COS 423, SPRING 2018

THEORY OF ALGORITHMS

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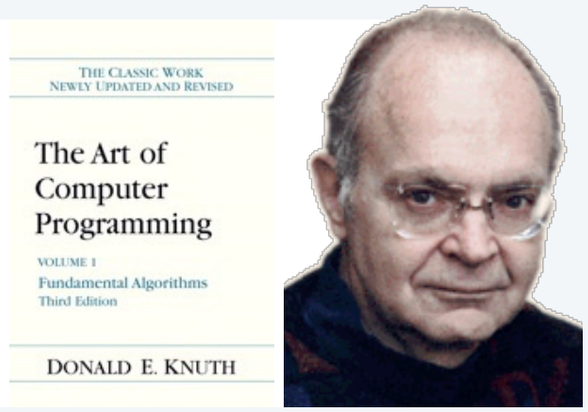
www.cs.princeton.edu/courses/archive/spring18/cos423

Algorithm definitions

" A procedure for solving a mathematical problem (as of finding the greatest common divisor) in a finite number of steps that frequently involves repetition of an operation. " — *webster.com*

" An algorithm is a finite, definite, effective procedure, with some input and some output. "

— *Donald Knuth*



Algorithm etymology

Etymology. [Knuth, TAOCP]

- *Algorism* = process of doing arithmetic using Arabic numerals.
- A misperception: *algiros* [painful] + *arithmos* [number].
- True origin: Abu 'Abd Allah Muhammad ibn Musa al-Khwarizm was a famous 9th century Persian textbook author who wrote *Kitāb al-jabr wa'l-muqābala*, which evolved into today's high school algebra text.


كتاب الجبر والمقابلة

COS 226 vs. COS 423

COS 226. Implementation and consumption of classic algorithms.

- Stacks and queues.
- Sorting.
- Searching.
- Graph algorithms.
- String processing.

```
private static void sort(double[] a, int lo, int hi)
{
   if (hi <= lo) return;
   int lt = lo, gt = hi;
   int i = lo;
   while (i <= gt)
   {
      if      (a[i] < a[lo]) exch(a, lt++, i++);
      else if (a[i] > a[lo]) exch(a, i, gt--);
      else                   i++;
   }

   sort(a, lo, lt - 1);
   sort(a, gt + 1, hi);
}
```

Emphasizes critical thinking, problem-solving, and code.

COS 226 vs. COS 423

COS 423. Design and analysis of algorithms.

- Greedy.
- Divide-and-conquer.
- Dynamic programming.
- Network flow.
- Randomized algorithms.
- Intractability.
- Coping with intractability.
- Data structures.

$$\begin{aligned}
\sum_{i=1}^{n} \sum_{j=i+1}^{n} \frac{2}{j-i-1} &= 2 \sum_{i=1}^{n} \sum_{j=2}^{n-i+1} \frac{1}{j} \\
&\leq 2n \sum_{j=1}^{n} \frac{1}{j} \\
&\sim 2n \int_{x=1}^{n} \frac{1}{x} dx \\
&= 2n \ln n
\end{aligned}$$

Emphasizes critical thinking, problem-solving, and rigorous analysis.

Why study algorithms?

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

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

Computers. Circuit layout, databases, caching, networking, 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, ...

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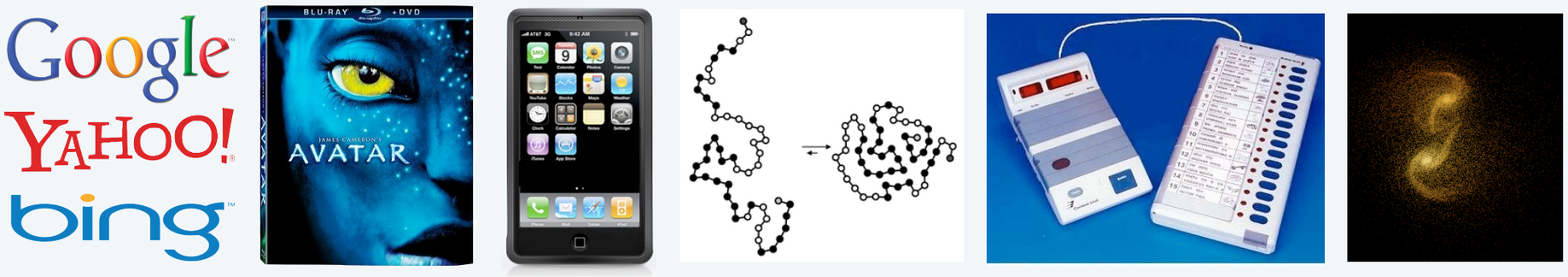


We emphasize algorithms and techniques that are useful in practice.

