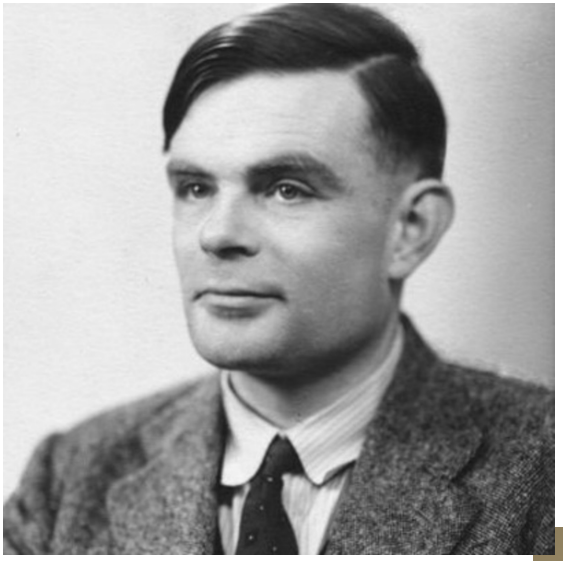
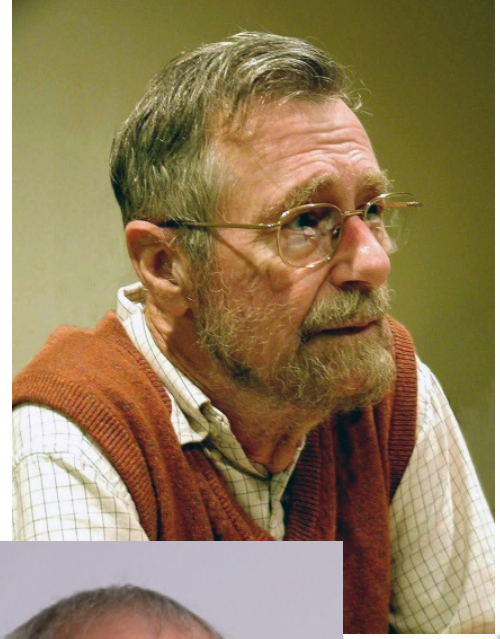
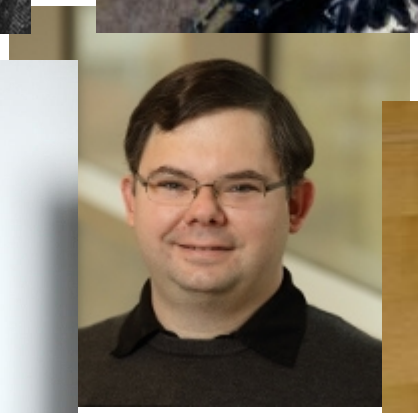
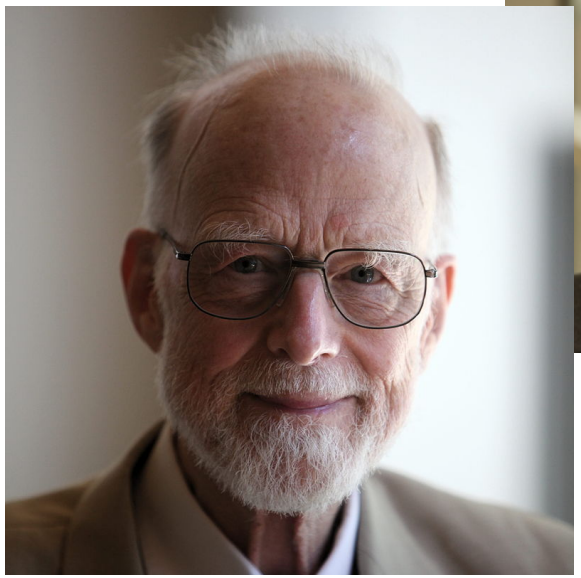
CS4102 Algorithms

