

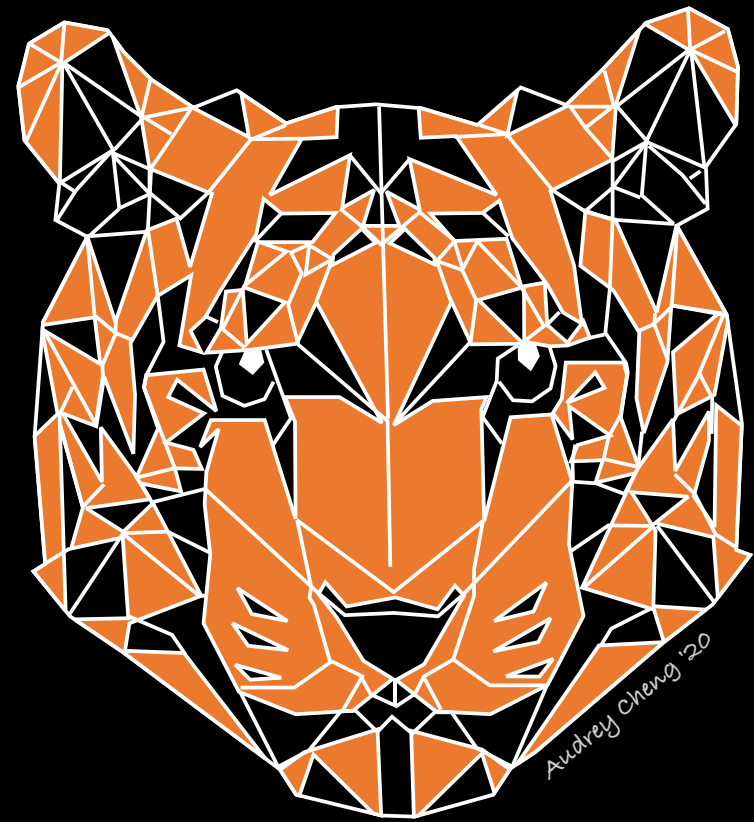
**COS 226, FALL 2020**

**ALGORITHMS**  
and  
**DATA STRUCTURES**

**KEVIN WAYNE · MAIA GINSBURG · DAN LEYZBERG**



# FINE PRINT



*I will be recording our class sessions to ensure that they are available to students regardless of their geographic location and time zone. Please contact me if you wish to be edited out of any recording in which you appear.*

*Because of privacy, compliance, and legal considerations, you may not post recording of this class online or share them with anyone other than students enrolled in this course.*



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

## INTRO TO COS 226

---

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

# INTRO TO COS 226

---

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




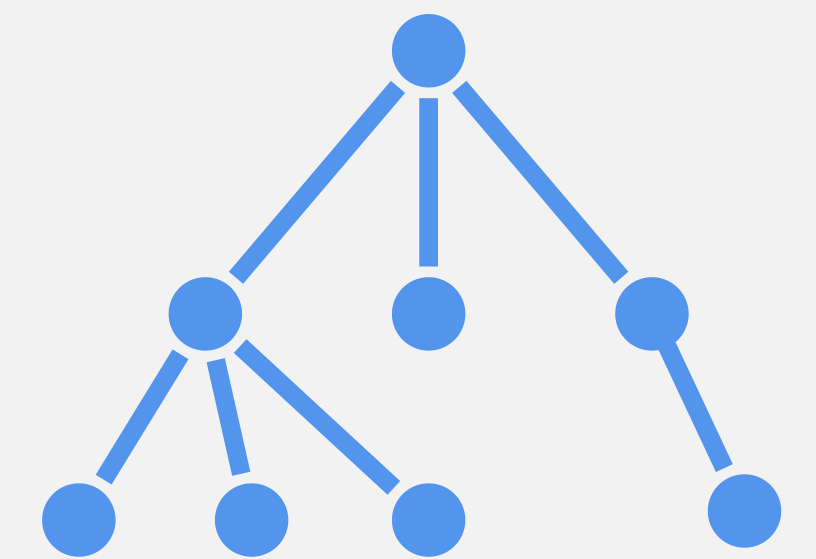
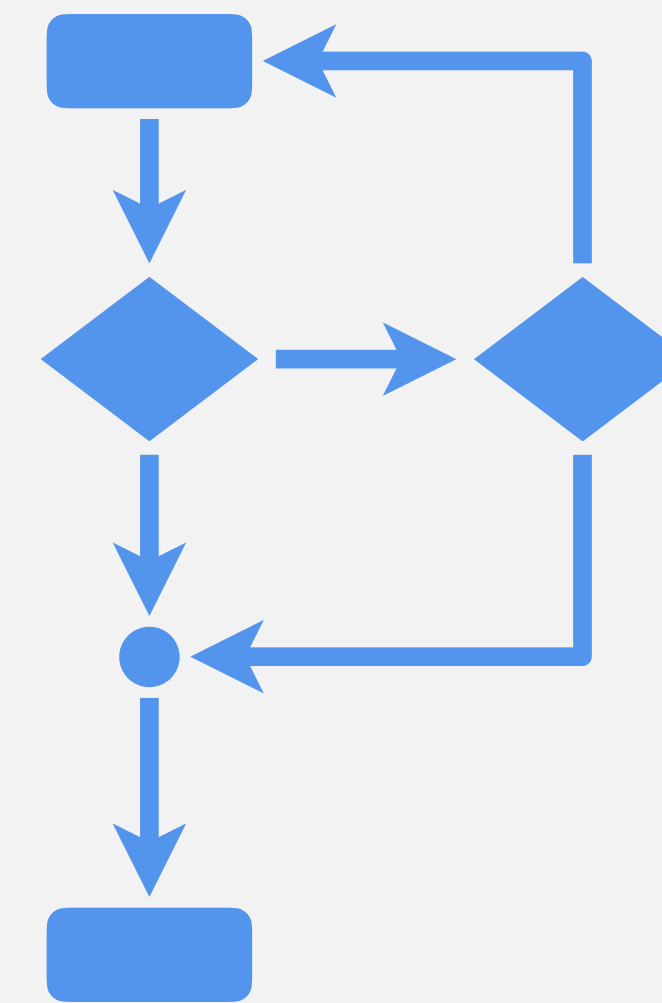
<https://algs4.cs.princeton.edu>

# COS 226 course overview

## What is COS 226?

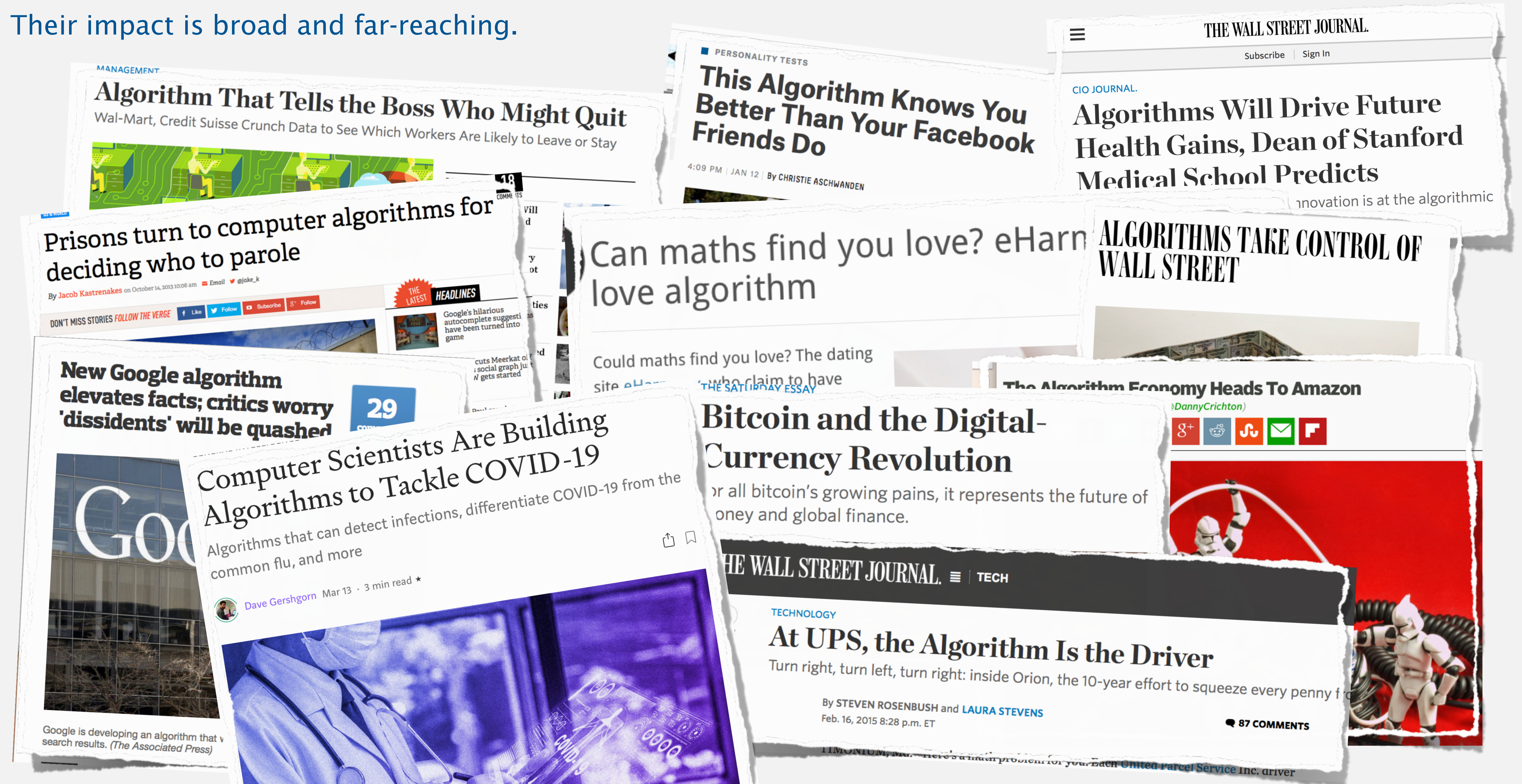
- Intermediate-level survey course.
- Programming and problem solving, with applications.
- **Algorithm:** step-by-step procedure for solving a problem.
- **Data structure:** method for organizing data in a computer.

