CS 441: Discrete Structures for Computer Science

PhD. Nils Murrugarra-Llerena
nem177@pitt.edu

Who am I?

B.S. Computer Science at **National University of Trujillo**

M.S. in Computer Science at **University of São Paulo** in **AI**

Who am I?

PhD in Computer Science at **University of Pittsburgh** in **Computer Vision**

Research scientist at **Snap Inc.**

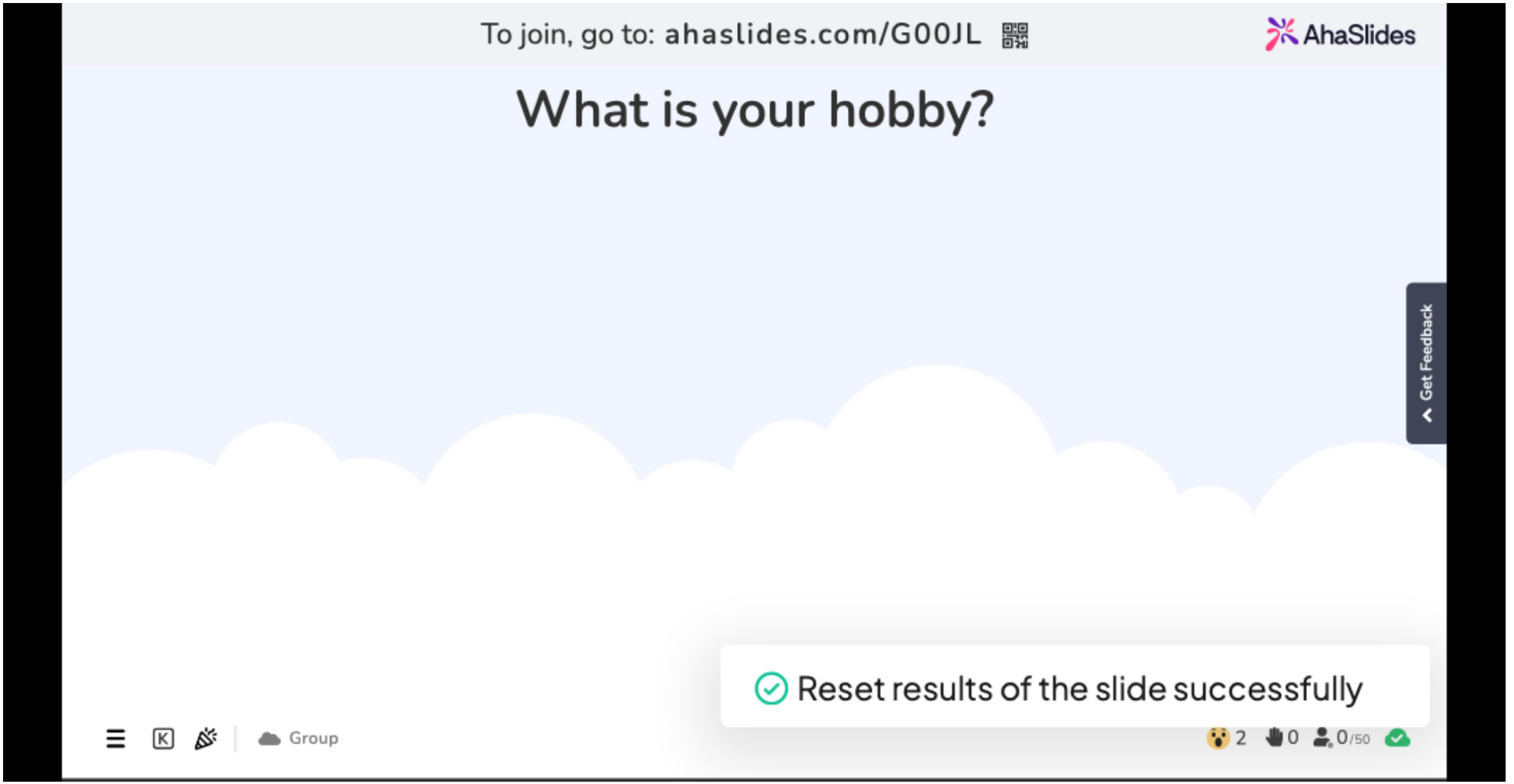
Who am I?

