

ALGORITHMS and ***DATA STRUCTURES***





I will be recording lectures and make them available in Canvas.

*Because of privacy, compliance, and legal considerations,
you may not record or redistribute recordings of this class.*



<https://algs4.cs.princeton.edu>

INTRO TO COS 226

- ▶ *motivation*
- ▶ *course structure*
- ▶ *assessments*
- ▶ *resources*



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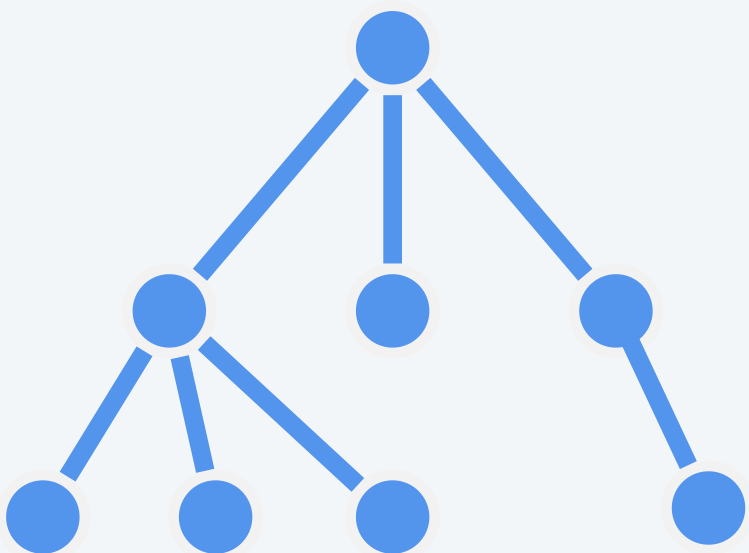
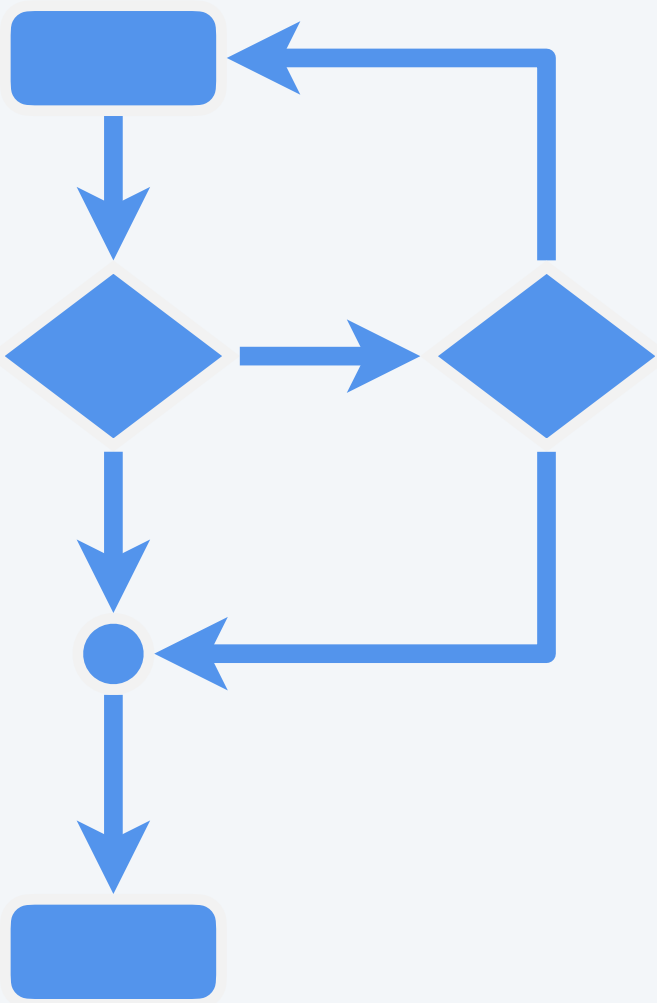
INTRO TO COS 226


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COS 226 course overview

What is COS 226?