topic	algorithms and data structures 
data types	stack, queue, union-find, priority queue
sorting	quicksort, mergesort, heapsort, radix sorts
searching	BST, red-black BST, hash table, kd-tree
graphs	BFS, DFS, Prim, Kruskal, Dijkstra, Ford-Fulkerson
strings	tries, suffix arrays, data compression



# Why study algorithms and data structures?

Their impact is broad and far-reaching.

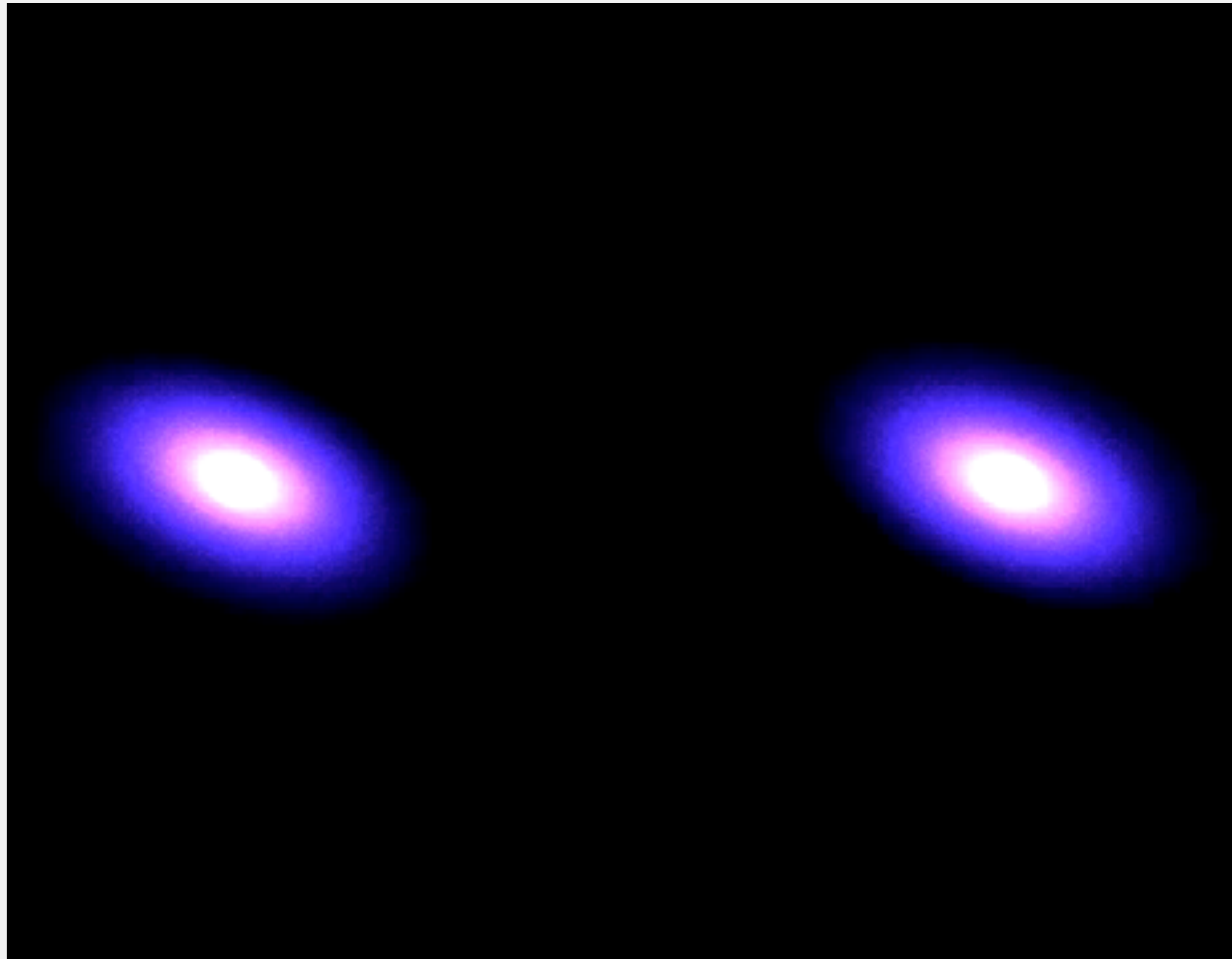


# Why study algorithms and data structures?

---



They may unlock the secrets of life and of the universe.



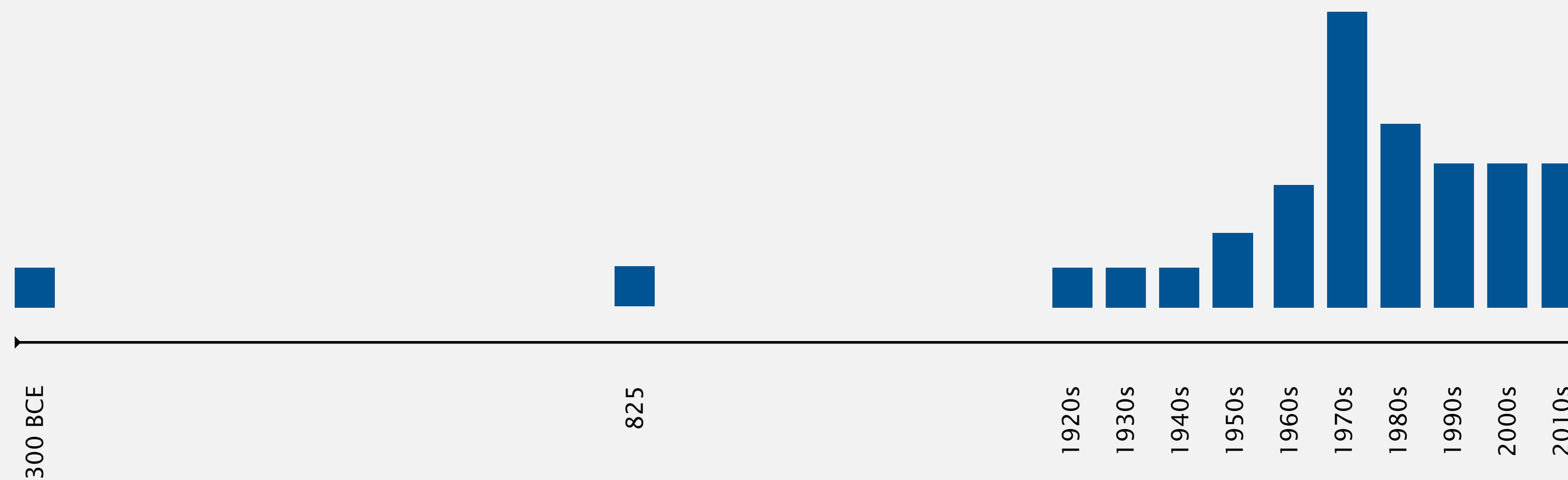
[https://www.youtube.com/watch?v=ua7YIN4eL\\_w](https://www.youtube.com/watch?v=ua7YIN4eL_w)

# Why study algorithms and data structures?

---

## Old roots, new opportunities.

- Study of algorithms dates at least to Euclid.
- Named after Muḥammad ibn Mūsā al-Khwārizmī.
- Formalized by Church and Turing in 1930s.
- Some important algorithms were discovered by undergrads in a course like this!