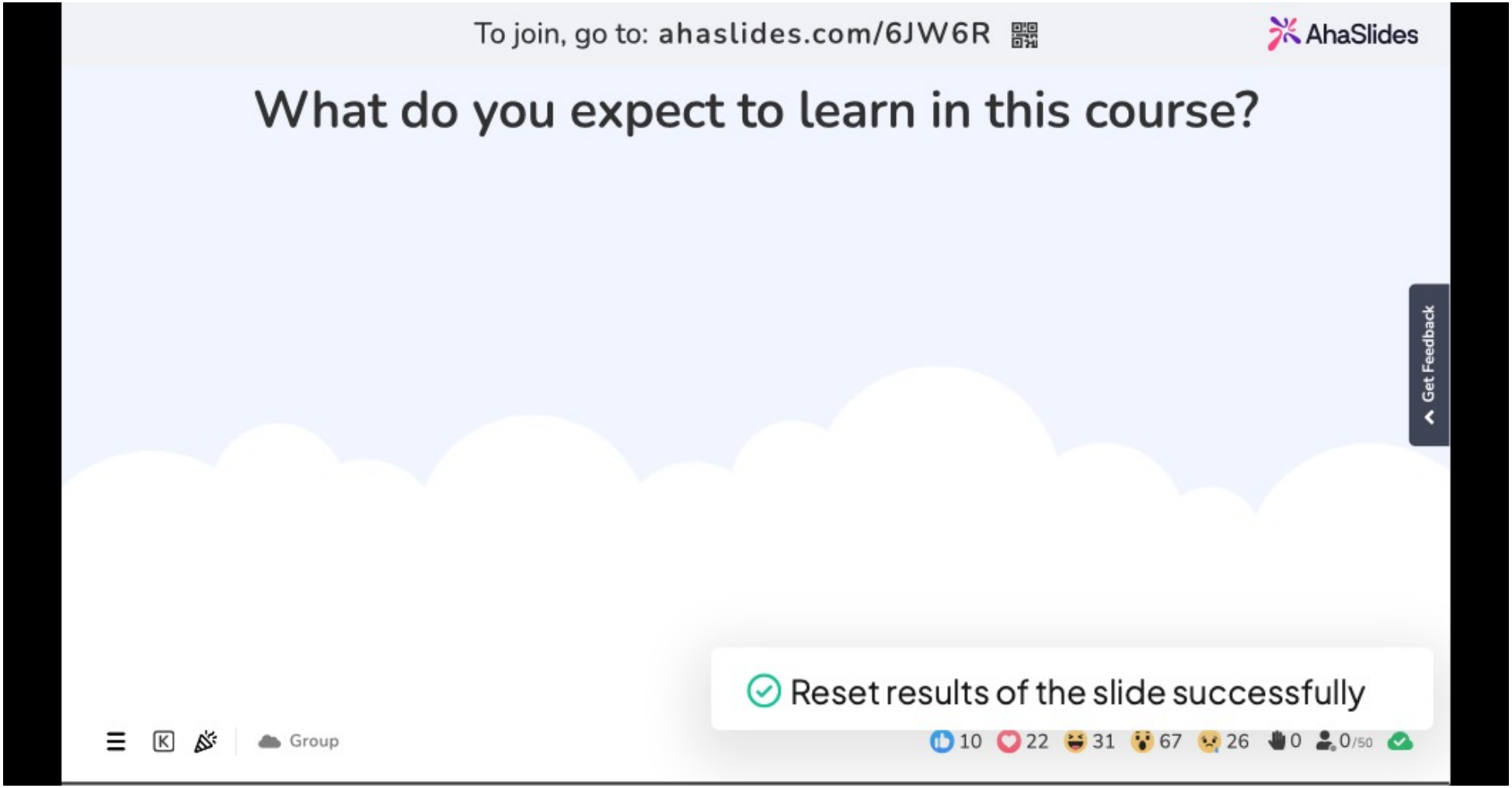
Assistant professor at
Weber State University

Teaching Assistant Professor at **University of Pittsburgh**

[Students' presentations]

Name, hobbies, and mention one thing that you expect to learn in this course ☺


To join, go to: ahaslides.com/G00JL
AhaSlides
What is your hobby?
Get Feedback
Reset results of the slide successfully
Group
2
0
0/50

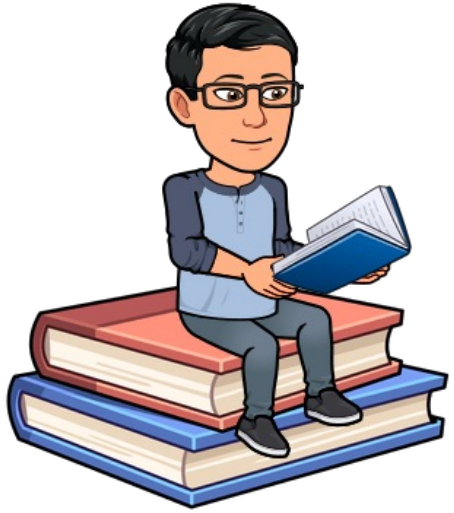

To join, go to: ahaslides.com/6JW6R
AhaSlides
What do you expect to learn in this course?
Get Feedback
Reset results of the slide successfully
Group
10 22 31 67 26 0 0/50


To join, go to: ahaslides.com/D5CI0
AhaSlides
Please, can you bring a Computer to class?
Yes
No
Get Feedback
Reset results of the slide successfully
11
1
2
8
4
0
1/50

Syllabus

Syllabus

Course intro: Syllabus



- Contact Information
  - Prof. Nils Murrugarra
  - nem177@pitt.edu
  - Please, add prefix “[CS 441]” in all emails.
  - Website: https://nineil.github.io/courses/fall25_cs441/
- Lectures:
  - [Section A] Mon/Wed: 1:00pm - 2:15pm @ SENSQ 5502
  - [Section B] Mon/Wed: 3:00pm - 4:15pm @ IS 404
- Office hours:
  - TBD (Please, fill this form). Inputs will be considered with my other courses, and my own schedule

Course intro: Textbook

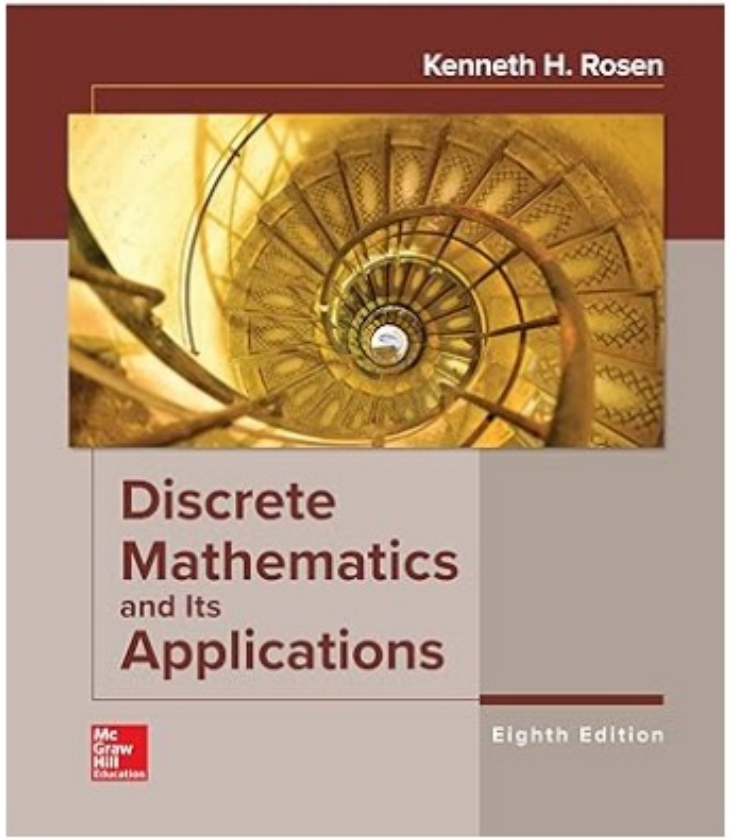
Discrete Mathematics and its Applications

