



Victory Lap

CSE 312 Summer 21
Lecture 25

Content

Combinatorics (*fancy* counting)

Permutations, combinations, inclusion-exclusion, pigeonhole principle

Formal definitions of Probability

Probability space, events, conditional probability, independence, expectation, variance

Common patterns in probability

Equations and inequalities, common random variables, tail bounds

Continuous Probability

Density, sample distributions, Central Limit Theorem, Estimating probabilities

Applications

Across CS

Themes

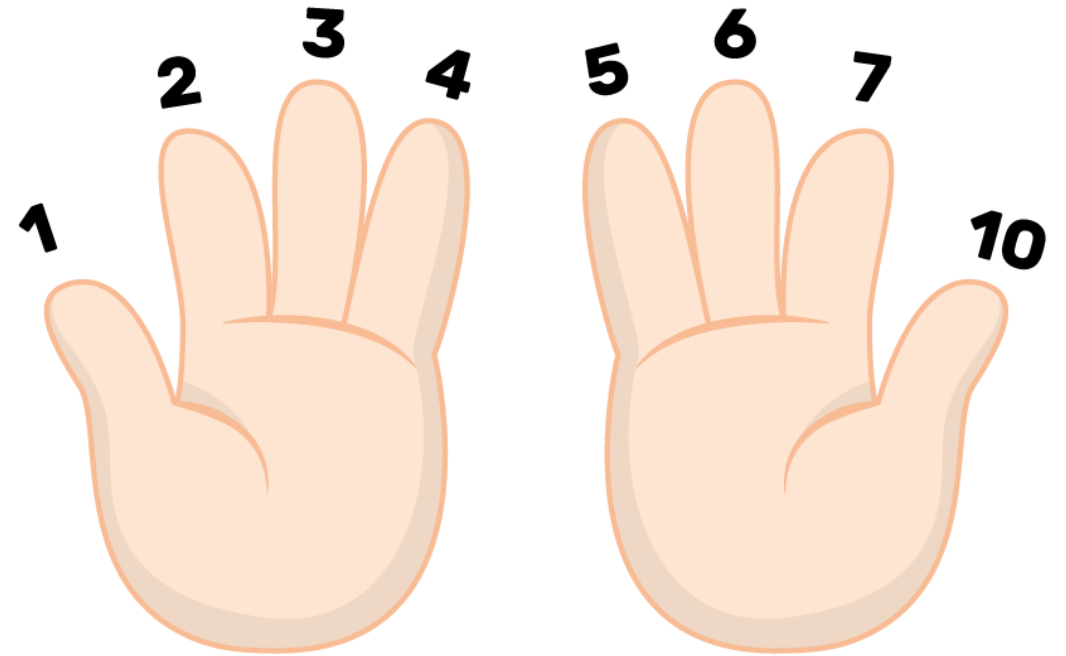
Precise mathematical communication
Both reading and writing dense statements.

Probability in the “real world”
A mix of CS applications
And some actual “real life” ones.

Refine your intuition
Most people have some base level feeling of what the chances of some event are.
We’re going to train you to have better gut feelings.

