Probability with Engineering Applications [Sp26]

ECE 313

Agenda

Course staff – Instructor & TA

Course logistics

Website, grading, HW, etc.

Course content + course Teaser

Am I in the right class?

Technical contents

Course staff - Instructor

Yu-Lin Wei

https://yulinlw2.web.illinois.edu/

UIUC Ph.D. at ECE

Research area

acoustic signal processing, IoT,
wireless/ visible light communication, indoor positioning,
applied machine learning

Course Logistics

Webpage: https://courses.grainger.illinois.edu/ece313/sp2026
Office Hour: Wednesday 10AM-11AM @ ECEB 3034

Course Load: 12-13 weekly HWs + 2 midterms + 1 final
Grading Policy: 15% HW + (15-30%) midterms + (35-40%) final
Only **highest 10 HWs** will be counted

Refer to the course website for MUCH more details
https://courses.grainger.illinois.edu/ece313/sp2026

AI-policy: Treat it as your (smart?) classmate

Course Logistics (2)

Lecture

- Core concepts + clear examples
- **Engaging > Idea > Details**

HWs

- Need extensive efforts, some “**twists**” to class examples
- Same with lecture pace

Exams

- Harder than lecture but easier than HW
- Avoid unseen solving skills

Textbook

- Smooth learning. Strongly recommend if you miss lectures
- Useful when doing HWs

FLEX feedbacks last semester

- HW + textbook + short answer questions
- Find your own way – Lecture and/ or textbook

Comments
I recommend reading the textbook, doing the short–answer questions, and watching their solution videos before doing the homework to make sure you understand the material. If you still don't understand the material, do the even–numbered questions in the textbook and check your answers until you are ready to do the homework.
just study. It's not hard.
Strongly recommend this professor, the course is much more well designed than it used to be
do the homeworks thouroghly
Study a lot
I would say just keep up with the flow of the course and make sure to go back to the homeworks and retry them before exams. Make sure to understand the homeworks completely.
Read the textbook.
Attend lectures + take notes, reference textbook when confused
Read the textbook, do as many practice problems as possible, and attend as many lectures as possible.

Lecture style

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Slido (https://www.slido.com/)

- This section will use Slido for some interactions!

Notes

- Fill-in the blank style like this
- Pre notes/ Post notes will be made available on the website
- Easy to focus, Harder to write from scratch
- Questions/ Interruptions welcomed!

No recordings

Other sections (sections B & C)

- Same HWs/ same exams/ similar paces

Am I in the right class?

- What is probability
- Why should I know probability?
- What to expect in 313
- Probability vs. statistics

Agenda

Foundations (Ch 1.1)

- What is probability
- Why should I know probability
- What to expect in this course

Probability Event (Ch 1.2)

- Terminologies
- Karnaugh map
- De Morgan’s Law

What is probability?

- Textbook
  - Roll dices
  - Balls in bins
- Real-world things
  - Poker games
  - Rainy/ Sunny
- Engineering problems
  - Prediction
  - Modeling
  - Generation

Why should I know probability?

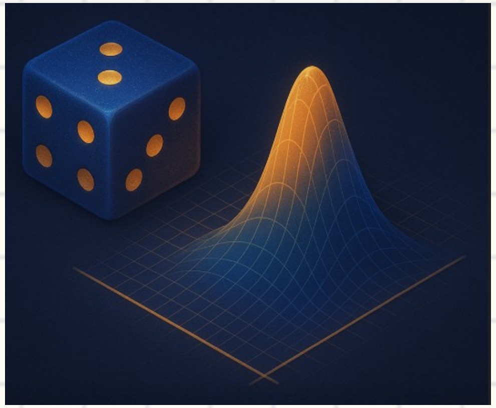
- Common in our daily life
  - Probable, maybe, unlikely, …
  - What's the chance that I'll get an A?
  - How likely is it going to rain if
    - 50% humidity?
    - Given I'm at Chicago?
    - And it's summer?

- Reasoning the events
  - Why am I always waiting for late buses?
  - Why are my friends more popular than me?
  - Why is everyone so calmed when the fire alarm beeps?