Edition: 8th

By Kenneth Rosen

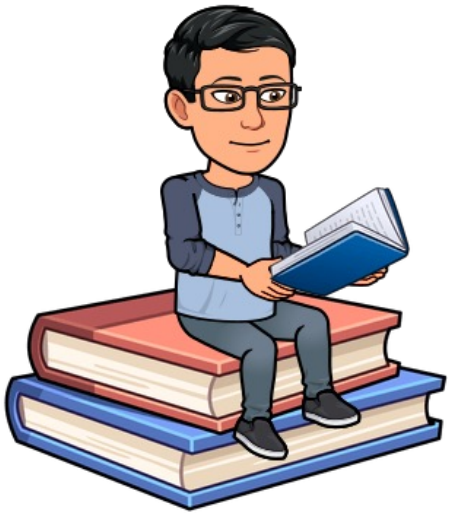
ISBN: 1260091996

Year: 2018



Course intro: What to expect?

- Material is based on previous iterations of *CS 441: Discrete Structures for Computer Science*.
- Exams mainly cover this material
- We will do around 11 to 13 assignments



Course intro: What to expect?

- There will be a lot of work!
- However, you will learn a lot :). Please, ask questions in class and use office hours as needed.
- I would like to help you much as possible.

Course intro: What to expect?

H/T Kirk Pruhs

Review Syllabus

Canvas Link:

Section A
Section B

Questions?

Course overview

- What ***is*** discrete mathematics?
- Why is a math course part of the computer science curriculum?
- Will I really ever use this stuff again?
- How to succeed in this course?

What is discrete mathematics?

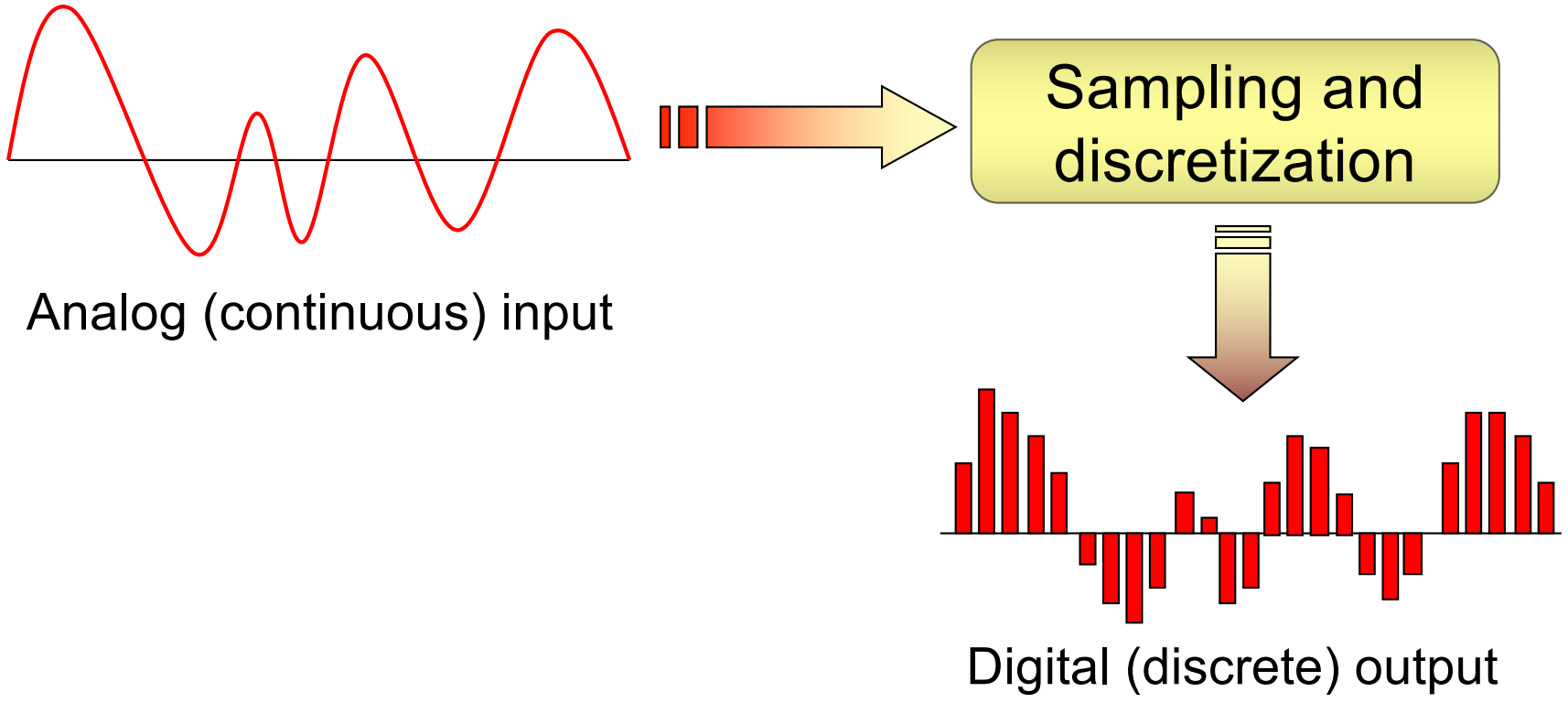
- Discrete mathematics is the study of *distinct* objects or structures and their relationships to one another

- For example:
  - How many ways can a valid password be chosen?
  - Can traffic flow between two computers in a network?
  - How can we transform messages to hide their contents?
  - How do we parse a given sequence of commands?