- **Algorithm:** step-by-step procedure for solving a problem.
- **Data structure:** method for organizing data in a computer.
- Programming and problem solving, with applications.



topic	algorithms and data structures 
data types	stack, queue, union–find
sorting	insertion sort, quicksort, mergesort, priority queue
searching	BST, red–black tree, hash table, k-d tree
graphs	BFS, DFS, Prim, Kruskal, Dijkstra
advanced	randomness, multiplicative weights, intractability

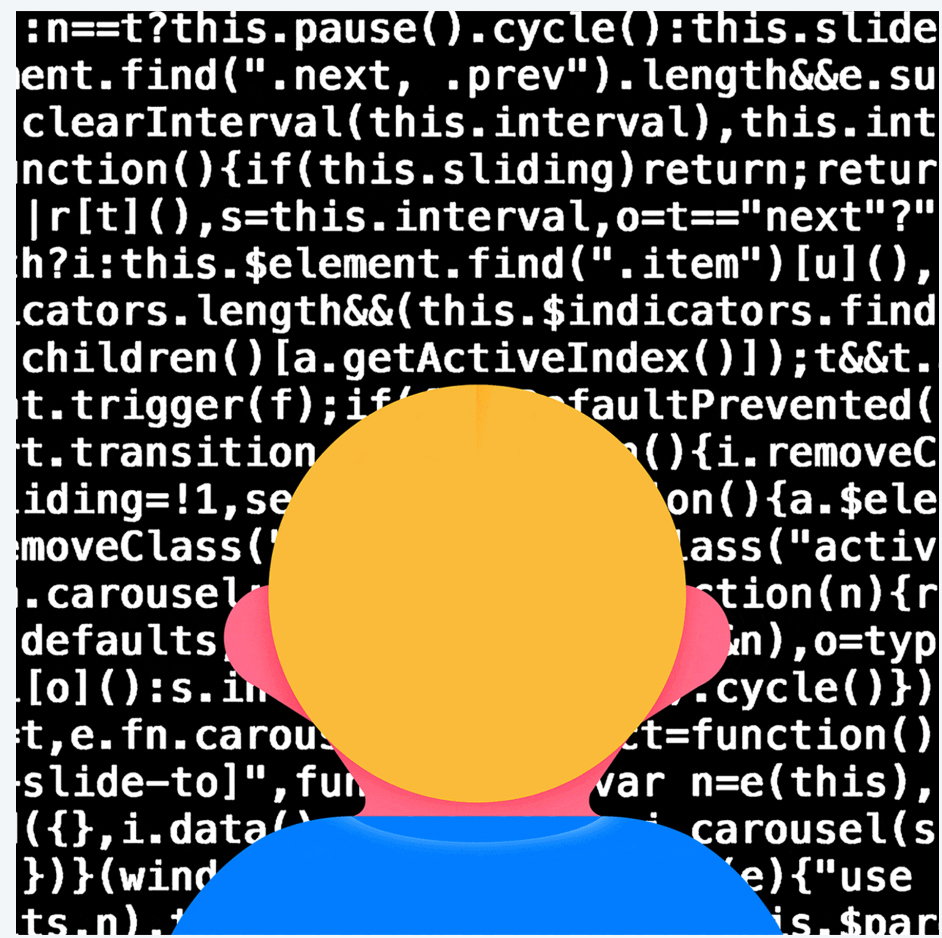
Why study algorithms and data structures?

Their impact is broad and far-reaching.



Why study algorithms and data structures?

To become a proficient programmer.



*“ I will, in fact, claim that the difference between a bad programmer and a good one is whether [they] consider [their] code or [their] data structures more important. Bad programmers worry about the code. Good programmers worry about **data structures** and their relationships.”* — **Linus Torvalds** (architect of Linux and git)



Why study algorithms and data structures?

For intellectual stimulation.



*“For me, **great algorithms are the poetry of computation.** Just like verse, they can be terse, allusive, dense, and even mysterious. But once unlocked, they cast a brilliant new light on some aspect of computing.”* — Francis Sullivan

Why study algorithms and data structures?

For fun and profit.

