CS4102 Algorithms

Spring 2020

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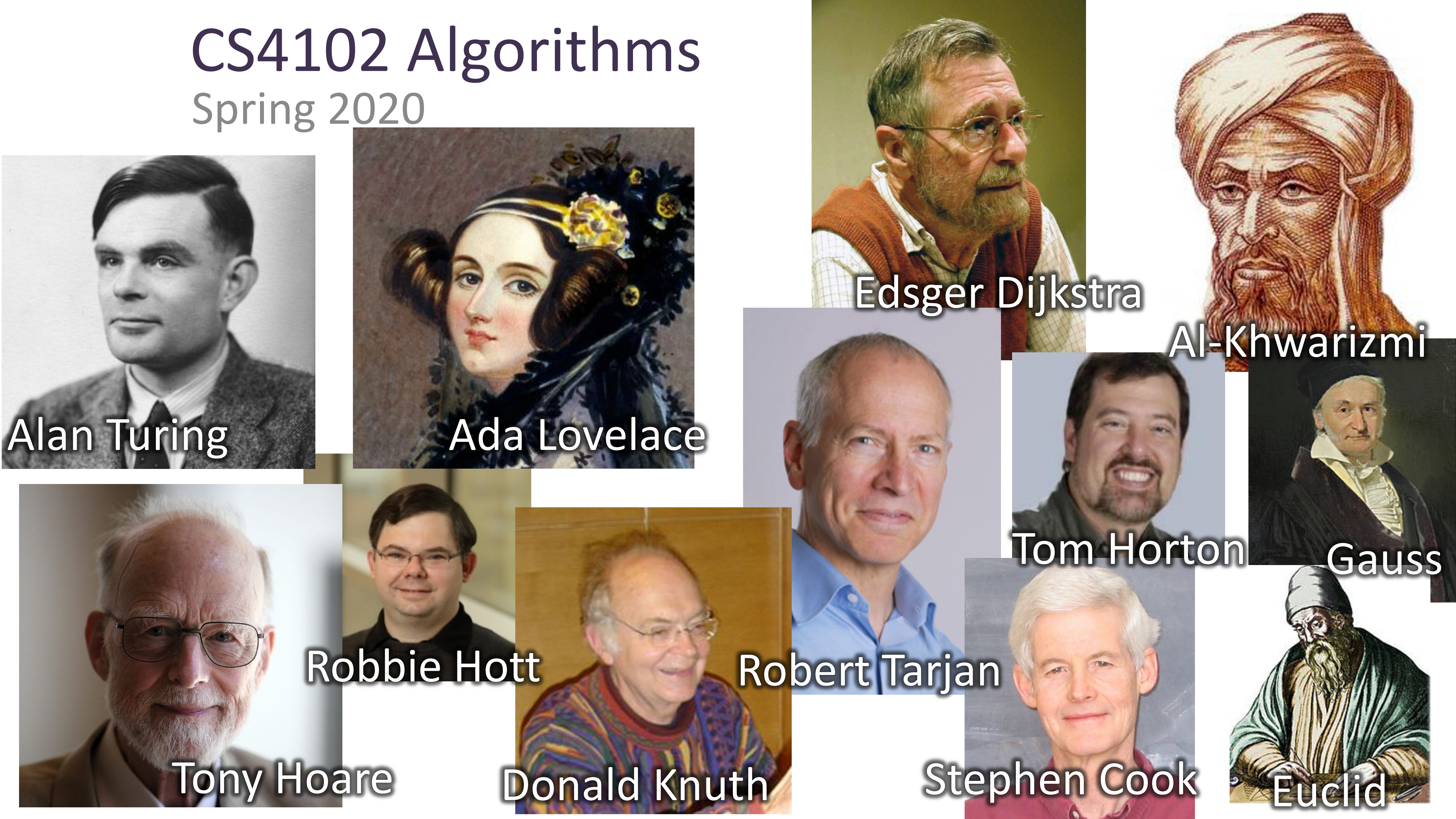


What is an algorithm?

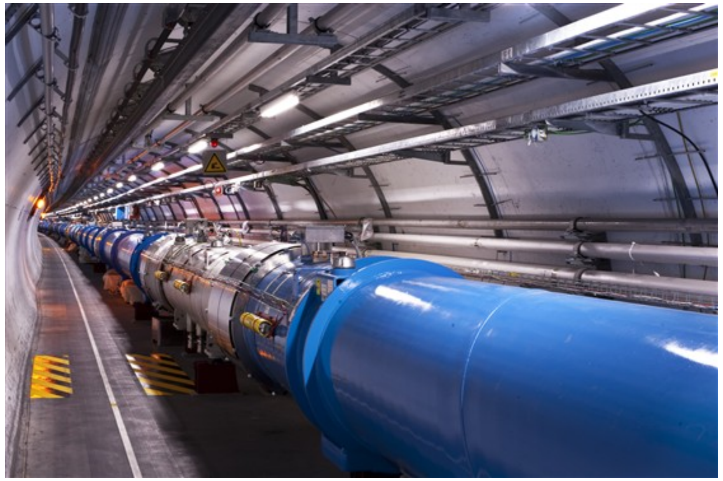
- In mathematics and computer science, an algorithm is a self-contained sequence of actions to be performed. Algorithms can perform calculation, data processing and automated reasoning tasks. [Wikipedia Aug 2018]
- In mathematics and computer science, an algorithm is an unambiguous specification of how to solve a class of problems. Algorithms can perform calculation, data processing and automated reasoning tasks. [Wikipedia Jan 2019]
- In mathematics and computer science, an algorithm is a set of instructions, typically to solve a class of problems or perform a computation. Algorithms are unambiguous specifications for performing calculation, data processing, automated reasoning, and other tasks. [Wikipedia Aug 2019]

What is an algorithm?

