COS 226, Fall 2019

Algorithms

and

Data Structures

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Princeton University

https://algs4.cs.princeton.edu

Intro to COS 226

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

COS 226 course overview

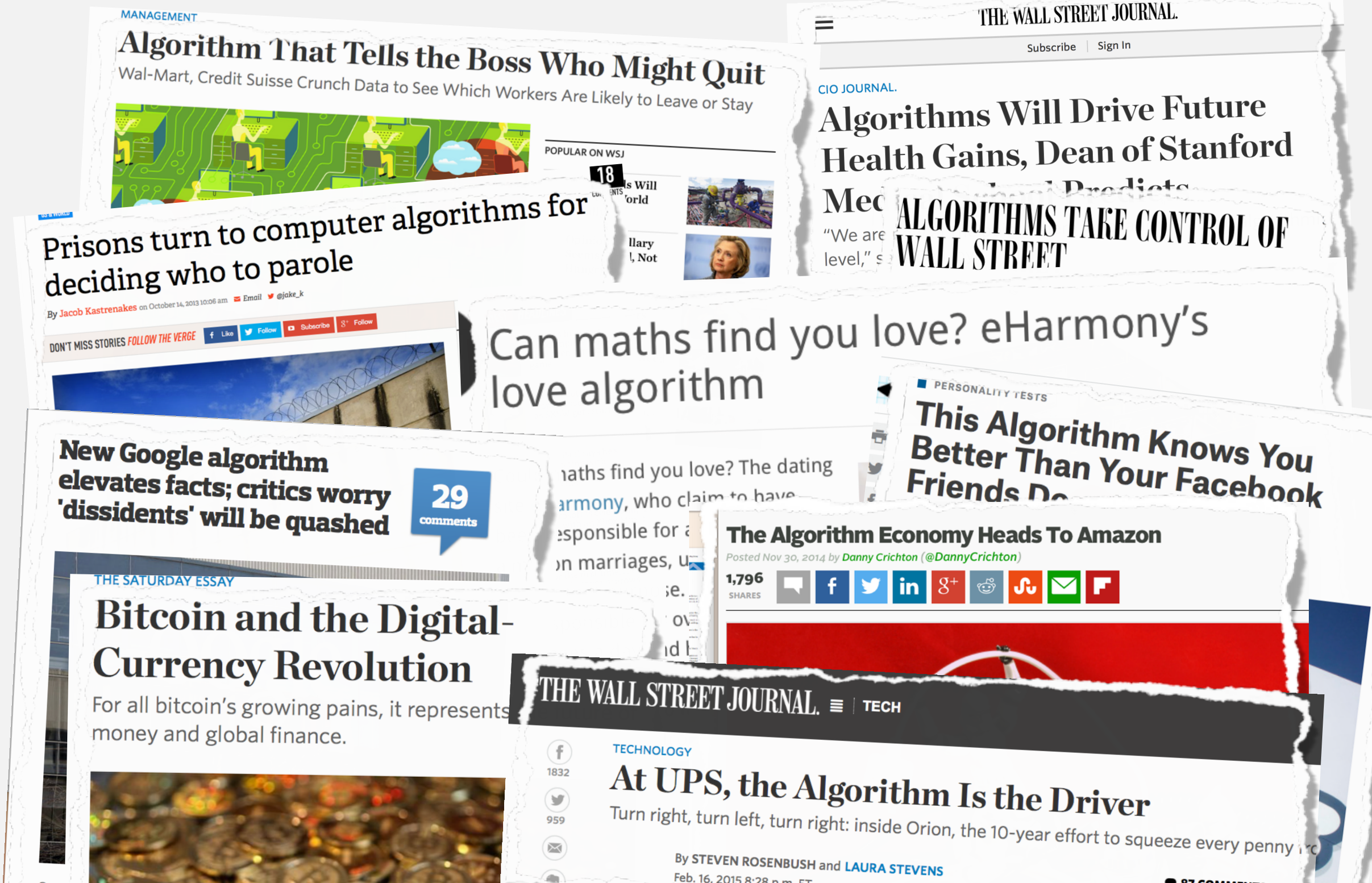
What is COS 226?

- Intermediate-level survey course.
- Programming and problem solving, with applications.
- Algorithm: sequence of instructions for solving a problem.
- Data structure: method to organize data in a computer.

topic	data structures and algorithms
data types	stack, queue, union–find, priority queue
sorting	quicksort, mergesort, heapsort, radix sorts
searching	BST, red–black BST, hash table
graphs	BFS, DFS, Prim, Kruskal, Dijkstra
strings	KMP, regular expressions, tries, data compression
advanced	k-d tree, suffix array, maxflow

