(26) Chem 220b 2023-01-17 Tu Th 2-3:30 (1a)

INTRODUCTION TO STOCHASTIC THERMODYNAMICS "STATISTICAL MECHANICS"

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ADITYA SINGH

What matters Now
→ Dynamics
→ Small systems

80% of talks!

1 Information Theory

2 Thermodynamics - Relations; physics of information
work, heat, energy, entropy, free energy, thermo equilibrium
physics of information.

3 Fluctuation Theorems

4 Linear Response

5 Dynamics DTMC, CTMC, Classical, Langevin, MD, Quantum

6 Advanced Topics

7 Guest Lectures - Contemporary Stat Mech.

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→ Discussion sections
Office Hours

Prerequisites

- Equilibrium Thermodynamics / :)
- stat. Mech
- Quantum
- Linear Algebra
- Code (elementary school level)

OFFICE HOURS

319A Gilman

Tu 11–12
Th 3:30 – 4:30

Discussion Sections

GRADING

~7-8 Homeworks
~ 65%

35% - Field report
on a topic of your choosing
Due in reading week

2^{30} $P(\text{one}) \approx 1$

$\ln 10^{30}$

$\ln 10^{30} \approx \ln e^{70}$

≈ 70

Coin flip

- Coin
- flip Heads or tails
- what's the probabilities. Heads or tails?
  what assumptions are you making

→ flip & Lick.

→ what the probabilities

Digression a frequentist

→ look at coin

what's your probability? what's mine.

I tell you Lucas? what's your probabilities

→ ~~information~~

E. T Jaynes - Great proponent of Bayesian reasoning.

subjective, versus objective

Probabilities are not a property of the system But of what we Know (Contextual)

How we Know

$0 \leq P(a) \leq 1$ $\quad P(\text{coin is heads}) \neq$ $\quad P(\text{true}) = 1$, $P(\text{false}) = 0$

(Probabilities are numbers representing degrees of plausibility

$P(\text{heads}) = 1/2 \quad P(\text{tails}) = 1/2 \quad \sum_c P(c) = 1$

$c = \{\text{heads}, \text{tails}\}$

(Why $1/2$? Permutation symmetry $P(x) = \frac{1}{N}$)

Probabilities arguments are logical statements.

~~Ensemble (Probability space)~~

So

Sample space $a_1\ a_2\ a_3 \ldots$

Ensemble (Probability Space) A set of propositions $\mathcal{A}_A = \{a, b, c \ldots\}$

Dice = 1 2 3 4 ...

This Dice is $\frac{1}{6}$ $P_A(a)$ $P(A=a)$ $P(a)$

↑ Random variable

	C	$\bar{C}$
	?	?
	?	?

Count

→ A

B

	0	1	
0	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{2}$ Probabilities
1	$\frac{1}{2}$	0	$\frac{1}{2}$

$P(a) = \{\frac{1}{2}, \frac{1}{2}\}$

$P(b) = \{\frac{3}{4}, \frac{1}{4}\}$

Joint ensemble A, B

Joint Probability $P_{AB}(a, b)$ $P(a \text{ and } b)$

	Bool		
a and b	ab	$a \vee b$	a, b
a or* b	$a+b$	$a \wedge b$	
not a	$\bar{a}$	$\neg a$	