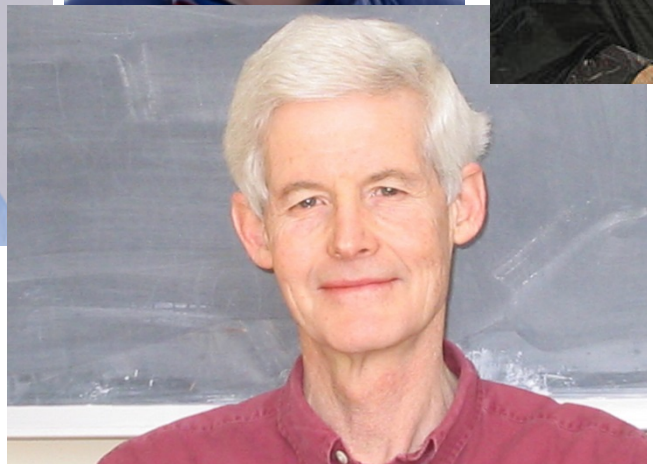
Fall 2019









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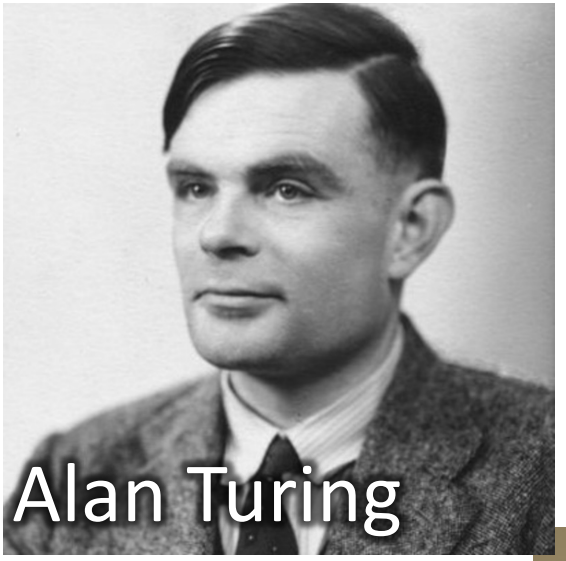
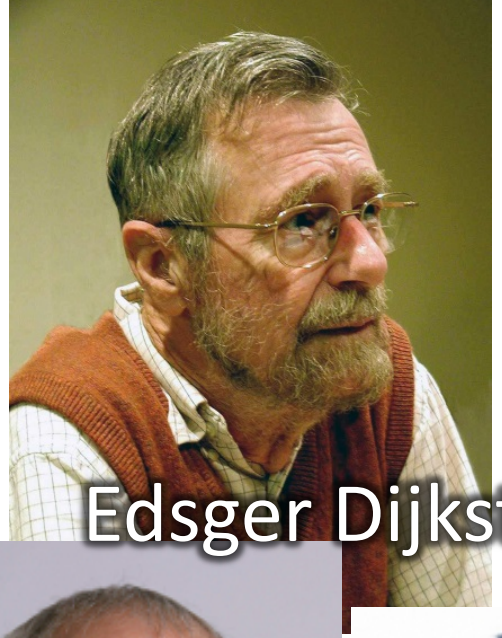