- By contrast, continuous mathematics (e.g., calculus) studies objects and relationships that vary continuously
  - e.g., position, velocity, and acceleration of a projectile

Why study discrete math?

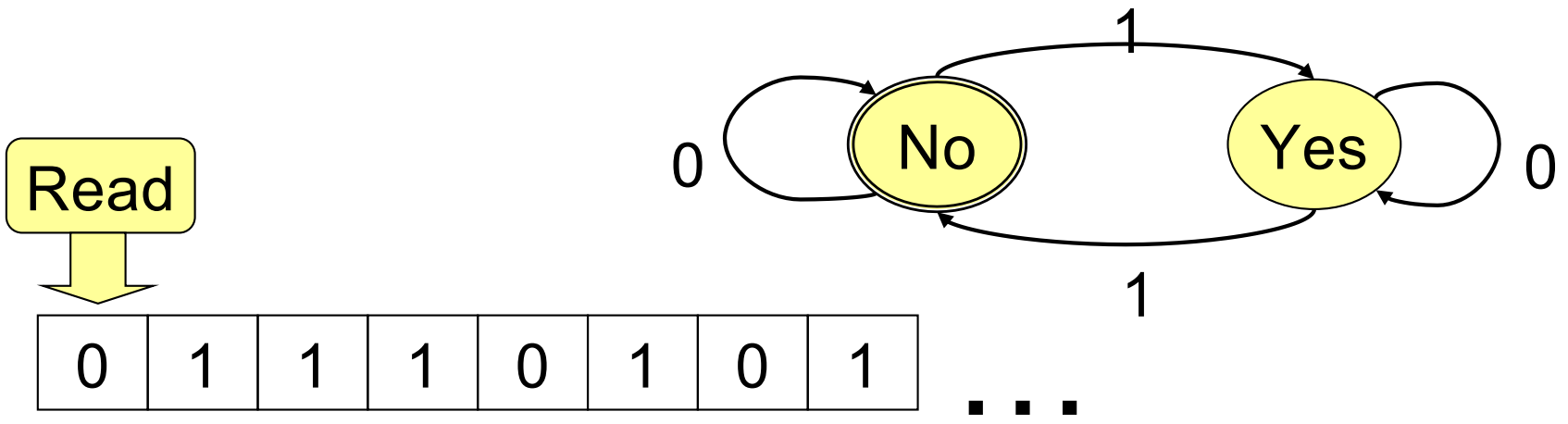
Reason 1: Computers do not process continuous data



Why study discrete math?

Reason 2: Computers aren't actually all that smart, they are just deterministic functions that map discrete inputs to discrete outputs

Example: Does a given bit string contain an odd number of 1s?



Why study discrete math?

In general: Discrete mathematics allows us to better understand computers and algorithms

```
function fib(int n)
  if(n == 0 || n == 1)
    return 1;
  else
    return fib(n-1) + fib(n-2);
```

```
function fib(int n)
  int first = 0;
  int second = 1;
  int tmp;
  for(i = 1 to n)
    tmp = first + second;
    first = second;
    second = tmp;
  end for
  return first;
```

Activity: Why study discrete math?

Start: 0:00

Floating Point Numbers: 2:33
https://www.online-python.com/

Set Theory: 4:14

Complexity Theory: 6:24

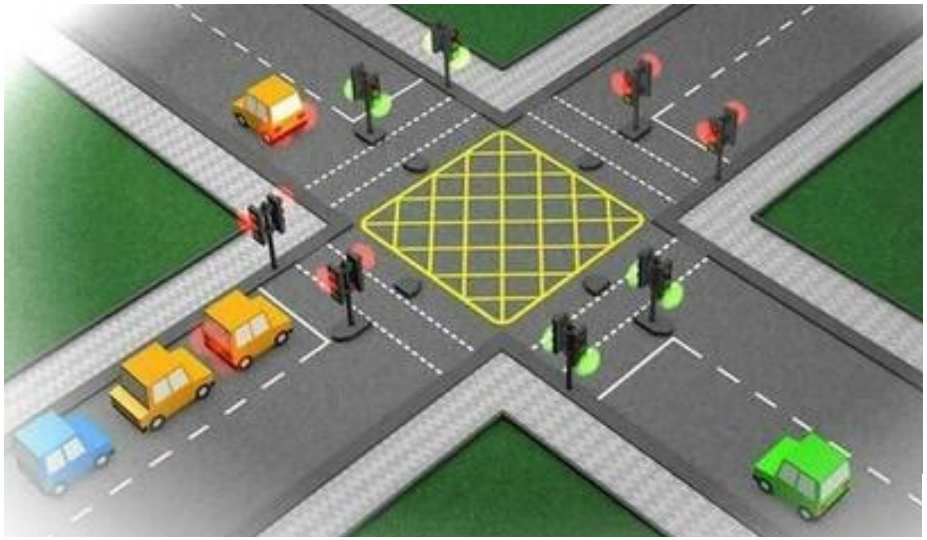
Statistics: 7:06

Tentative Syllabus

- Logic and proofs
- Sets
- Functions
- Algorithms and analysis
- Integers, modular arithmetic, cryptography
- Induction
- Relations

Are these topics really useful?

