

ALGORITHMS AND DATA STRUCTURES

KEVIN WAYNE



<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, k-d tree, suffix array, maxflow

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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, ...

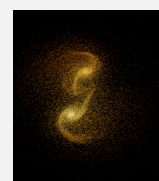
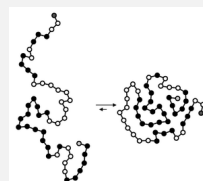
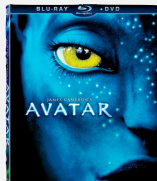
Multimedia. MP3, JPG, DivX, HDTV, face recognition, ...

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

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

⋮

Google
YAHOO!
bing



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Why study algorithms?

Their impact is broad and far-reaching.

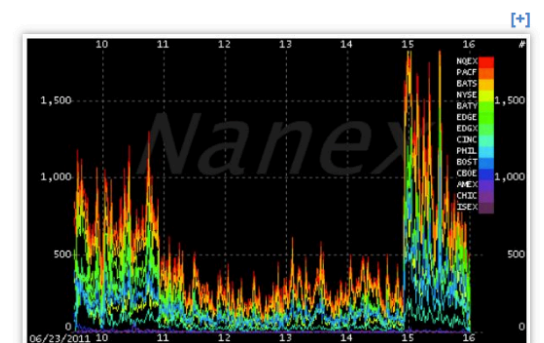
Mysterious algorithm was 4% of trading activity last week

October 11, 2012

A single mysterious computer program that placed orders — and then subsequently canceled them — made up 4 percent of all quote traffic in the U.S. stock market last week, according to the top tracker of [high-frequency trading](#) activity.

The motive of the algorithm is still unclear, [CNBC](#) reports.

The program placed orders in 25-millisecond bursts involving about 500 stocks, according to Nanex, a market data firm. The algorithm never executed a single trade, and it abruptly ended at about 10:30 a.m. ET Friday.



Generic high frequency trading chart (credit: Nanex)

"My guess is that the algo was testing the market, as high-frequency frequently does," says Jon Najarian, co-founder of TradeMonster.com. "As soon as they add bandwidth, the HFT crowd sees how quickly they can top out to create latency." ([Read More: Unclear What Caused Kraft Spike: Nanex Founder.](#))

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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!



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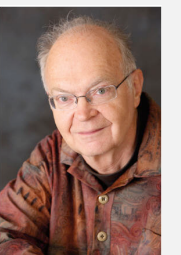
Why study algorithms?

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



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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



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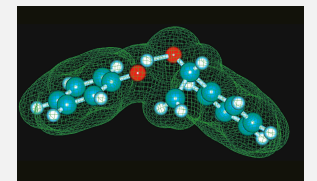
Why study algorithms?

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

“Computer models mirroring real life have become crucial for most advances made in chemistry today.... Today the computer is just as important a tool for chemists as the test tube.”
— Royal Swedish Academy of Sciences
(Nobel Prize in Chemistry 2013)



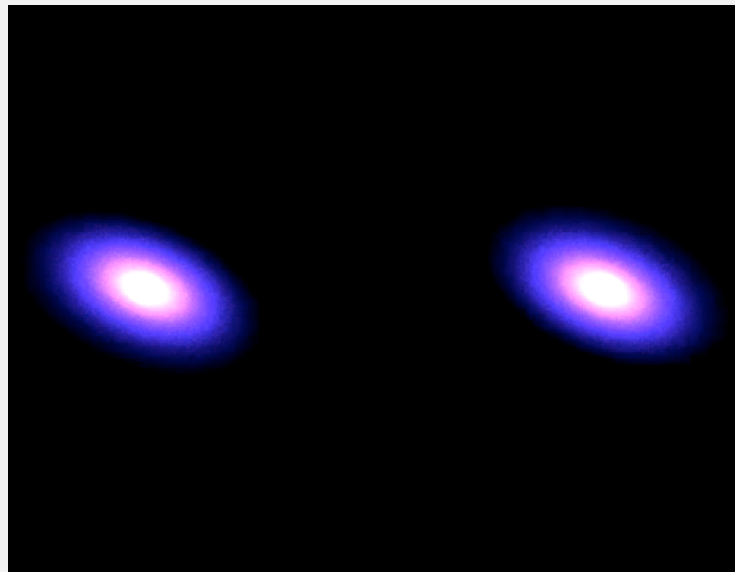
Martin Karplus, Michael Levitt, and Ariele Warshel



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Why study algorithms?

