Lecture 1 - Intro to Stat Mech

(1) Macrostate : defined by thermodynamic variables : $p, T, U, V, \ldots$

(2) Microstate : defined by positions, velocities, spin, ... for each particle (atom / molecule)

↳ Accessible microstate : associated macrostate consistent with wider system (i.e.)

(3) Single particle state (SPS) : one particle state, ignoring all others

3 Types of States

Distinguishability : Can we put a label on each particle?

Billiards: yes

Gas: no ← if we distinguish when simulating we are not reflecting reality

If gas particles are indistinguishable.

1 micro state : $(\vec{r}_1, \vec{v}_1, \vec{r}_2, \vec{v}_2, \vec{r}_3, \vec{v}_3, \ldots)$
$(\vec{r}_2, \vec{v}_2, \vec{r}_1, \vec{v}_1, \vec{r}_3, \vec{v}_3, \ldots)$ } same microstate

Postulates of Statistical Mechanics

1. Microstates exist
2. Energy is conserved
3. Any closed system in equilibrium is equally likely to be in any of its accessible microstates ← we assume this, but it's still a hypothesis

↓

let's us def the STATISTICAL WEIGHT

Statistical Weight :

W_i : sta n° of accessible microstates

$$P(\text{macrostate } i) = P_i = \frac{W_i}{\text{Total n° of microstates}}$$

ex1

Deck of cards

- Microstate: Queen of clubs
- Macrostate → suit → clubs
  → card of any suit → queen

(1) $W_{clubs} = 13$, $P_{clubs} = \frac{\text{n° clubs}}{\text{n° cards}_{tot}} = \frac{1}{4}$

(2) $W_{queen} = 4$, $P_{queen} = \frac{1}{13}$

How likely are U to draw a club against a queen?

$$\frac{P_{clubs}}{P_{queen}} = \frac{W_{clubs}}{W_{queen}} = \frac{13}{4} = 3.25$$

ex2

$N_{coins} = 10$

- Macrostate n n° of tails
  $n = 0, \dots, 10$ (1 variable)
- Microstate : sequence TH…
  (10 variables, with 2 value per var)

SPS one coin H or T (1 var)

Weight $W(n)$ ← Binomial series

$$W(n) = {}^N C_n = \frac{N!}{n!(N-n)!}$$

$W(5) = 252$

$W(10) = 1$

How many sequences are there to get 5 or 10 tails?

$$\frac{P(5)}{P(10)} = 252 \quad , \quad P(5) = \frac{W(5)}{2^{10}} = 25\%$$

$P(10) = 0.1\%$