Google



GitHub



facebook

RSA
SECURITY

airbnb

NETFLIX



slack

CISCO SYSTEMS

Square

in

Morgan Stanley

IBM

lyft



nVIDIA

TESLA

JANE
STREET

SPACEX



Adobe



UBER

zoom

P X A R
ANIMATION STUDIOS

DE Shaw & Co

ORACLE

YAHOO!

amazon

intel

Microsoft

Akamai

Why study algorithms and data structures?

- Their impact is broad and far-reaching.
- To become a proficient programmer.
- For intellectual stimulation.
- For fun and profit.

Why study anything else?





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Lectures

Live lectures. Introduce new material.

What	When	Where	Who	Office Hours
L01	TTh 11–12:20pm	Friend 101	Kevin Wayne Pedro Paredes	<i>see web</i>



Prof. Kevin Wayne




Prof. Pedro Paredes

Questions. Raise your hand and ask a question. ← *carpe diem!*

Electronic devices. Permitted *only* to support lecture. ← *viewing slides, taking notes, iClickers, ...*



iClicker (required). To earn participation credit:

- Create iClicker Cloud account.  *using Canvas-preferred email*
- Answer multiple choice questions during lecture.



<https://www.iclicker.com>

If you could have more of one of the following, which would it be?

A. Fame. 

B. Fortune. 

C. Friends. 

D. Free time. 

Precepts

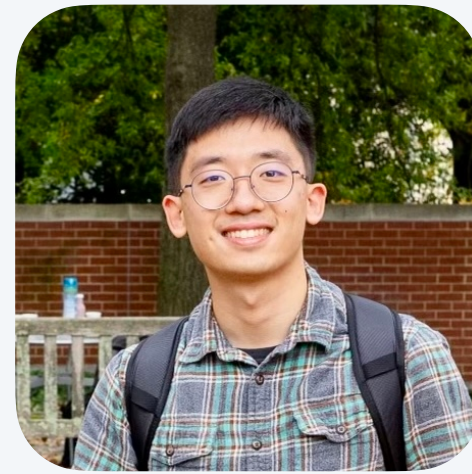
Active learning. Problem-solving, discussion, assignment prep, ...



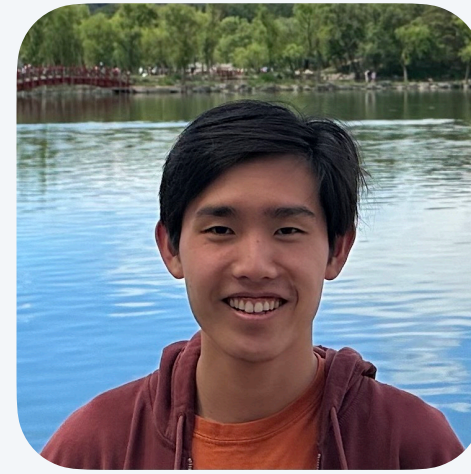
Victor Chu



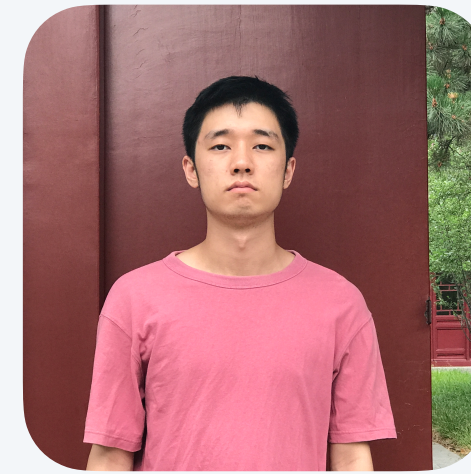
Emma Farkash



Brendan Wang



Stanley Wei



Han Xu



Zhiyue Zhang



Anny Zhou

Special precept P04. F 1:30–2:50pm.

- Intended for students seeking a more advanced treatment of material.
- Covers topics beyond scope of the course.