* logical or

$$P(a \text{ or } b) = P(a) + P(b) - P(a \text{ and } b)$$

$$P(a=0 \text{ or } b=1) = 1/2 + \frac{1}{4} - 1/4 = 1/2$$

Independence $P(a,b) = P(a)\,P(b)$

$$\begin{pmatrix} 3/8 & 1/8 \\ 3/8 & 1/8 \end{pmatrix}$$

~~Bayes~~

Conditional Probability: ~~$P(b|a) =$~~

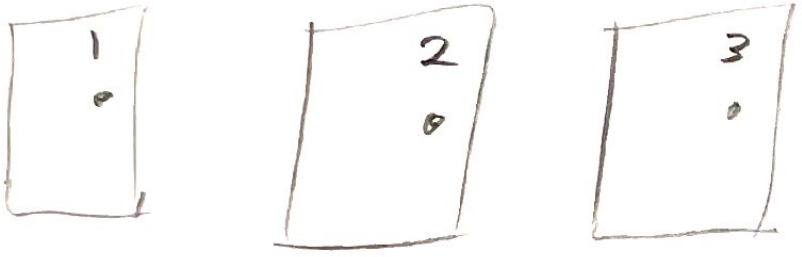
$P(a|b) =$ chain rule / product Rule

$P(a,b) = P(a|b)\,P(b) = P(b|a)\,P(a)$

$P(a|b) = \dfrac{P(b|a)\,P(a)}{P(b)}$ Bayes' Rule

Probabilities depend on what you know.

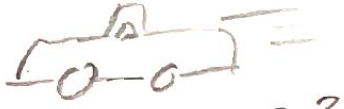
Monty Hall Problem



Pick #1

Monte opens

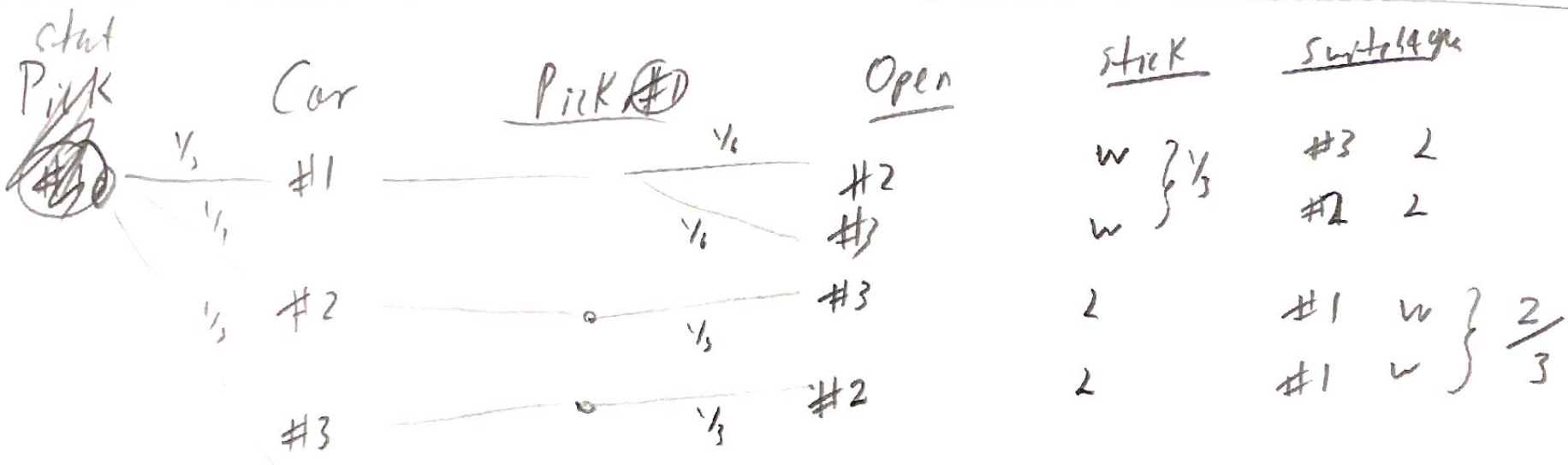
Prize behind one door.



1, 2, or 3?

1) stick
2) switch
3) Dosn't Matter

I vote!



Why do people get this wrong?

The car does not move? So how does Monty even make a difference?)

P(car loc. | monte opened door b, I picked door a)

Probabilities are contextual

Reading → Monty Hall problem (e.g. Wikipedia)

Information Theory (ch 2 of Thomas & Cover)

Extra Card problem

Probability a 30 digit number is Prime?

$$P(\text{Given } N \text{ is Prime}) \simeq \frac{1}{\ln N} = \frac{1}{\ln 10^{30}} = \frac{1}{\ln e^{70}} \sim \frac{1}{70}$$

Prime number Theorem

→ Probabilistic Tests

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