Alan Turing


Ada Lovelace

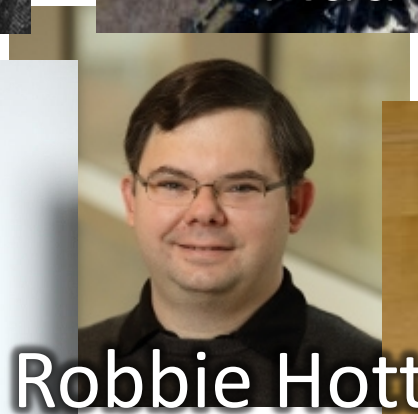

Edsger Dijkstra

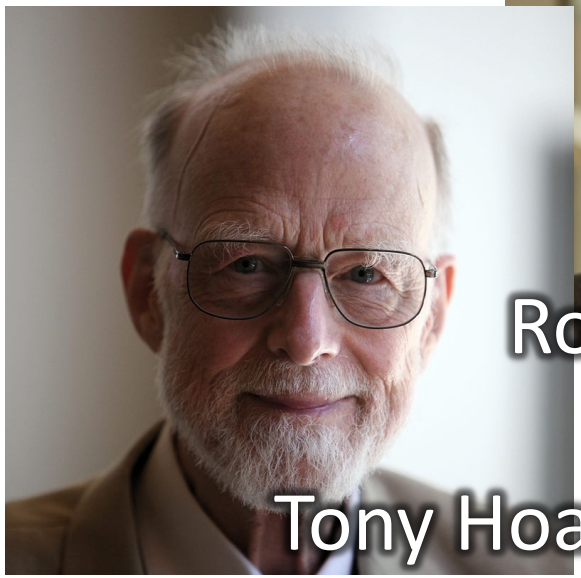

Al-Khwarizmi


Robert Tarjan


David Wu


Gauss


Robbie Hott


Tony Hoare

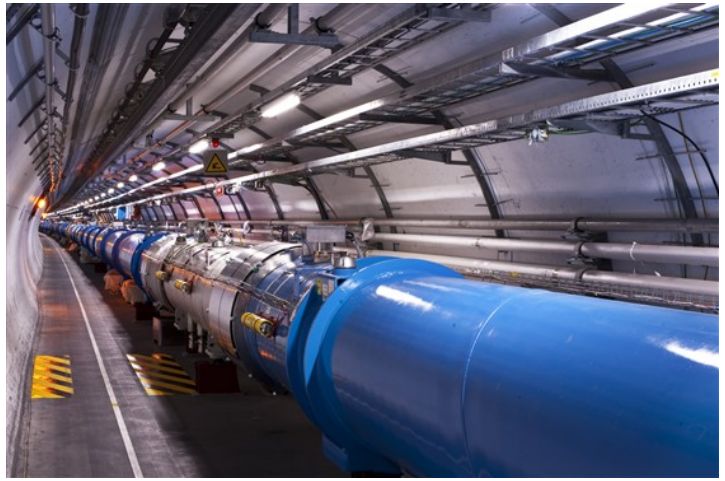

Donald Knuth


Stephen Cook

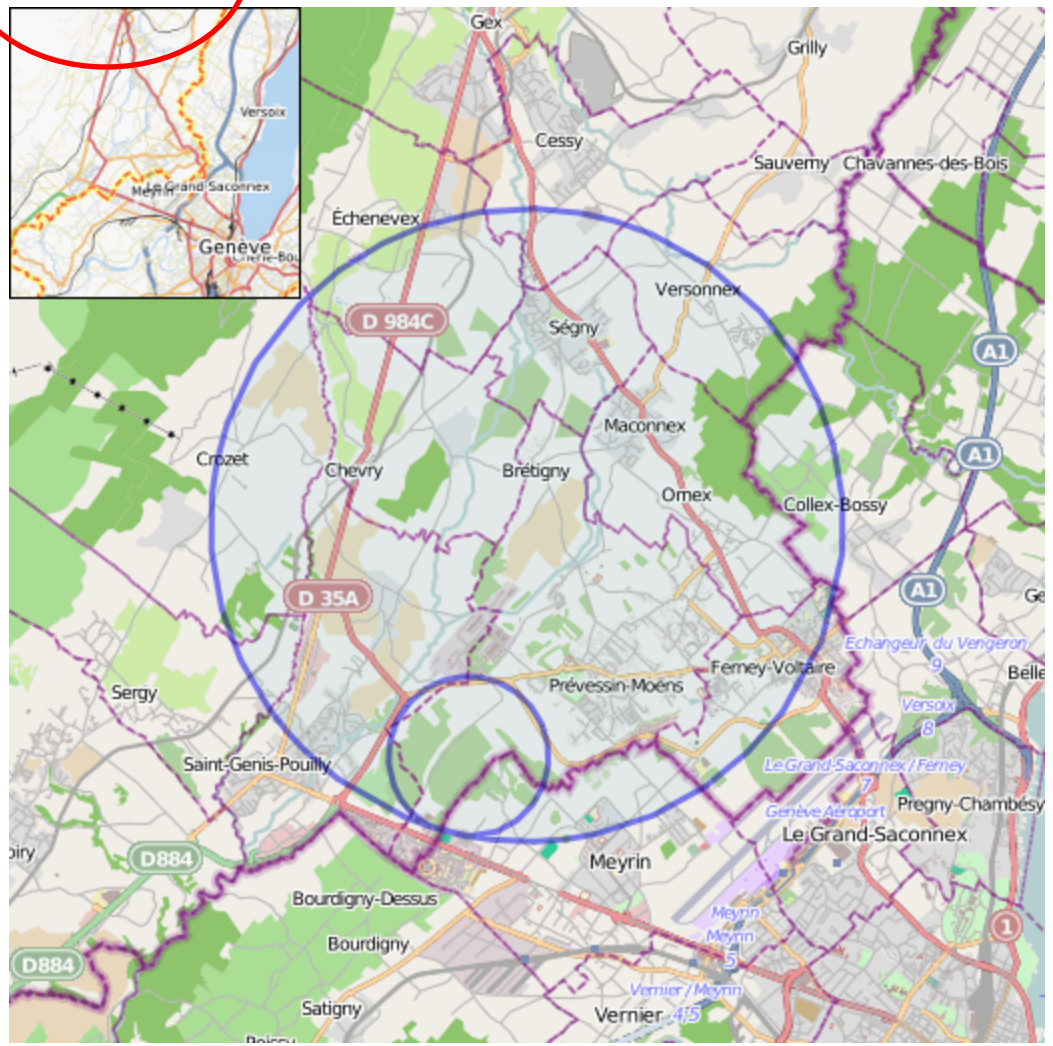
What is an algorithm?

- 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]
- 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



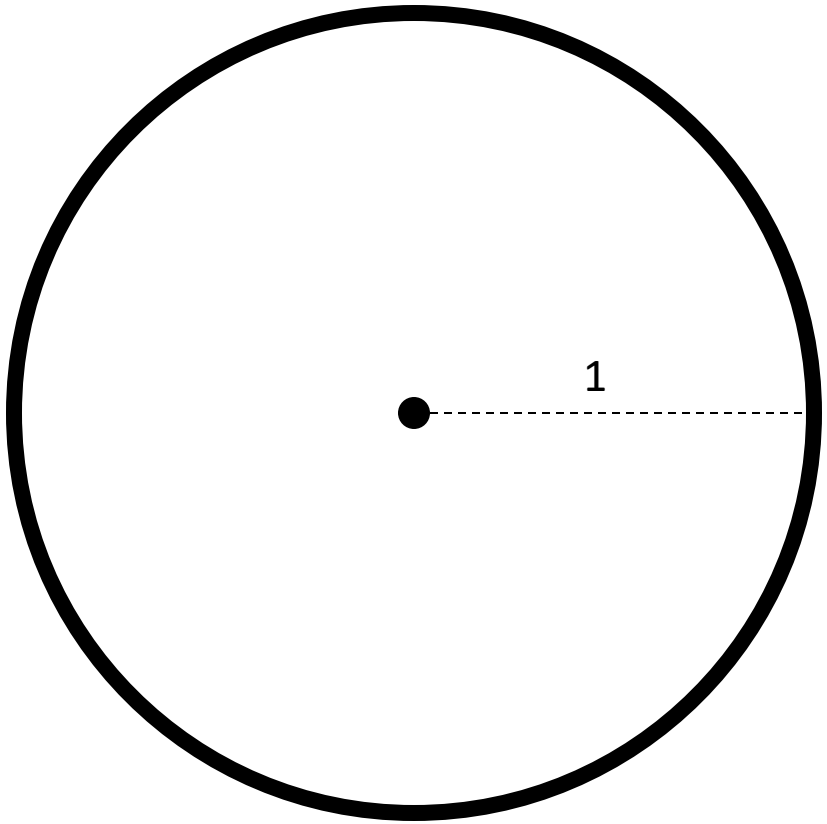
How much concrete do I need?