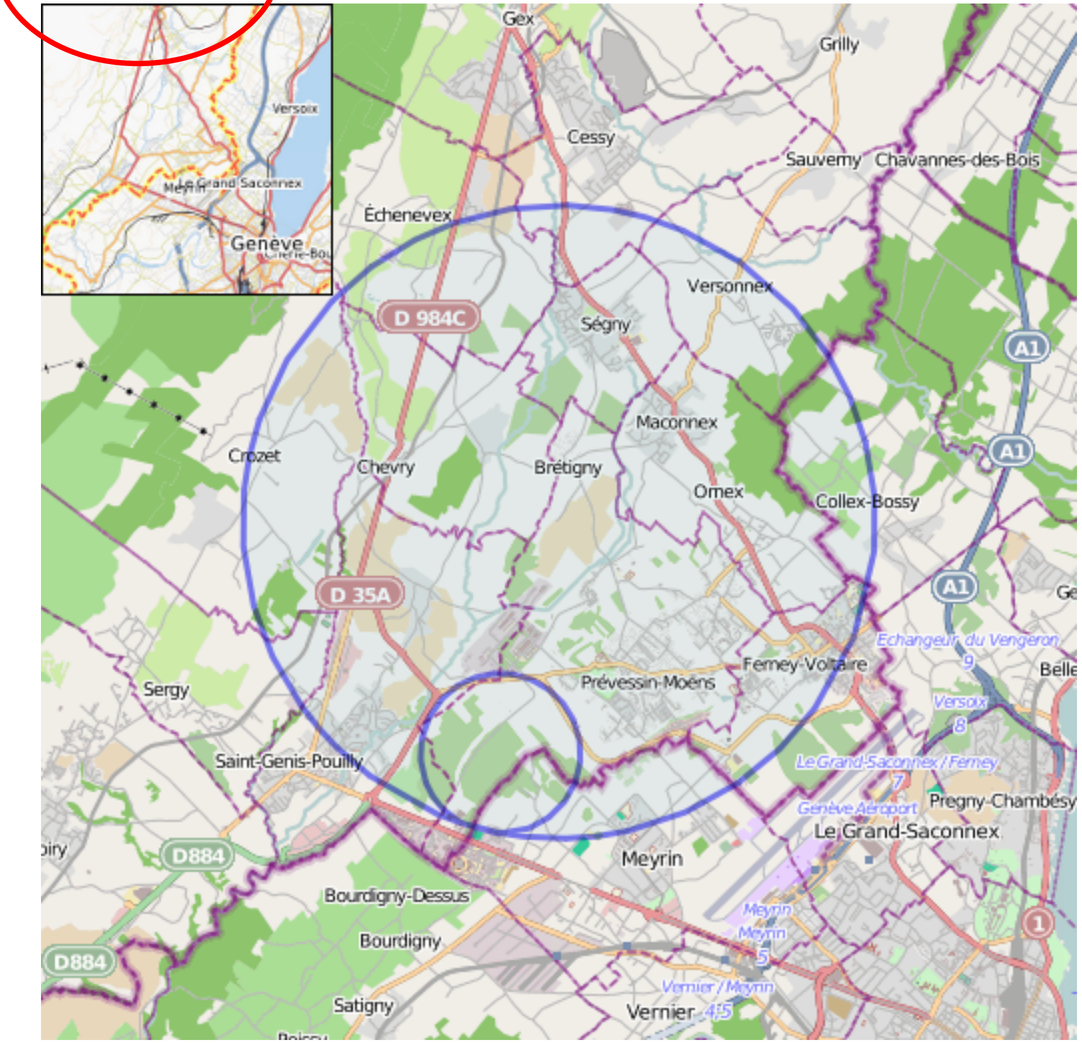
- In mathematics and computer science, an algorithm is a finite sequence of well-defined, computer-implementable instructions, typically to solve a class of problems or to perform a computation. Algorithms are unambiguous specifications for performing calculation, data processing, automated reasoning, and other tasks. [Wikipedia Jan 2020]
- An algorithm is a step by step procedure to solve logical and mathematical problems. [Simple English Wikipedia Aug 2019]
- Motivating example

Need an accurate approximation

π



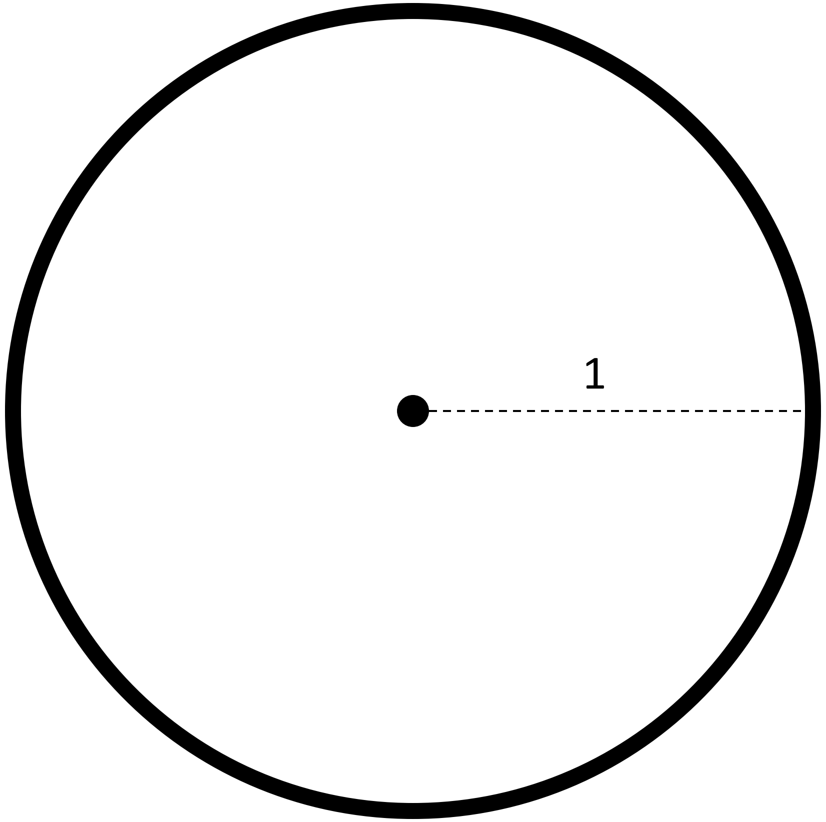
How much concrete do I need?