To solve problems that could not otherwise be addressed.



http://www.youtube.com/watch?v=ua7YIN4eL_w

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Why study algorithms?

Everybody else is doing it.

```
% sort -rn PU2013-14.txt
774 COS 126 General Computer Science
615 ECO 100 Introduction to Microeconomics
471 ECO 101 Introduction to Macroeconomics
444 ENG 385 Children's Literature
440 MAT 202 Linear Algebra with Applications
414 COS 226 Algorithms and Data Structures
405 MAT 201 Multivariable Calculus
384 CHV 310 Practical Ethics
344 REL 261 Christian Ethics and Modern Society
320 PSY 101 Introduction to Psychology
300 COS 217 Introduction to Programming Systems
...
```

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Why study algorithms?

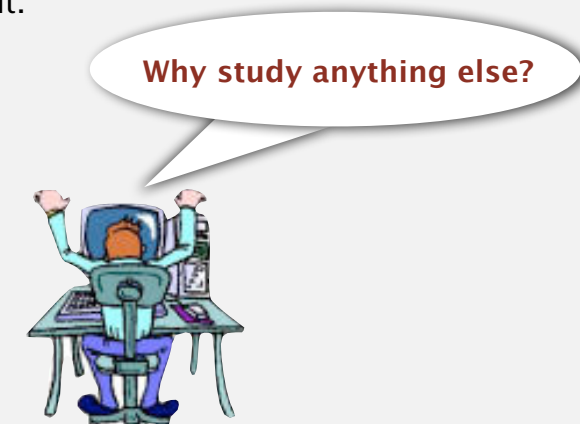
For fun and profit.



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Why study algorithms?

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



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Lectures

Traditional lectures. Introduce new material.

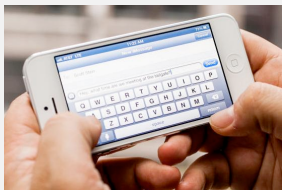
Electronic devices. Permitted, but only to enhance lecture.



no



no



no

What	When	Where	Who	Office Hours
L01	MW 11-12:20	McCosh 10	Kevin Wayne	see web

Lectures

Traditional lectures. Introduce new material.

Flipped lectures.

- Watch videos online before lecture.
- Complete pre-lecture activities.
- Attend only one "flipped" lecture per week (interactive, collaborative, experimental).
- Apply via web ASAP: results by 5pm today.



What	When	Where	Who	Office Hours
L01	MW 11-12:20	McCosh 10	Kevin Wayne	see web
L02	W 11-12:20	Frist 307	Josh Hug Andy Guna	see web

Precepts

Discussion, problem-solving, background for assignments.

What	When	Where	Who	Office Hours
P01	Th 11-11:50	CS 102	Andy Guna †	see web
P02	Th 12:30-1:20	Bobst 105	Andy Guna †	see web
P03	Th 1:30-2:20	Bobst 105	Nevin Li	see web
P04	F 10-10:50	Bobst 105	Jennifer Guo	see web
P05	F 11-11:50	Bobst 105	Madhu Jayakumar	see web
P05A	F 11-11:50	Sherrerd 001	Ruth Dannenfelser	see web
P06	F 2:30-3:20	Friend 108	Chris Eubank	see web
P06A	F 2:30-3:20	Friend 111	TBA	see web
P06B	F 2:30-3:20	Friend 109	Josh Hug †	see web
P07	F 3:30-4:20	Friend 108	Josh Hug †	see web

↑
likely to change

† lead preceptor

Coursework and grading

Programming assignments. 45%

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

Exercises. 10%

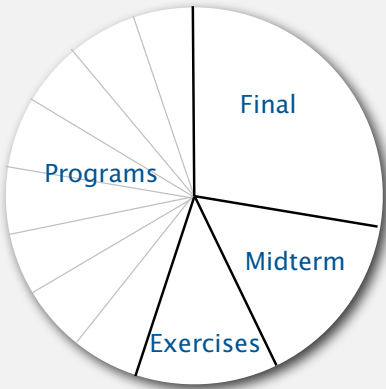
- Due on Sundays at 11pm in Blackboard.
- Collaboration/lateness policies: see web.

