

COS 226, FALL 2012

ALGORITHMS AND DATA STRUCTURES

KEVIN WAYNE



PRINCETON
UNIVERSITY

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

COS 226 course overview

What is COS 226?

- Intermediate-level survey course.
- Programming and problem solving, with applications.
- **Algorithm:** method for solving a problem.
- **Data structure:** method to store information.

topic	data structures and algorithms
data types	stack, queue, bag, 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	B-tree, suffix array, maxflow, simplex

Why study algorithms?

Their impact is broad and far-reaching.

Internet. Web search, packet routing, distributed file sharing, ...

Biology. Human genome project, protein folding, ...

Computers. Circuit layout, file system, compilers, ...

Computer graphics. Movies, video games, virtual reality, ...

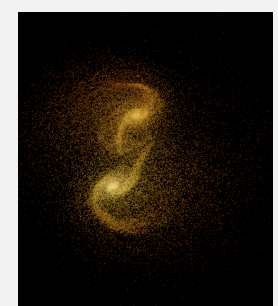
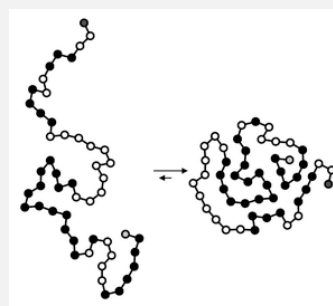
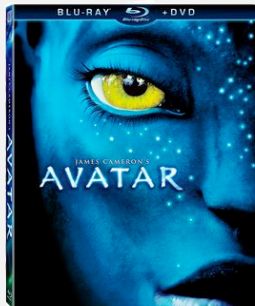
Security. Cell phones, e-commerce, voting machines, ...

Multimedia. MP3, JPG, DivX, HDTV, face recognition, ...

Social networks. Recommendations, news feeds, advertisements, ...

Physics. N-body simulation, particle collision simulation, ...

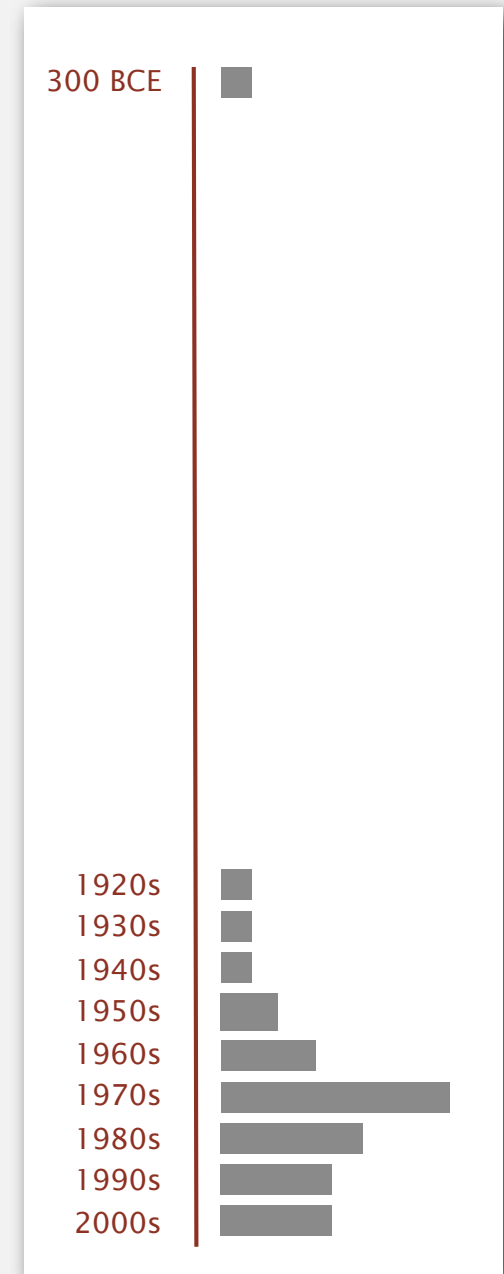
⋮



Why study algorithms?

Old roots, new opportunities.

- Study of algorithms dates at least to Euclid.
- Formalized by Church and Turing in 1930s.
- Some important algorithms were discovered by undergraduates in a course like this!