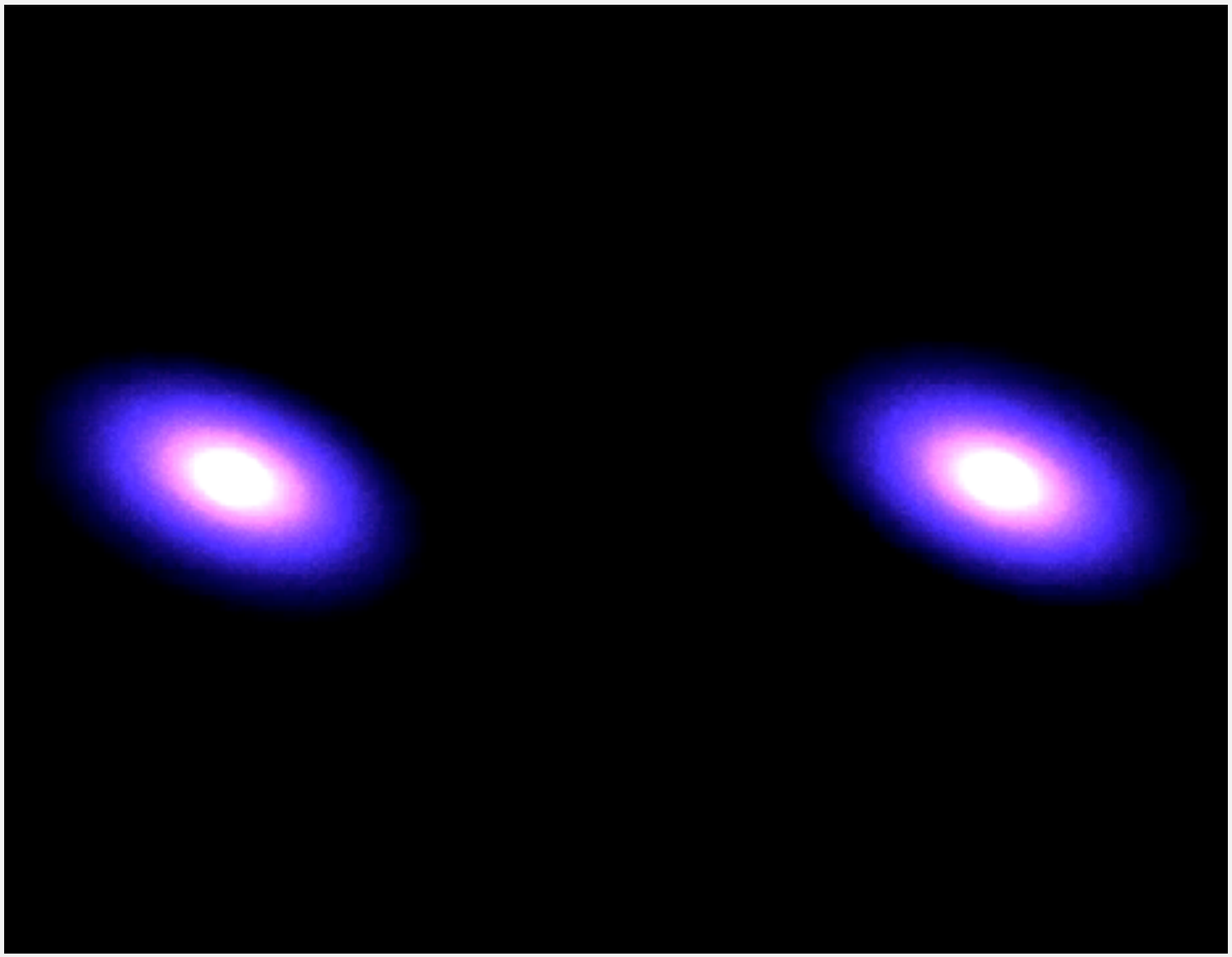
Why study algorithms and data structures?

Their impact is broad and far-reaching.



Why study algorithms and data structures?

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

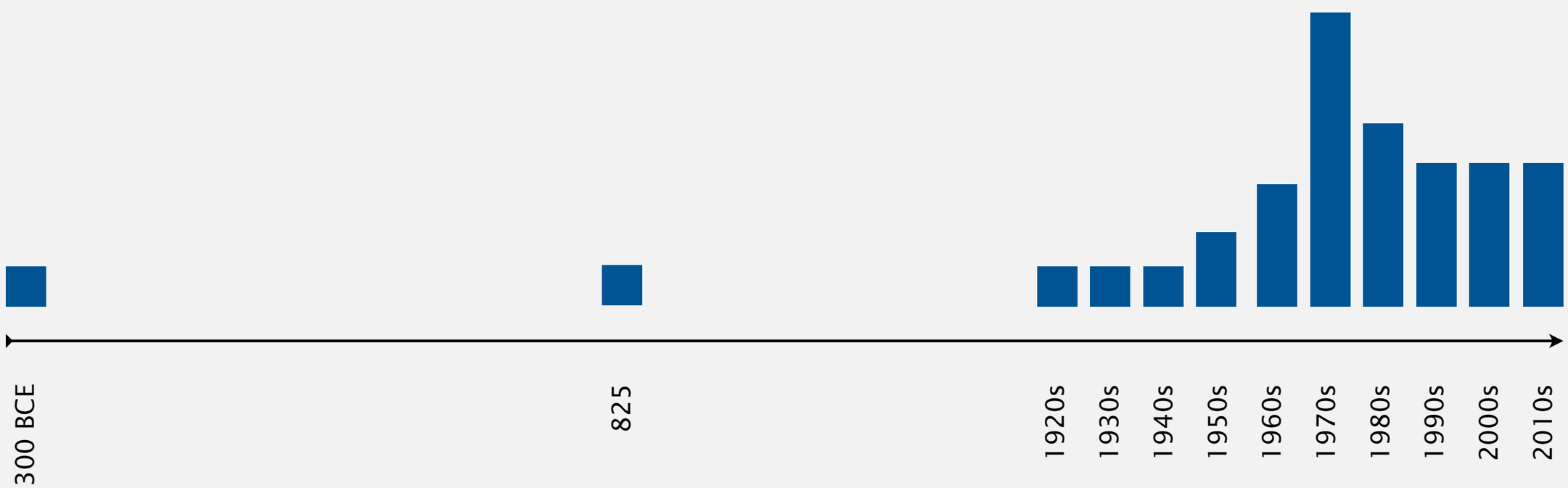


http://www.youtube.com/watch?v=ua7YlN4eL_w

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 he considers his code or his 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*

FROM THE EDITORS

THE JOY OF ALGORITHMS

Francis Sullivan, Associate Editor-in-Chief

THE THEME OF THIS FIRST-OF-THE-CENTURY ISSUE OF *COMPUTING IN SCIENCE & ENGINEERING* IS ALGORITHMS. IN FACT, WE WERE BOLD ENOUGH—AND PERHAPS FOOLISH ENOUGH—TO CALL THE 10 EXAMPLES WE'VE SELECTED "THE TOP 10 ALGORITHMS OF THE CENTURY."