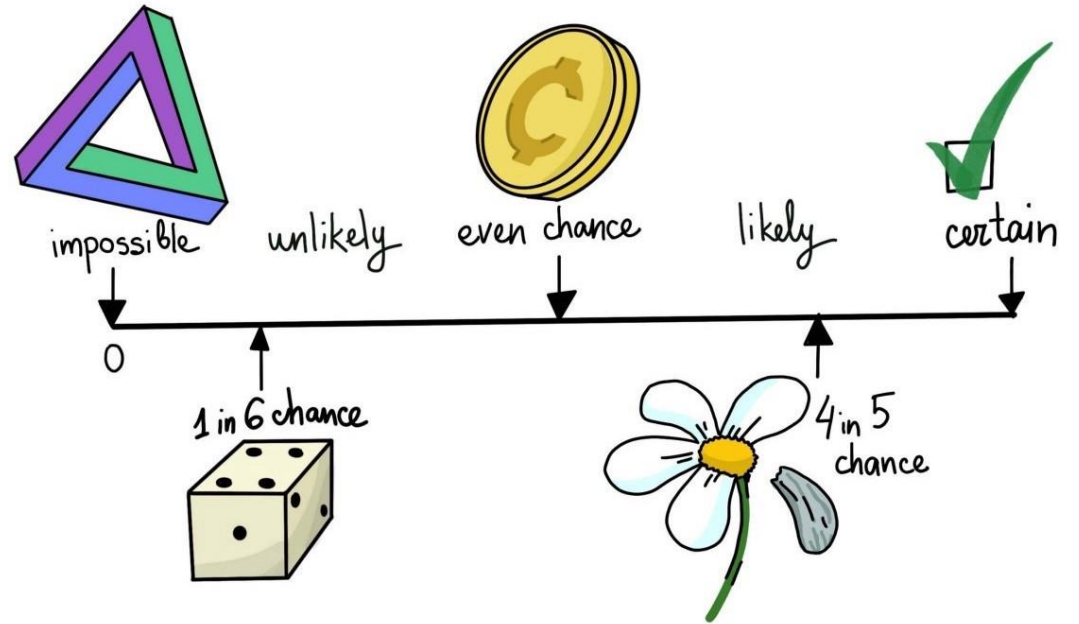
Combinatorics

- Sum and Product Rule
- Permutations and Combinations
- Complementary Counting
- Binomial Coefficients
- Principle of Inclusion-Exclusion
- Pigeonhole Principle
- Stars and Bars
- Combinatorial Proofs