4.3km (2.7mi) diameter

π Approximation Algorithm

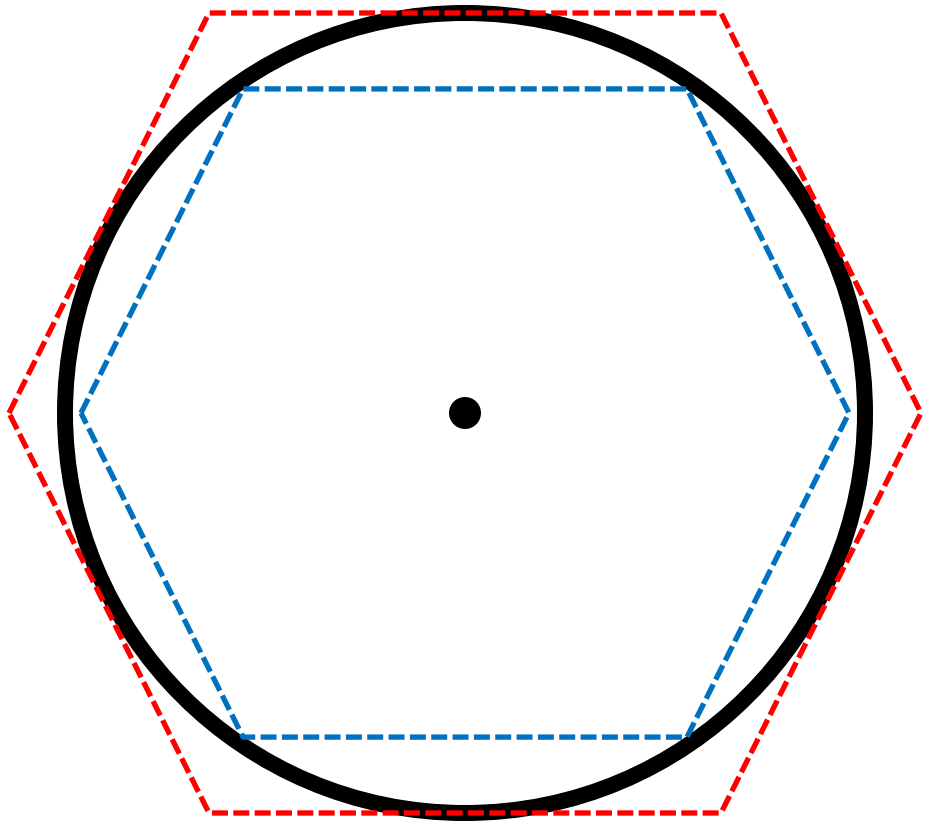
$\pi = 3.14159265359...$



Circumference = 2π

π Approximation Algorithm

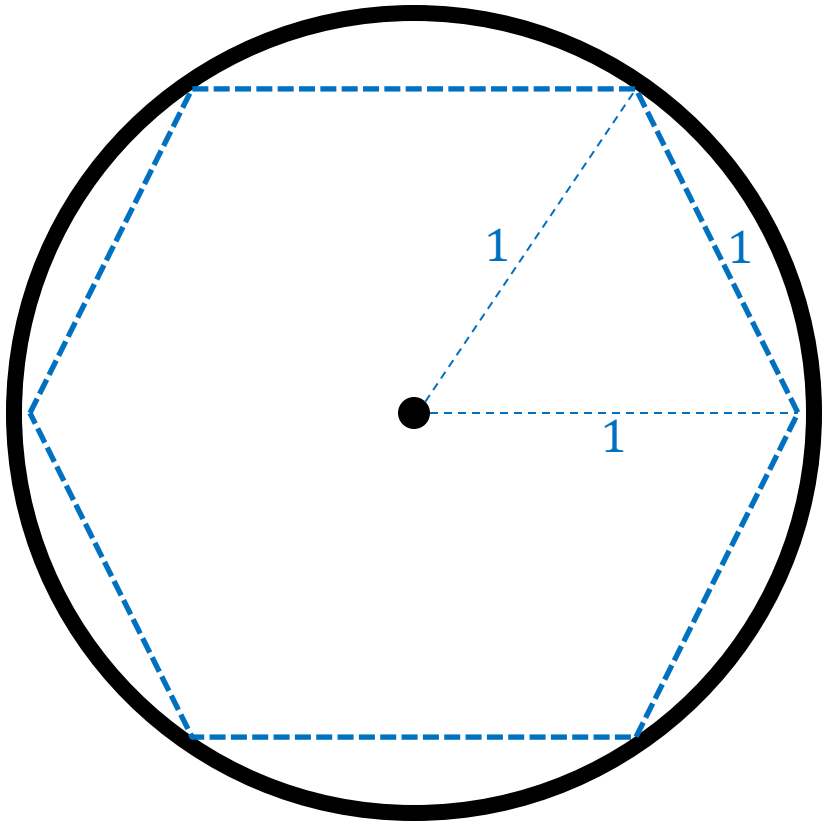
$\pi = 3.14159265359...$



Perimeter > 2π > Perimeter

π Approximation Algorithm

$\pi = 3.14159265359\ldots$



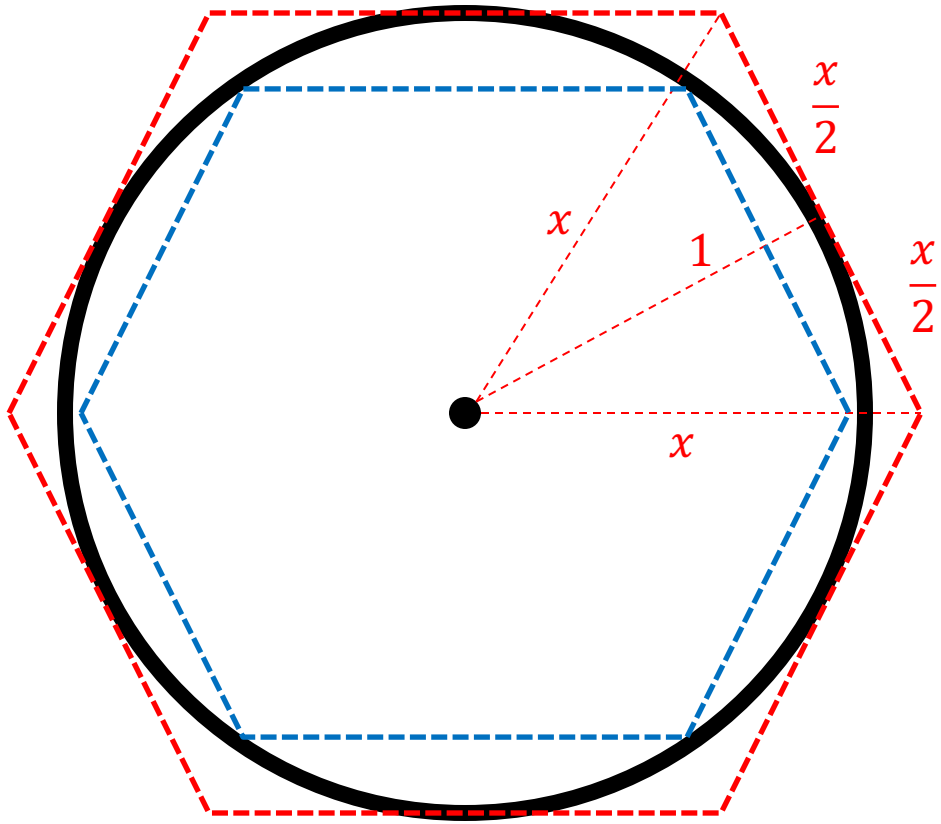
$2\pi >$ Perimeter $= 6$

π Approximation Algorithm

$\pi = 3.14159265359\ldots$ 1 digit correct

Solve for x