Computational algorithms are probably as old as civilization. Sumerian cuneiform, one of the most ancient written records, consists partly of algorithm descriptions for reckoning in base 60. And I suppose we could claim that the Druid algorithm for estimating the start of summer is embodied in Stonehenge. (That's really hard hardware!)

Like so many other things that technology affects, algorithms have advanced in startling and unexpected ways in the 20th century—at least it looks that way to us now. The algorithms we chose for this issue have been essential for progress in communications, health care, manufacturing, economics, weather prediction, defense, and fundamental science. Conversely, progress in these areas has stimulated the search for ever-better algorithms. I recall one late-night bull session on the Maryland Shore when someone asked, "Who first ate a crab? After all, they don't look very appetizing." After the usual speculations about the observed behavior of sea gulls, someone gave what must be the right answer—namely, "A very hungry person first ate a crab."

The flip side to "necessity is the mother of invention" is "invention creates its own necessity." Our need for powerful machines always exceeds their availability. Each significant computation brings insights that suggest the next, usually much larger, computation to be done. New algorithms are an attempt to bridge the gap between the demand for cycles and the available supply of them. We've become accustomed to gaining the Moore's Law factor of two every 18 months. In effect, Moore's Law changes the constant in front of the estimate of running time as a function of problem size. Important new algorithms do not come along every 1.5 years, but when they do, they can change the exponent of the complexity!

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. Researchers have cracked many hard problems since 1 January 1900, but we are passing some even harder ones on to the next century. In spite of a lot of good work, the question of how to extract information from extremely large masses of data is still almost untouched. There are still very big challenges coming from more "traditional" tasks, too. For example, we need efficient methods to tell when the result of a large floating-point calculation is likely to be correct. Think of the way that check sums function. The added computational cost is very small, but the added confidence in the answer is large. Is there an analog for things such as huge, multidisciplinary optimizations? At an even deeper level is the issue of reasonable methods for solving specific cases of "impossible" problems. Instances of NP-complete problems crop up in attempting to answer many practical questions. Are there efficient ways to attack them?

I suspect that in the 21st century, things will be ripe for another revolution in our understanding of the foundations of computational theory. Questions already arising from quantum computing and problems associated with the generation of random numbers seem to require that we somehow tie together theories of computing, logic, and the nature of the physical world.

The new century is not going to be very restful for us, but it is not going to be dull either!

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.

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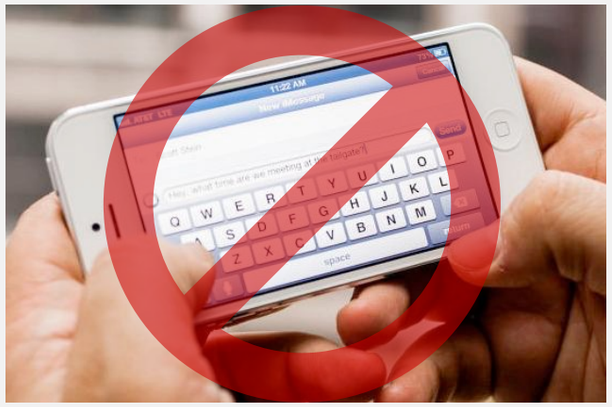
Lectures

Live lectures. Introduce new material.

What	When	Where	Who	Office Hours
L01	TTh 11–12:20	Friend 101	Kevin Wayne	M 1:30–3:30pm

Electronic devices. Permitted *only* to support lecture (e.g., viewing slides and taking notes).



Student response system (required).

- Any hardware version of iClicker.

  (use iClicker Reef at your own risk, WiFi issues?)
- Register your iClicker in Blackboard.
- Available at Labyrinth Books ($30).

save serial number
to maintain resale value

use only one device
per lecture!

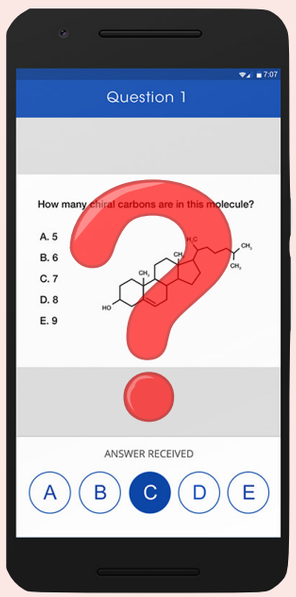
Which model of iClicker are you using?

A. iClicker.

B. iClicker+.

C. iClicker 2.

D. iClicker Reef.



Precepts

Discussion, problem-solving, assignment prep, …

Maia Ginsburg

Faculty

Lead Preceptor

Ibrahim Albluwi

Faculty

Lead Preceptor

Bob Tarjan

Faculty

Preceptor

Lisa Jian

Graduate Student

Preceptor

Chris Sciavolino

Graduate Student

Preceptor

Devon Loehr

Graduate Student

Preceptor

Precepts

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

What	When	Where	Who
P01	Th 1:30–2:50pm	Friend 016	Maia Ginsburg
P02	Th 3–4:20pm	Friend 016	Chris Sciavolino
P04	F 11–12:20pm	Friend 009	Ibrahim Albluwi
P05	F 11–12:20pm	Friend 111	Lisa Jian
P07	F 1:30–2:50pm	Friend 009	Devon Loehr
P08	F 3–4:20pm	Friend 009	Ibrahim Albluwi
P09	Th 3–4:20pm	Sherrerd 001	Bob Tarjan
P10	Th 3–4:20pm	TBA	Maia Ginsburg