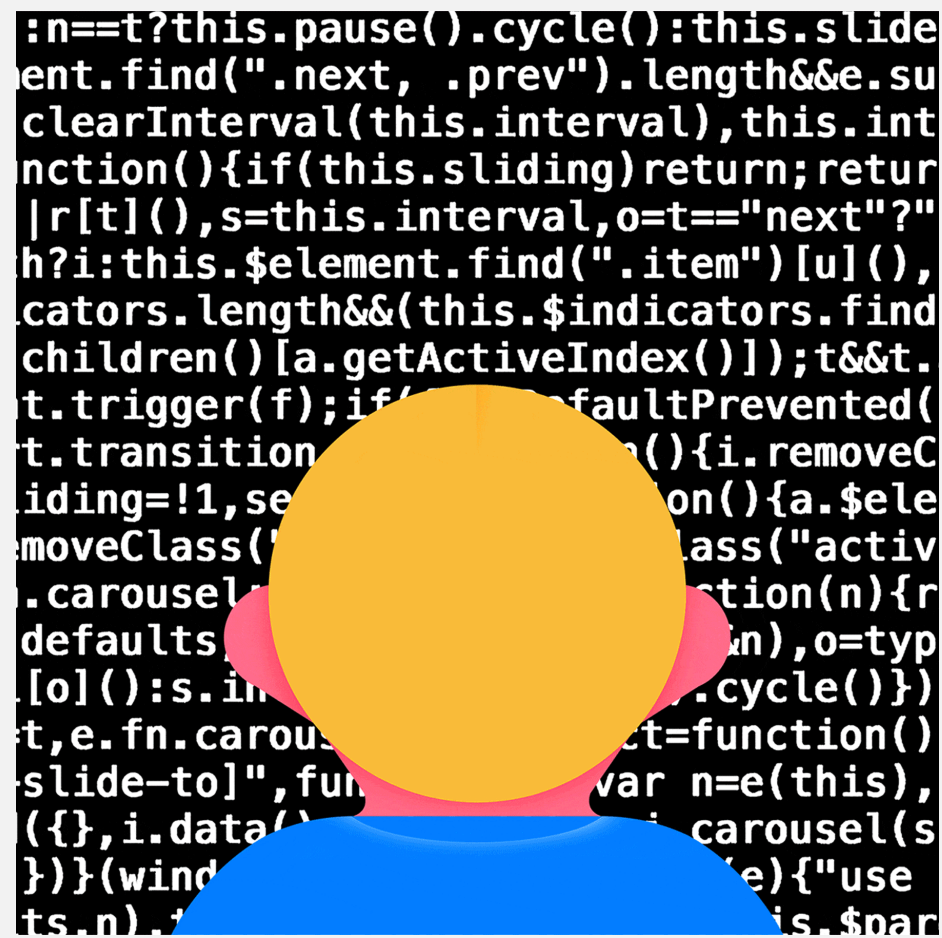




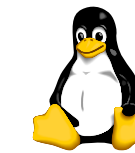
# Why study algorithms and data structures?

---

To become a proficient programmer.



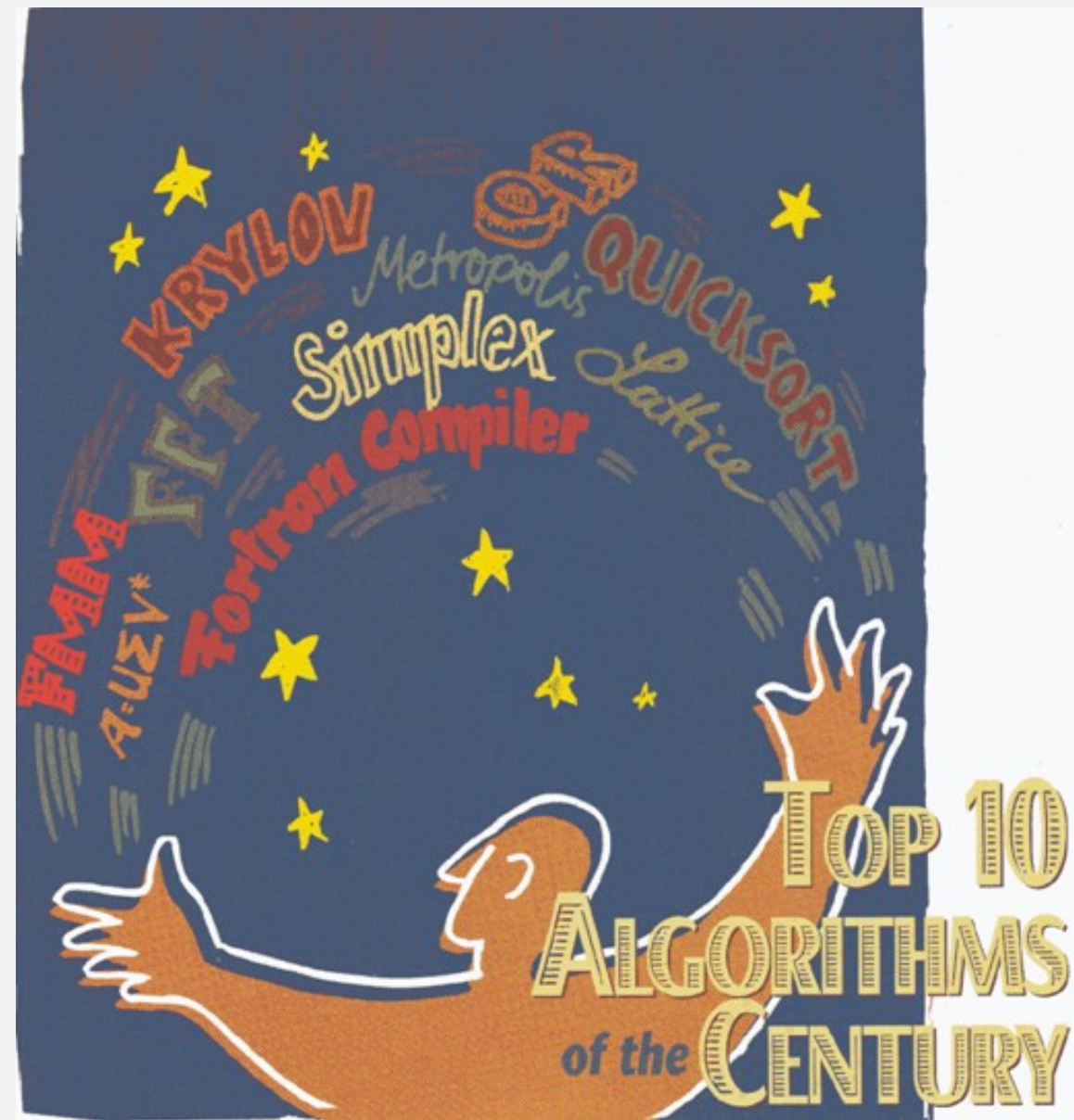
*“ I will, in fact, claim that the difference between a bad programmer and a good one is whether [they] considers [their] code or [their] data structures more important. Bad programmers worry about the code. Good programmers worry about data structures and their relationships. ”* — *Linus Torvalds (architect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



# Why study algorithms and data structures?

---

For intellectual stimulation.

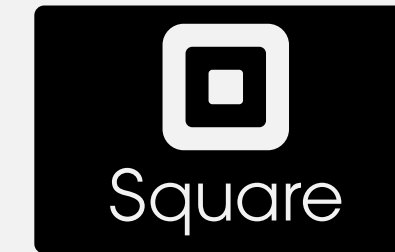
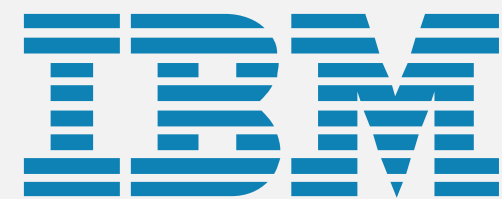
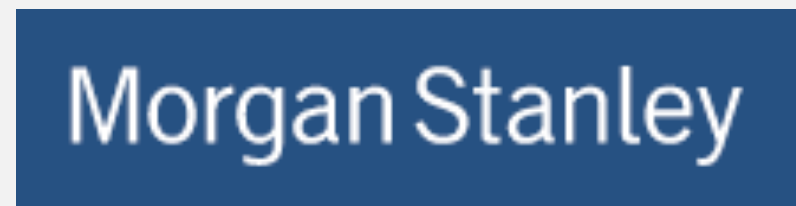
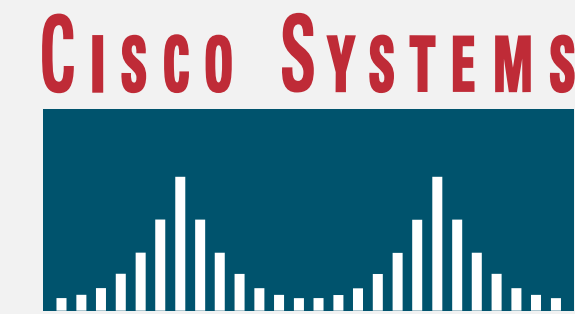
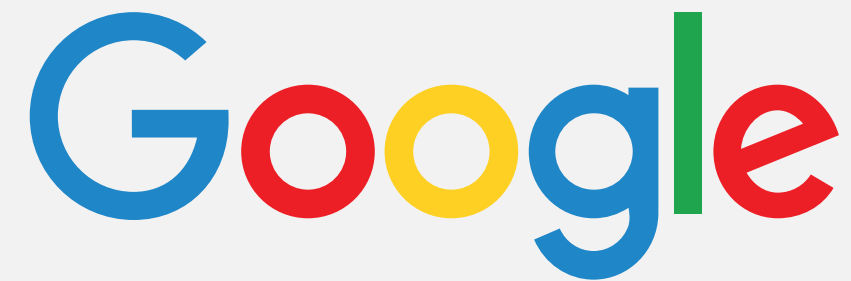


*“For me, great algorithms are the poetry of computation. Just like verse, they can be terse, allusive, dense, and even mysterious. But once unlocked, they cast a brilliant new light on some aspect of computing.” — Francis Sullivan*

# Why study algorithms and data structures?

---

For fun and profit.