Logic and proofs

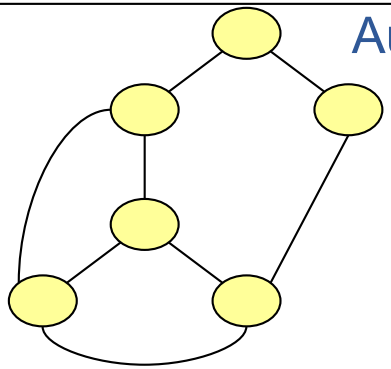


Logic and proofs

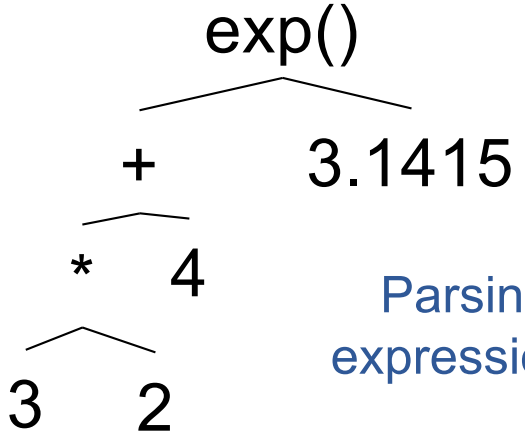
```
grant(X, projector) :- role(X, presenter), located(X, 104)
located(adam, 104)
role(adam, presenter)

=> ?grant(adam, projector)
=> true
```

Automated reasoning, AI, security



Verifying data structures and hardware

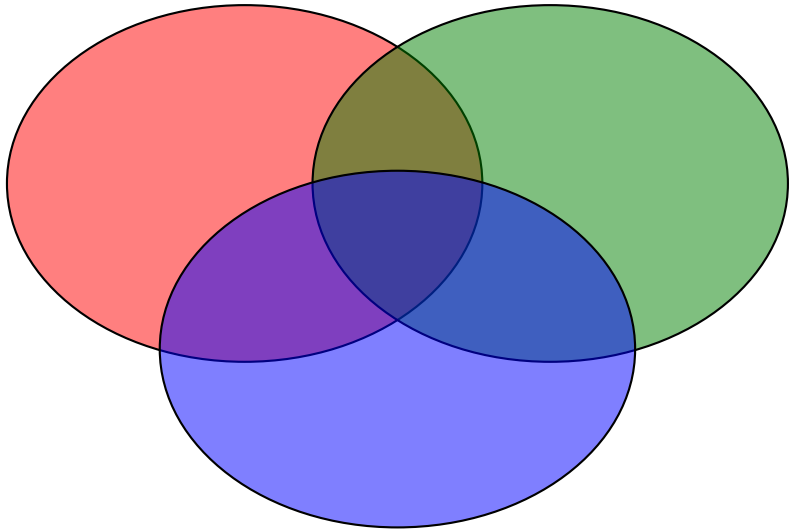


Parsing expressions

```
function fib(int n)
  int first = 0;
  int second = 1;
  int tmp;
  for(i = 1 to n)
    tmp = first + second;
    first = second;
    second = tmp;
  end for
  return first;
```

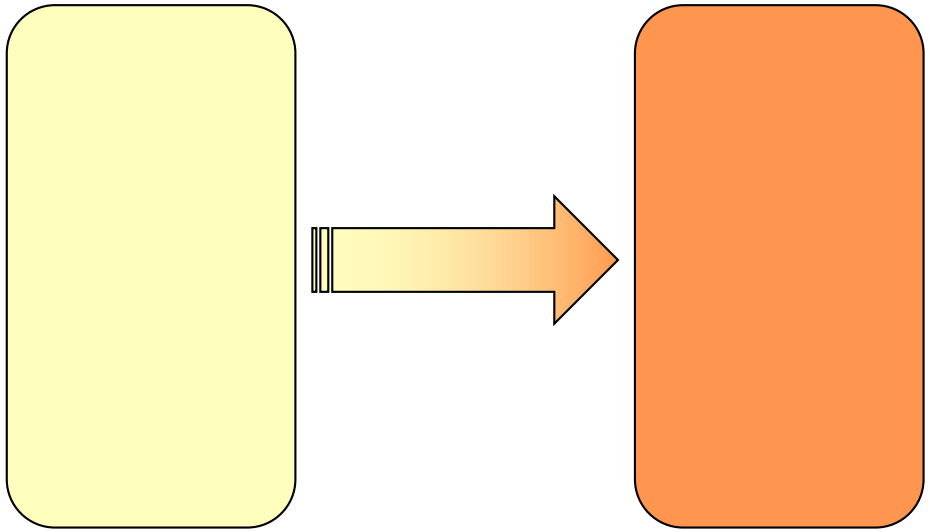
Algorithm and protocol analysis

Sets

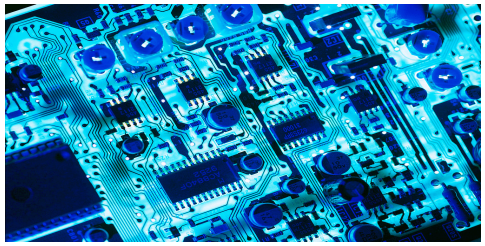


Sets define collections of objects…

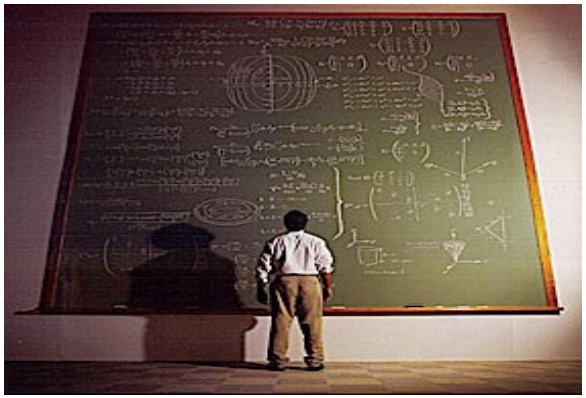
… and give us a means of reasoning about the relationships between objects → Database Operations