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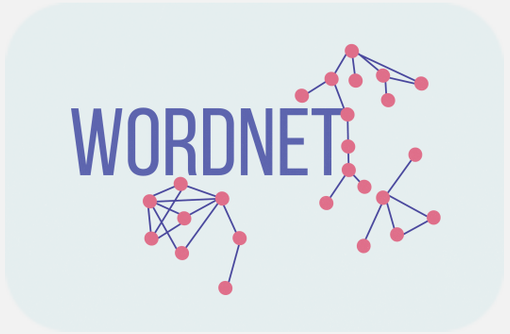
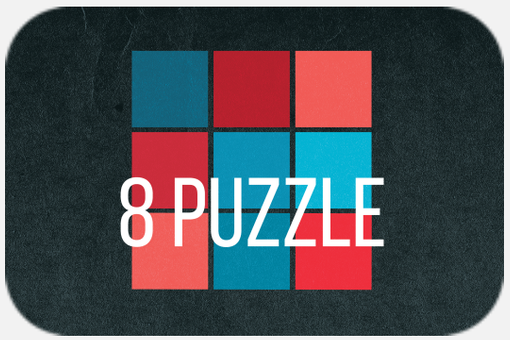
- *union–find*

Programming assignments

Implement an efficient algorithm or data structure.



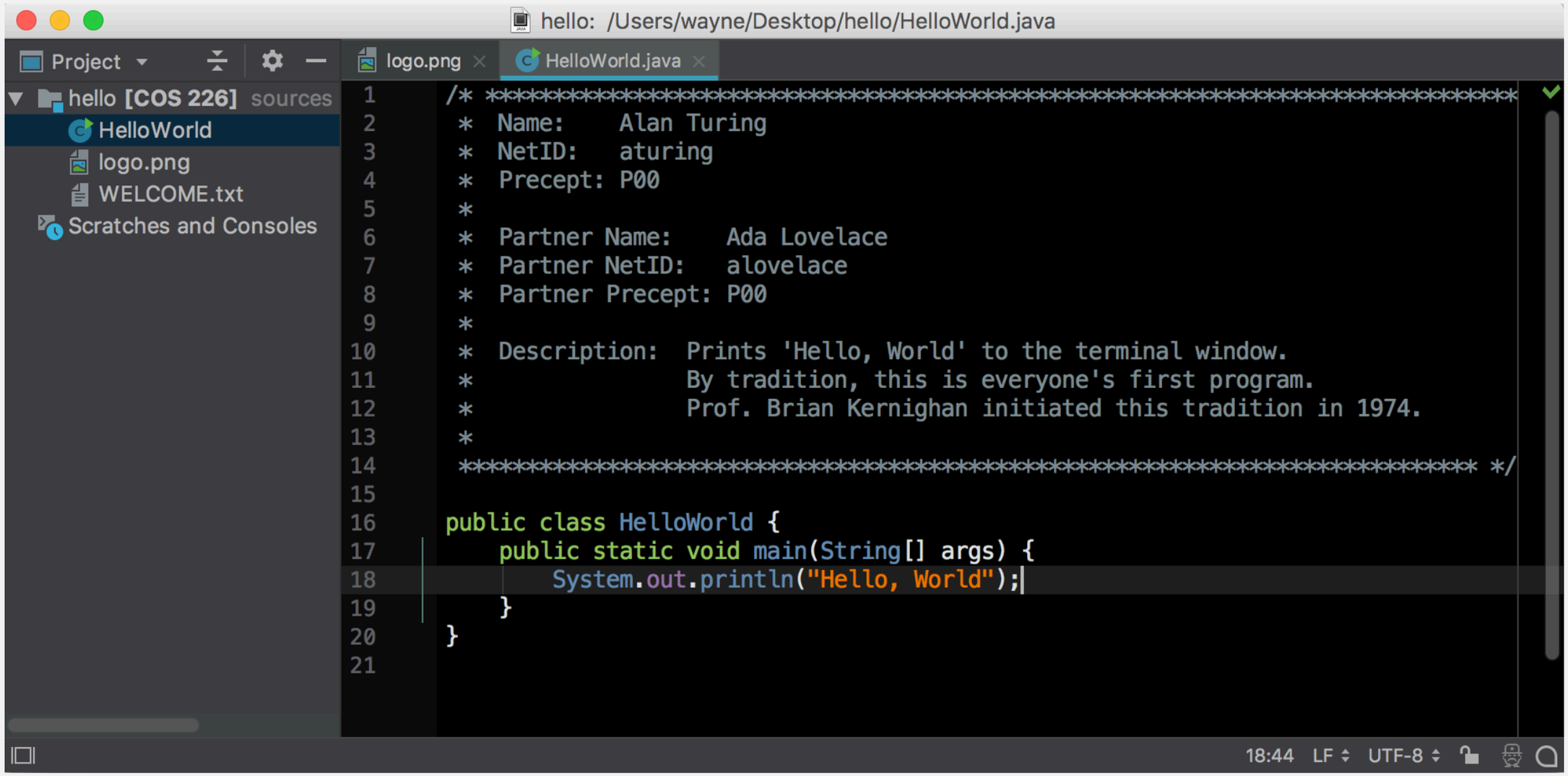
Solve an interesting application using a “textbook” algorithm.