# Why study algorithms and data structures?

---

- Their impact is broad and far-reaching.
- They may unlock the secrets of life and of the universe.
- Old roots, new opportunities.
- To become a proficient programmer.
- For intellectual stimulation.
- For fun and profit.



# INTRO TO COS 226

---

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




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

# Lectures

---

Live lectures. Introduce new material.

What	When	Where	Who	Office Hours
L01	TTh 11-12:20pm	Zoom 	Kevin Wayne	<i>see web</i>

Attendance. Required.

Waivers. As verified by your residential college.

Zoom links. Available via Canvas.


Zoom recordings. Available via Canvas.

Live questions during lecture. Raise hand and unmute.

Live questions after lecture. Stay in Zoom.

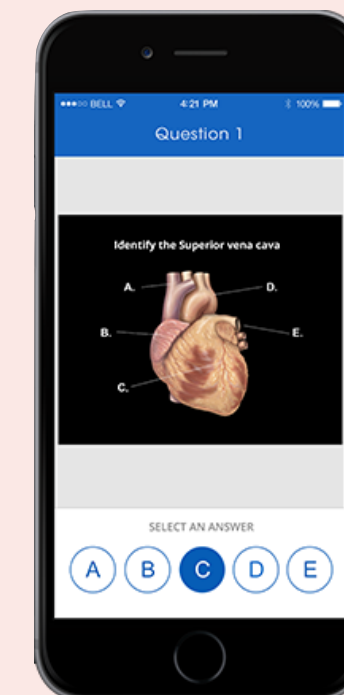
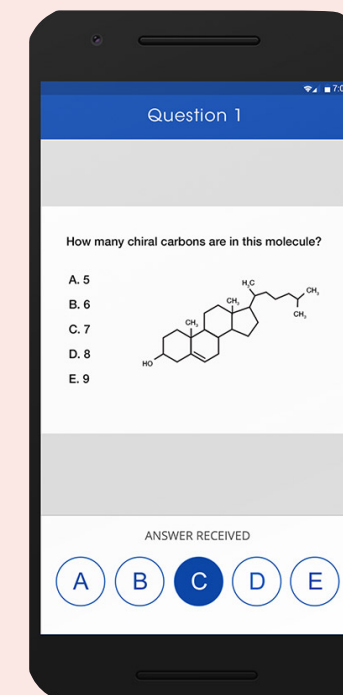
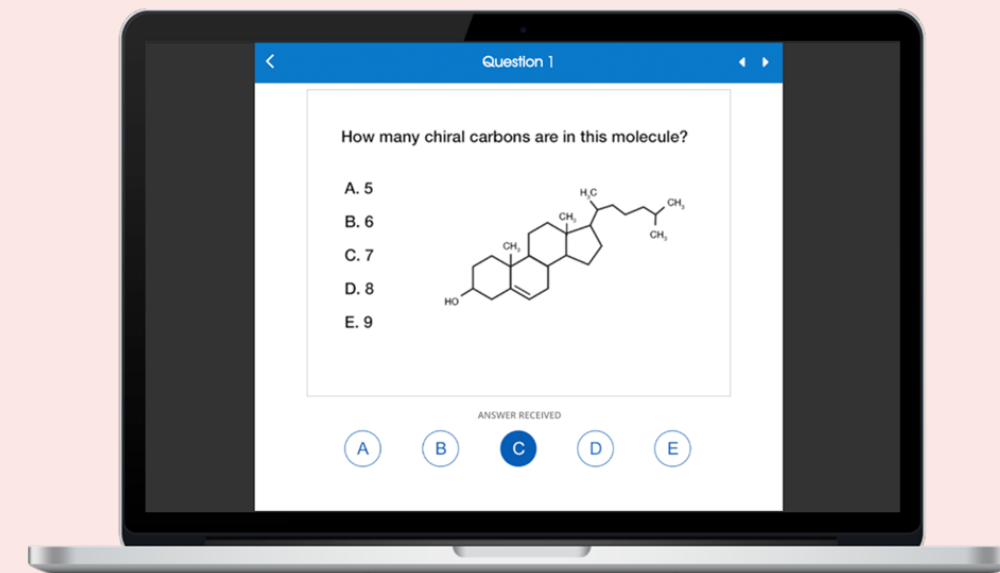
Side channel for questions during lecture. Zoom Chat today.

## Student response system (required).

- Multiple choice questions to increase engagement.
- Register iClicker Reef  using your Princeton email address.

## Which iClicker are you using?

- A. Web app.
- B. iPhone app.
- C. Android app.
- ~~D. Hardware.~~



# Precepts

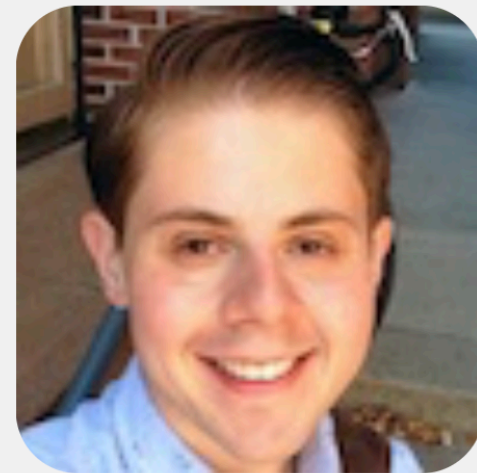
---

Discussion, problem-solving, assignment prep, ...



**Maia Ginsburg** ✉

Faculty  
Lead Preceptor



**Dan Leyzberg** ✉

Faculty  
Lead Preceptor



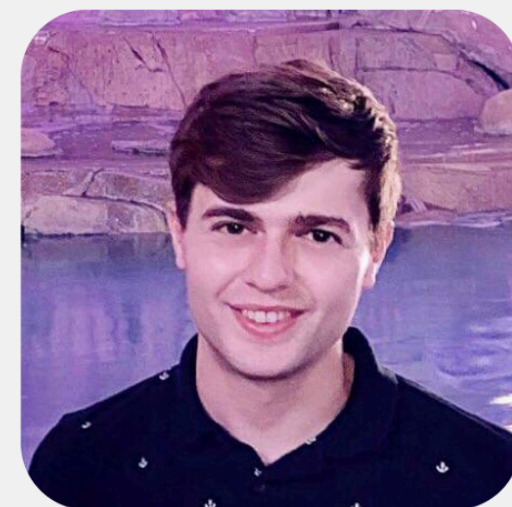
**Zak Kincaid** ✉

Faculty  
Preceptor



**Anat Kleiman** ✉

Graduate Student  
Preceptor



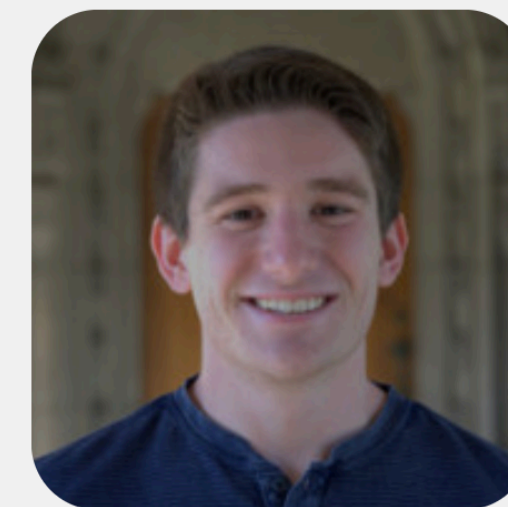
**Deniz Oktay** ✉

Graduate Student  
Preceptor



**Victor Ongkowitz** ✉

Graduate Student  
Preceptor



**Chris Sciavolino** ✉

Graduate Student  
Preceptor



# Precepts

---

What	When	Where	Who	Office Hours
P02	Th 3–4:20pm		Dan Leyzberg	<i>see web</i>
P03	F 11–12:20pm		Maia Ginsburg	<i>see web</i>
P04	F 11–12:20pm		Anat Kleiman	<i>see web</i>
P05	F 11–12:20pm		Zak Kincaid	<i>see web</i>
P06	F 1:30–2:50pm		Deniz Oktay	<i>see web</i>
P07	F 1:30–2:50pm		Chris Sciavolino	<i>see web</i>
P08	F 3–4:20pm		Victor Ongkowijaya	<i>see web</i>
P09	F 4:30–5:50pm		Maia Ginsburg	<i>see web</i>
P10	Th 4:30–5:50pm		Dan Leyzberg	<i>see web</i>