Prof. Huacheng Yu



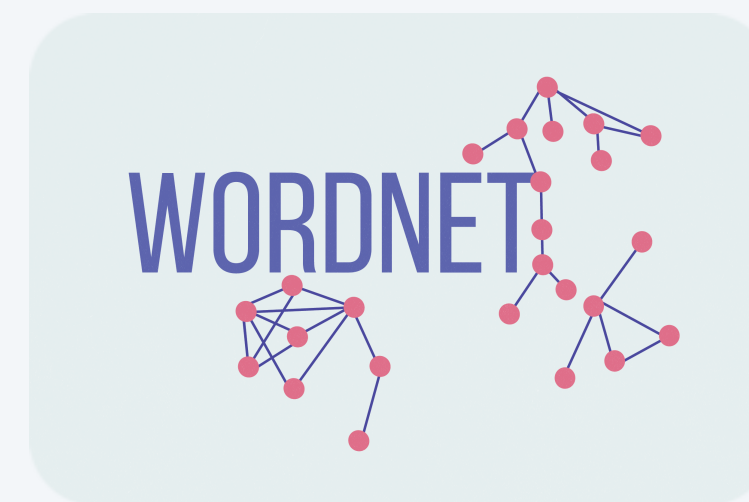
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INTRO TO COS 226

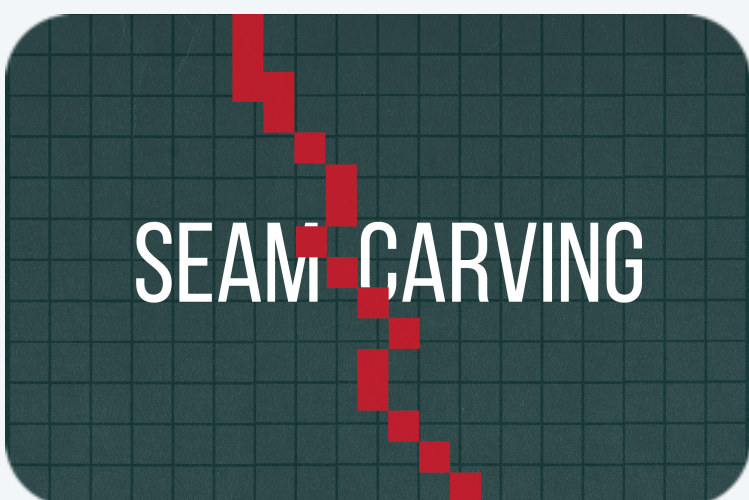
- *motivation*
- *course structure*
- *assessments*
- *resources*
- *union-find*

Programming assignments

Implement an efficient **algorithm** or **data structure**:



Solve an interesting **application** using a “textbook” algorithm:



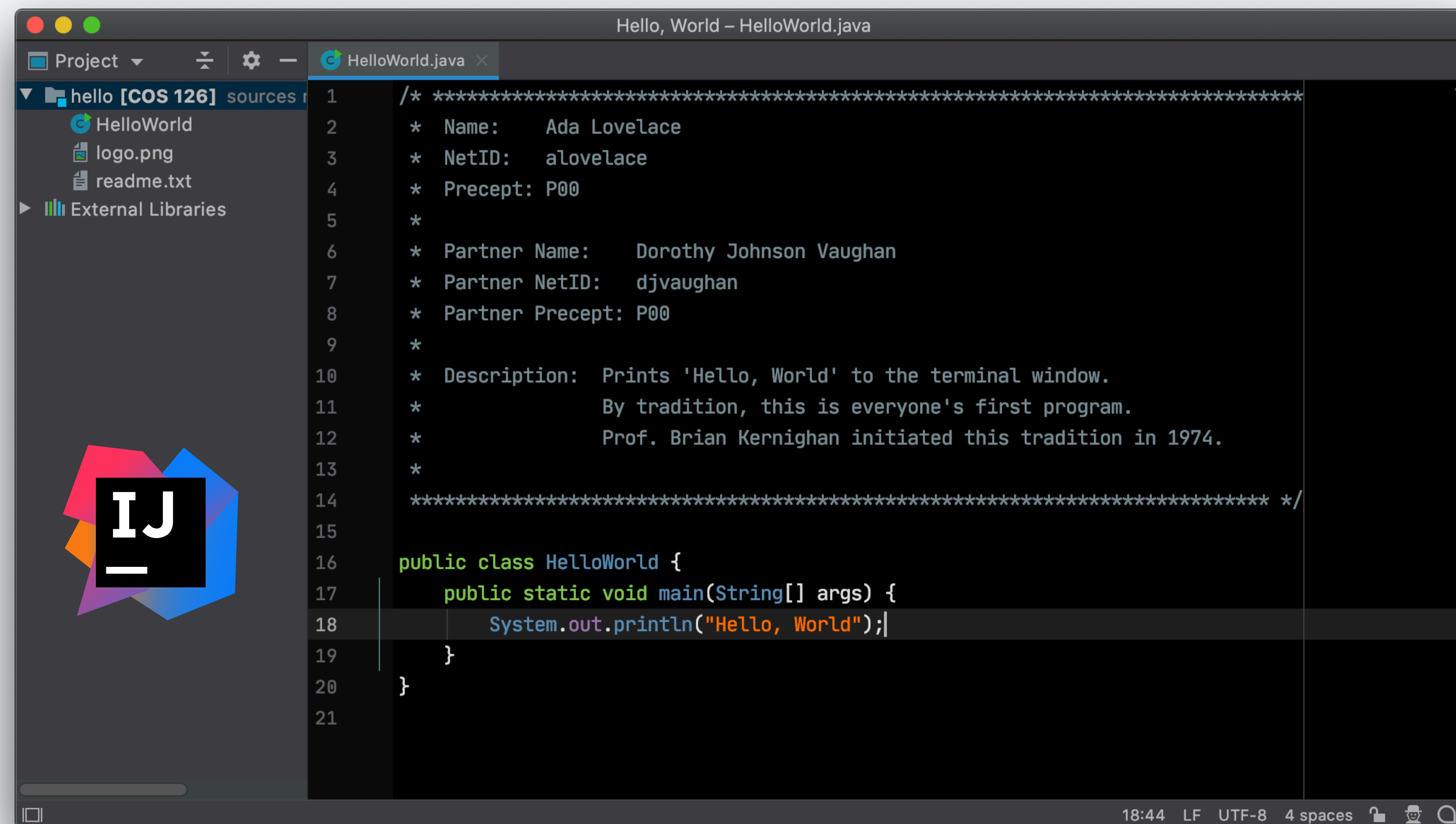
Pair programming encouraged on designated assignments.



Programming environment

Recommended IDE. Custom IntelliJ 2024.2 environment.  *upgrade to Fall 2024 version*

- Embedded Bash terminal.
- Autoformat, autoimport, autocomplete, ...
- Continuous code inspection; integrated Checkstyle and SpotBugs.
- ...



PrairieLearn platform.

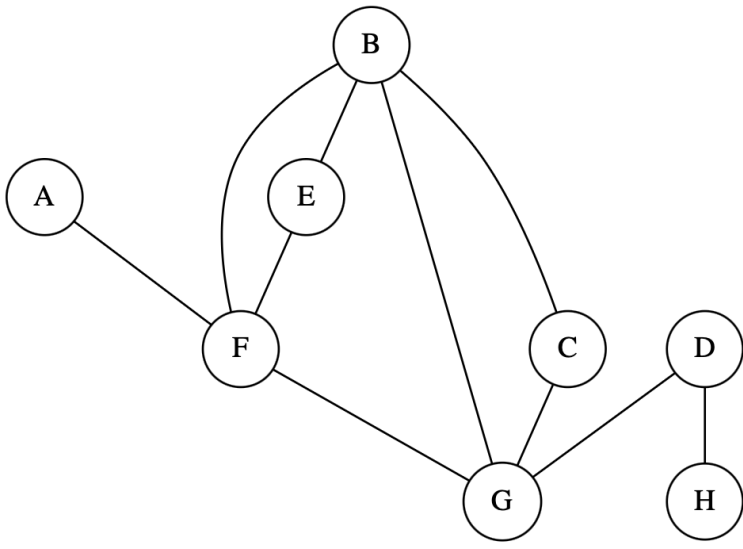
- 2–3 short questions per lecture.
- Solve using pencil and paper.
- Unlimited attempts per question. *← different variant for each attempt;
delay between attempts*
- Your score = max over all attempts.