Exams. 15% + 30%

- Midterm (in class on Wednesday, March 12).
- Final (to be scheduled by Registrar).

Staff discretion. [adjust borderline cases]

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



Resources (textbook)

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



Available in hardcover and Kindle.

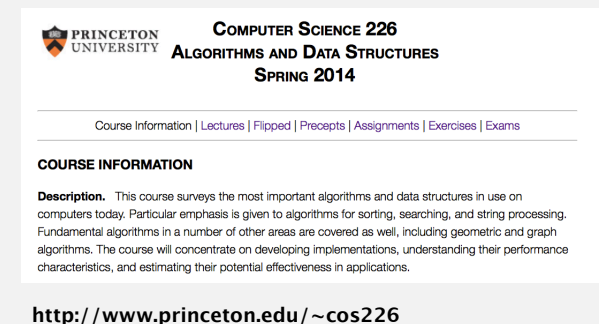
- Online: Amazon (\$60/\$35 to buy), Chegg (\$25 to rent), ...
- Brick-and-mortar: Labyrinth Books (122 Nassau St).
- On reserve: Engineering library.

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Resources (web)

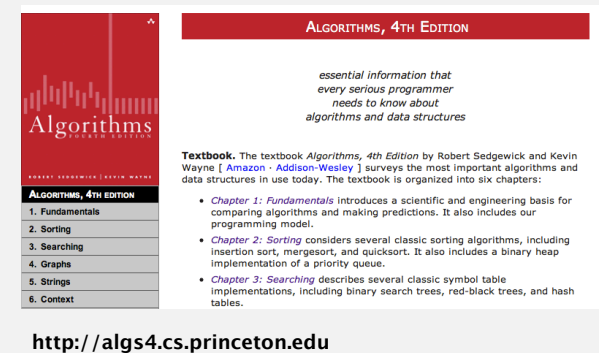
Course content.

- Course info.
- Lecture slides.
- Flipped lectures.
- Programming assignments.
- Exercises.
- Exam archive.



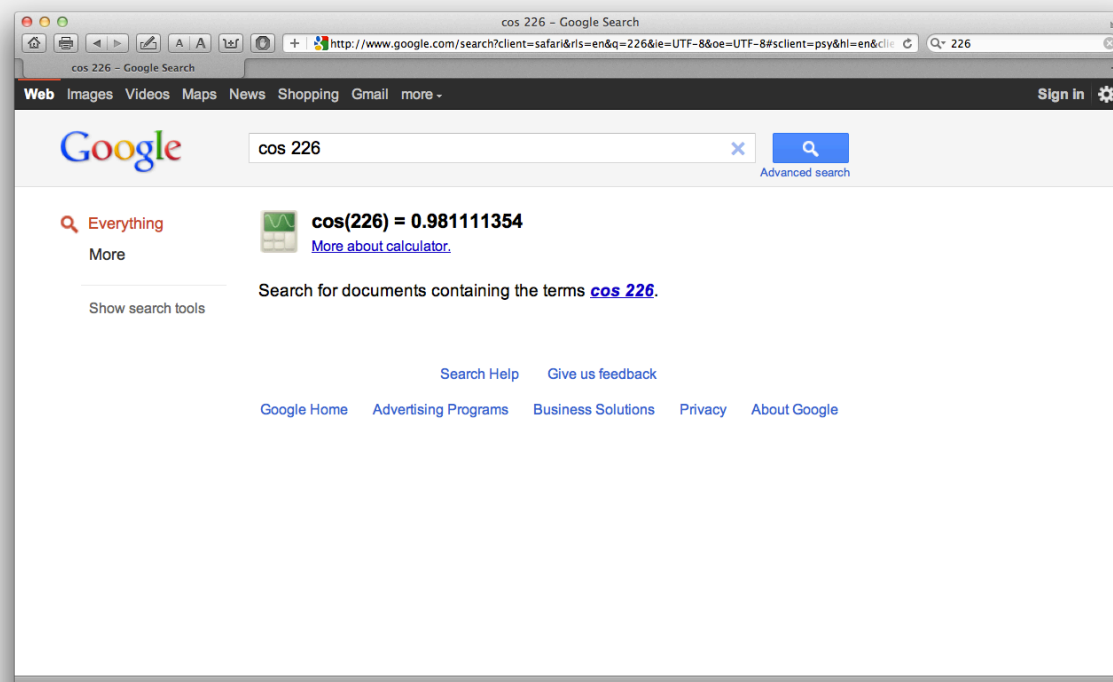
Booksite.

