

## THEORY OF ALGORITHMS

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[www.cs.princeton.edu/courses/archive/spring13/cos423](http://www.cs.princeton.edu/courses/archive/spring13/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](http://webster.com)



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

— Donald Knuth

THE CLASSIC WORK  
NEWLY ILLUSTRATED REVISION  
The Art of  
Computer  
Programming  
VOLUME 1  
Fundamental Algorithms  
Third Edition  
DONALD E. KNUTH



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## 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.



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## 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**.

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## 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.

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## 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, ...

⋮



We emphasize algorithms and techniques that are useful in practice.

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## Administrative stuff

### Lectures. [Kevin Wayne]

- Monday and Wednesday 11–12:20pm in Friend 005.
- 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 2–3pm in a room TBA. ← precept begins this week
- Preceptor works out problems.
- Attendance is recommended.



Kevin



Dan



Sachin

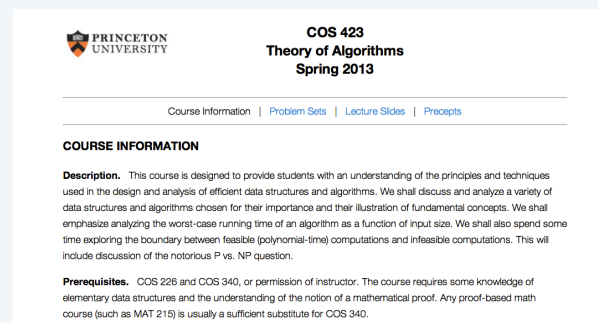
see me after class

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

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## Course website

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

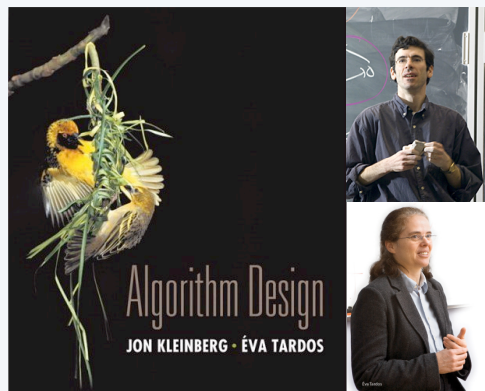


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## Textbook

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



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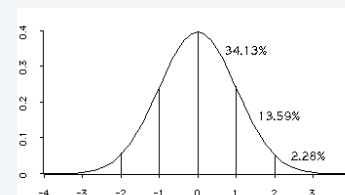
## Grades

### 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  $\text{\LaTeX}$  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.



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## 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.



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## Where to get help?

**Textbook.** Read the textbook—it's good!



**Piazza.** Online discussion forum.

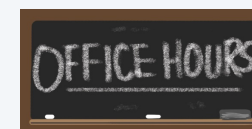
- Low latency, low bandwidth.
- Mark as private any solution-revealing questions.

**piazza**

[www.piazza.com/class#spring2013/cos423](http://www.piazza.com/class#spring2013/cos423)

**Office hours.**

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



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