Q7.2. Breadth-First Search Trace

Consider the following adjacency-lists representation of a graph with **8** vertices and **10** edges:

```
A: F
B: G E C F
C: G B
D: H G
E: B F
F: G A B E
G: B C F D
H: D
```

Here is a graphical representation of the same graph:



Run breadth-first search (using the adjacency-lists representation) from vertex **A**. Give the sequence in which the vertices are dequeued from the FIFO queue.

Your answer should be a sequence of **8** uppercase letters starting with **A**, separated by whitespace.

dequeued =

Save & Grade 2 attempts left **Save only**

Additional attempts available with new variants ⓘ
Can only be graded once every 2 minutes ⓘ



Written exams.

- Questions drawn from lectures, precepts, and quizzes.
- Emphasizes **non-programming** material.

COS 226 MIDTERM, SPRING 2023

3

3. Data structures. (6 points)

(a) Consider the following *parent-link* representation of a *weighted quick union* (link-by-size) data structure.

parent[]

4	5	4	5	?	5	2	5	8	5
0	1	2	3	4	5	6	7	8	9

Which of the following values could be `parent[4]`?

Fill in all checkboxes that apply.

☐

0

☐

1

☐

2

☐

3

☐

4

☐

5

☐

6

☐

7

☐

8

☐

9

Grading A+

Programming assignments. 45%

- Due at 11:59pm on Mondays.
- Collaboration/lateness policies: see web.