4.3km (2.7mi) diameter

π Approximation Algorithm

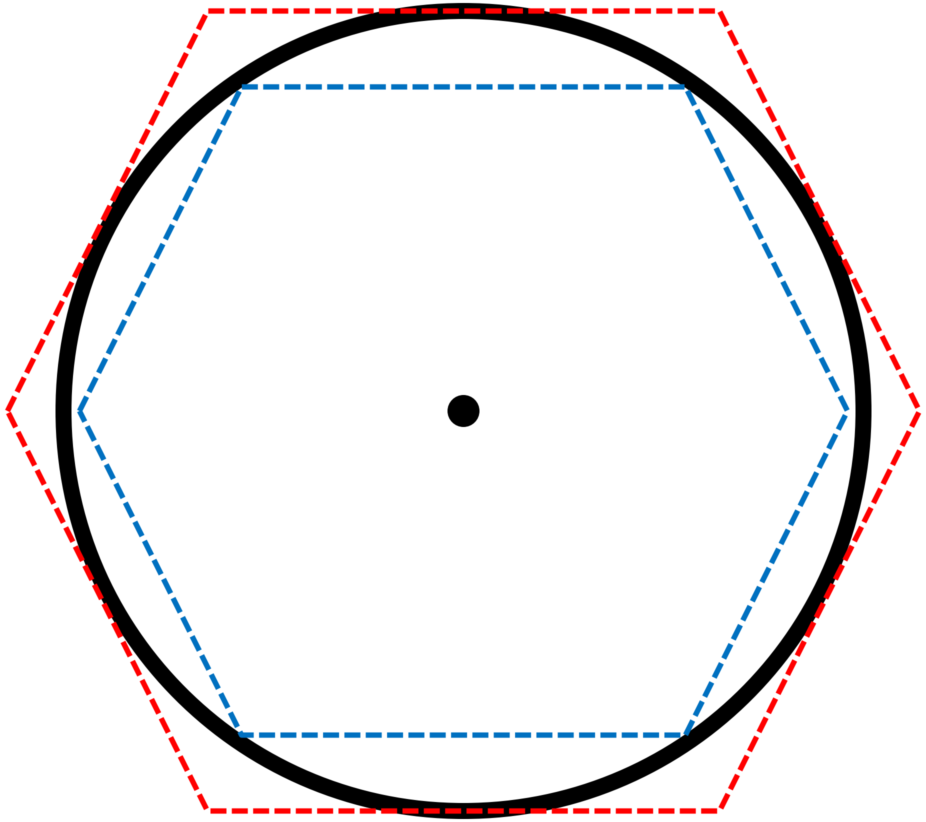
$\pi = 3.14159265359...$



Circumference = 2π

π Approximation Algorithm

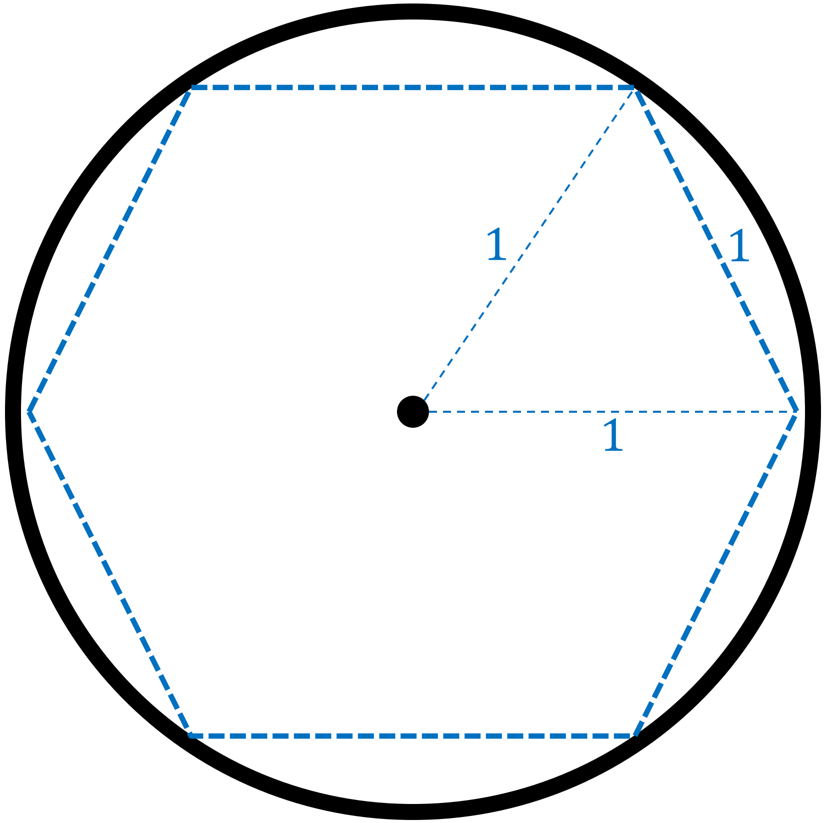
$\pi = 3.14159265359...$



Perimeter > 2π > Perimeter

π Approximation Algorithm

$\pi = 3.14159265359...$



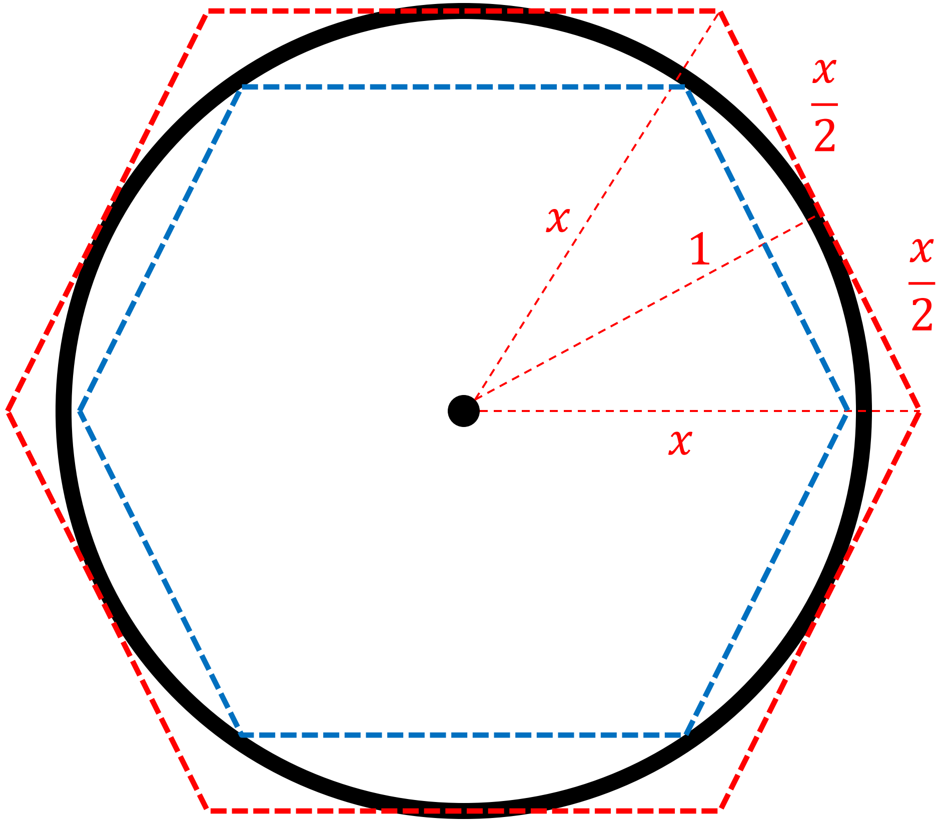
$2\pi >$ Perimeter $= 6$

π Approximation Algorithm

