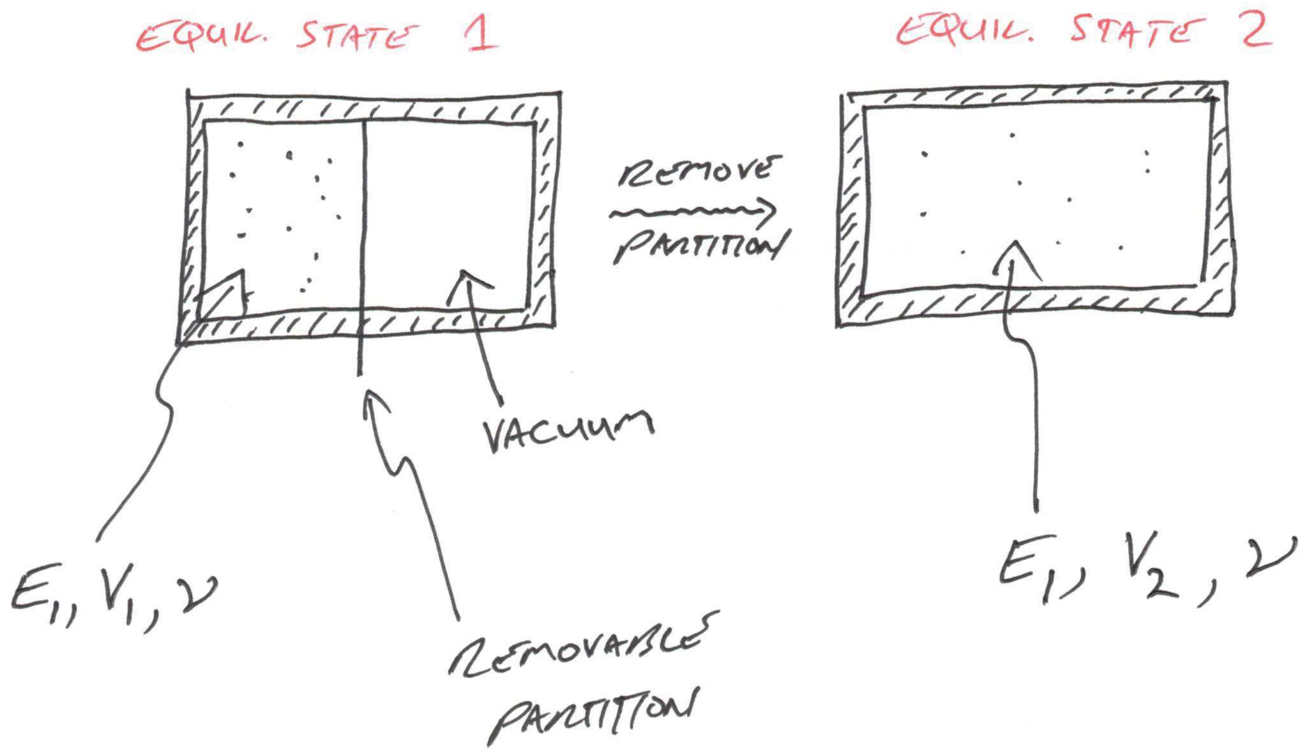
- GIVEN AN INDEPENDENT SET OF MACROSCOPIC VARIABLES USED TO COMPLETELY CHARACTERISE THE EQUIL. STATE OF A SYSTEM (eg E, V, ν_i) WE CAN VISUALISE A GIVEN EQUIL. STATE AS A SINGLE POINT IN A MULTI-DIMENSIONAL PARAMETER SPACE