Programming assignments

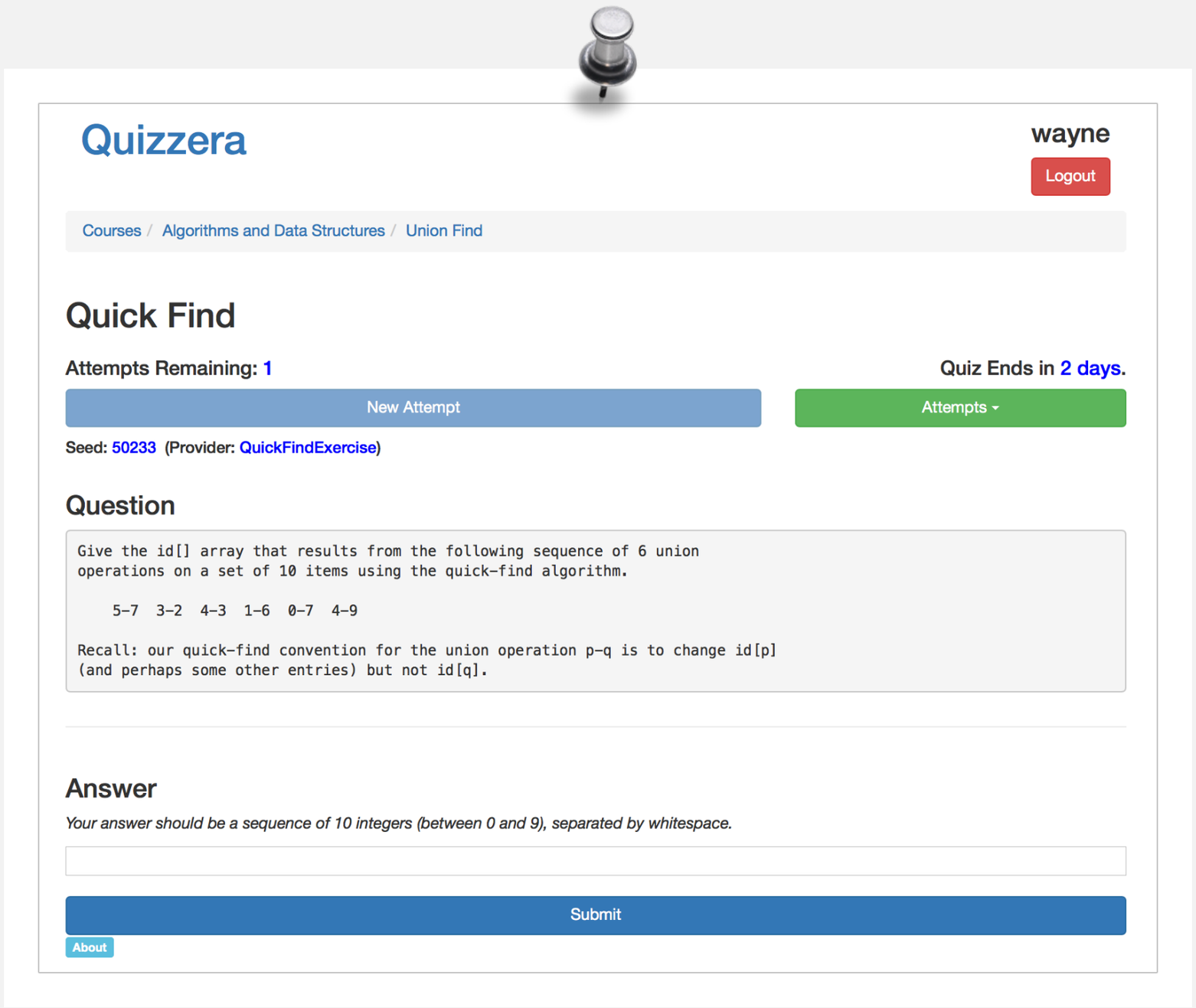
Recommended IDE. Custom IntelliJ environment (used in COS 126).

- Continuous code inspection; integrated Checkstyle and Spotbugs.
- Autoformat, autoimport, and autocomplete.
- Embedded bash terminal.
- ...



Quizzes

- 2–3 short questions per lecture.
- 3 attempts per question.
- Use pencil and paper.



Midterm and final

Written exams.

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

COS 226 **Algorithms and Data Structures** **Fall 2017**

Midterm

This exam has 10 questions (including question 0) worth a total of 55 points. You have 80 minutes. This exam is preprocessed by a computer, so please **write darkly** and **write your answers inside the designated spaces.**

Policies. The exam is closed book, except that you are allowed to use a one page cheatsheet (8.5-by-11 paper, one side, in your own handwriting). No electronic devices are permitted.

Grading

Programming assignments. 45%

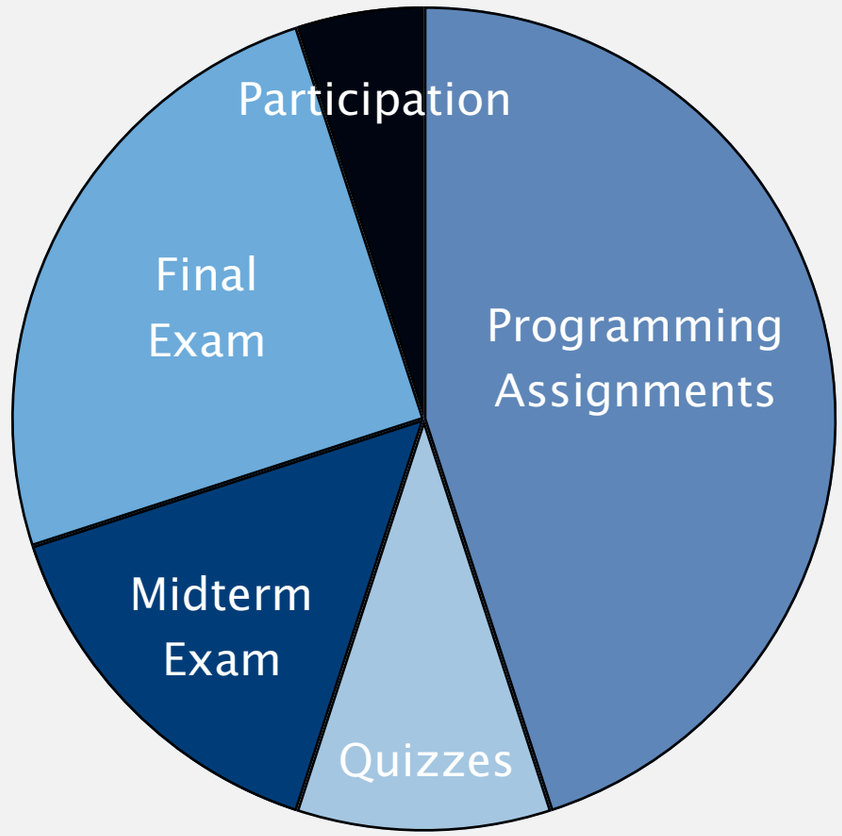
- Due at 11pm on Mondays via TigerFile.
- Collaboration/lateness policies: see web.