$\pi = \boxed{3.}14159265359...$ 1 digit correct

Solve for x

$$x = \frac{2}{\sqrt{3}}$$

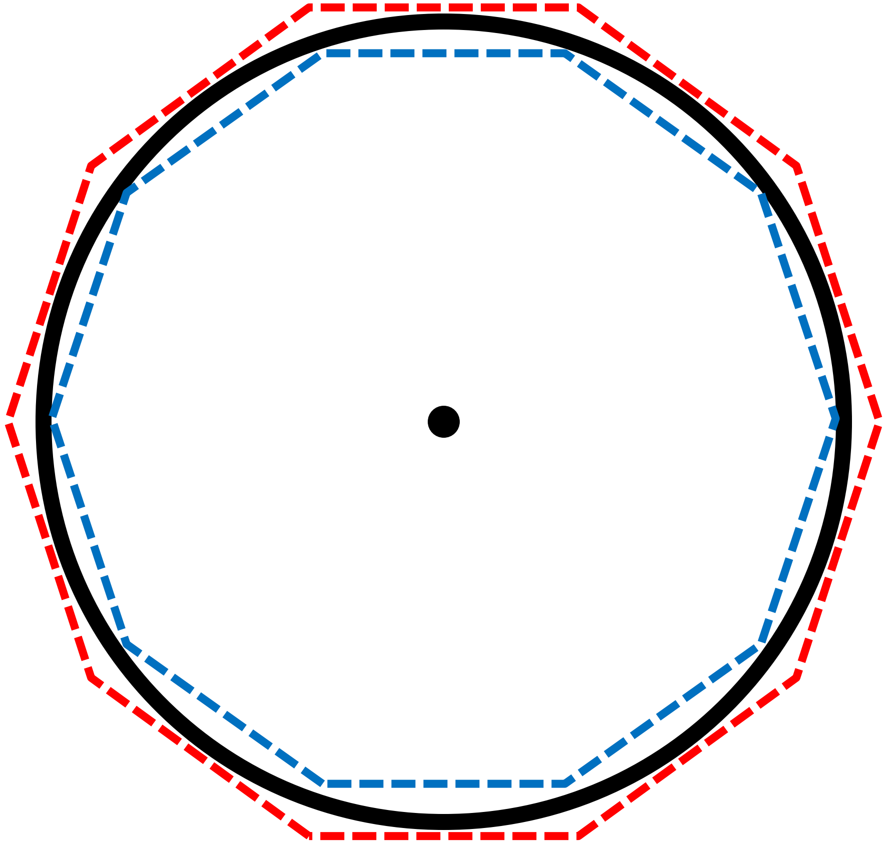


$$\frac{12}{\sqrt{3}} = \text{Perimeter} > 2\pi > \text{Perimeter} = 6$$

$$3.46 > \pi > 3$$

π Approximation Algorithm

$$\pi = \boxed{3.14}159265359\ldots$$ 3 digits correct



$$6+\frac{20}{70} = \text{Perimeter} > 2\pi > \text{Perimeter} = 6+\frac{20}{71}$$