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

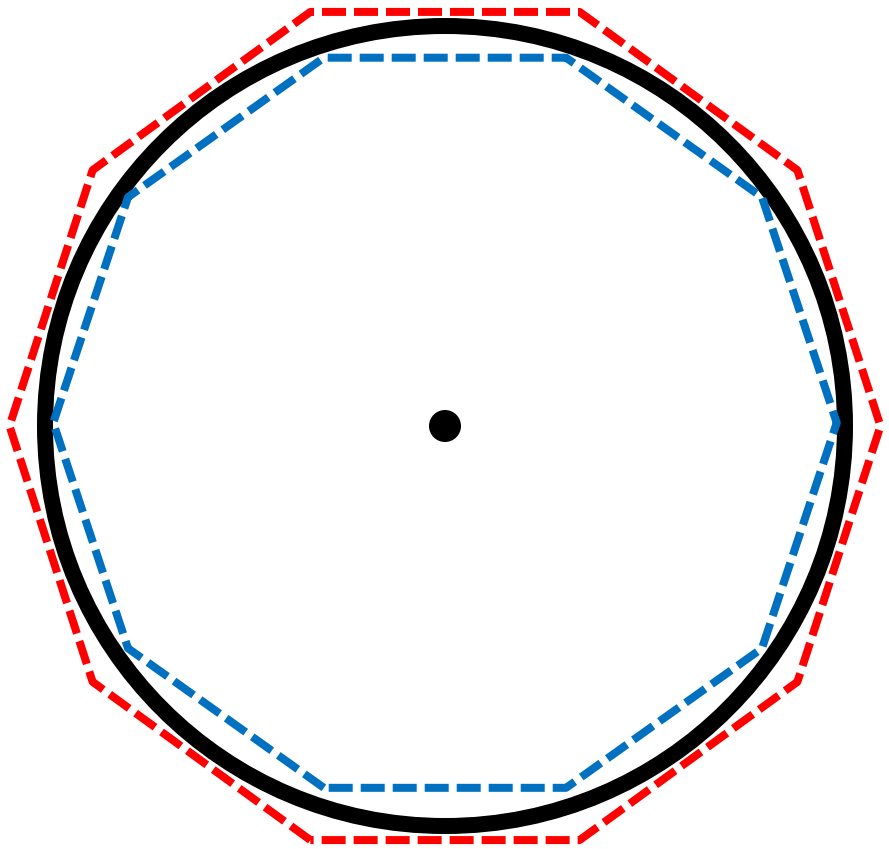


$$\frac{12}{\sqrt{3}} = \text{Perimeter} > 2\pi > \text{Perimeter} = 6$$

$$3.46 > \pi > 3$$

π Approximation Algorithm

$\pi = 3.14159265359\ldots$ 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)

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

$\pi = 3.14159265358979323846264338327950288419716939937510582097494459$

$k = 0$

$\pi \approx 3.1415927$

8 digits per iteration!