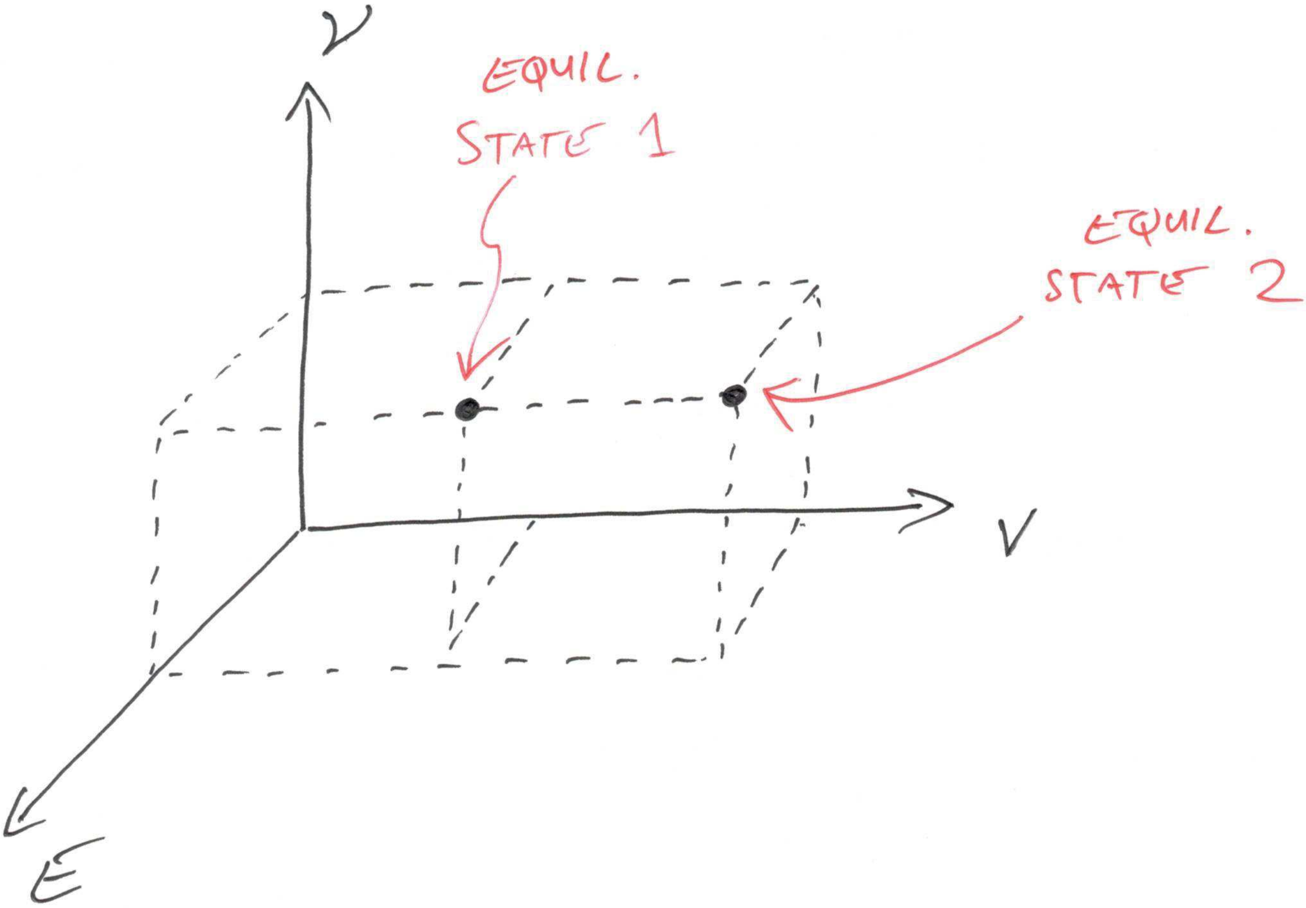


- EACH POINT IN THIS SPACE CORRESPONDS TO A DIFFERENT EQUIL. STATE OF THE SYSTEM.

- TO MOVE THE SYSTEM FROM ONE POINT TO ANOTHER, WE MUST DO SOMETHING (eg DO WORK ON THE SYSTEM, ADD HEAT TO THE SYSTEM, REMOVE A CONSTRAINT).