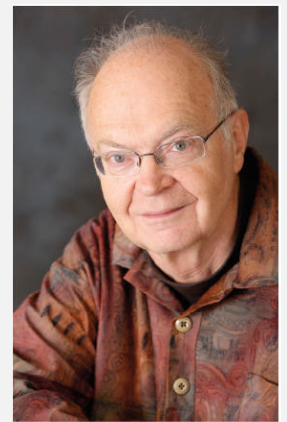
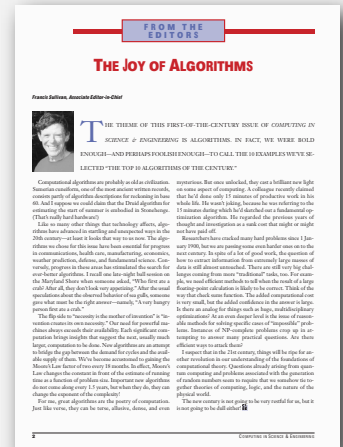


Why study algorithms?

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

“An algorithm must be seen to be believed.” — Donald Knuth



Why study algorithms?

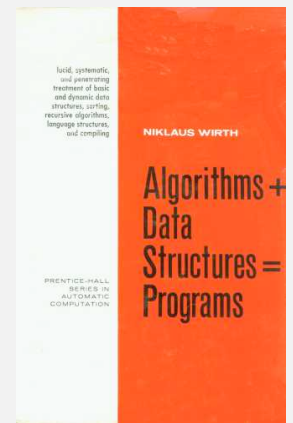
To become a proficient programmer.

“ 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 (creator of Linux)



“ Algorithms + Data Structures = Programs. ” — Niklaus Wirth



Why study algorithms?

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

Scientists are replacing mathematical models with computational models.

$$E = mc^2$$
$$F = ma \quad F = \frac{Gm_1m_2}{r^2}$$
$$\left[-\frac{\hbar^2}{2m} \nabla^2 + V(r) \right] \Psi(r) = E \Psi(r)$$

20th century science
(formula based)

```
for (double t = 0.0; true; t = t + dt)
  for (int i = 0; i < N; i++)
  {
    bodies[i].resetForce();
    for (int j = 0; j < N; j++)
      if (i != j)
        bodies[i].addForce(bodies[j]);
  }
```

21st century science
(algorithm based)

“Algorithms: a common language for nature, human, and computer.” — Avi Wigderson

Why study algorithms?

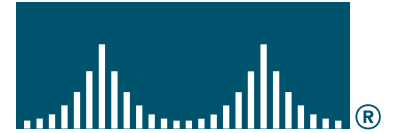
For fun and profit.



Apple Computer

facebook

CISCO SYSTEMS



IBM

Nintendo



Morgan Stanley

NETFLIX



DE Shaw & Co

ORACLE



YAHOO!

amazon.com

Microsoft



Why study algorithms?

- Their impact is broad and far-reaching.
- Old roots, new opportunities.
- To solve problems that could not otherwise be addressed.
- For intellectual stimulation.
- To become a proficient programmer.
- They may unlock the secrets of life and of the universe.
- For fun and profit.

Why study anything else?



The usual suspects

Lectures. Introduce new material.

Precepts. Discussion, problem-solving, background for assignments.

What	When	Where	Who	Office Hours
L01	TTh 11–12:20	Frist 302	Kevin Wayne	see web
P01	F 11–11:50	Friend 109	Maia Ginsburg †	see web
P02	F 12:30–1:20	Friend 109	Diego Perez Botero	see web
P03	F 1:30–2:20	Friend 109	Diego Perez Botero	see web
P03B	F 1:30–2:20	Friend 110	Dushyant Arora	see web
P04	Th 2:30–3:20	Friend 109	Maia Ginsburg †	see web
P04A	Th 2:30–3:20	Friend 112	Dan Larkin	see web

† lead preceptor

Where to get help?

Piazza. Online discussion forum.

- Low latency, low bandwidth.
- Mark solution-revealing questions as private.

The logo for Piazza, featuring the word "piazza" in a lowercase, blue, sans-serif font.

<http://www.piazza.com/class#fall2012/cos226>

Office hours.

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



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

Computing laboratory.

- Undergrad lab TAs in Friend 017.
- For help with debugging.
- See web for schedule.



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

Coursework and grading

Programming assignments. 45%

- Due on Tuesdays at 11 pm via electronic submission.
- Collaboration/lateness policies: see web.