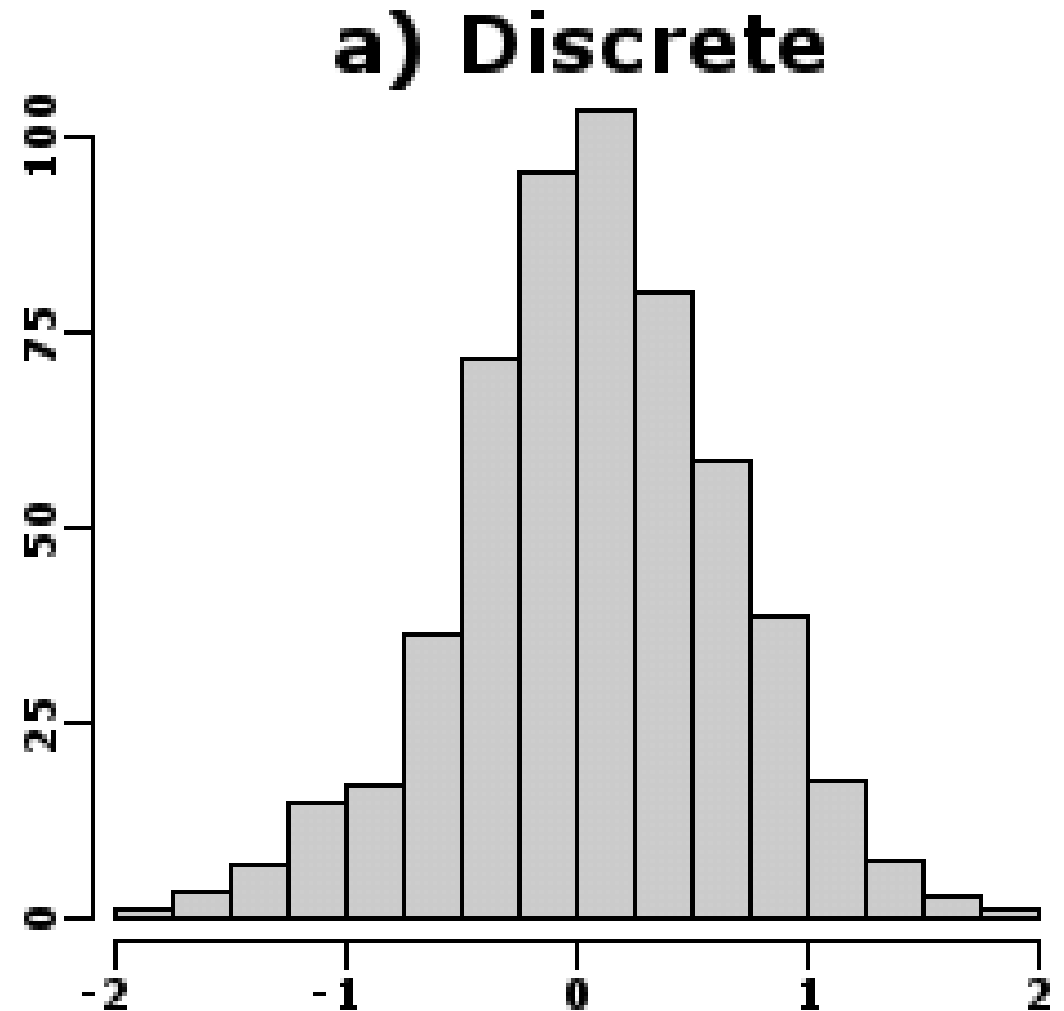
Discrete Probability

- Axioms of Probability
- Equally Likely Outcomes
- Conditional Probability
- Bayes Theorem
- Law of Total Probability
- Chain Rule
- Independence
- Conditional Independence



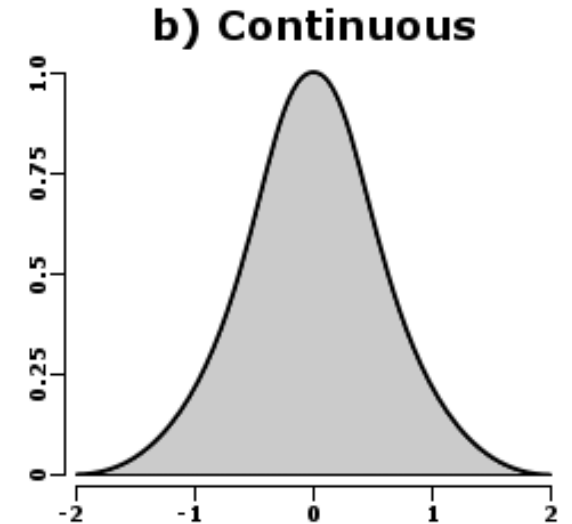
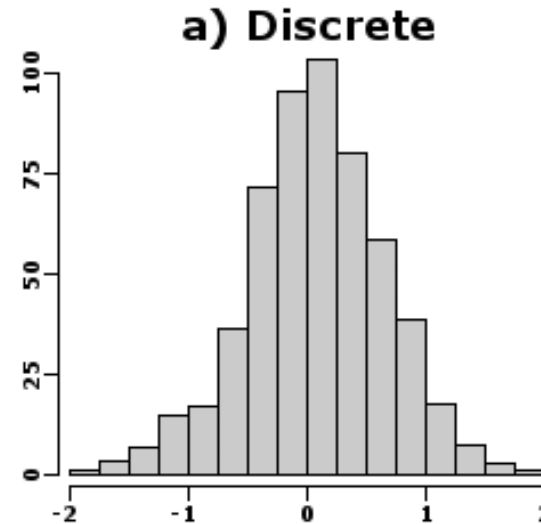
Discrete Distributions

- Probability Mass Function
- Expectation
- Indicator Random Variables
- Linearity of Expectation
- Variance and Standard Deviation
- LOTUS (Expectation of a function $g(X)$)
- Independence of RVs
- Zoo of Distributions