$k = 1$

$\pi \approx 3.141592653589793 8$

Goals

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

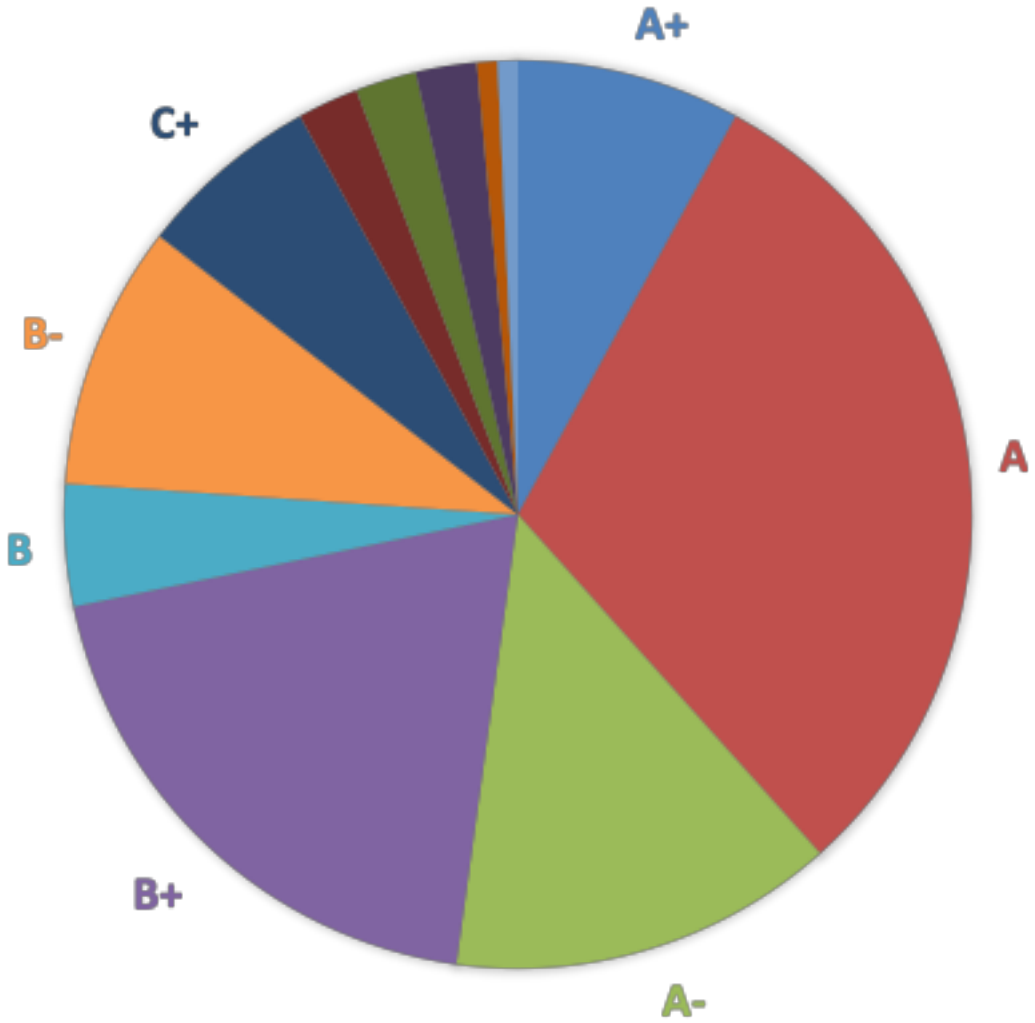
Warning

- 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.**

While difficult, students have done well…



Who Am I?


UNIVERSITY of VIRGINIA
snac
Search
About
Help
Login
Social Networks and Archival Context
All Types
Search for...
Search
Goddard, Arabella, 1836-1922
Thomas, Cyrus, 1825-1910
Wilson, William Bauchop, 1862-1934
Lindquist, Roy E. (Roy Ernest), 1907-1986
Nixon, Richard M. (President)

Office Hours

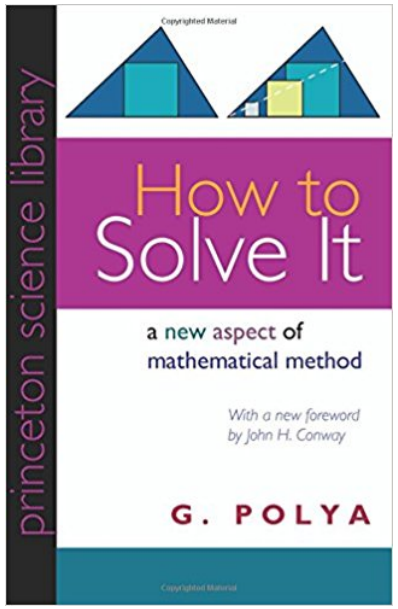
- Rice 210
  - Poll time! www.menti.com code: 34 29 54
  - By appointment

Requirements

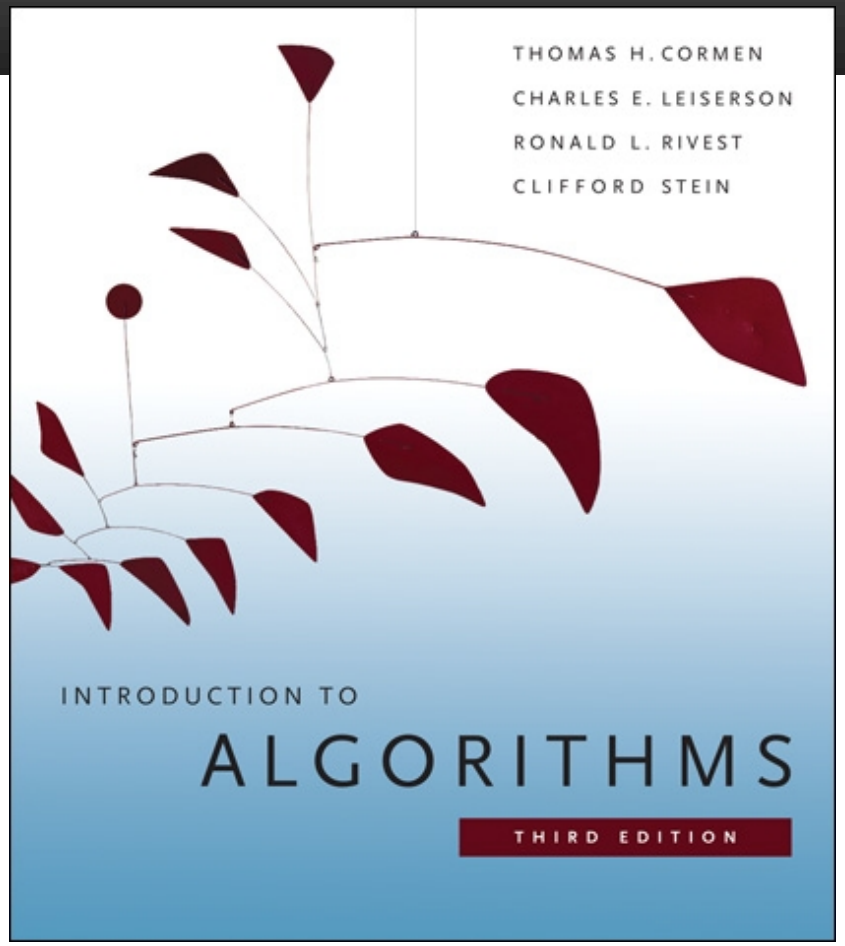
- Discrete Math (CS 2102)
- Data Structures (CS 2150)
- Derivatives, series (Calc I)
- Tenacity
- Inquisitiveness
- Creativity