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

# INTRO TO COS 226

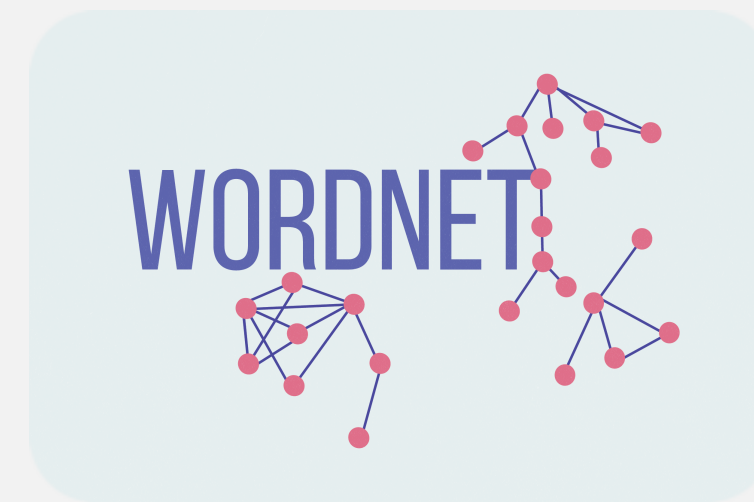
---

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

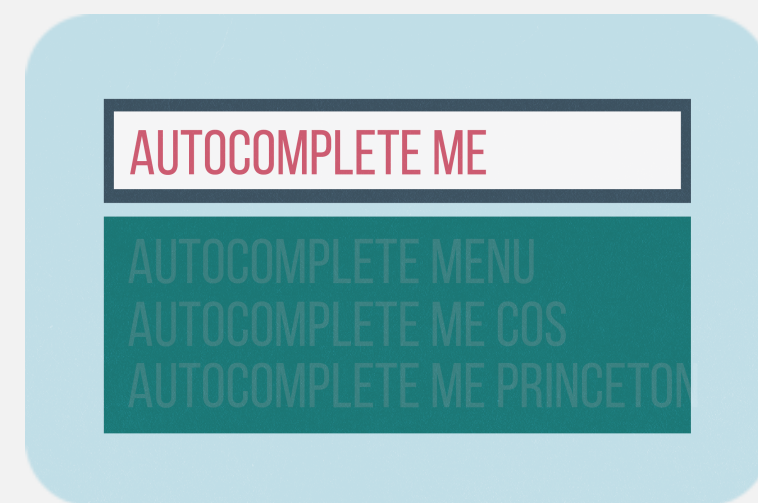
# Programming assignments

---

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



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



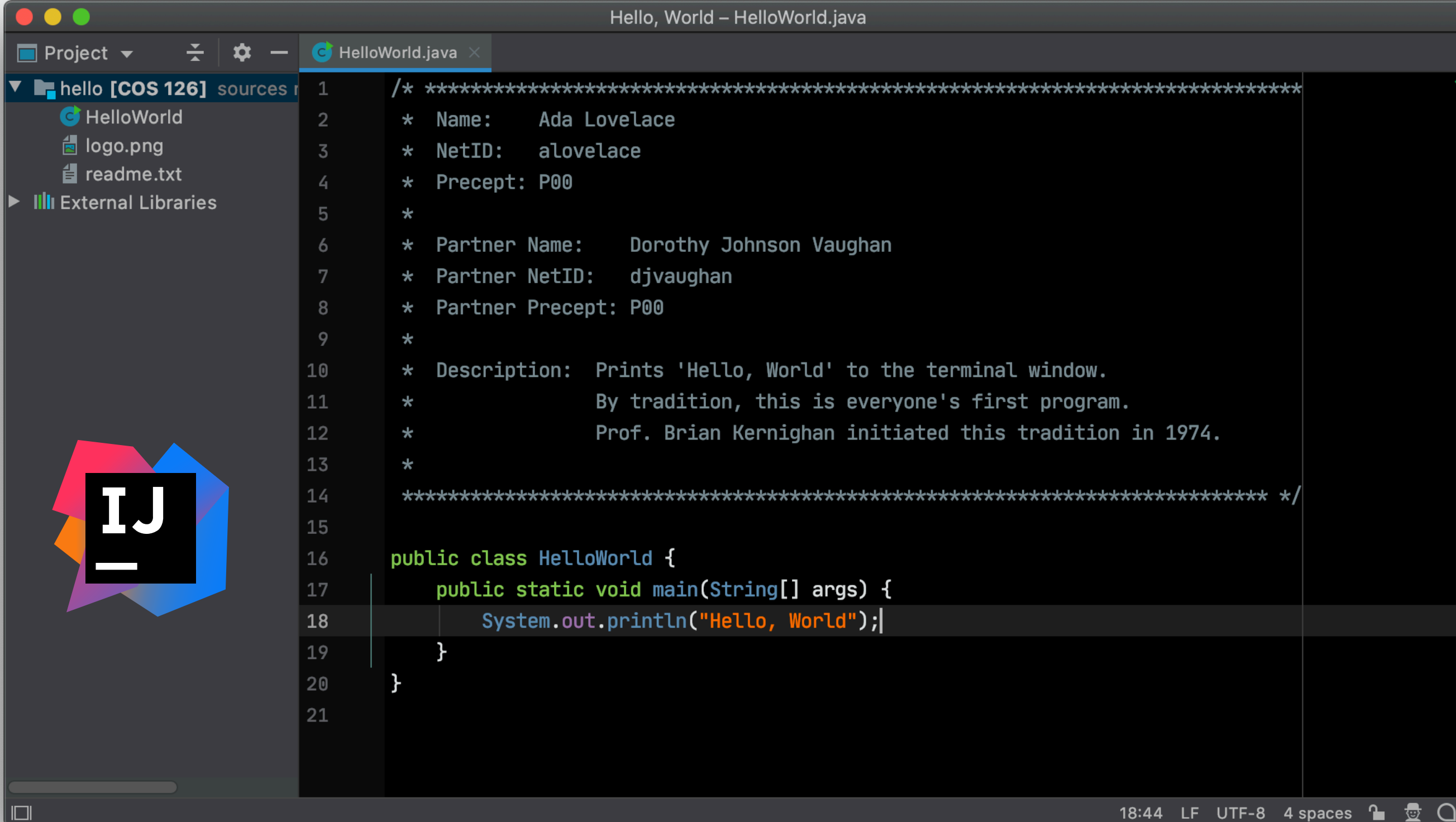
**Pair programming** (via Zoom) encouraged on designated assignments.