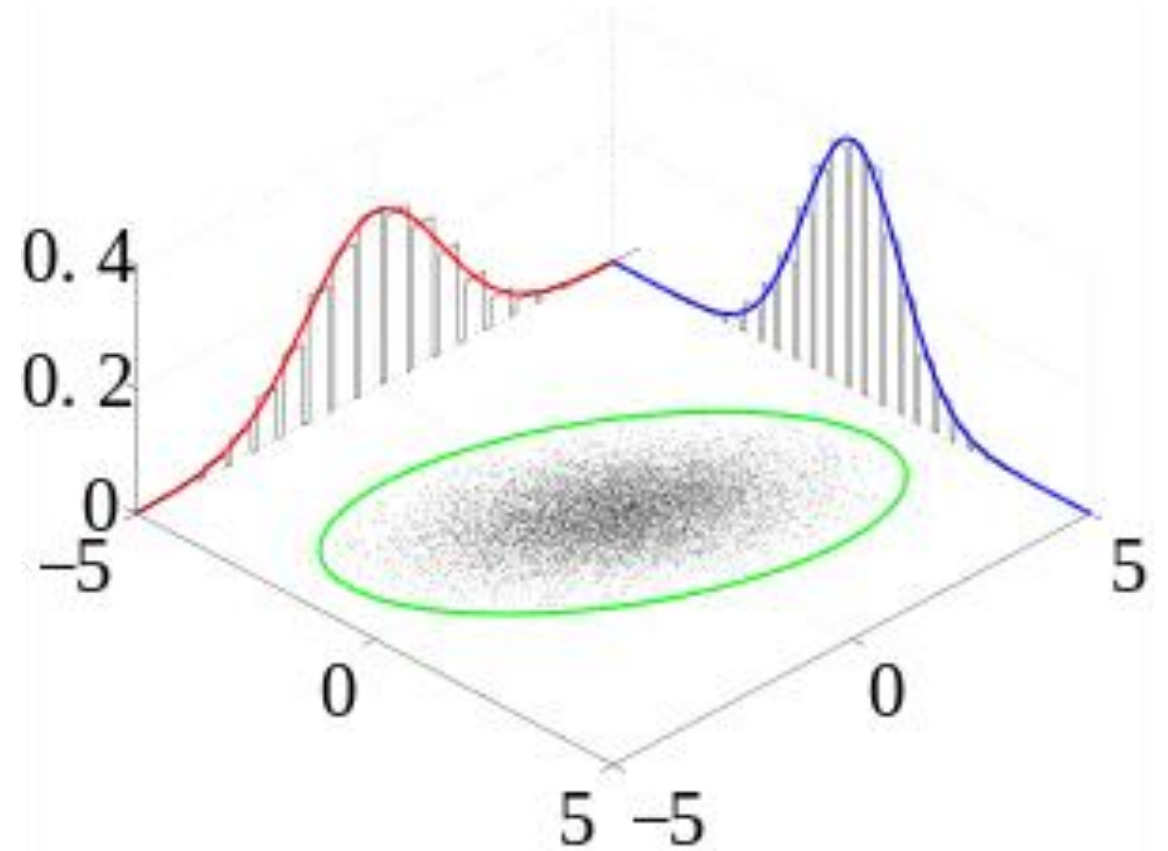
Continuous Distributions

- Probability Density Function
- Cumulative Distribution Function
- Zoo of Continuous RVs
- Normal Distribution
 - Standardizing
 - Linear Transformation
 - Sum of Normals \rightarrow Normal