EXAMPLE : IDEAL GAS





- GIVEN TWO EQUILIBRIUM STATES THERE IS NO UNIQUE WAY FOR THE SYSTEM TO MOVE BETWEEN THEM — USUALLY WE CANNOT EVEN CONNECT THEM VIA A CONTINUOUS PATH IN PARAMETER SPACE

QUASISTATIC PROCESS : AN IMAGINARY PROCESS TAKING A SYSTEM FROM AN INITIAL EQUILIBRIUM STATE i TO A FINAL EQUILIBRIUM STATE f WHERE THERMAL EQUILIBRIUM IS ESTABLISHED AT ALL POINTS INBETWEEN. THIS TAKES AN INFINITE No OF INTERMEDIATE STEPS — CONTINUOUSLY PASSING THROUGH EQUIL. STATES. IT IS REPRESENTED BY A CONTINUOUS CURVE IN PARAMETER SPACE.

1^{ST} LAW OF THERMODYNAMICS

(CONSERVATION OF ENERGY)

- FOR A SYSTEM UNDERGOING A <u>FINITE</u> PROCESS FROM $i \longrightarrow f$

$$\boxed{\Delta E = E_f - E_i = W + Q}$$

1^{ST} LAW

CHANGE OF INTERNAL ENERGY OF SYSTEM

WORK DONE <u>ON</u> SYSTEM

HEAT ADDED <u>TO</u> SYSTEM

- FOR AN <u>INFINITESIMAL</u> PROCESS

$$\boxed{dE = đW + đQ}$$

"d-BAR" OR "d-SLASH"

CLAIM: FOR AN INFINITESIMAL QUASISTATIC COMPRESSION OR EXPANSION OF A SYSTEM

$$\boxed{đW = -p\,dV}$$

p - PRESSURE OF SYSTEM

$dV > 0$ FOR EXPANSION

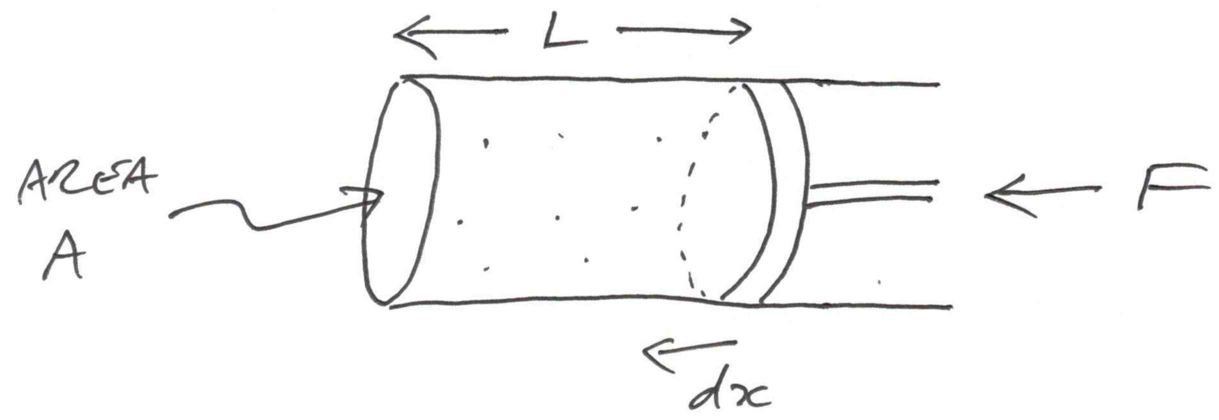
$dV < 0$ FOR COMPRESSION.