# Programming environment

Recommended IDE. Custom IntelliJ 2020.1 environment.  upgrade to latest version

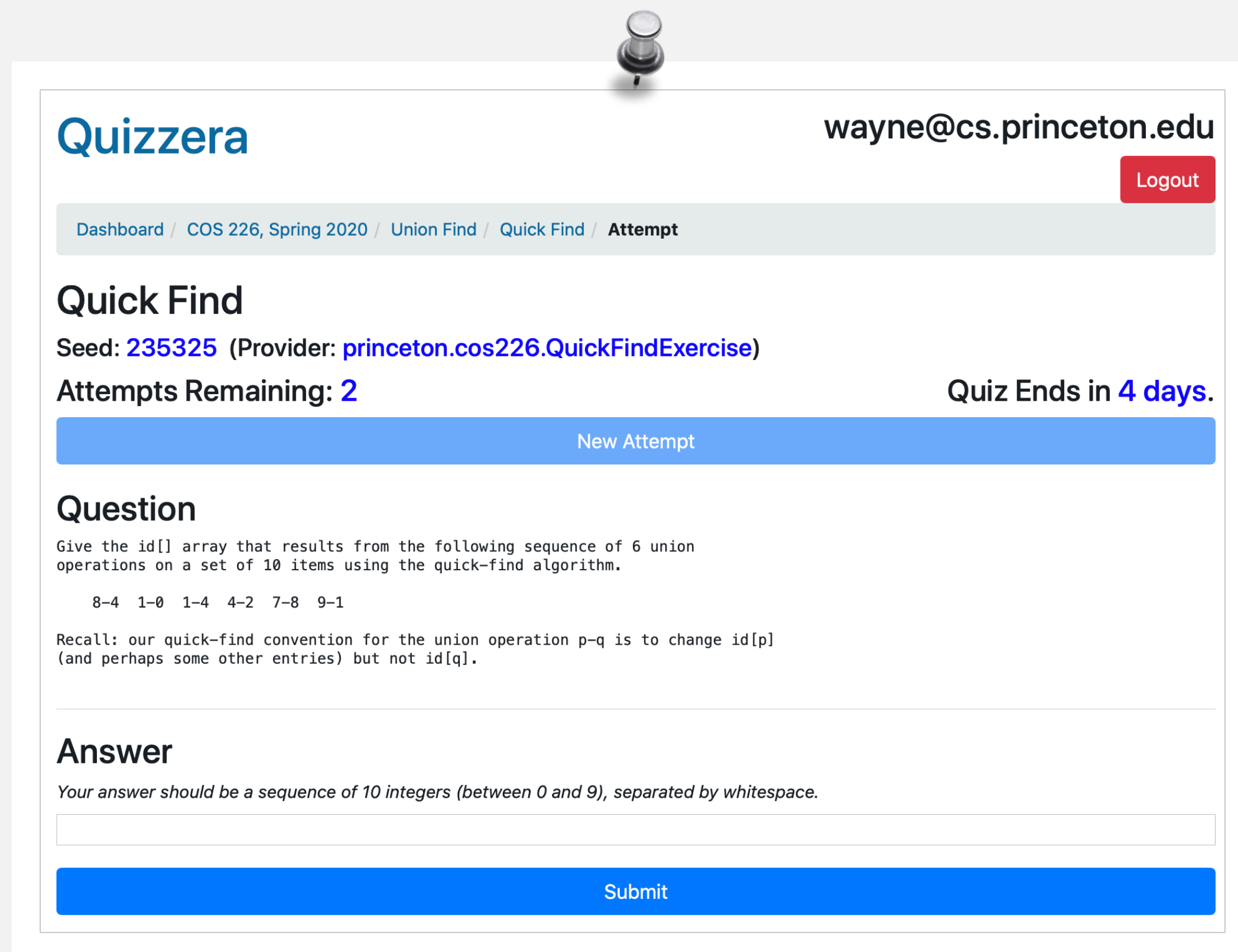
- Continuous code inspection; integrated Checkstyle and SpotBugs.
- Autoformat, autoimport, and autocomplete.
- Embedded Bash terminal.
- ...



```
1  /* *****  
2  * Name:    Ada Lovelace  
3  * NetID:   alovelace  
4  * Precept: P00  
5  *  
6  * Partner Name:    Dorothy Johnson Vaughan  
7  * Partner NetID:   djvaughan  
8  * Partner Precept: P00  
9  *  
10 * Description: Prints 'Hello, World' to the terminal window.  
11 *              By tradition, this is everyone's first program.  
12 *              Prof. Brian Kernighan initiated this tradition in 1974.  
13 *  
14 ***** */  
15  
16 public class HelloWorld {  
17     public static void main(String[] args) {  
18         System.out.println("Hello, World");  
19     }  
20 }  
21
```

## Quizzera platform.

- 2–3 short questions per lecture.
- Solving using pencil and paper.
- 3 attempts per question (score = max of each question).



The screenshot shows the Quizzera interface for a user named wayne@cs.princeton.edu. The page title is "Quizzera" and the user is logged in. The breadcrumb trail is "Dashboard / COS 226, Spring 2020 / Union Find / Quick Find / Attempt". The quiz is titled "Quick Find" and has a seed of 235325. The user has 2 attempts remaining and the quiz ends in 4 days. A blue button labeled "New Attempt" is visible. The question asks for the id[] array after a sequence of 6 union operations on a set of 10 items. The operations are: 8-4, 1-0, 1-4, 4-2, 7-8, and 9-1. A recall note states that the quick-find convention for the union operation p-q is to change id[p] (and perhaps some other entries) but not id[q]. Below the question is a text input field for the answer and a blue "Submit" button.

**Quizzera** wayne@cs.princeton.edu [Logout](#)

[Dashboard](#) / [COS 226, Spring 2020](#) / [Union Find](#) / [Quick Find](#) / **Attempt**

### Quick Find

Seed: 235325 (Provider: [princeton.cos226.QuickFindExercise](#))

Attempts Remaining: 2 Quiz Ends in 4 days.

[New Attempt](#)

### Question

Give the `id[]` array that results from the following sequence of 6 union operations on a set of 10 items using the quick-find algorithm.

8-4 1-0 1-4 4-2 7-8 9-1

Recall: our quick-find convention for the union operation `p-q` is to change `id[p]` (and perhaps some other entries) but not `id[q]`.

---

### Answer

Your answer should be a sequence of 10 integers (between 0 and 9), separated by whitespace.

[Submit](#)

# Midterm and final

---

## Written exams.

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

**Midterm.** 90-minute remote exam (24-hour window).

**Final.** 3-hour remote exam (24-hour window).

## Final Exam

**STUDENT NAME**

**Q1 Initialization**  
3 Points

*This exam has 16 questions (including this one) worth a total of 100 points. You have 180 minutes, plus a 10-minute grace period. The Gradescope timer starts at 190 minutes, which includes the 10-minute grace period.*

# Grading **A+**

---

## Programming assignments. **45%**

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

## Quizzes. **10%**

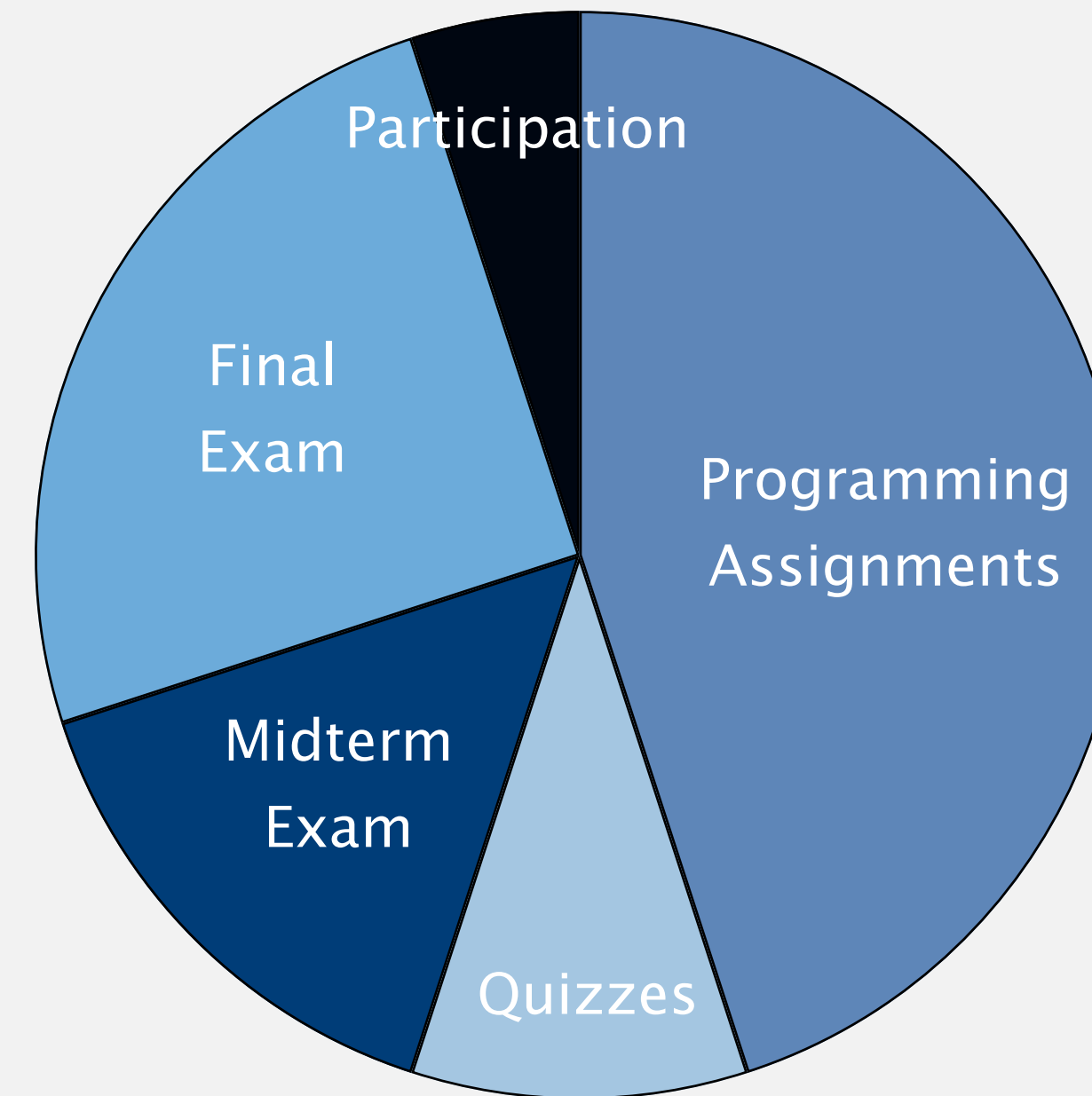
- Due at 11:59pm on Fridays via Quizzera.
- Collaboration/lateness policies: see web.