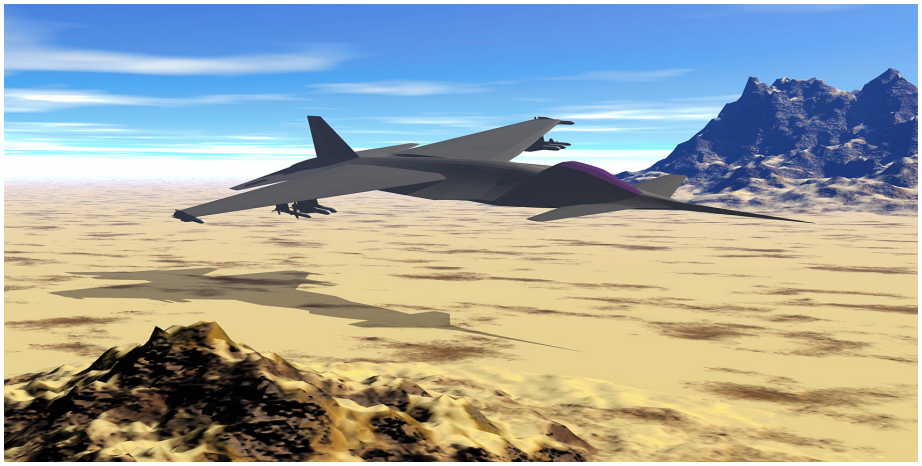
Functions



Hardware design

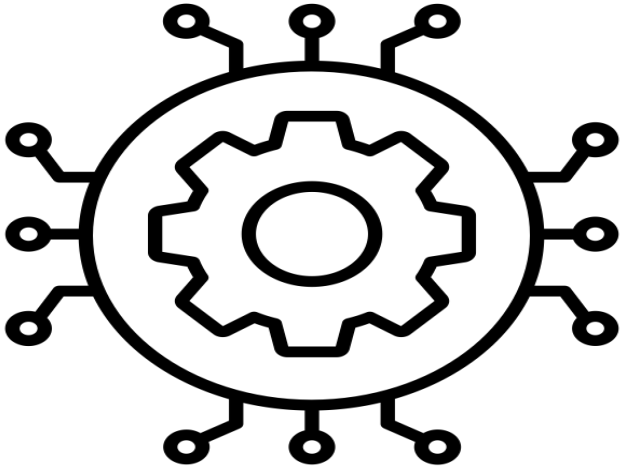


Theory of computation



Computer graphics

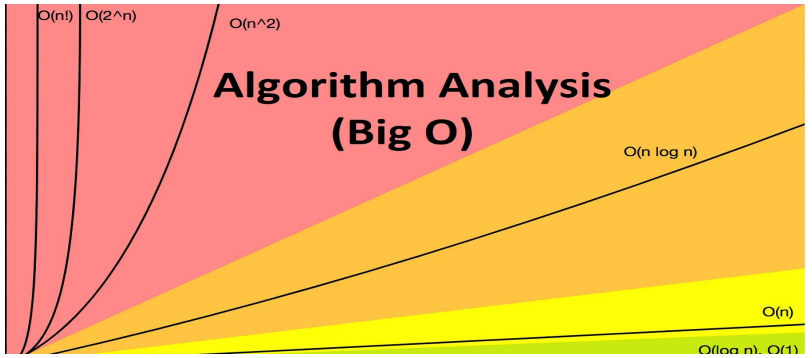
Algorithms and analysis



Studying algorithms helps us write better code…

LeetCode

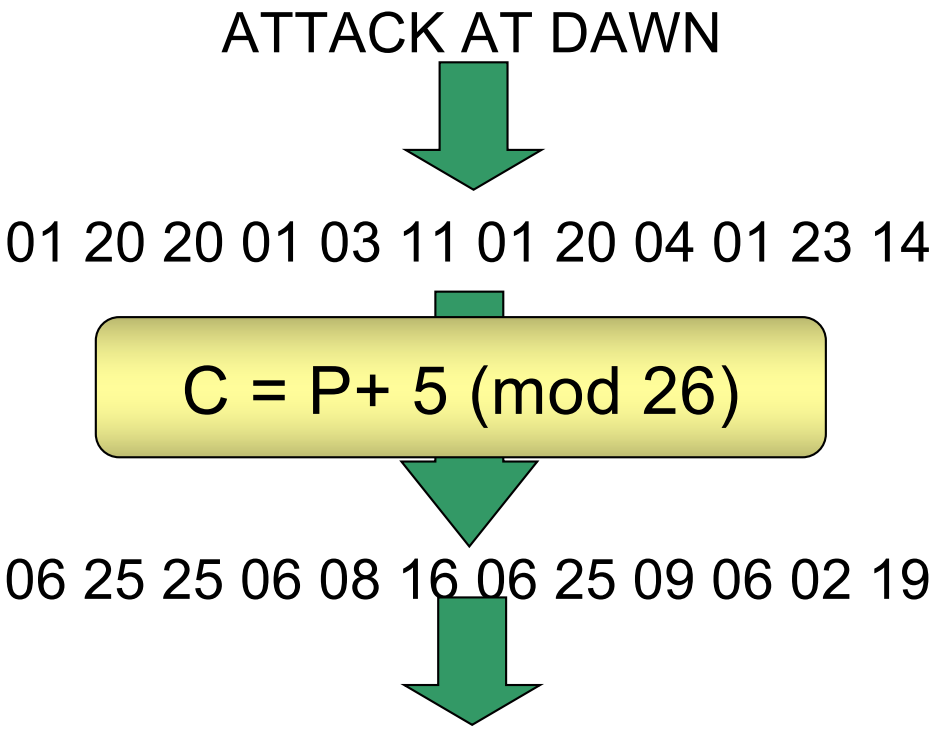
… and algorithm analysis helps us determine which approaches scale best



Integers and Modular Arithmetic

```
  0111 0101 0110 1011
+ 0101 1001 1110 0001
  1100 1111 0100 1100
```