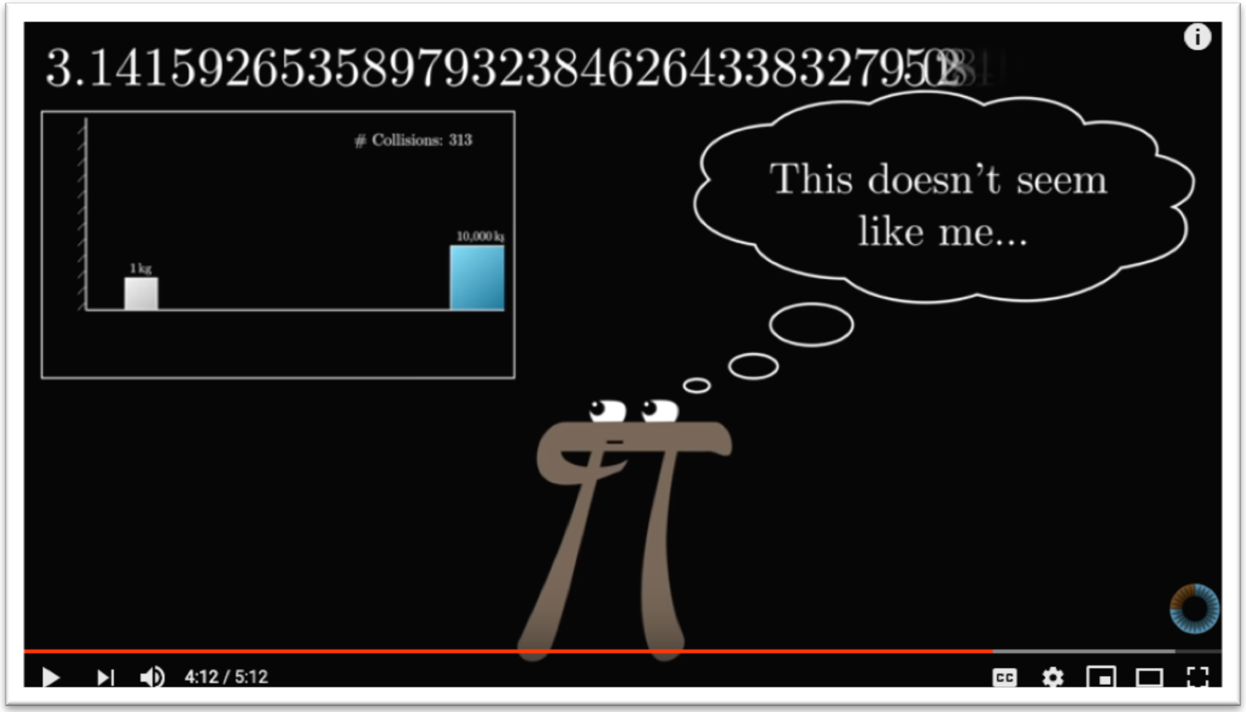
$$3.14285 > \pi > 3.14084$$

How to analyze this approach?

- How fast do we “converge?”
- How much work is needed to do better?

Another Algorithm

- https://youtu.be/HEfHFsfGXjs
- Look up and explain the solution for extra credit!



Better π Approximation (Ramanujan)

$$\frac{1}{\pi} = \frac{2\sqrt{2}}{9801} \sum_{k=0}^{\infty} \frac{(4k)!\,(1103 + 26390k)}{(k!)^4\, 396^{4k}}$$

$$\pi = \boxed{3.141592}\boxed{653589793}238462643383279502884197169399375105820974944 5$$

$k = 0$

$\pi \approx 3.1415927$

8 digits per iteration!

$k = 1$

$\pi \approx 3.1415926535897938$

Goals

- Create an awesome learning experience
- Instill enthusiasm for problem solving
- Give broad perspective on Computer Science
- Have fun!

Warning

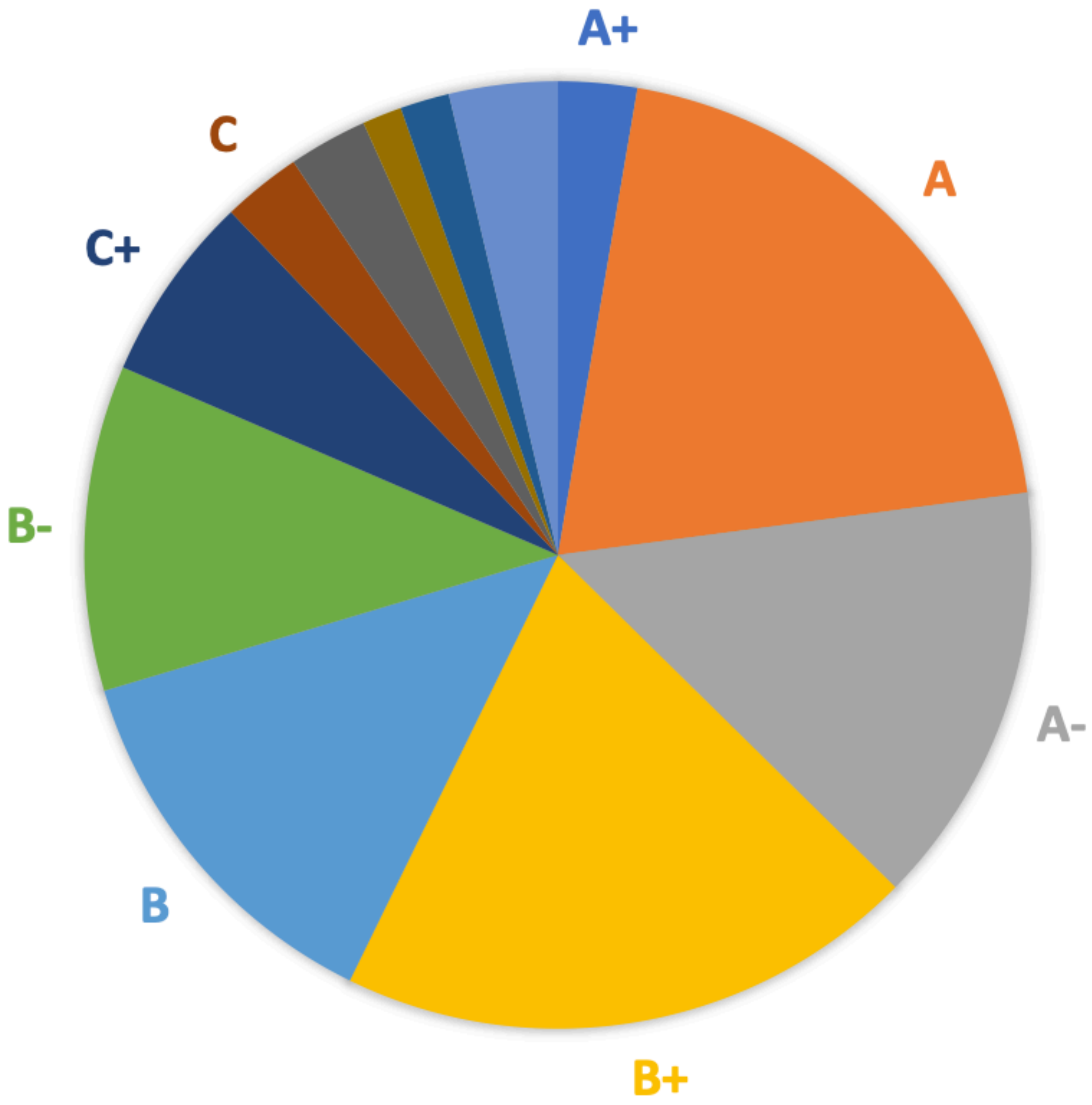
- This will be a very difficult class
  - Hard material
  - “Holy Grail” of computer science
  - Useful in practice
  - Job Interviews
- Lots of opportunities to succeed!