So $\quad dE = -p\,dV + đQ$

$$\Rightarrow \boxed{đQ = dE + p\,dV}$$

— 1^{ST} LAW QUASISTATIC

PROOF: COMPRESSION



$V = AL \qquad dV = -A\,dx$

WORK ON GAS: $\quad đW = F\,dx$

$$= \frac{F}{A} \cdot A\,dx$$

$$= \frac{F}{A}(-dV)$$

So $\boxed{đW = -\frac{F}{A}\,dV}$ — (1)

TO COMPRESS THE GAS WE REQUIRE

$$\boxed{F = pA + \varepsilon} \qquad \varepsilon > 0$$

$$\Rightarrow \quad đW = -\frac{(pA + \varepsilon)}{A}\, dV$$

IN THE LIMIT $\varepsilon \to 0$ (THE QUASISTATIC LIMIT) WE ARRIVE AT

$$\boxed{đW = -p\,dV}$$

THE MEANING OF d AND đ

$$dE = \text{đ}Q + \text{đ}W$$

d — A MATHEMATICAL OPERATION KNOWN AS A DIFFERENTIAL. THIS INDICATES AN INFINITESIMAL CHANGE IN SOME WELL DEFINED FUNCTION

dE — CHANGE OF INTERNAL ENERGY E

— EXAMPLE OF AN EXACT DIFFERENTIAL

$$dE = E_f - E_i$$

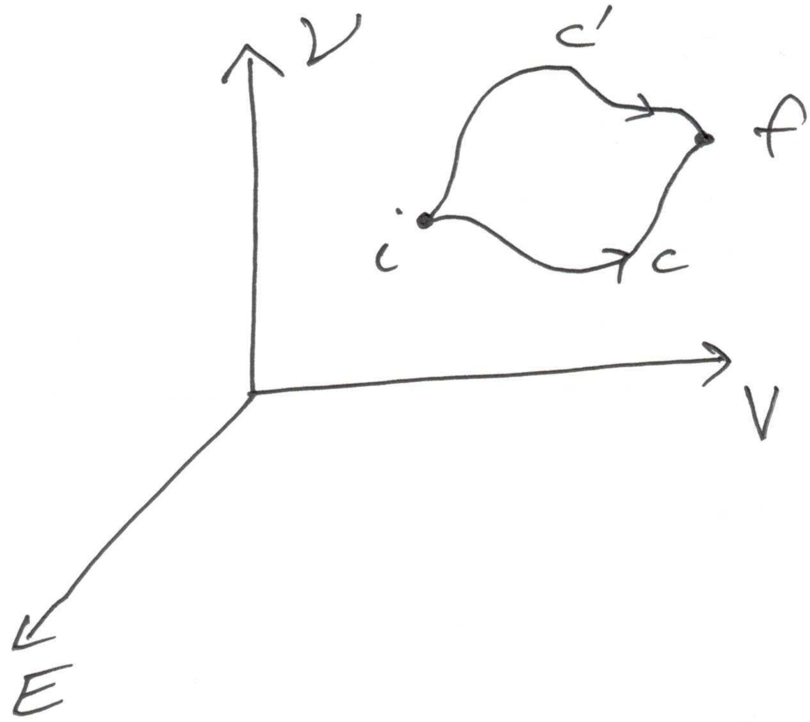
đ – INDICATES AN INFINITESIMAL AMOUNT OF SOMETHING, NOT THE CHANGE IN A FUNCTION.

$\text{đ}Q$ – NOT A CHANGE IN A "HEAT FUNCTION" (THERE IS NO SUCH THING) — JUST A SMALL AMOUNT OF ADDED HEAT

$\text{đ}W$ – SMALL AMOUNT OF WORK

$\text{đ}W$ & $\text{đ}Q$ ARE EXAMPLES OF INEXACT DIFFERENTIALS

IN TERMS OF INTEGRALS



$$\int_{c} dE = \int_{c'} dE = E_f - E_i$$

PATH INDEPENDENT

(THIS IS THE FUNDAMENTAL THEOREM OF CALCULUS)

BUT:

$$\int_{c} đW \neq \int_{c'} đW$$

NOT PATH INDEPENDENT

(DEPENDS ON THE PROCESS)