Administrative stuff

Lectures. [Kevin Wayne]

- Monday and Wednesday 11–12:20pm in Friend 006.
- Attendance is required.
- No electronic devices except to aid in learning. ← viewing lecture slides taking notes

Precept. [Dan Larkin and Sachin Ravi]

- Thursday 4:30–5:20pm or Friday 11–11:50am in COS 105. ← precept begins this week
- Preceptor works out problems.
- Attendance is recommended.

Kevin

Dan

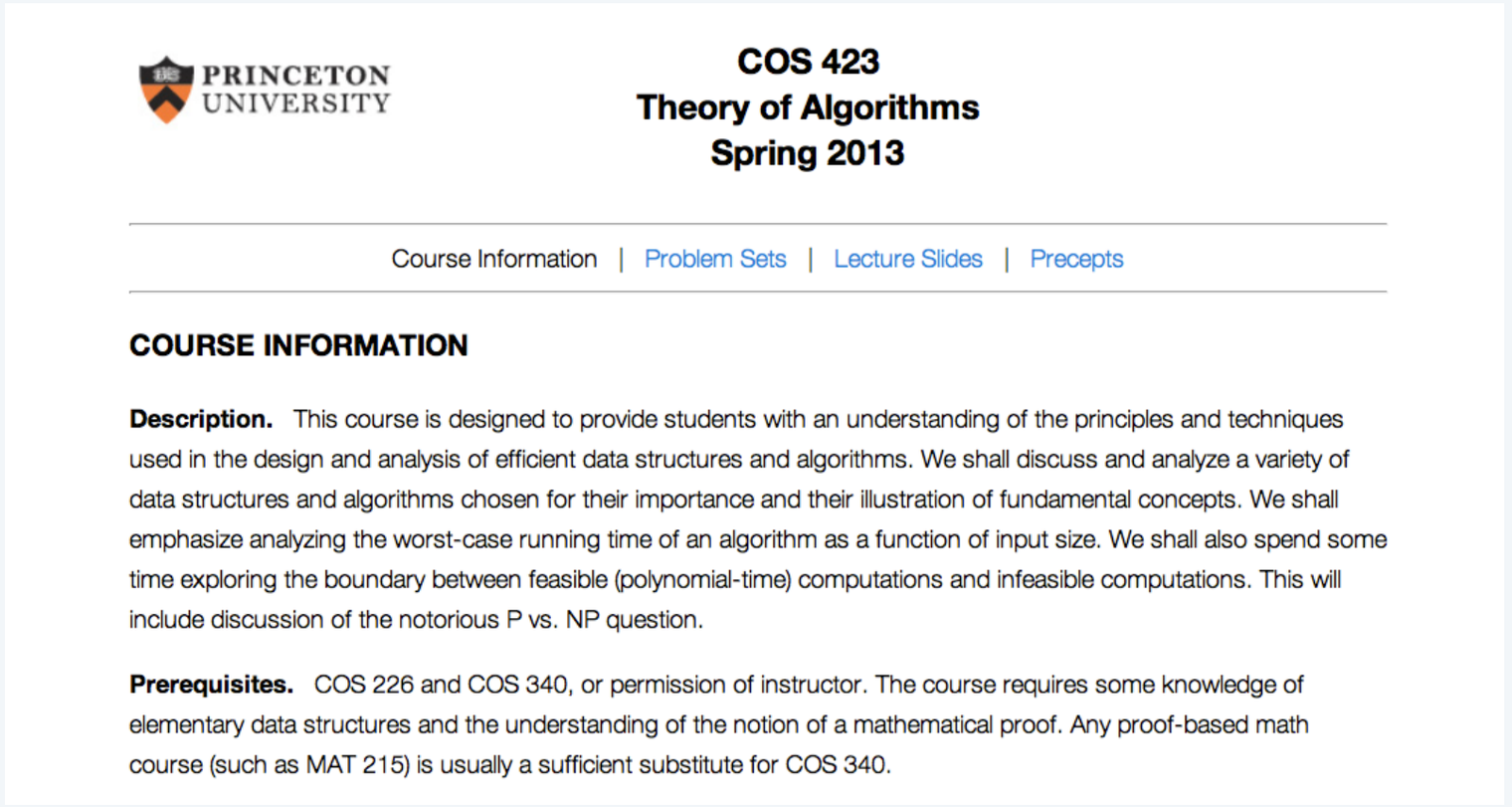
Sachin

see me after class ↙

Prerequisites. COS 226 and COS 340, or instructor's permission.