## Exams. **15% + 25%**

- Midterm (Monday, October 19).
- Final (to be scheduled by Registrar).

## Active participation. **5%**

- Participate in precept/lecture.  
[ perfect attendance not required to earn 100% of participation points ]
- Answer questions in online discussion forum.





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

# INTRO TO COS 226

---

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



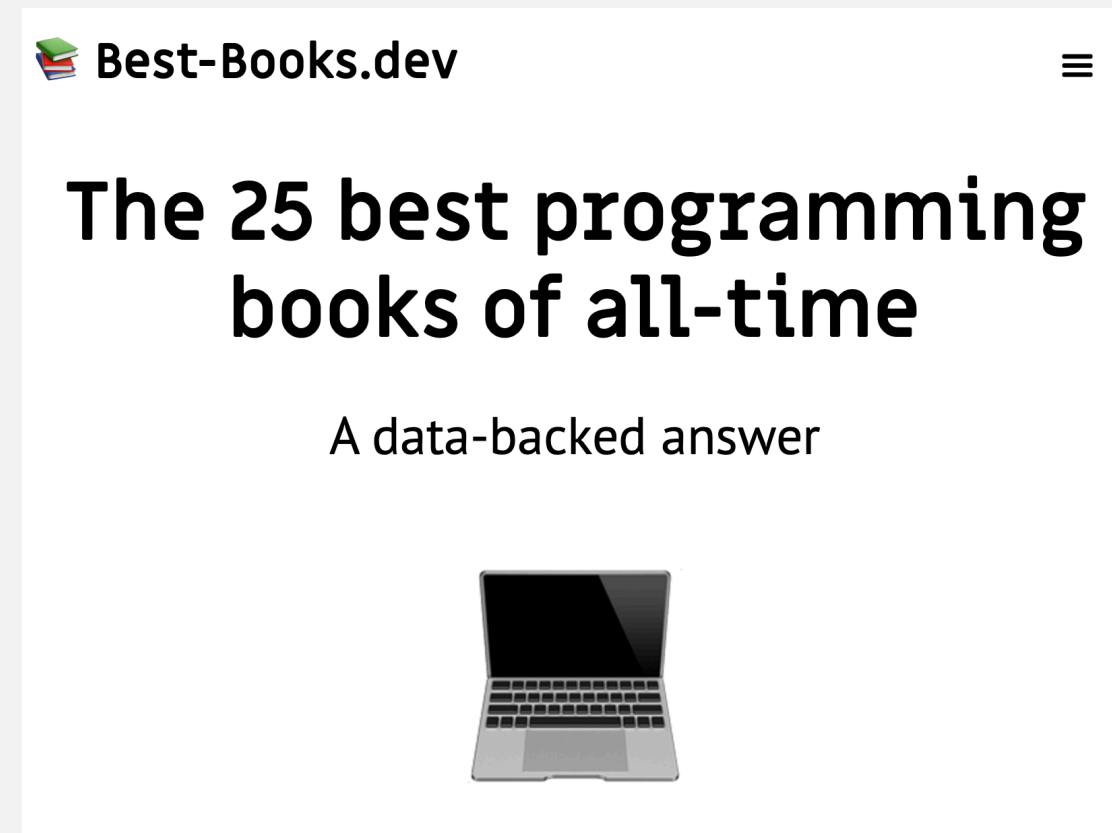
## Resources (textbook)

---

**Readings (required).** Algorithms 4<sup>th</sup> edition by R. Sedgwick and K. Wayne, Addison-Wesley Professional, 2011, ISBN 0-321-57351-X.



4<sup>th</sup> edition (2011)



Available from various vendors and formats.

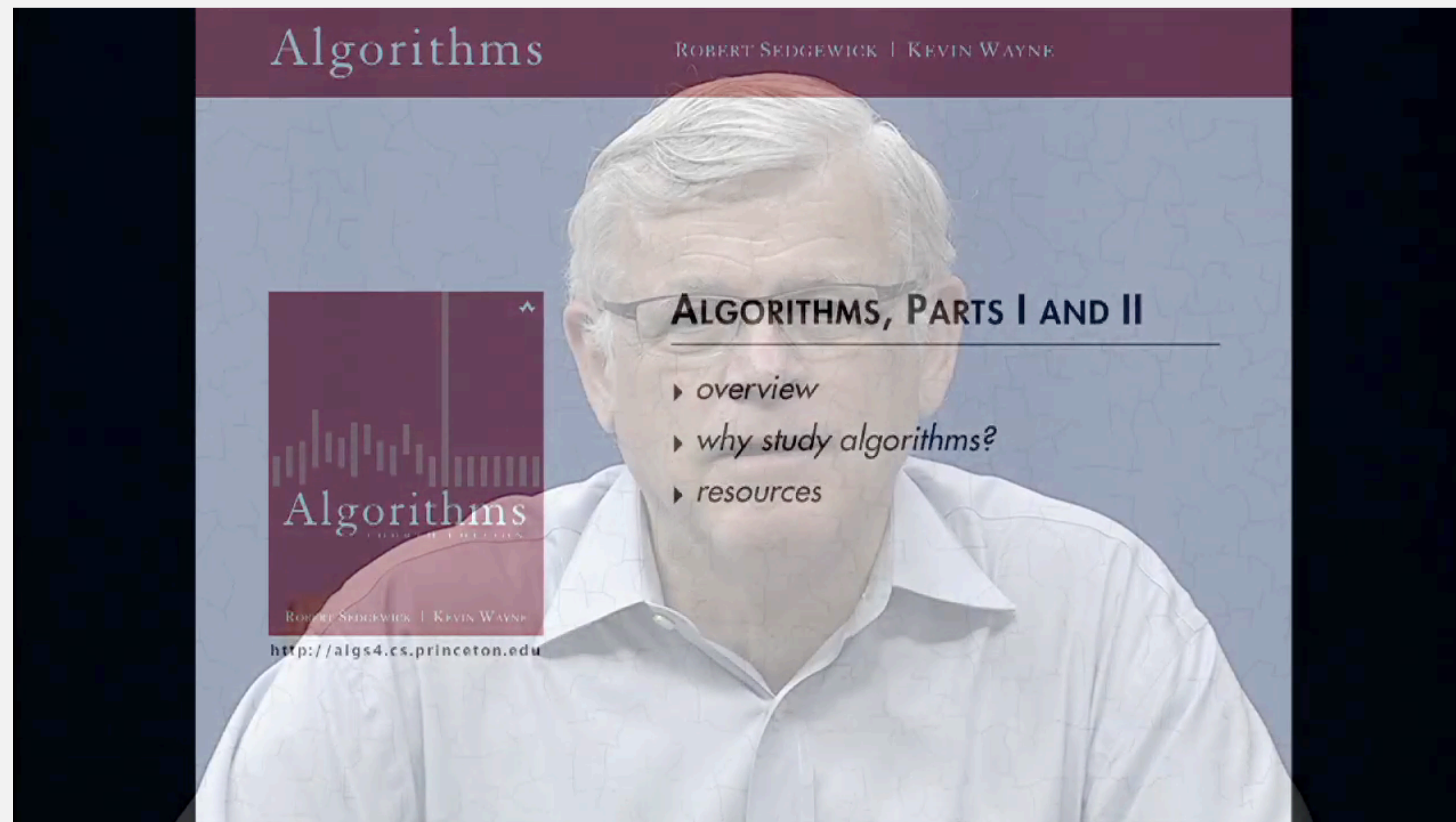
- Amazon: \$70 hardcover, \$58 Kindle, ...
- ~~Labyrinth: \$63 hardcover, \$40 rent.~~
- Safari Tech Books Online, \$0.





## Studio-produced videos (optional).

- Different perspective.



# Resources (studio-produced videos)

## Studio-produced videos (optional).

- Different perspective.
- Transcript search.

**cuvids**

ALL COLLECTIONS  Hello, cas-princeton-university-wayne

### Algorithms, 4th Edition

Need to subscribe all modules?

Search Results: "percolation" Include: everything

**1.E Applications** 9:22 0%

**3.F\* Applications** 13:25 0%

#### 1.E Applications

0:56 So, the one we're going to talk about now is called **percolation**.

2:49 That's just a few examples of the **percolation** model.

6:17 So the **percolation** model on the left corresponds to the, connection model on the right, according to what we've been doing.