Binary arithmetic and bitwise operations

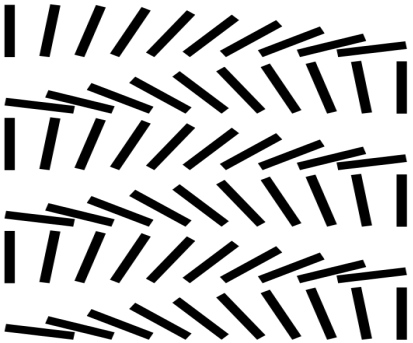


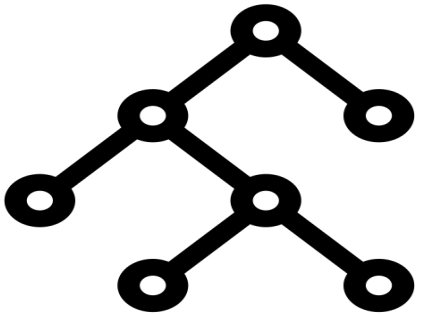
Cryptography

Induction

Induction is a proof technique that helps us reason about infinite objects (e.g. recursion)…

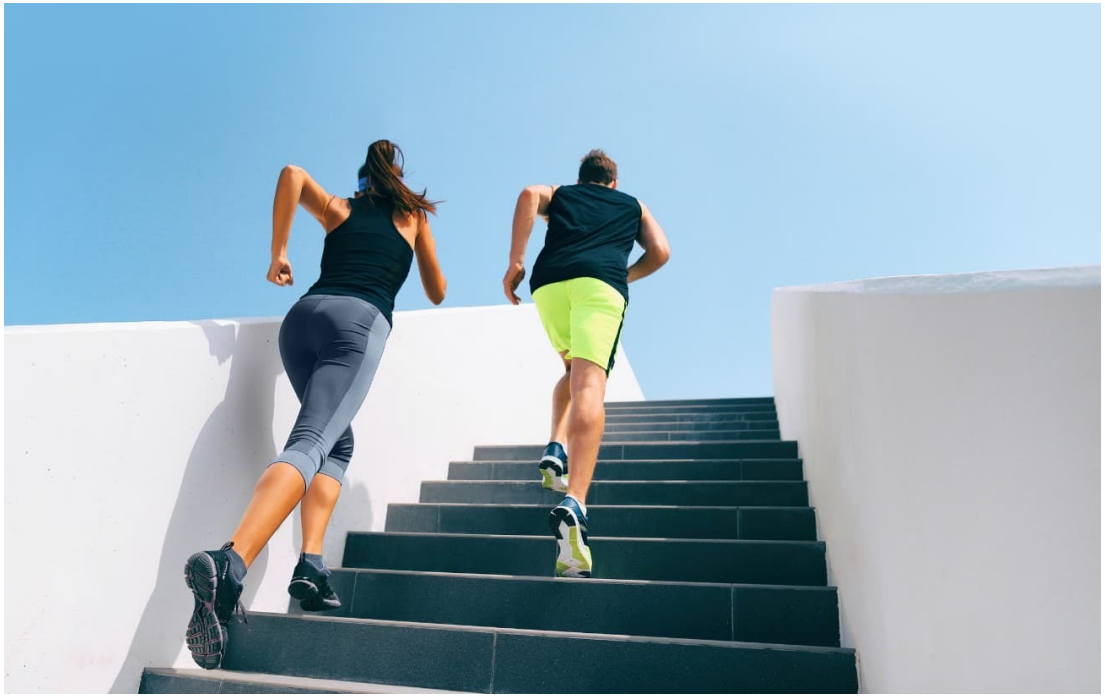
… and processes…





… and data structures!

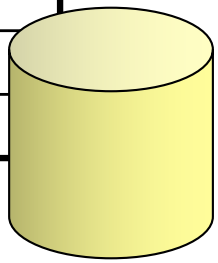
Relations



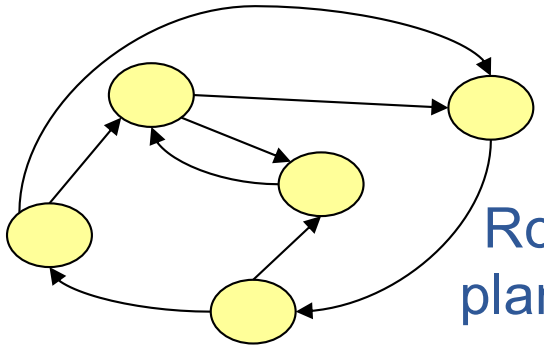
How to climb a stair?

Relations

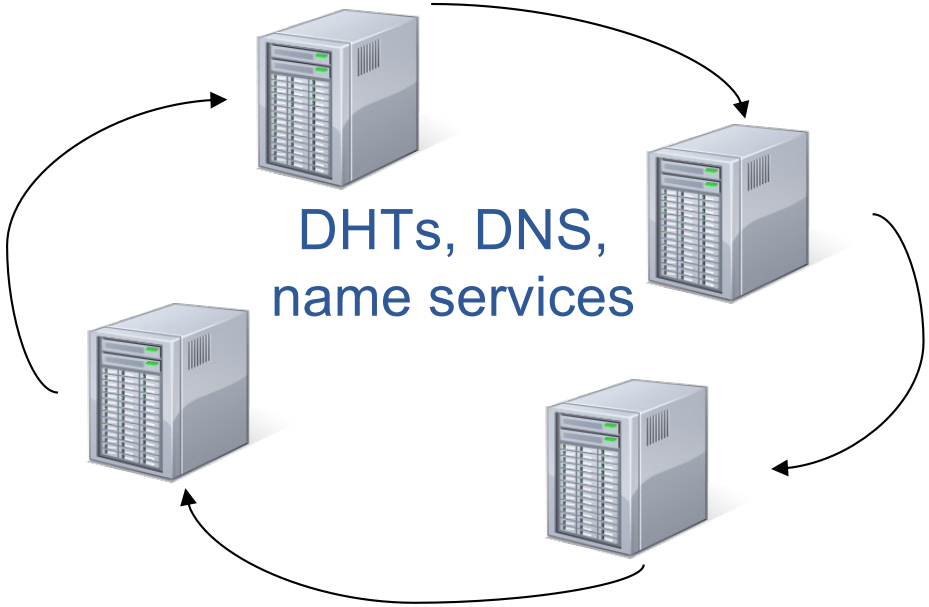
Name	Age	Phone
Alice	19	555-1234
Danielle	33	555-5353
Zach	27	555-3217
Charlie	21	555-2335



Relational databases



Route planning



DHTs, DNS, name services

Syllabus, redux

- Logic and proofs
- Sets
- Functions
- Algorithms and analysis
- Integers, modular arithmetic, cryptography
- Induction
- Relations

Are these topics really useful?