Course website

- Syllabus.
- Office hours.
- Problem sets.
- Lecture slides.
- Electronic submission.
- ...



PRINCETON UNIVERSITY

COS 423
Theory of Algorithms
Spring 2013

Course Information | Problem Sets | Lecture Slides | Precepts

COURSE INFORMATION

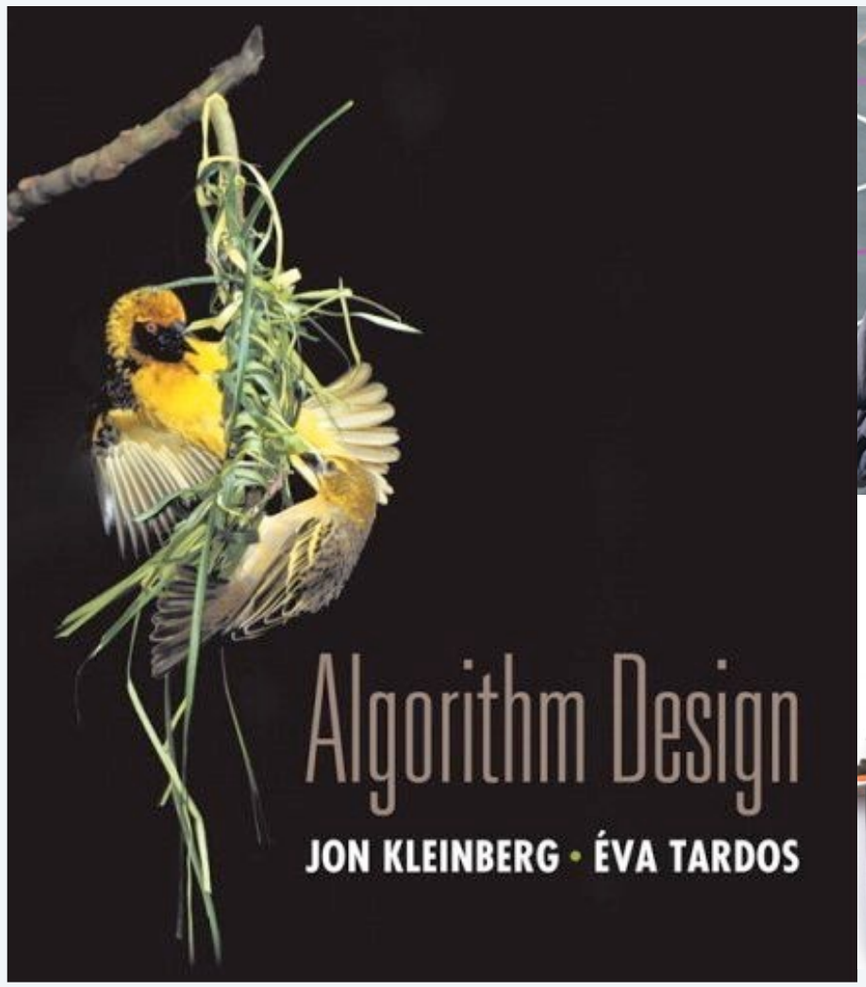
Description. This course is designed to provide students with an understanding of the principles and techniques used in the design and analysis of efficient data structures and algorithms. We shall discuss and analyze a variety of data structures and algorithms chosen for their importance and their illustration of fundamental concepts. We shall emphasize analyzing the worst-case running time of an algorithm as a function of input size. We shall also spend some time exploring the boundary between feasible (polynomial-time) computations and infeasible computations. This will include discussion of the notorious P vs. NP question.