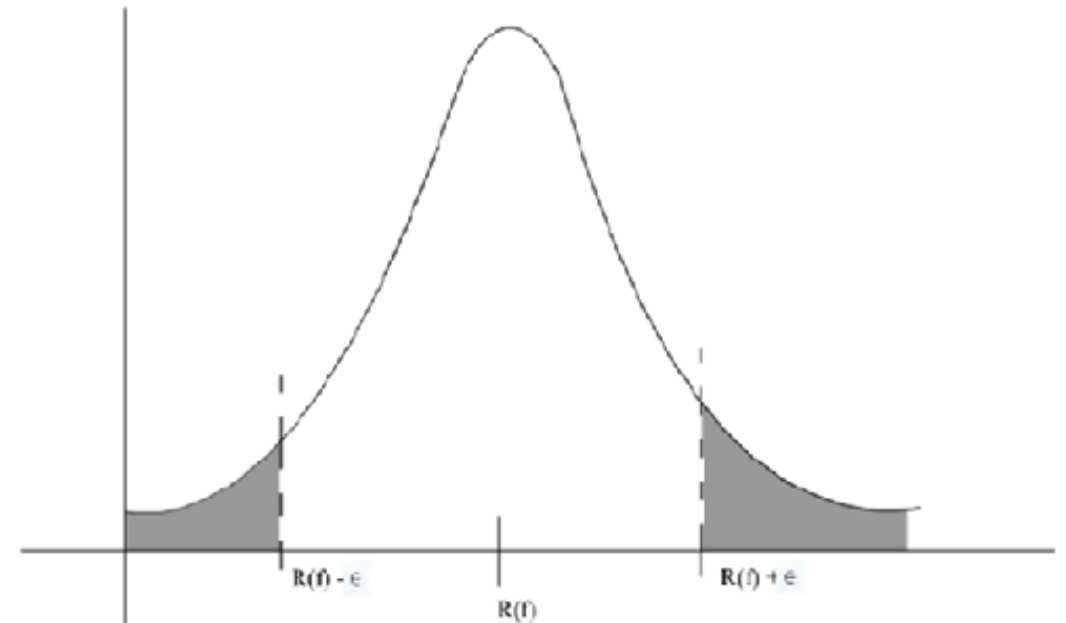
Multiple Random Variables

- Joint PMFs / PDFs
- Marginal PMFs / PDFs
- Conditional PMFs / PDFs
- Law of Total Expectation
- Covariance
- Central Limit Theorem



Tail Bounds or Concentration Inequalities

- Markov's Inequality
- Chebyshev's Inequality
- Chernoff Bound
- Union Bound

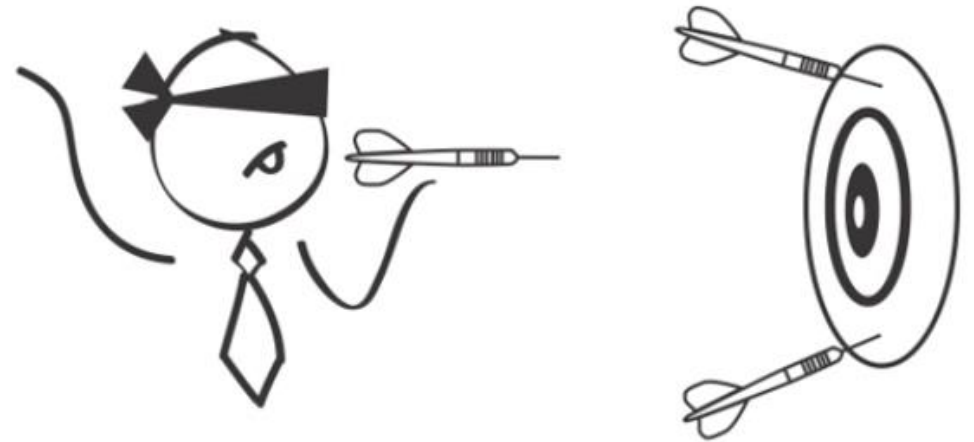


Estimation

- Likelihood
- Log-likelihood
- Maximum Likelihood Estimation
- Two Parameter Estimation
- Bias

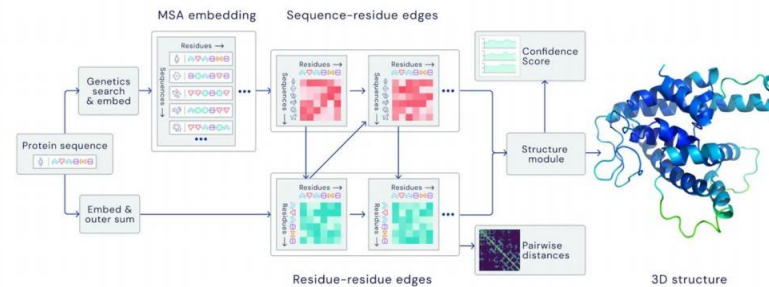
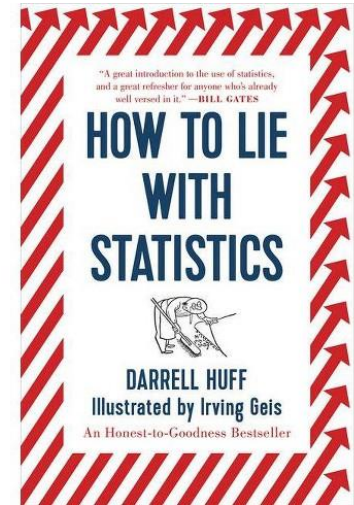
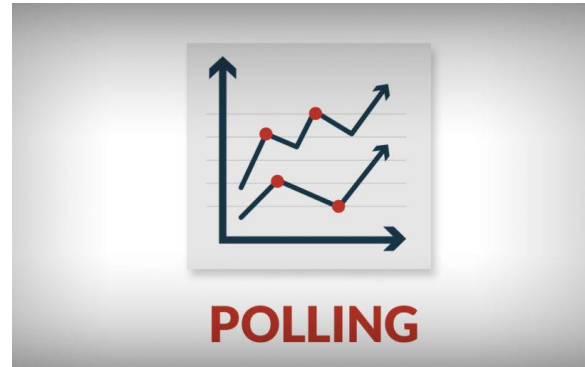
Estimation