Why should I know probability (ECE)?

- Circuits - Thermal noise in circuits
- Communication - RF signal detection
- Network – packet drop rate, flow control
- Reliable systems – Failure rates
- ML – Variational inference
- And many others…

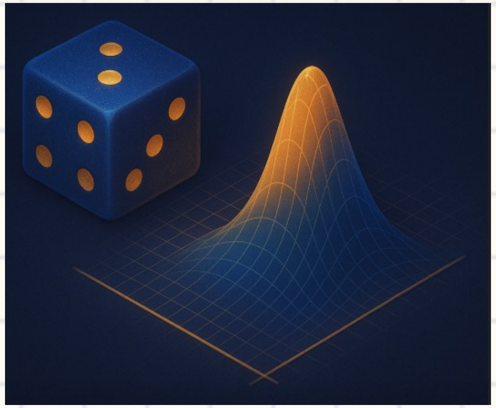
What to expect in 313



- You will learn
  - Describe a probable event
  - Assume ideal cases
  - Compute the probability
  - Examples

- NOT covered but important
  - Formulate a probability problem
  - Application-depend approach

Probability vs. Statistics



- Similar, but there are some differences
  - Probability assumes a model (precisely), statistics inference from data
  - What's the probability of 6 Head out of 10 tosses on a fair coin?
  - We got 6 Head out of 10 tosses on a coin, is the coin a fair coin?
    - I have 95% confidence it's fair

Slido!

Which options are probability related?

A. Average and variance of heights of students

B. Whether a customer will click the ad

C. Best move for tic-tac-toe

D. Best move for Go

E. Best route from ECE building to Union today

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How to describe/ define a probability event?

Probability Terminologies

- Experiments
  - Toss a fair coin
- Outcome
  - {Head} or {Tail}
- Trials
  - Do this x times – x trials

Sample space

- The set of possible outcomes of an experiment is called a sample space Ω of the experiment

- For example :
  - Tossing a coin $\Omega = \{H, T\}$
  - Rolling a die $\Omega = \{1,2,3,4,5,6\}$
  - Measuring a noise voltage $\Omega = [-5V, 5V]$

Event

- A subset of the sample space Ω

- Experiment of rolling a fair die
  - What's the probability that the outcome is odd?

$\{1,3,5\}$ out of $\{1,2,3,4,5,6\}$

  - We call this odd subset an " event "
  - $A = \{ \quad 1,2,3 \quad \}$ are events happen on a sample space $\Omega = \{ 1,2,3,4,5,6 \}$

We are ready to describe!

Roll two fair dices, what's the probability that you get a "Pair" (two of the same kind)

$$\Omega = \left\{ \begin{matrix} [1,1] & \cdots & [1,6] \\ \vdots & \ddots & \vdots \\ [6,1] & \cdots & [6,6] \end{matrix} \right\}$$

$|\Omega| = 36$

$$A = \{[1,1], [2,2], \cdots, [6,6]\}$$

$|A| = 6$

If every outcome is equally probable , $P(A) = \frac{|A|}{|\Omega|} = \frac{6}{36} = \frac{1}{6}$

How should we define the outcome?

$A_3 = \{[1,5] \cdots [5,1]\}$

Roll two fair dices, what's the probability that the sum is ~~7~~ 6

$\Omega_1 = \{2, 3, \cdots, 12\}$ $|\Omega_1| = 11$

$A_1 = \{7\}$

$|A_1| = 1$

Ω_1 is NOT equally probable

$$\Omega_2 = \left\{ \begin{matrix} [1,1] & \cdots & [1,6] \\ \vdots & \ddots & \vdots \\ [6,1] & \cdots & [6,6] \end{matrix} \right\}$$