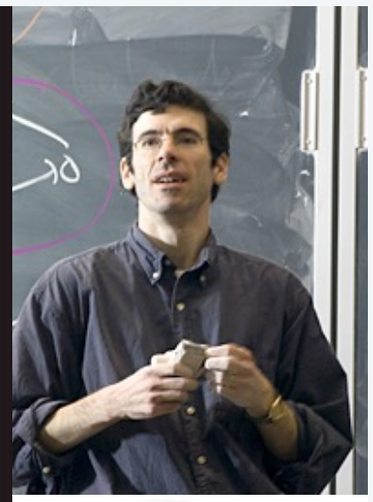
Prerequisites. COS 226 and COS 340, or permission of instructor. The course requires some knowledge of elementary data structures and the understanding of the notion of a mathematical proof. Any proof-based math course (such as MAT 215) is usually a sufficient substitute for COS 340.

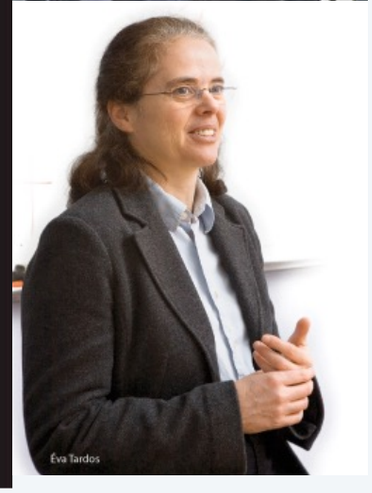
www.cs.princeton.edu/courses/archive/spring13/cos423

Textbook

Required reading. *Algorithm Design* by Jon Kleinberg and Éva Tardos. Addison-Wesley 2005, ISBN 978-0321295354.







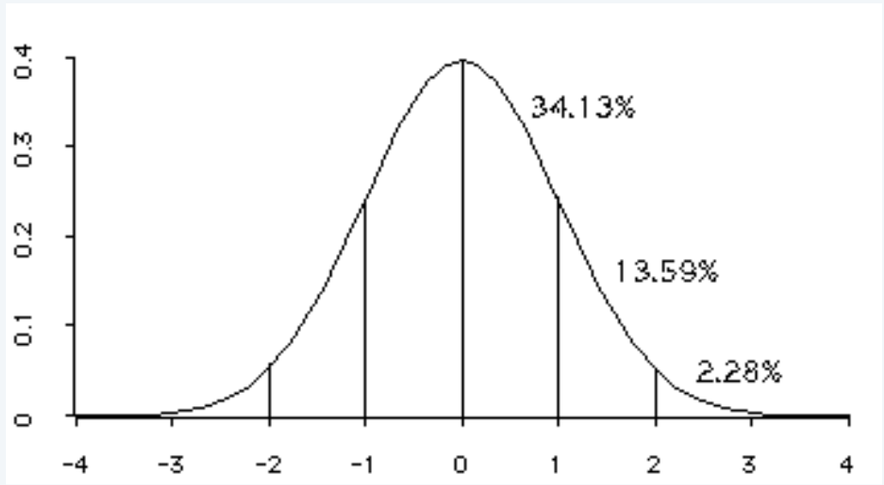
Grades

Problem sets.

- "Weekly" problem sets, due via electronic submission. ← problem set 1 is due due Wednesday 2/13
- Graded for correctness, clarity, conciseness, rigor, and efficiency.
- Use LaTeX template for writing solutions.

Course grades.

- Primarily based on problem sets.
- Staff discretion used to adjust borderline cases.
- Undergrads: determined without considering grad students.
- Grads: determined using undergrad scale.



Collaboration

Collaboration policy. [see syllabus for full details; ask if unsure]

- Course materials (textbook, slides, handouts) are always permitted.
- No external resources, e.g., can't Google for solutions.

"Collaboration permitted" problem sets.

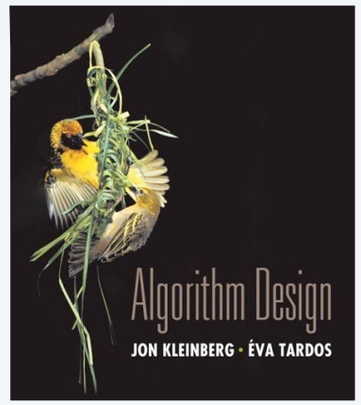
- You may discuss ideas with classmates.
- You must write up solutions on your own, in your own words.

"No collaboration" problem sets.

- You may discuss ideas with course staff.

Where to get help?

Textbook. Read the textbook—it's good!



Piazza. Online discussion forum.

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

piazza

www.piazza.com/princeton/spring2018/cos423

Office hours.

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

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Questions?