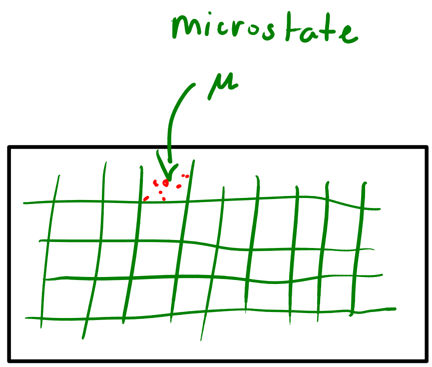
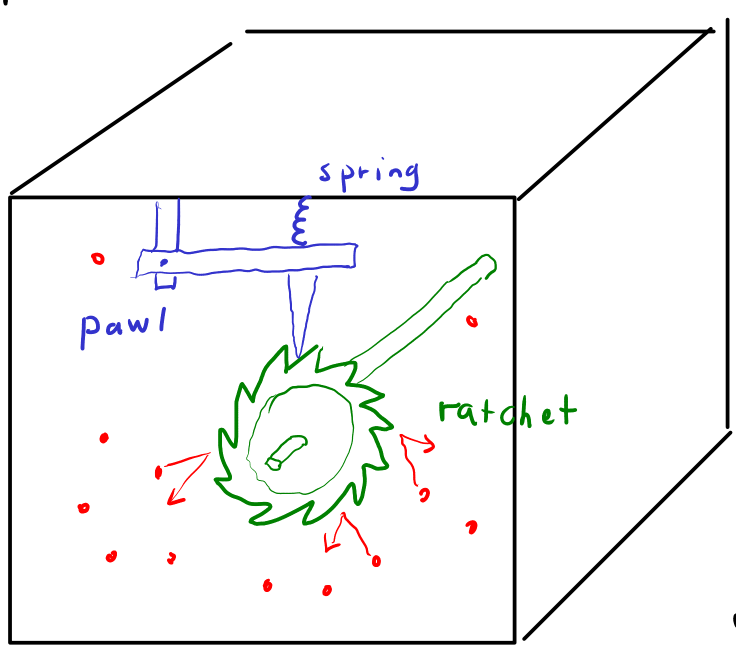
Rule of thumb: if a system has many particles ("degrees of freedom") + if they are "strongly" interacting $\Rightarrow$ assume ergodicity + mixing



$$p_\mu(t) \xrightarrow[t\to\infty]{} p_\mu^s = \frac{1}{\Theta(E)}$$

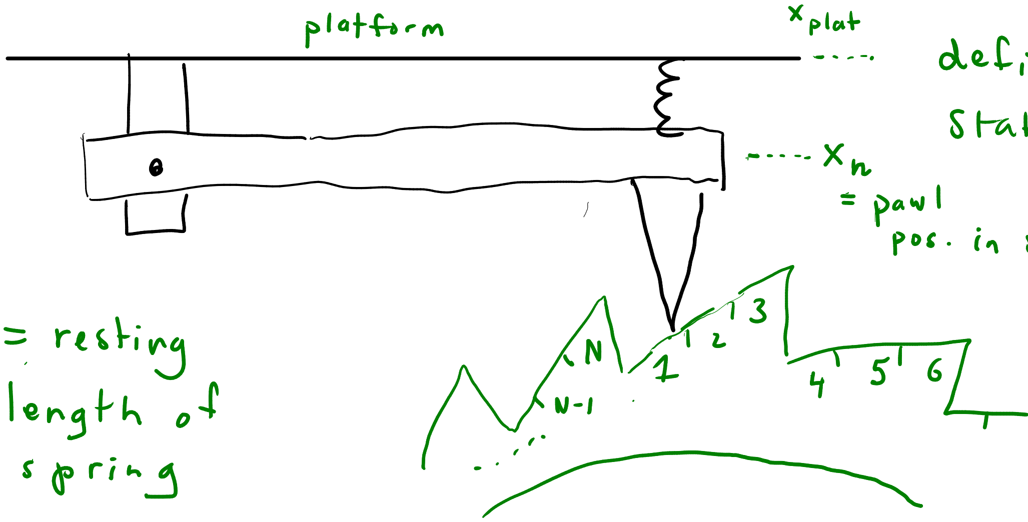
$\Theta(E)$ = # of microstates on surface w/ total energy E

Example: Feynman's ratchet + pawl



- total system is isolated (total energy is conserved)
- assume the total system is ergodic + mixing
- choose a focus:

total = system (ratchet + pawl) + environment (gas in box) define system states $n = 1, \ldots, N$



L = resting length of spring

$$E_n = \text{sys. energy in state } n$$
$$= \frac{1}{2} k \left(x_{plat} - x_n - L\right)^2$$

conserved (indep. of sys. state)

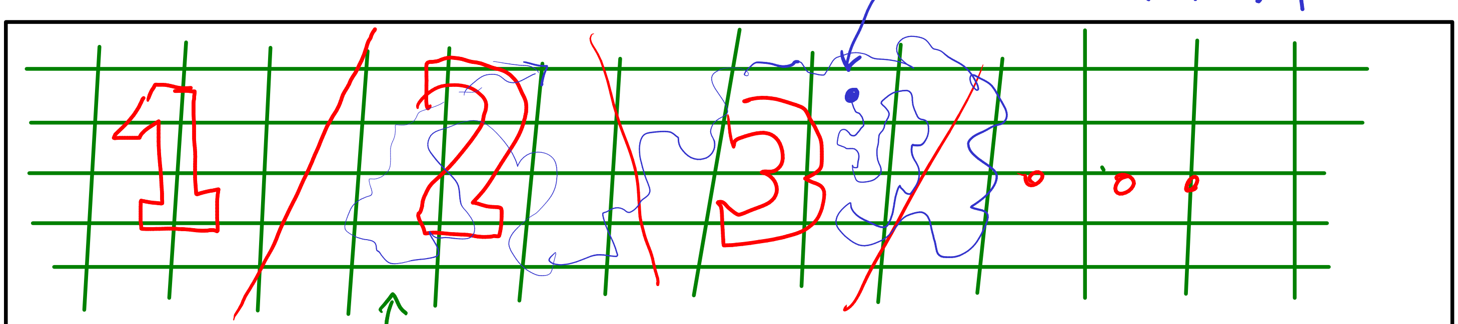
$$E_{tot} = E_n + E_n^{env}$$

total energy when sys. is in state n

energy of environ. when sys is in state n (stored in gas in the box)

cartoon of phase space:

point: configs of gas, ratchet, pawl



"macrostate": region representing all configs where sys. is in one state

"microstate": box of pts representing similar configs (volume a)

whole surface: all pts with same E_{tot}

ergodicity & mixing:

$$P_\mu(t) \xrightarrow[t\to\infty]{} \frac{1}{\Theta(E_{tot})} \equiv \frac{1}{\Theta_{tot}}$$

Θ_{tot} ↓ total # of microstates ("boxes")

Θ_n = # of microstates in macrostate n (# boxes of vol. a in each region)

(could be diff. depending on n since E^{env}_n changes w/ n ⟹ possible config. space of environment)

$$\Theta_{tot} = \sum_{i=1}^{N} \Theta_n$$

N = # of macrostates

assumptions:

- environment has many more degrees of freedom than sys:

  $\Theta_n >> N$

  $\Theta_{tot} >> N$

  gas has many possible configs, etc.

- mixing is fast
- dynamics of exploring within a macrostate happens faster than transitions b/t macrostates

$\Rightarrow$ prob. of visiting next macrostate depends at most on the current one ("memory" of deeper past is lost, b/c of chaotic mixing dynamics)