Textbook

- No textbook required
- Highly recommended:

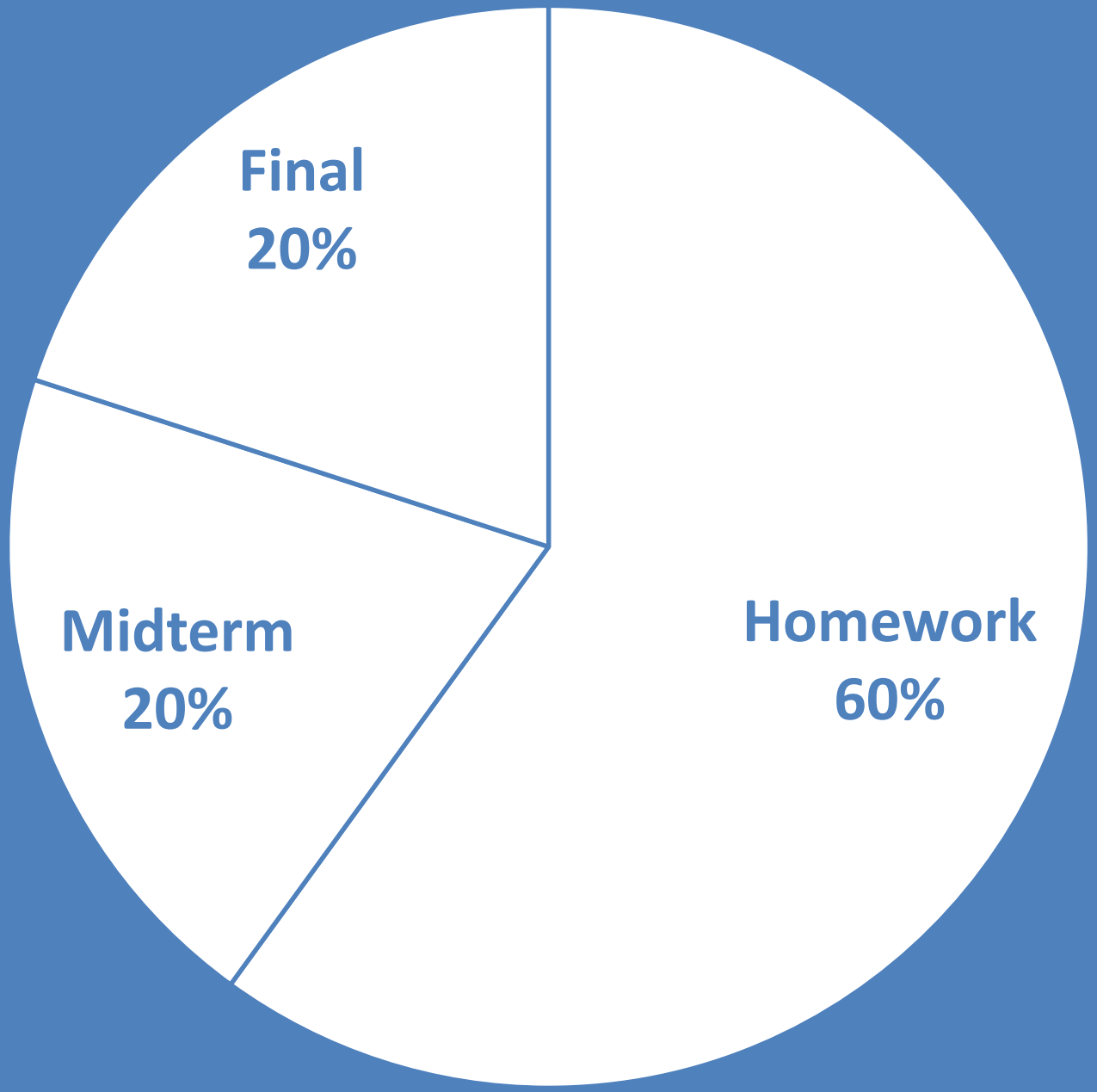


Polya. *How to Solve It.*



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

Grade Breakdown



10% Extra Credit

Homework

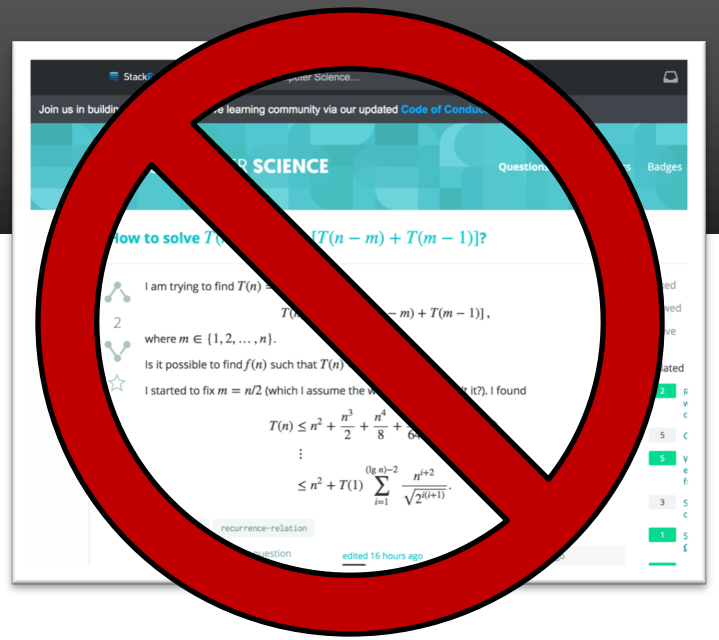
- 11 assignments total
- Mix of written and programming assignments
- Written:
  - 2/3 of all assignments
  - Must be typeset in LaTeX (tutorial is HW0)
  - Submit as a **pdf** and a **zip** folder containing tex file and any supplements
    - Submissions without **both attachments** (pdf, zip) will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

Homework 0

- Homework 0 is out!
  - 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