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



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Resources (web)



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

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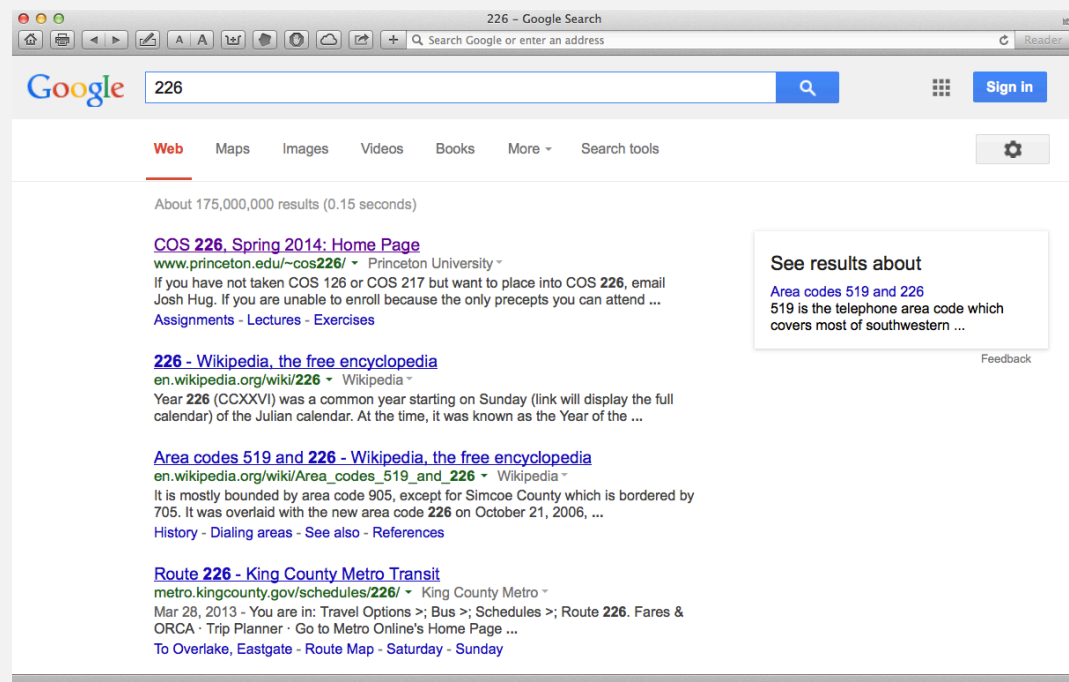
Resources (web)