Quizzes. 10%

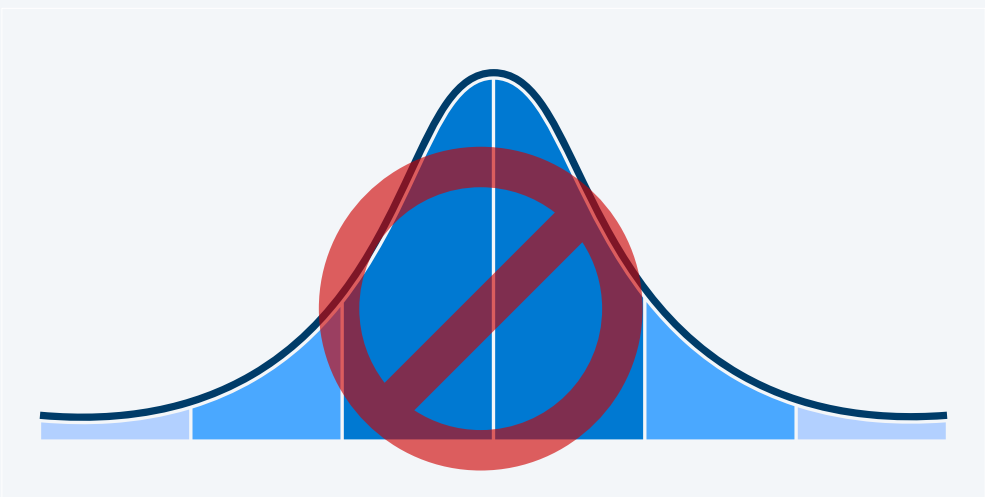
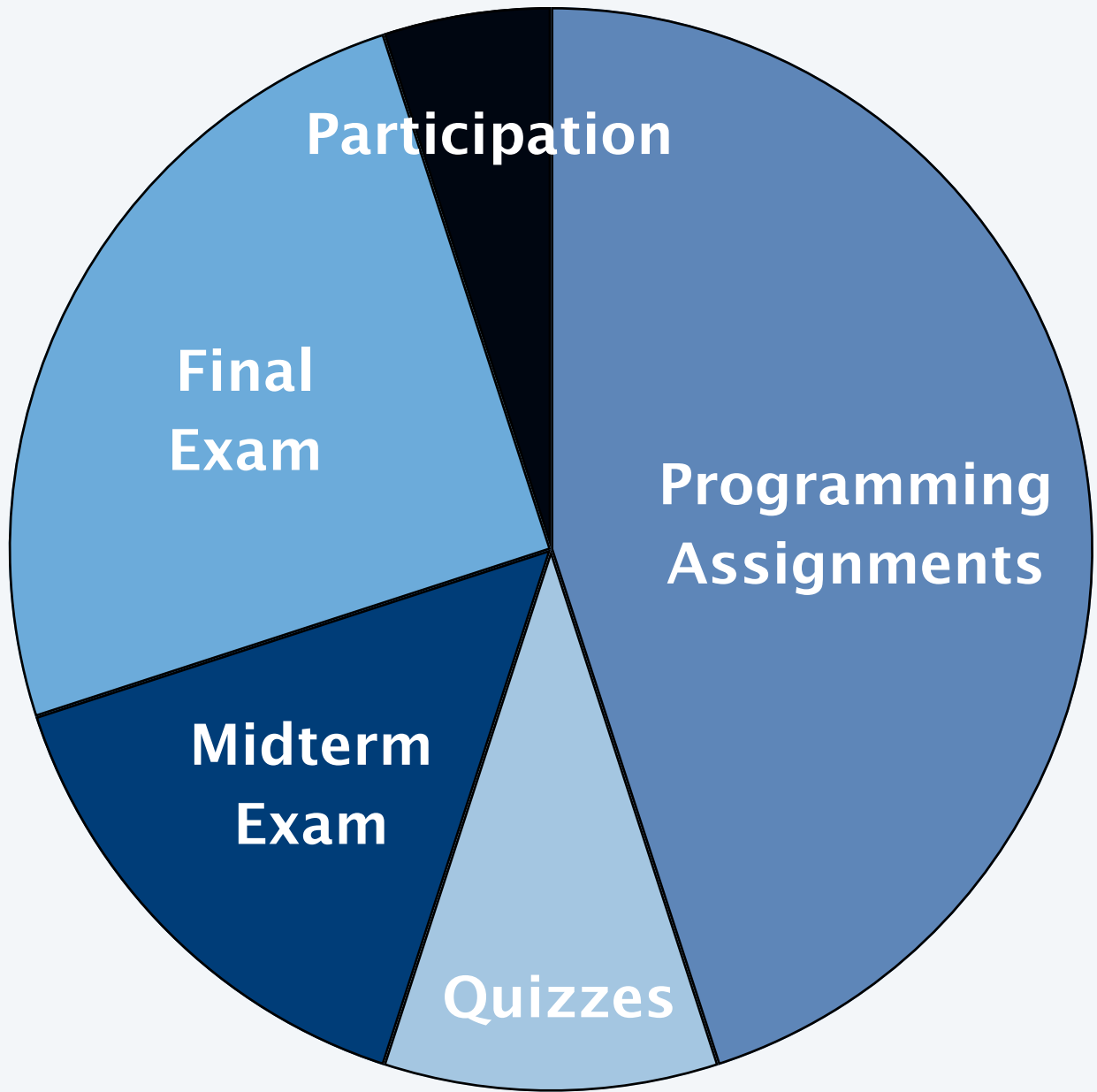
- Due at 11:59pm on Saturdays.
- Collaboration policy: see web.

Written exams. 15% + 25%

- 80-minute midterm on Tuesday, March 4.
- 3-hour in-person final, on Sunday, May 11.

Active participation. 5%

- iClicker participation in lecture.
- Collaborative participation in precept.



grade	score
A	93.0%
A–	90.0%
B+	87.0%
⋮	⋮



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Resources (textbook)




Readings (required). *Algorithms 4th edition* by R. Sedgewick and K. Wayne, [← Labyrinth Books, Amazon, ...](#)
Addison–Wesley Professional, 2011, ISBN 0–321–57351–X.



4th edition (2011)

Course content.

- Course info.
- Lecture slides.
- Precept lessons.
- Programming assignments.
- Quizzes.
- Exam archive.

 **COS226** [Syllabus](#) [Lectures](#) [Precepts](#) [Assignments](#) [Quizzes](#) [Exams](#)

SYLLABUS


Description. This course surveys the most important algorithms and data structures in use on computers today. Particular emphasis is given to algorithms for sorting, searching, graphs, and strings. The course concentrates on developing implementations, understanding their performance characteristics, and estimating their potential effectiveness in applications.

Prerequisites. COS 126 or ISC 231–234 or approval by the COS placement officer.

<https://www.princeton.edu/~cos226>

Booksite.

- Brief summary of content.
- Download code from book.
- APIs and Javadoc.