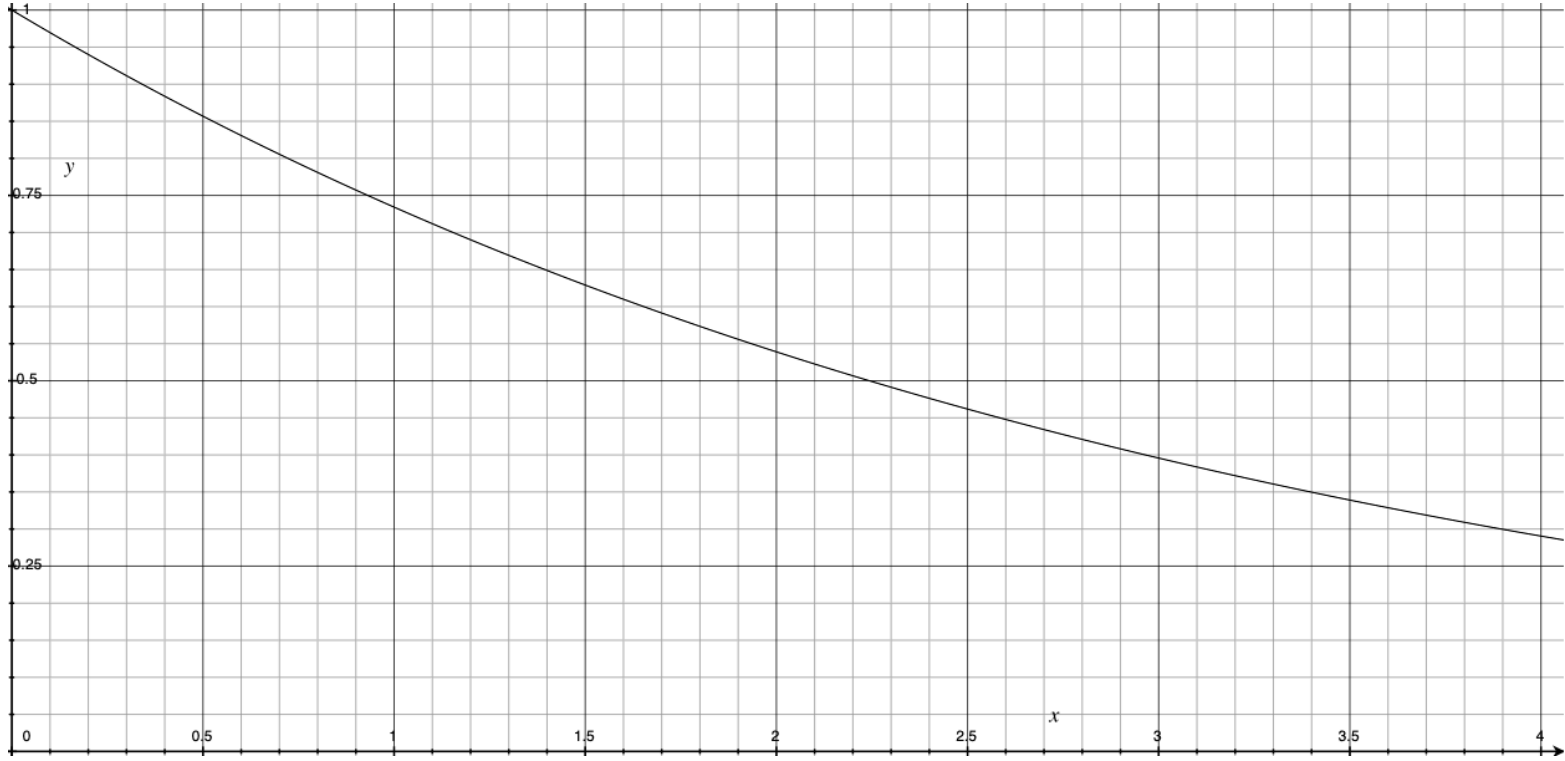
- Collaboration Encouraged!
  - Groups of up to 5 per assignment
  - List your collaborators (by UVA computing ID)
- Write-ups/code written independently
  - DO NOT share written notes / pictures
  - DO NOT share documents (ex: Overleaf)
- Be able to explain any solution you submit!
- DO NOT seek published 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
  - October 15
  - In-class / take-home hybrid
- Final
  - Registrar's official date/time (COMBINED)
  - Monday, December 9, 7-10pm

Regrades

- Conducted in person with course staff
  - Time and Location: TBD
  - By appointment

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: **extra.credit.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