Hopefully not you…

- **Very difficult course**. Besides the grading/homework thing though, **I really loved the course** and I loved Hott.
- Algorithms can be a boring subject, but Hott introduces complex problems in class which makes it fun to follow along with. I thoroughly enjoyed the homework assignments although **they were VERY difficult**. It was nice to collaborate with my friends. **We actually had some fun** doing the assignments.
- I just have so say, **I both love and hate this class at the same time**. I hate that this class seemed to take up my life and I saw my group members and TA's more than my friends this semester, but I LOVE the professors who taught this class. They both have a similar sense of humor and love for puzzles, have their own quirky humor to liven up class, and just make class somewhere you can't hate to be.
- You can tell that **he really cares about students** and their understanding of the material and doesn't want to torture students too much.
- Although I hated discrete math and theory of computation, **this class was one of my favorites** I have taken as a CS major.
- **It is a great course.**

- **<3 Hott. He is amazing and very helpful. I can tell he really wants students to succeed.**
- His dedication to the class and his students is unquestionable, and **I have never learned more** from a lecture than in his class. He is an amazing educator and makes the class interesting and engaging no matter how difficult the subject matter is.
- **If you wanted to put in the time** to succeed in the course, Professor Hott **gave you the resources to succeed.** Whether that was holding office hours a bit longer to answer all remaining questions, making time in his hectic schedule (even during times of family situations), to address concerns or just offering advice, Professor Hott did it all. **The material taught in the class is very very relevant. During my coding interviews, I was asked material that was presented in class.**
- **I loved this course**! It honestly was not as bad as some people say with regards to content or time commitment.
- This class is just **hard and time consuming.**
- This was a **challenging yet extremely rewarding course**, as I feel that I have learned so much that I will use in my future career in computer science.

While difficult, students have done well…



Who Am I?

Social Networks and Archival Context

Image from Wikimedia Commons
Unknown - Public Domain

Goddard, Arabella, 1836-1922

Image from Wikimedia Commons

Thomas, Cyrus, 1825-1910

Image from Wikimedia Commons
Bain News Service, publisher - Public Domain

Wilson, William Bauchop, 1862-1934

Image from Wikimedia Commons
Unknown War photographer - Public Domain

Lindquist, Roy E. (Roy Ernest), 1907-1986

Office Hours

- Rice 210
  - Poll time! www.menti.com code: 81 53 43
  - By appointment

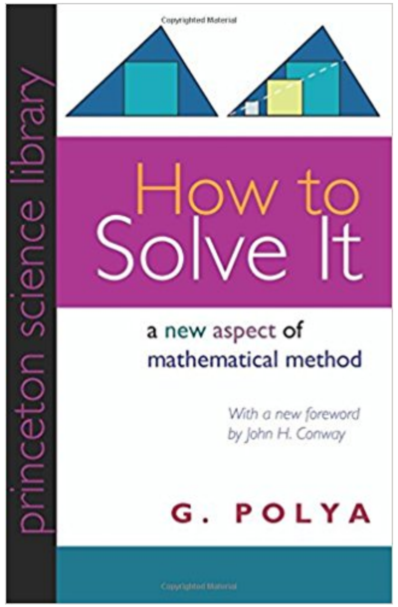
Requirements

- Discrete Math (CS 2102)
- Data Structures (CS 2150*)
- Derivatives, series (Calc I)
- Tenacity
- Inquisitiveness
- Creativity

* Enforced pre-req of C- or better.