7:41 And that's where we get the result that, by running enough simulations for a big-enough n, that this, **percolation** threshold is about.

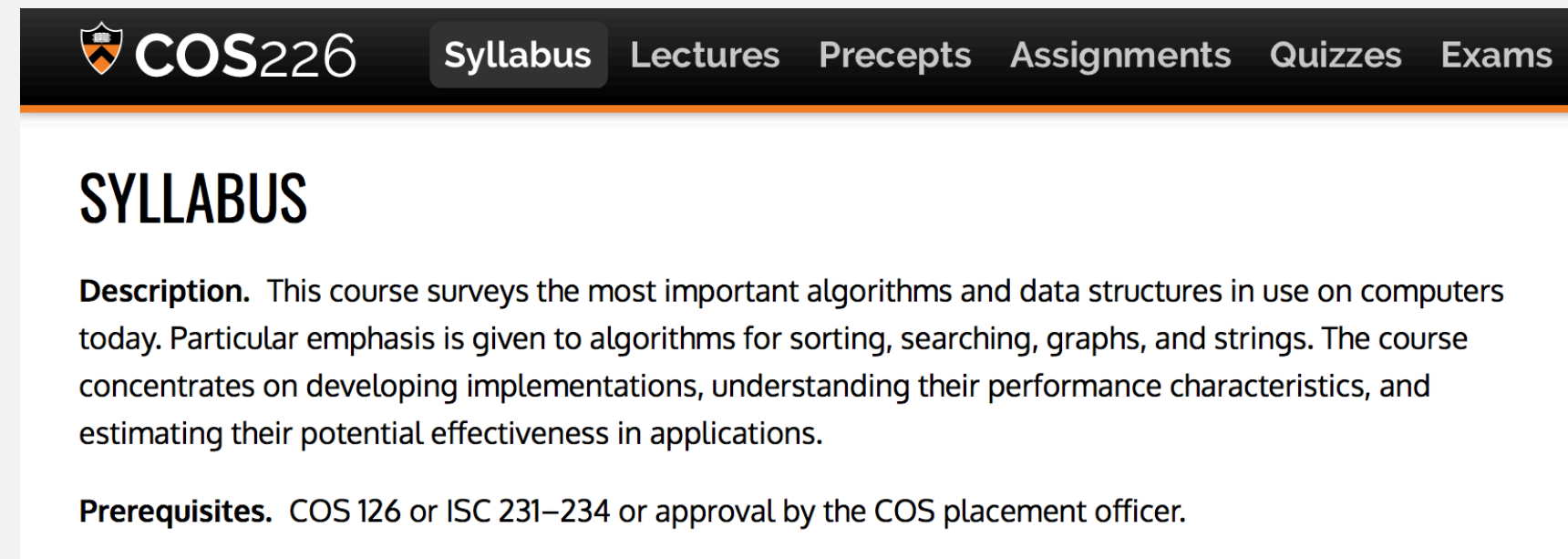
<https://cuvids.io>

# Resources (web)

---

## Course content.

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

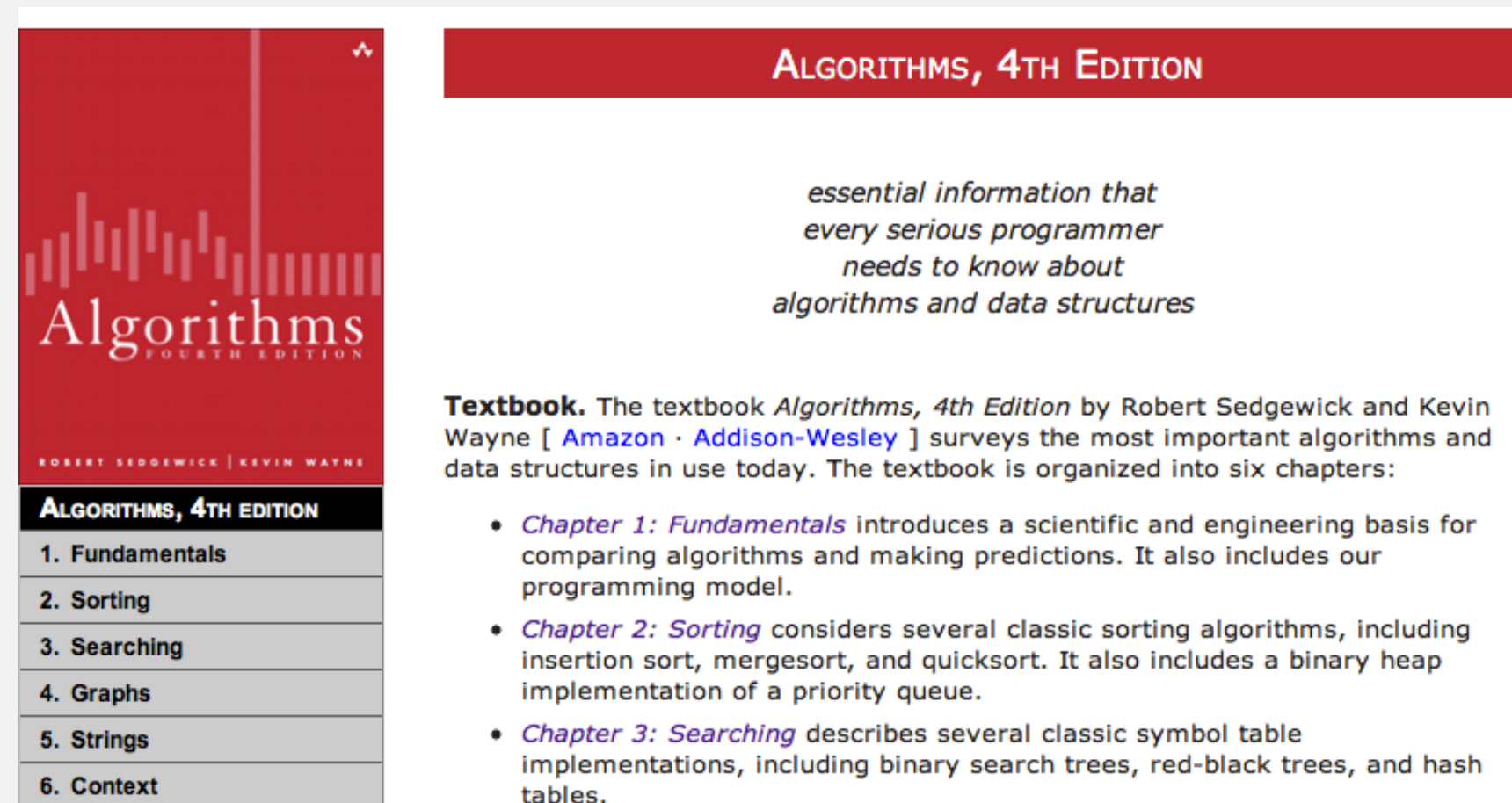


The screenshot shows the top navigation bar of the COS226 website with links for Syllabus, Lectures, Precepts, Assignments, Quizzes, and Exams. The main heading is 'SYLLABUS'. Below it, the 'Description' states: 'This course surveys the most important algorithms and data structures in use on computers 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.' The 'Prerequisites' section lists: '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.



The screenshot shows the book's website with a red header 'ALGORITHMS, 4TH EDITION'. The main text reads: 'essential information that every serious programmer needs to know about algorithms and data structures'. Below this, the 'Textbook' section describes the book by Robert Sedgwick and Kevin Wayne, available on Amazon and Addison-Wesley. It lists six chapters: 1. Fundamentals, 2. Sorting, 3. Searching, 4. Graphs, 5. Strings, and 6. Context. A list of chapter descriptions follows: Chapter 1 introduces a scientific and engineering basis for comparing algorithms; Chapter 2 covers sorting algorithms like insertion sort and mergesort; Chapter 3 describes symbol table implementations like binary search trees and hash tables.

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

# Resources (people)

---

## Online discussion forum.

- Low latency, low bandwidth.
- See Ed Discussion for guidelines.
- Use Ed; do not email course staff.



<https://us.edstem.org/courses/638>

## Office hours.



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



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

## “Computing laboratory.”



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



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

# A typical week (including this one!)



Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1
2	3	4 Lecture 1 (Union-Find)	5	6 Lecture 2 (Analysis)	7 Precept 1 Quiz 0, 1, 2	8
9	10 Assignment 1 (Percolation)	11	12	13	14	15

you are here!

again on  
Thursday

support lecture material;  
assignment prep

content based on  
week's material

content based on  
corresponding lectures

## Administrative Q+A

---

**Not registered?** Register ASAP; attend any precept this week (Zoom links in Canvas).

**Change precept?** Use TigerHub.

**All non-conflicting precepts closed?** Contact Colleen Kenny.

**Haven't taken COS 126?** See COS placement officer.

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

**Additional administrative questions.** Ask now in Zoom; ask anytime in Ed Discussion.