$A_2 = \{[1,6], [2,5], \cdots, [6,1]\}$

$|A_2| = 6$

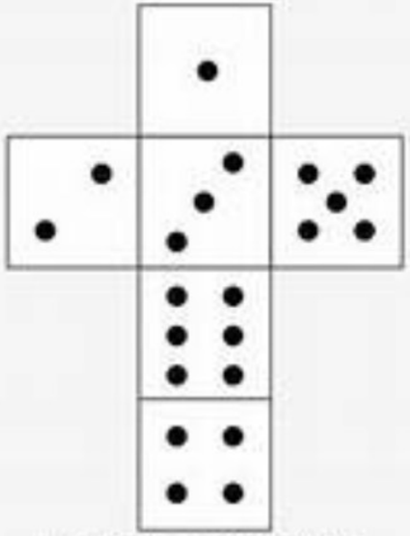
$$P(A_2) = \frac{\|A_2\|}{\|\Omega_2\|} = \frac{1}{6}$$

Complement set/ other terminologies

- $A^c = \Omega \backslash A.$ or $A \cup A^c = \Omega$ or $AA^c = \emptyset$
  - E.g., "Odd numbers" and "Even numbers"

- If any $A_i A_j = \emptyset$ for $A_1, A_2 \; \ldots A_N$
  - A_i excludes A_j
  - $A_1, A_2 \; \ldots, A_N$ are mutually exclusive / disjoint
  - E.g. $A_1 = \{1,2\}, A_2 = \{4,5\}$

- If $A_1 \cup A_2 \ldots \cup A_N = \Omega$
  - $A_1, A_2 \; \ldots, A_N$ is a partition of Ω
  - E.g. $A_1 = \{1,6\}, A_2 = \{2,5\}, A_3 = \{3,4\}$



$\{1,2,6\}$ A_1, A_2, A_3 is NOT a partition.

Karnaugh Map/ De Morgan’s Law

Karnaugh Map

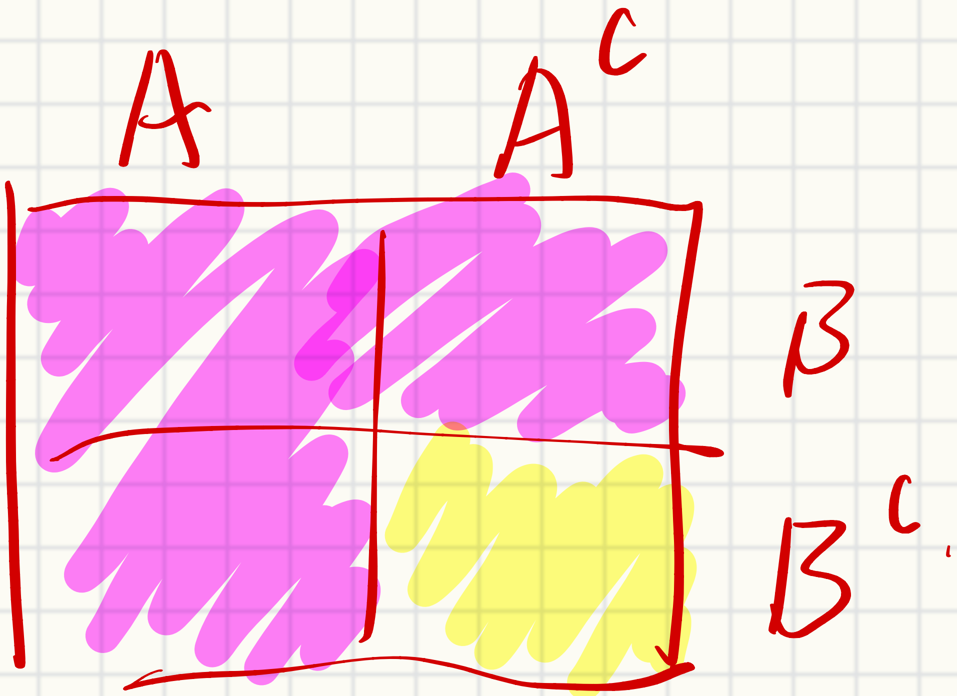
- A table list combinations of events
- For N events, there will be 2^N entries

- Roll a die
  - A is "odd numbers"; B is "greater than 3"