Textbook

- Highly recommended: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How to Solve It
a new aspect of mathematical method
With a new foreword by John H. Conway
G. POLYA
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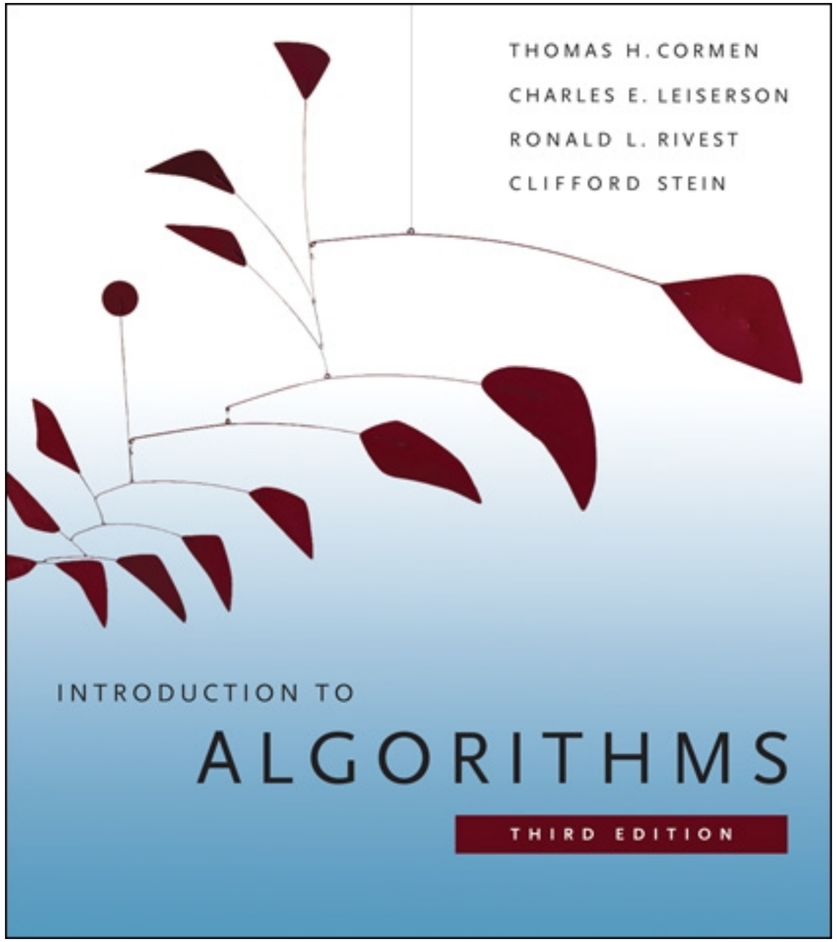
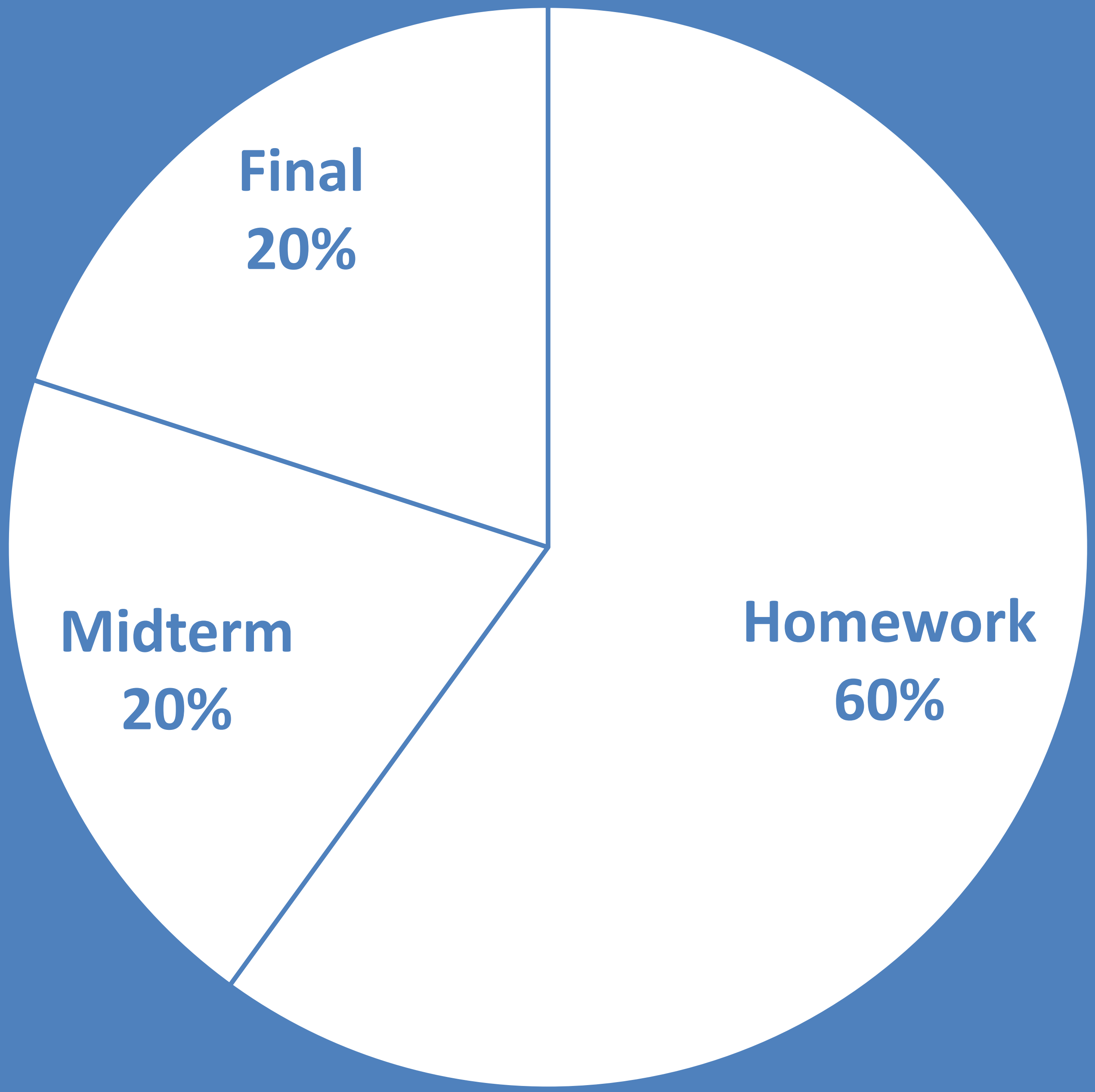
Polya. *How to Solve It.*



Cormen et al. (CLRS) *Introduction to Algorithms*. Third Edition.

Grade Breakdown



10% Extra Credit

Homework

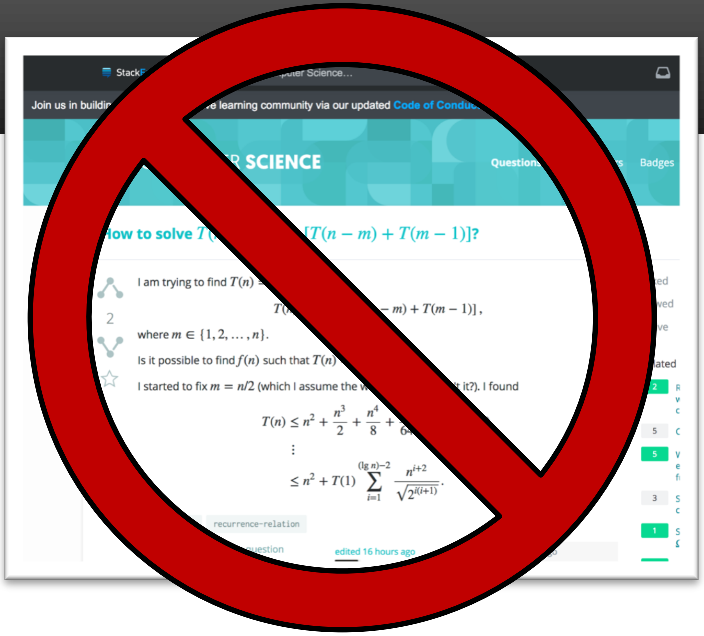
- 10 assignments total
- Mix of written and programming assignments
- Written:
  - 2/3 of all assignments
  - Must be typeset in LaTeX (tutorial is HW0)
  - Submit a **pdf** and a **zip** folder containing tex file and any supplements
    - Submissions without **both attachments** (pdf, zip) will **not** be graded
- Programming:
  - 1/3 of all assignments
  - Must implement in **Python** or **Java**

Homework 0

- Homework 0 out **today**!
  - Learning LaTeX
  - You MUST submit **both**:
    - A zip with your tex and image
    - A PDF of the final document
  - Due next Tuesday (but don’t wait that long!)