Quizzes. 10%

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

Exams. 15% + 25%

- Midterm (in class on Tuesday, October 22).
- 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 on Piazza.

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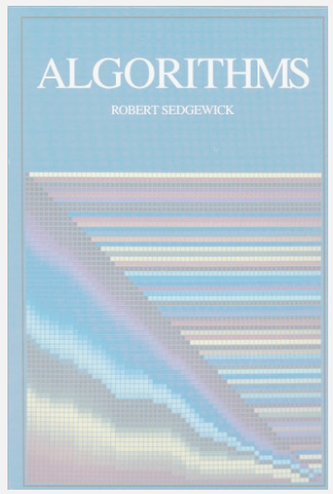
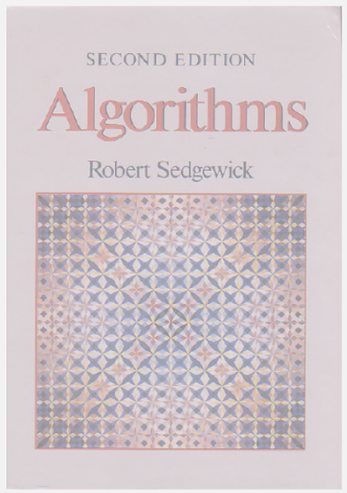
Resources (textbook)

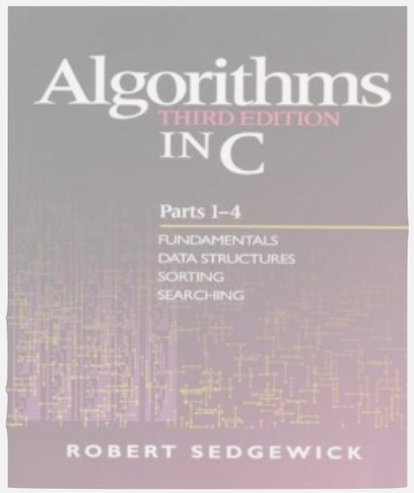
Readings (required). Algorithms 4th edition by R. Sedgewick and K. Wayne, Addison-Wesley Professional, 2011, ISBN 0–321–57351–X.



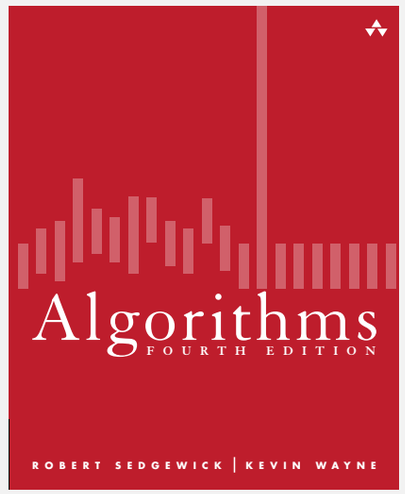
1st edition (1982)



2nd edition (1988)



3rd edition (1997)



4th edition (2011)