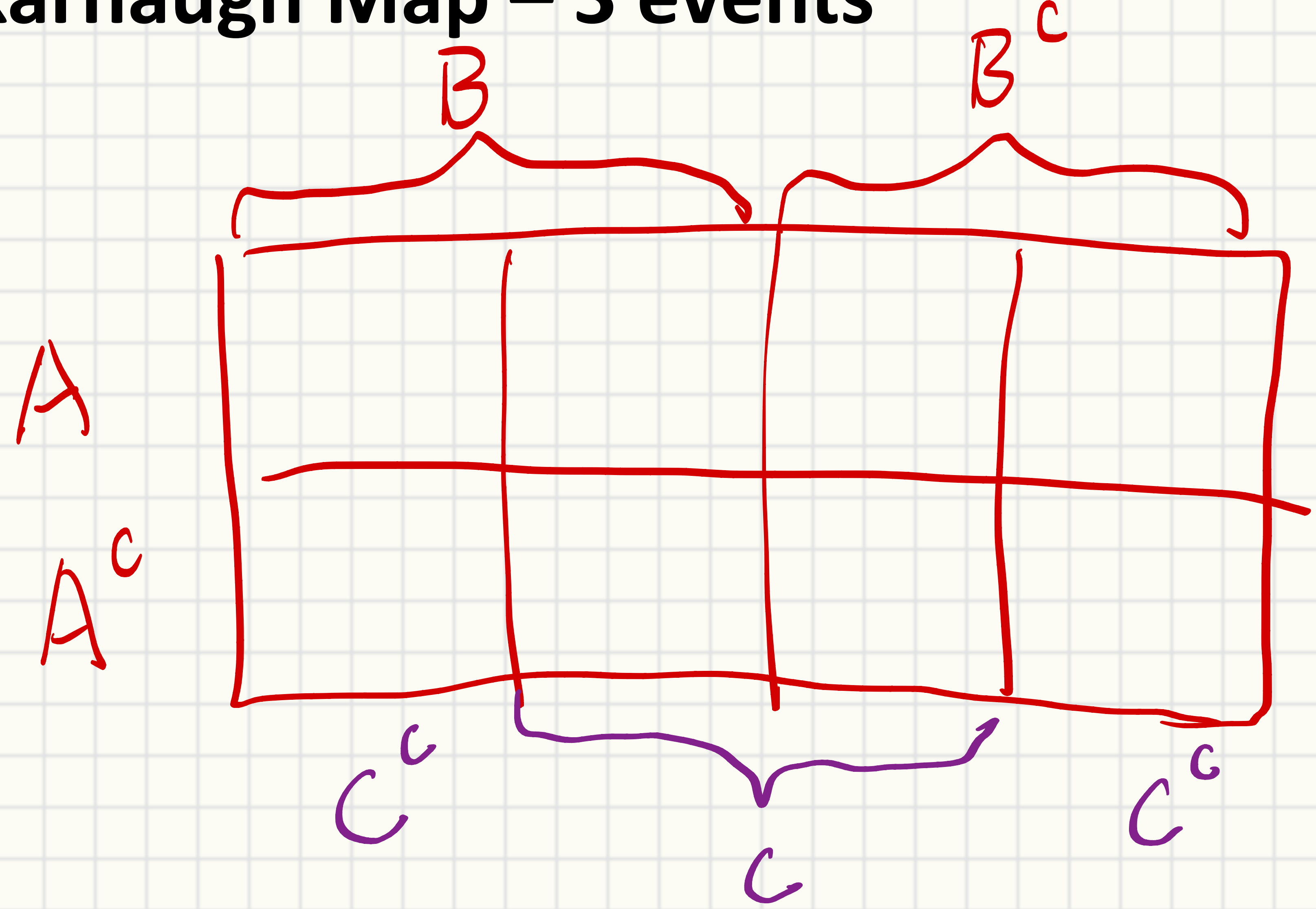
	A	A^c
B	5	4, 6
B^c	1, 3	2

De morgan's Law

- $(A \cup B)^c = A^c \cap B^c$, $(AB)^c = A^c \cup B^c$
- Can be verified with Karnaugh map



Karnaugh Map – 3 events



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A = “Even”
B= “divided exactly by 3”
C= “Greater than 4”

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B		B^c		
	x			A
y				A^c
C^c	C		C^c	