Exercises. 10%

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

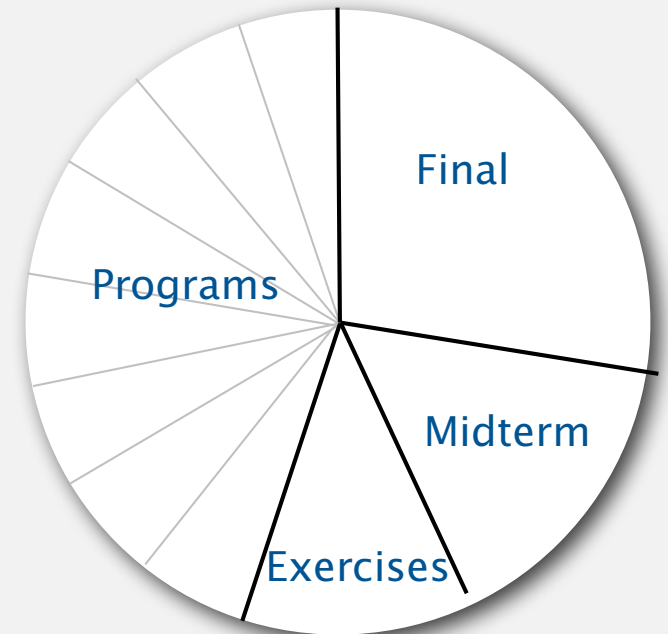
Exams. 15% + 30%

- Midterm (in class on Tuesday, October 23).
- Final (to be scheduled by Registrar).

Staff discretion. To adjust borderline cases.

- Report errata.
- Contribute to Piazza discussions.
- Attend and participate in precept/lecture.

experimental feature
(subject to change)

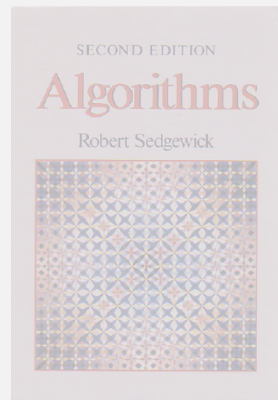


Resources (textbook)

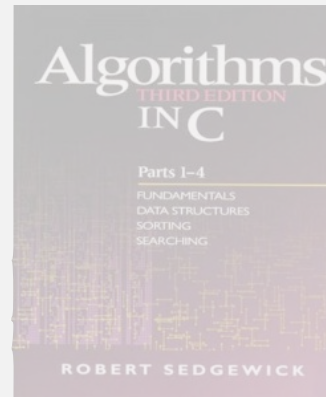
Required reading. Algorithms 4th edition by R. Sedgwick and K. Wayne, Addison-Wesley Professional, 2011, ISBN 0-321-57351-X.



1st edition (1982)



2nd edition (1988)



3rd edition (1997)



Available in hardcover and Kindle.

- Online: Amazon (\$60 to buy), Chegg (\$40 to rent), ...
- Brick-and-mortar: Labyrinth Books (122 Nassau St). ← 30% discount with PU student ID
- On reserve: Engineering library.


Resources (web)

Course content.

- Course info.
- Programming assignments.
- Exercises.
- Lecture slides.
- Exam archive.
- Submit assignments.

Booksites.

- Brief summary of content.
- Download code from book.




Computer Science 226
Algorithms and Data Structures
Spring 2012

[Course Information](#) | [Assignments](#) | [Exercises](#) | [Lectures](#) | [Exams](#) | [Booksite](#)

COURSE INFORMATION

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, and string processing. Fundamental algorithms in a number of other areas are covered as well, including geometric and graph algorithms. The course will concentrate on developing implementations, understanding their performance characteristics, and estimating their potential effectiveness in applications.

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



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.

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

<http://www.algs4.princeton.edu>

What's ahead?

Lecture 1. [today] Union find.

Lecture 2. [Tuesday] Analysis of algorithms.

Precept 1. [Thursday/Friday] Meets this week.



Exercise 1. Due via Bb submission at 11 pm on Monday.

Assignment 1. Due via electronic submission at 11 pm on Wednesday.

Right course? See me.

Placed out of COS 126? Review Sections 1.1–1.2 of Algorithms, 4th edition (includes command-line interface and our I/O libraries).

Not registered? Go to any precept this week.

Change precept? Use SCORE. ← see Colleen Kenny-McGinley in CS 210 if the only precept you can attend is closed