ALGORITHMS, 4TH EDITION
1. Fundamentals
2. Sorting
3. Searching
4. Graphs
5. Strings
6. Context

ALGORITHMS, 4TH EDITION

essential information that every serious programmer needs to know about algorithms and data structures

Textbook. The textbook *Algorithms, 4th Edition* by Robert Sedgwick and Kevin Wayne [[Amazon](#) · [Addison-Wesley](#)] surveys the most important algorithms and data structures in use today. The textbook is organized into six chapters:

- *Chapter 1: Fundamentals* introduces a scientific and engineering basis for comparing algorithms and making predictions. It also includes our programming model.
- *Chapter 2: Sorting* considers several classic sorting algorithms, including insertion sort, mergesort, and quicksort. It also includes a binary heap implementation of a priority queue.
- *Chapter 3: Searching* describes several classic symbol table implementations, including binary search trees, red-black trees, and hash tables.

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Resources (people)

Online discussion forum.

- Low latency, low bandwidth.
- Designate post as private only when necessary.
- See Ed FAQ for guidelines.



<https://us.edstem.org/courses/70149>

Office hours.

- High bandwidth, high latency.
- See web for schedule.



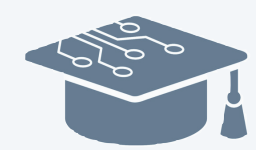
<https://www.princeton.edu/~cos226>






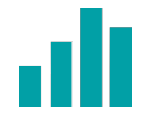


Intro COS lab.

- Undergrad lab TAs.
- For help with debugging.
- See web for schedule.



<https://introlab.cs.princeton.edu>



Platform	What
 Ed	<i>discussion forum, precept lessons</i>
 IntelliJ	<i>Java IDE</i>
 PrairieLearn	<i>quizzes</i>
 TigerFile	<i>assignment submissions</i>
 codePost	<i>assignment feedback</i>
 Gradescope	<i>exam feedback</i>
 Canvas	<i>grades, lecture recordings</i>
 iClicker	<i>lecture participation</i>

← *also use for communication with course staff
(do not email)*

A typical week (including this one!)



Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	31	1
		Lecture 1 (Union-Find)		Lecture 2 (Analysis)	Precept 1	Quiz 1
2	3	4	5	6	7	8
	Assignment 1 (Percolation)					

you are here!


again on Thursday

reinforce lecture material

content based on week's material

content based on corresponding lectures

Administrative Q+A

Not registered? Register today.  *must be enrolled to access various platforms*

Change precept? Use TigerHub.

All non-conflicting precepts closed? Contact our course admin, Kobi Kaplan.



Kobi Kaplan

Placed out of COS 126 / ECE 115? Review Sections 1.1–1.2 of Algorithms 4/e.

Haven't met COS 226 prerequisites? See COS placement officer.

Additional administrative questions. Ask now, after class, or any time in Ed Discussion.



Credits

image	source	license
<i>THX Eclipse Deep Note</i>	<u>THX Ltd.</u>	
<i>Wireframe Tiger</i>	Audrey Cheng '20	by author
<i>Programmer</i>	<u>Wall Street Journal</u>	
<i>Student Raising Hand</i>	<u>classroomclipart.com</u>	<u>educational use</u>
<i>Hands Raising Smartphones</i>	<u>Adobe Stock</u>	<u>education license</u>
<i>A is for Algorithms</i>	<u>comtechpass.com</u>	
<i>Assignment Logos</i>	Kathleen Ma '18	by author
<i>Normal Distribution</i>	<u>Adobe Stock</u>	<u>education license</u>
<i>Pair Programming</i>	<u>Adobe Stock</u>	<u>education license</u>
<i>Office Hours</i>	<u>clipground.com</u>	<u>CC BY 4.0</u>
<i>COS Lab TAs</i>	<u>Pulkit Singh '20</u>	by author
<i>Question Marks</i>	<u>pikpng.com</u>	<u>non-commercial use</u>
<i>Elbow Bump</i>	<u>The Noun Project</u>	<u>CC BY 3.0</u>
<i>Countdown Timer</i>	<u>YouTube</u>	