The fine art of guessing



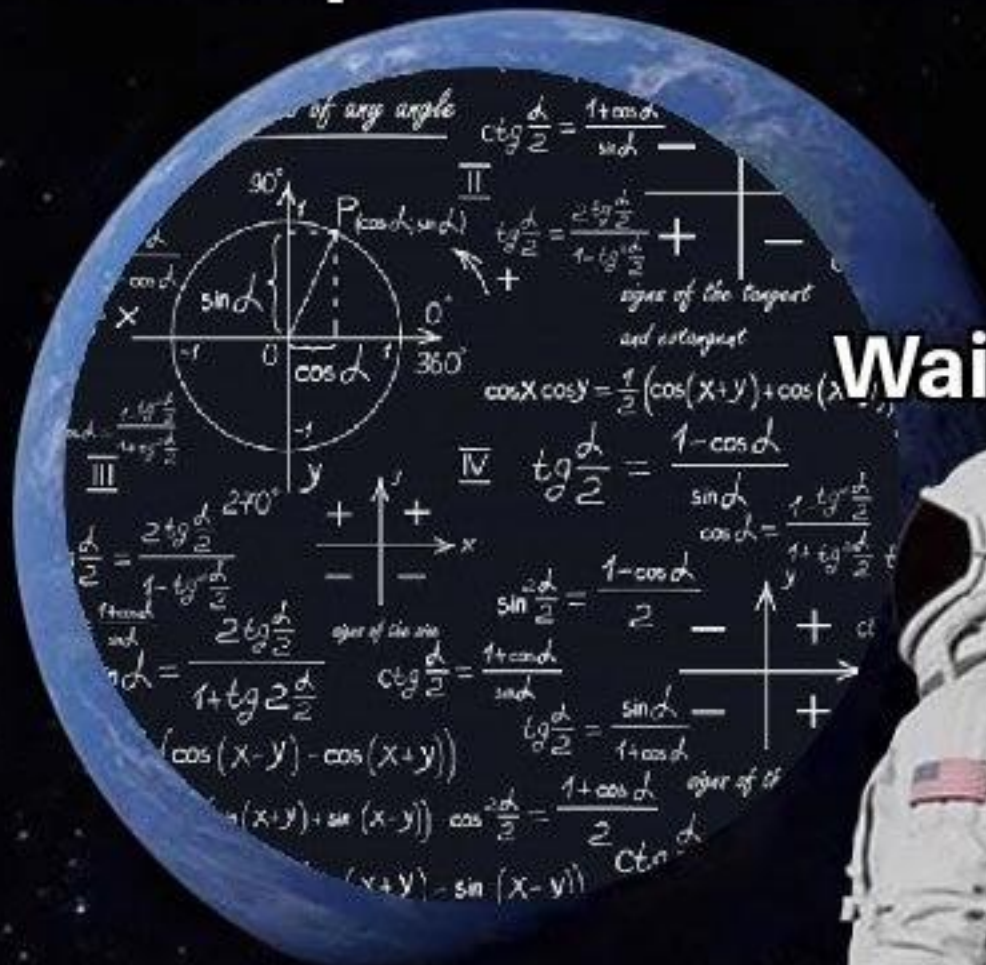
Applications

- In Lecture
 - Polling
 - How to Lie with Statistics
 - Protein Synthesis
- Assignments
 - Spam Filtering
 - Vaccine Efficacy
 - Distinct Elements



Computer Science

Always has been



Wait, It's all math?



Technical Skills Learned

- LaTeX
 - Difficult to start with
 - Very useful for Computer Scientists
 - Needed for Technical Writing and research papers
- Python
 - Understanding some libraries like numpy
 - Less wordy than Java
 - Most Data Science courses use Python

TEX



Use Your Powers Wisely

We've seen probability can be used in the real world!

But also, that:

It can be counter-intuitive / hard to explain (Bayes Rule/Real World 1)

Probability estimates can depend on the model you're using (Real World 2)



What to take next?