Academic Integrity

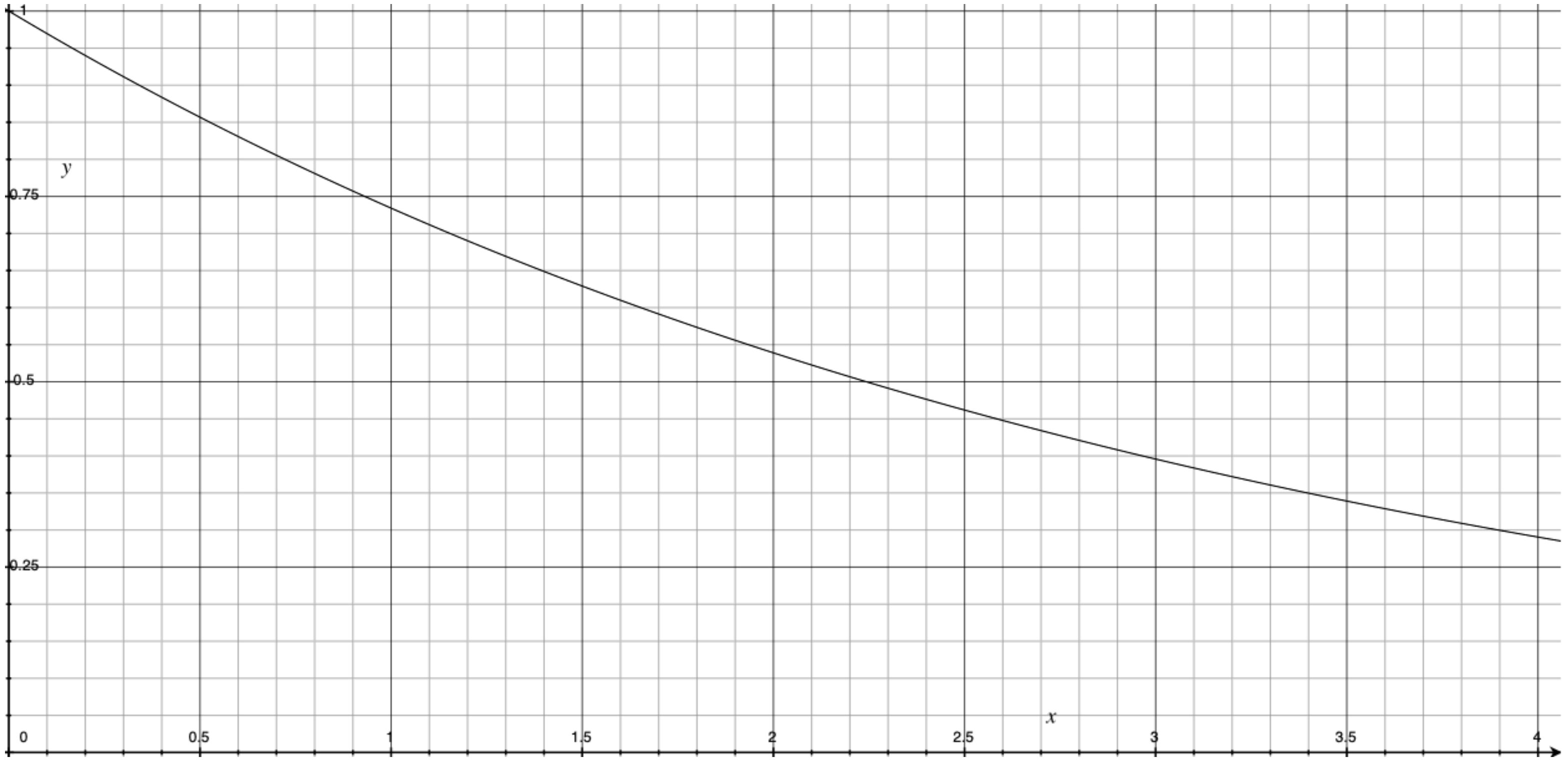
- Collaboration Encouraged!
  - Groups of up to 5 per assignment (you + 4)
  - List your collaborators (by UVA computing ID)
- Write-ups/code written independently
  - DO NOT share written notes / pictures / code
  - DO NOT share documents (ex: Overleaf)
  - DO NOT share debugging of code
- Be able to explain any solution you submit!
- DO NOT seek published solutions online



Late Policy

$$grade = grade_{earned}\, e^{-\frac{1}{2\phi} days}$$

- Exponential decay, accepted until solutions posted
- Extra credit: find a radioactive isotope with half-life closest to your homework's



Exams

- Midterm
  - March 4
  - In-class / take-home hybrid
- Final
  - Registrar’s official date/time (COMBINED)
  - Saturday, May 2, 7-10pm

Regrades

- Conducted in person with course staff
  - Time and Location: TBD
  - By appointment
  - Limited to 2 weeks after grades released

Extra credit

- Given for extraordinary acts of engagement
  - Good questions/comments
  - Quality discussions
  - Analysis of current events
  - References to arts and music
  - Extra credit projects
  - Slide corrections
  - Etc. Just ask!
- Email: **extracredit.cs4102@gmail.com**

Feedback

- I am not a course dictator, I am a civil servant
- I'm open to any suggestion to help you learn
- Let me know!
  - In person
  - Email
  - Piazza

Attendance

- How many people are here today?
- Naïve algorithm
  - Everyone stand
  - Professor walks around counting people
  - When counted, sit down
- Run time?
  - Class of *n* students
  - *O(n)*
- Other suggestions?

Better Attendance

1. Everyone Stand

2. Initialize your “count” to 1

3. Greet a neighbor who is standing: share your name, full date of birth (pause if odd one out)

4. If you are older: give “count” to younger and sit.
   Else if you are younger: add your “count” with older’s

5. If you are standing and have a standing neighbor, go to 3