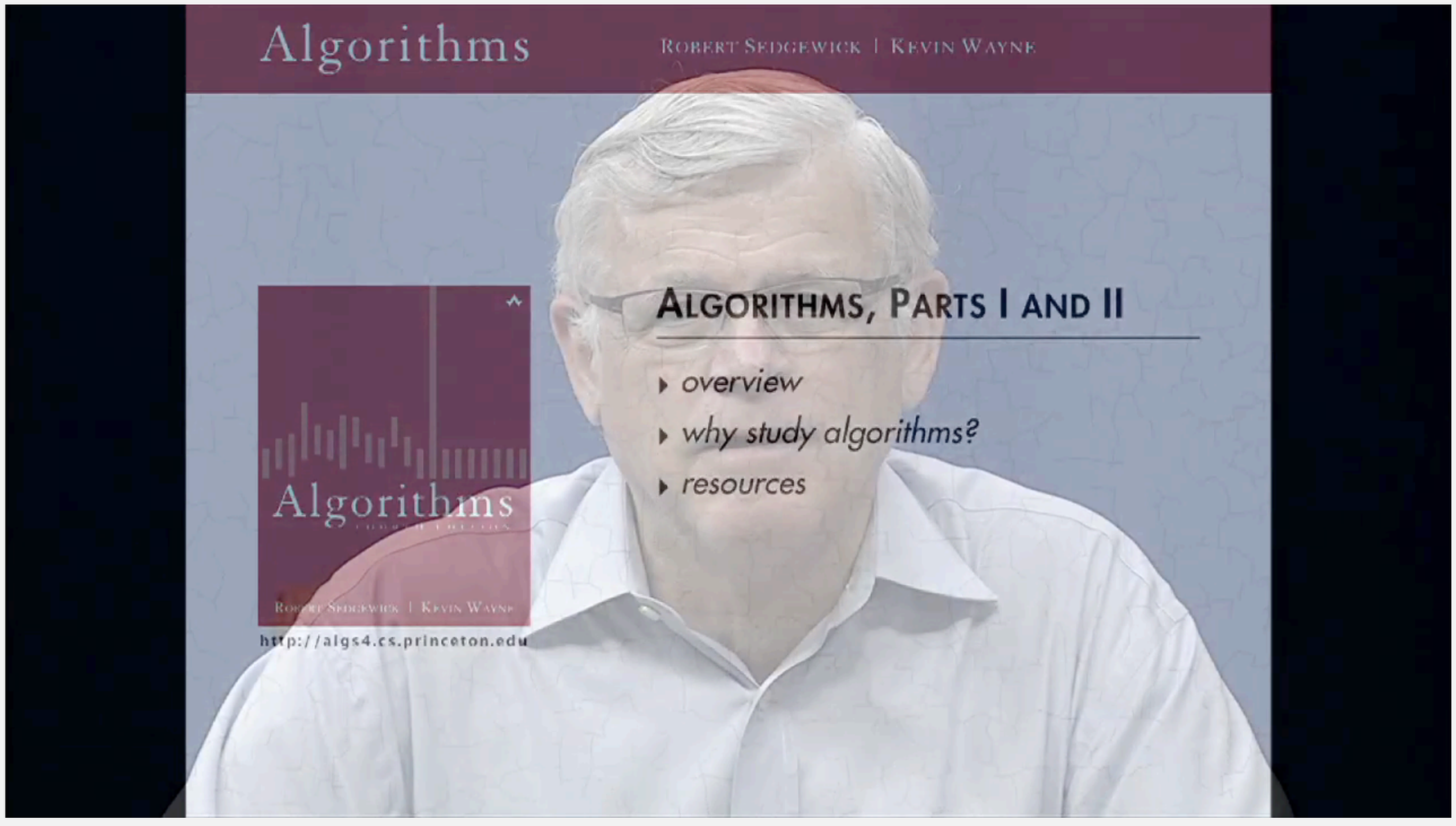
Available from various vendors in hardcover and ebook formats.

- Amazon: $75 hardcover, $58 Kindle, ...
- Labyrinth: $63 hardcover, $40 rent.
- Engineering library: on reserve.
- Safari Tech Books Online.

Resources (videos)

Lecture videos (optional).

- Missed lecture.
- Review for exams.



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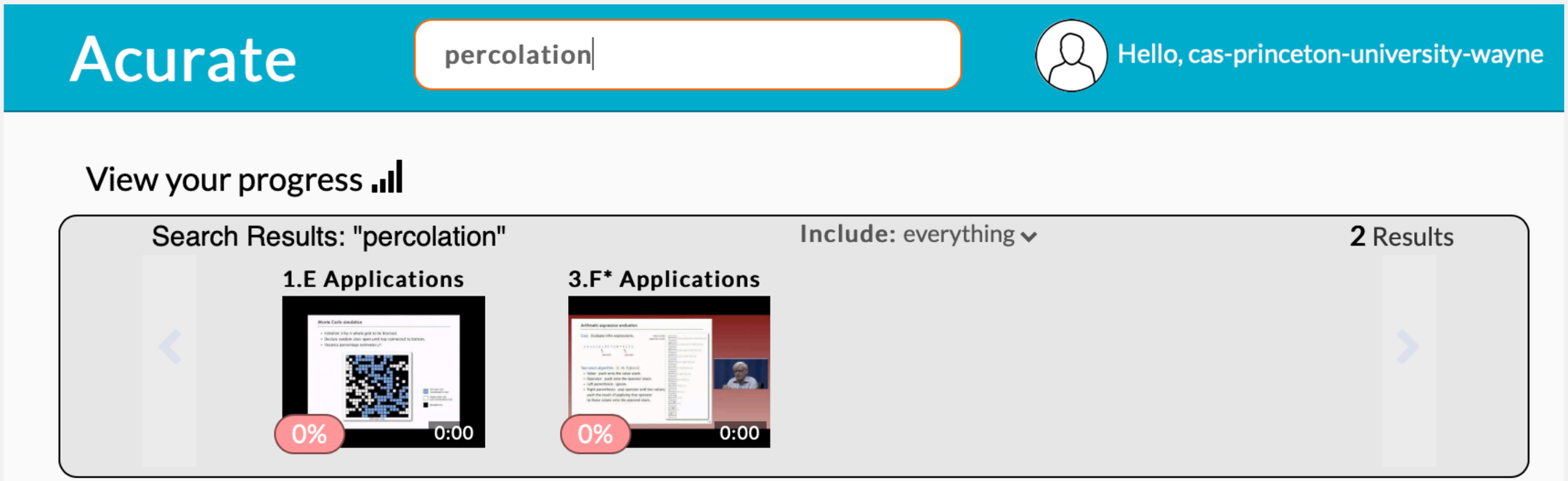
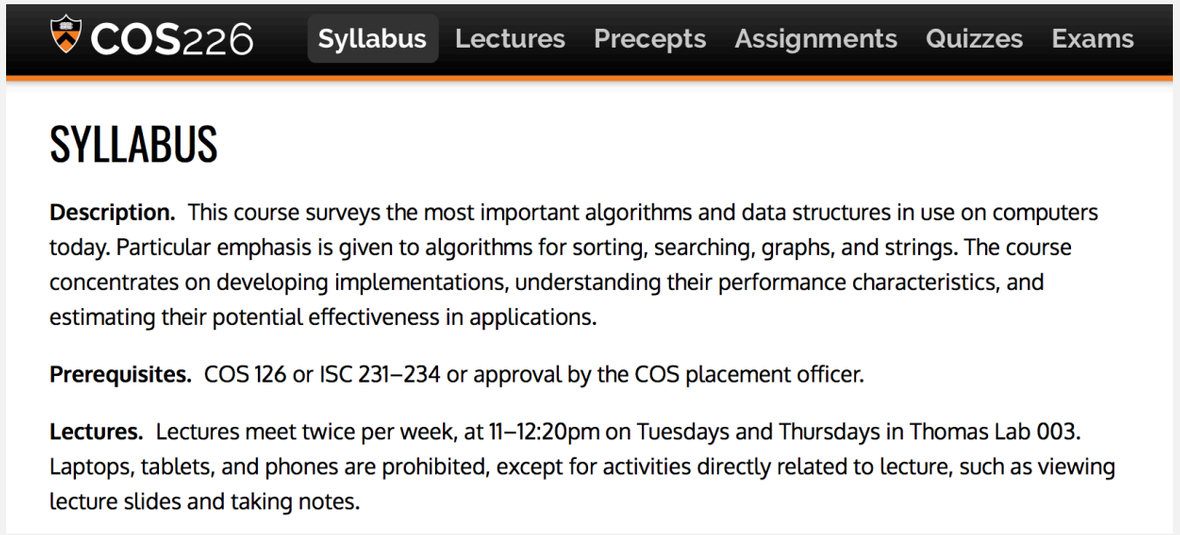