Yes

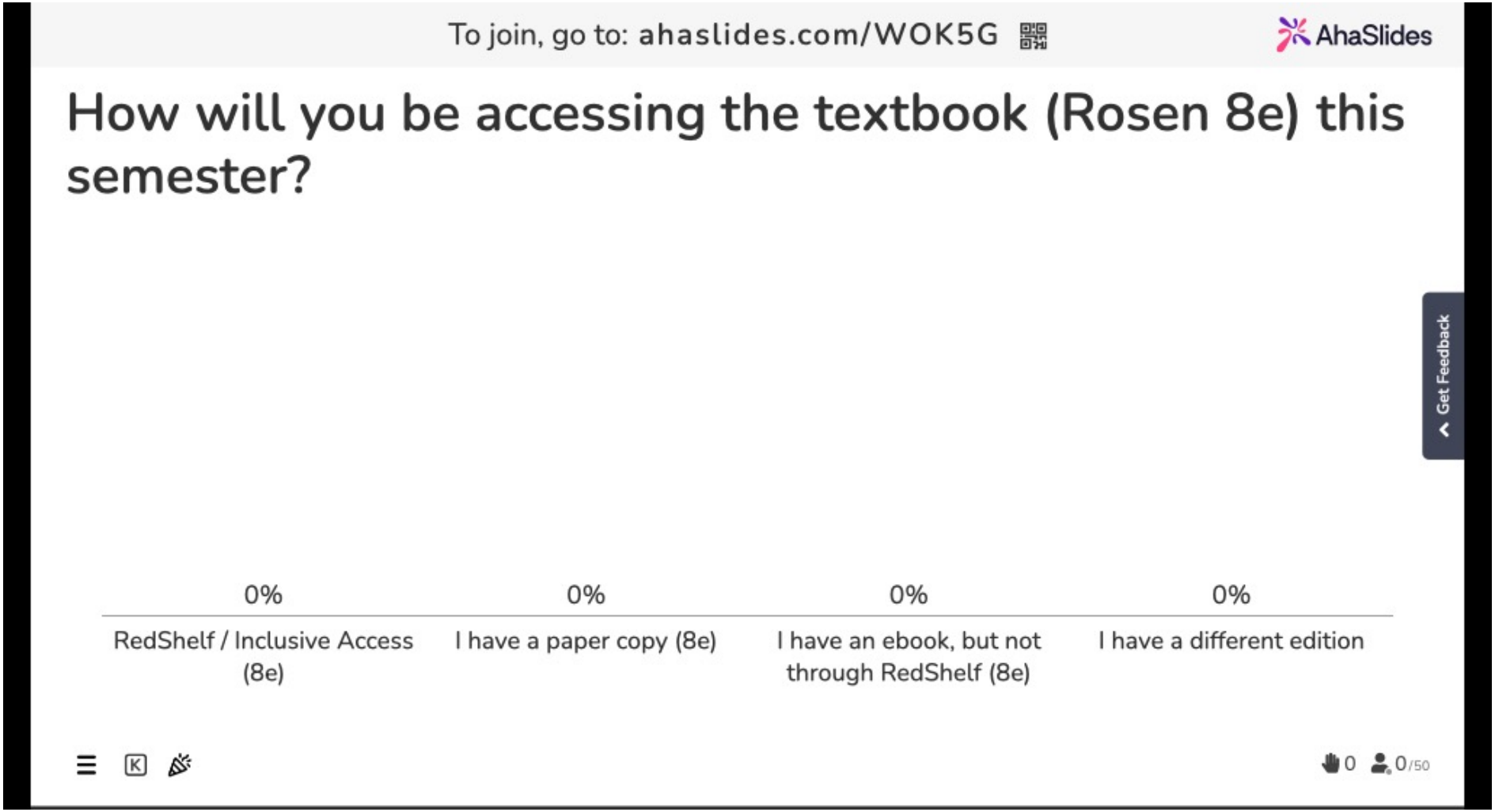
Mastering discrete mathematics requires practice!

- Succeeding in this class requires practicing the skills that we will acquire, thinking critically, and asking questions
  - We are practicing clear and precise communication in the language of mathematics and logic—be specific!

- Keys to success:
  - Attend class and take notes
  - Do your homework
  - Work extra problems when you're unsure
    - Solutions to odd-numbered exercises are provided in textbook
  - Go to your recitation every week
  - Take advantage of office hours

What should I do now?

1. Check your Canvas notification settings
2. Read the chapter for next lecture
3. Decide if you need Inclusive Access, and opt out if not
4. Watch for a Gradescope invitation, where you'll submit recitation and homework assignments
5. Email me if you have any special circumstances that you may need accommodated


To join, go to: ahaslides.com/WOK5G
AhaSlides
How will you be accessing the textbook (Rosen 8e) this semester?
Get Feedback
0%
RedShelf / Inclusive Access (8e)
0%
I have a paper copy (8e)
0%
I have an ebook, but not through RedShelf (8e)
0%
I have a different edition
0
0/50

Final thoughts

- Our goal is to prepare you to be stronger computer scientists by:
  - Exploring the formal foundations of computer science
  - Developing critical thinking skills
  - Articulating ties between theory and practice

- Next: Propositional logic (Sec 1.1)