CSE 446 ML – using probability, linear algebra, and other techniques to extract patterns from data and make predictions.

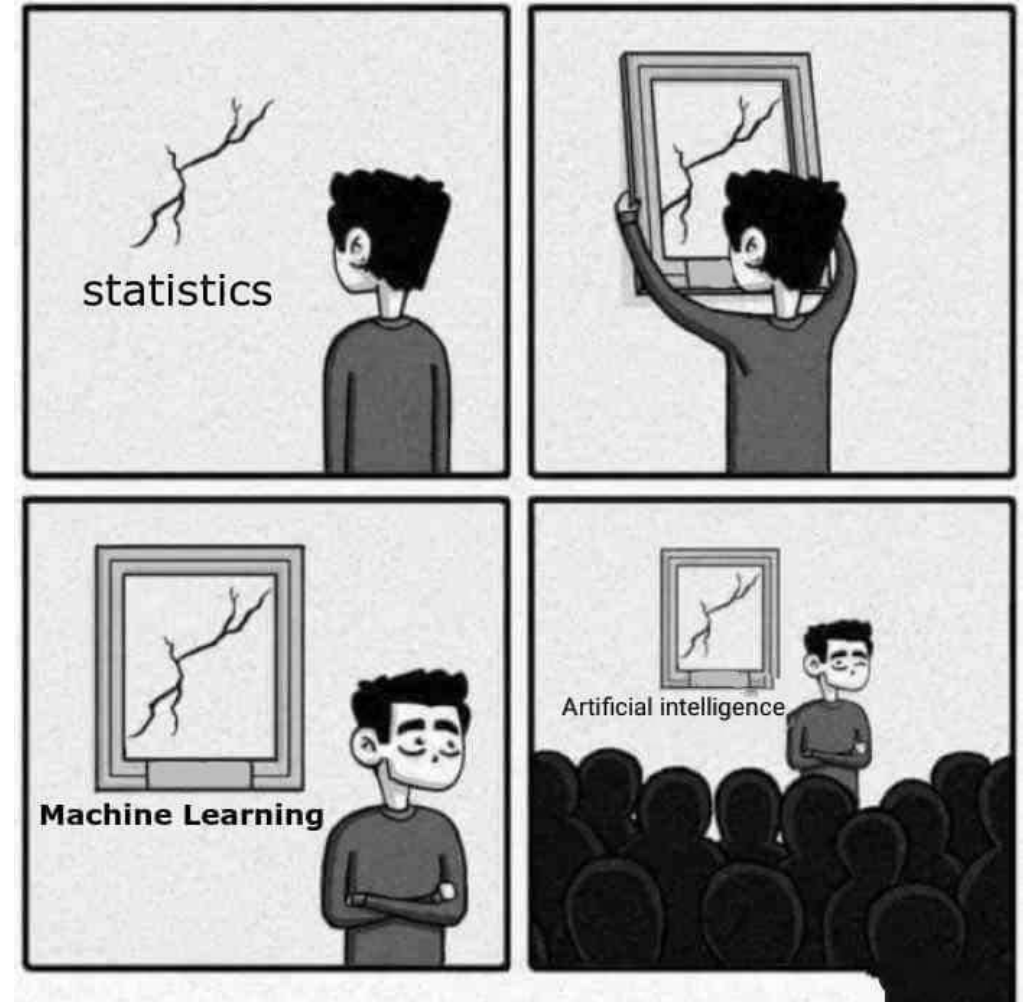
CSE 421 designing algorithms – very little direct probability, but the combinatorics we did at the beginning will be useful.

We also have a graduate level course in randomized algorithms which will utilize more of the content covered in 312, but it has a few more prereqs

CSE 447 Natural Language Processing

CSE 490C Cryptography

Other things!



Parting Thoughts

This course is always a grind in the way we move from topic to topic.

You made it through over a year into a pandemic

Over zoom

Completing

- 7 Problem Sets
- 3 Review Summaries
- 2 Real World mini-projects
- 27 Concept Checks
- **And a Final!!!**

Parting Thoughts

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Thank you!

Thank you all for a great quarter!

This course would not have been possible without our amazing TAs!!



IT'S BEEN AN HONOR



FAREWELL BUT NOT GOODBYE