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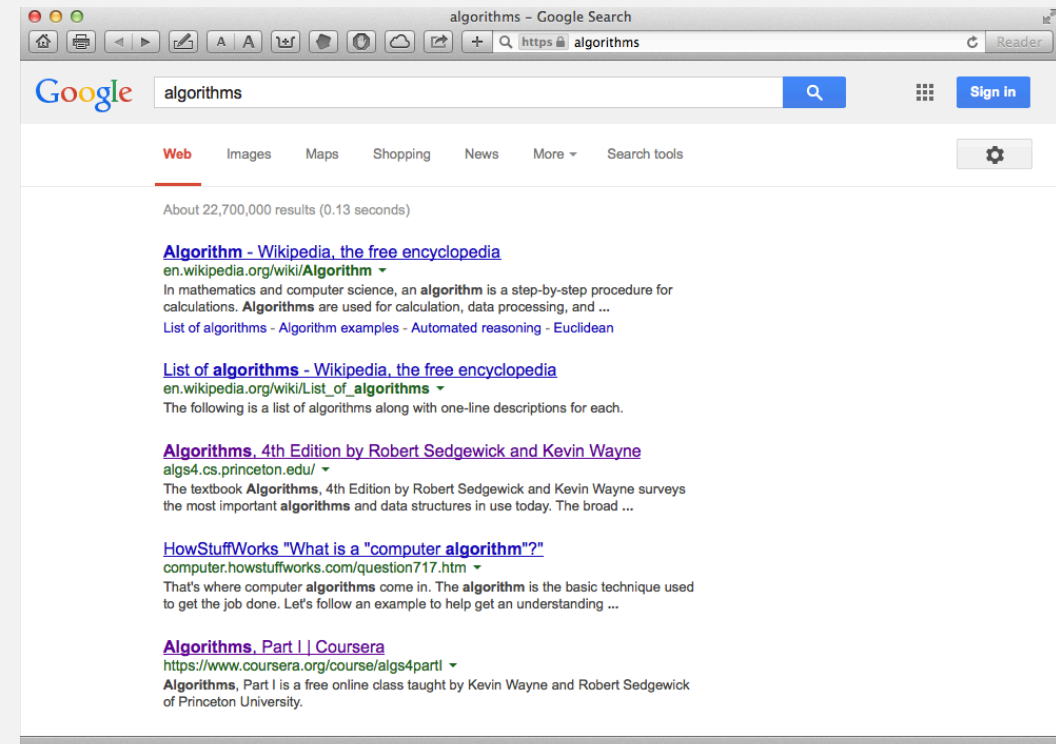
Resources (web)



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

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Resources (web)



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Where to get help?

Piazza discussion forum.

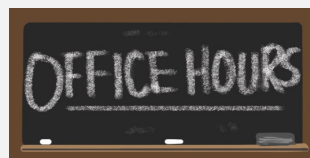
- Low latency, low bandwidth.
- Mark solution-revealing questions as private.

piazza

<http://piazza.com/princeton/spring2014/cos226>

Office hours.

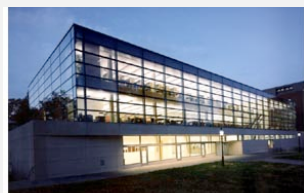
- High bandwidth, high latency.
- See web for schedule.



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

Computing laboratory.

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



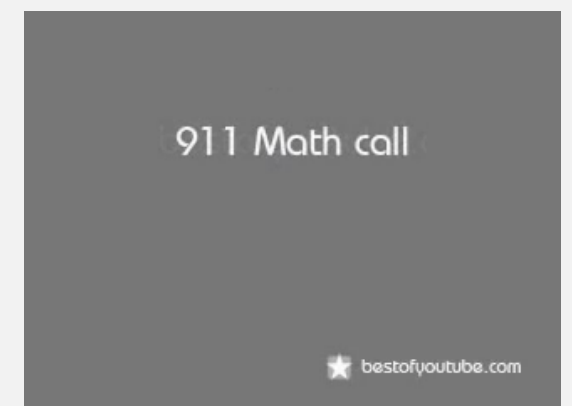
<http://www.princeton.edu/~cos226>

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Where not to get help?



<http://world.edu/academic-plagiarism>



<http://www.youtube.com/watch?v=FT4NOe4vtom>

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What's ahead?

Lecture 1. [today] Union find.

Lecture 2. [Wednesday] Analysis of algorithms.

Flipped lecture 1. [Wednesday] Watch video beforehand.

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



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

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

←
protip: start early

Right course? See me.

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

Not registered? Go to any precept this week.

Change precept? Use SCORE.

←
see Colleen Kenny-McGinley
in CS 210 if the only precepts
you can attend are closed