http://cuvids.io

Resources (web)

Course content.

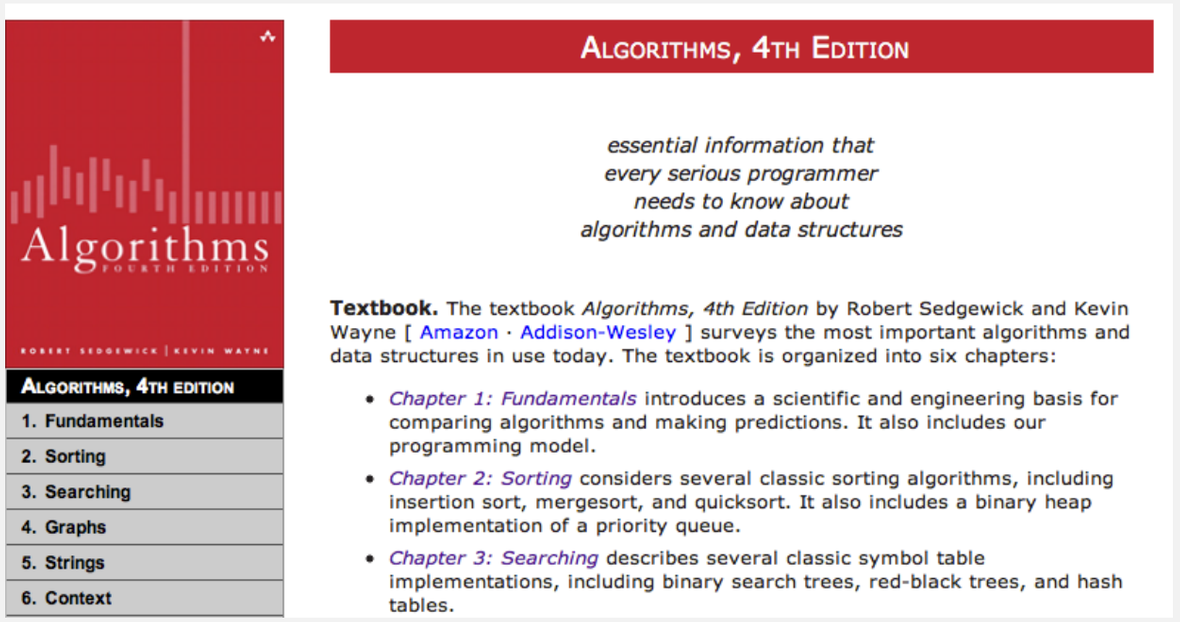
- Course info.
- Lecture slides.
- Programming assignments.
- Quizzes.
- Exam archive.



https://www.cs.princeton.edu/~cos226

Booksite.

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



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Resources (people)

Piazza discussion forum.

- Low latency, low bandwidth.
- See Piazza for guidelines.

piazza

https://piazza.com/princeton/fall2019/cos226

Office hours.

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

https://www.cs.princeton.edu/~cos226

Computing laboratory.

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

https://labta.cs.princeton.edu

This week

you are here!

precept starts tomorrow (or today)
read Assignment 1 before precept

Sun	Mon	Tue	Wed	Thu	Fri	Sat
8	9	10	11	12 **Lecture 1 (Union-Find)**	13 **Precept 1** **Quiz 0 and 1**	14
15	16 **Assignment 1 (Percolation)**	17	18	19	20	21
22	23	24	25	26	27	28

protip: start early

yes, really!

A typical week

support lecture material;
assignment prep

Sun	Mon	Tue	Wed	Thu	Fri	Sat
8	9	10	11	12	13	14
15	16	17 **Lecture 2 (Analysis)**	18	19 **Lecture 3 (Stacks)**	20 **Precept 2** **Quiz 2 and 3**	21
22	23 **Assignment 2 (Deques+RQs)**	24	25	26	27	28

content based on
week's material

content based on
corresponding lectures

Q+A

Not registered? Register ASAP; attend any precept this week.

Change precept? Use TigerHub.

All non-conflicting precepts closed? See Colleen Kenny-McGinley in CS 210.

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

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