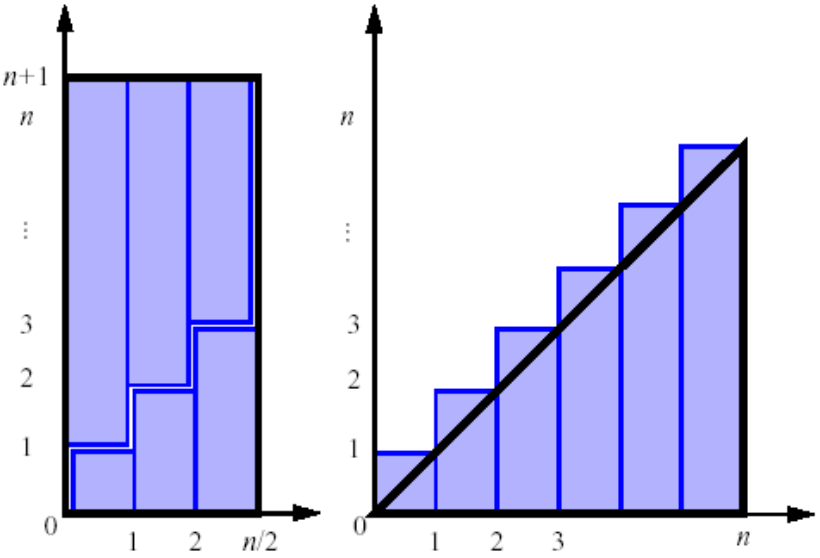
Pick up an in-class quiz from the table near the door

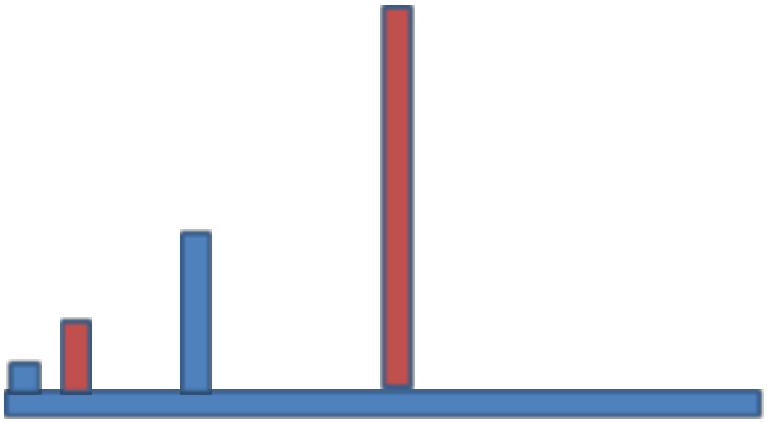
CSSE 230 Data Structures and Algorithm Analysis Day 1

$$\sum_{i=1}^{n} i = 1 + 2 + 3 + \ldots + n = \frac{n^2 + n}{2}$$

- two visual representations



Brief Course Intro
Math Review
Growable Array Analysis



And intro to daily quizzes, worth 5% of grade: Q1

Student Introductions

- Roll call
  - Introduce yourself to the person next to you
  - You'll share more with classmates on Piazza discussion forum, like what work you've done that you are most proud of.
  - Please write more than a couple of sentences about yourself.

And intro to daily quizzes, worth 5% of grade: Q1

Introductions

- Nate
  - At R-H since 2014. Math 2014-16, CSSE since 2016.
  - B.S., Harvey Mudd in Math-CS
  - Ph.D., Georgia Tech in Algorithms, Combinatorics, & Optimization
  - Special interests in cryptography, algorithms, discrete math
  - Courses taught at Rose:
    - CSSE230, Design & Analysis of Algorithms, Cryptography
    - DisCo 1 & 2, Calc 2 & 3, DE 1
  - Hobbies: cycling, running, triathlon, classical music, travel

Goal: independently design, develop, and debug software that uses correct, clear, and efficient algorithms and data structures

Prove: An AVL Tree has O(log n) height
Proof: By definition,
$|\text{height}(T_L) - \text{height}(T_R)| \leq 1$
...

Topic	I do	You do	You practice	You show off
Analysis	Explain, show, do	Listen, follow, read, quiz	Homework sets	Tests
Programming			Major programs	Tests, project

```
/**
 * A height-balanced binary tree with rank
 * that could be the basis for a text
 * editor.
 * @author Claude Anderson and Matt Boutell.
 */
public class EditTree {
    private Node root;
    private int rotationCount = 0;
    private Node singleLeftRotation(
            Node grandParent, Node parent) {
            // Set parent nodes
...
```

Why *efficient* algorithms?

Here's $1,000,000,000:

- Find serial number KB46279860I
- If unsorted, you could look at all 10 million bills.
- If sorted by serial number, binary search finds it by only looking at _____ bills.

https://commons.wikimedia.org/wiki/File:Oenbilliondollar.jpg

How to succeed in CSSE230

- Work hard
  - Re-do CSSE220 stuff as needed to make sure your foundations (recursion and linked lists) are strong
- Take initiative in learning
  - Read the text, search Javadocs, come for help
- Focus while in this class
  - https://www.rose-hulman.edu/class/cs/csse230/201820/MiscDocuments/LaptopsAreGreatButNotDuringaLectureoraMeeting.pdf (11/26/2017 NYT)
- Start early and plan for no all-nighters
  - Two assignments each week: 1 homework set and 1 major program
- Never give or use someone else's answers

Tools

- https://www.rose-hulman.edu/class/csse/csse230/201910/Schedule/ schedule, reading/HW/program assignments, room #s!
  - Read the **Syllabus**: Tomorrow's quiz will start with questions about it.

- www.piazza.com, not email: homework questions and announcements
  - If you email, I'll usually reply, "Great question! Please post it to Piazza"
  - It should auto-email you whenever there is a post.

- moodle.rose-hulman.edu: gradebook, homework pdf turn-in, peer evaluations, solutions

After today's class, you will be able to…

- analyze runtimes of code snippets by counting instructions.
- explain why arrays need to grow as data is added.
- derive the average and worst case time to insert an item into an array [GrowableArray exercise]

Analysis/Math Review

Notation

- Floor

$$\lfloor x \rfloor = \text{the largest integer} \leq x$$

- Ceiling

$$\lceil x \rceil = \text{the smallest integer} \geq x$$

- **`java.lang.Math`, provides the static methods `floor()` and `ceil()`**

Summations

- Summations
  - general definition:

$$\sum_{i=s}^{t} f(i) = f(s) + f(s+1) + f(s+2) + \ldots + f(t)$$

  - where f is a function, s is the start index, and t is the end index

Geometric progressions: each term is a constant multiple of the previous term

- Geometric progression: $f(i) = a^i$
  - given an integer $n \geq 0$ and a real number $0 < a \neq 1$

$$\sum_{i=0}^{n} a^i = 1 + a + a^2 + \ldots + a^n = \frac{1 - a^{n+1}}{1 - a}$$

Memorize this formula!

  - geometric progressions exhibit exponential growth

Exercise: What is $\sum_{i=2}^{6} 3^i$?

The sum can also be written:

$$\frac{a^{n+1} - 1}{a - 1}$$

This will be useful for today's Growable Arrays exercise!

Arithmetic progressions: constant difference
Most important to us: a difference of 1

- Arithmetic progressions:
  - An example

Memorize this formula!

$$\sum_{i=1}^{n} i = 1 + 2 + 3 + \ldots + n = \frac{n^2 + n}{2}$$

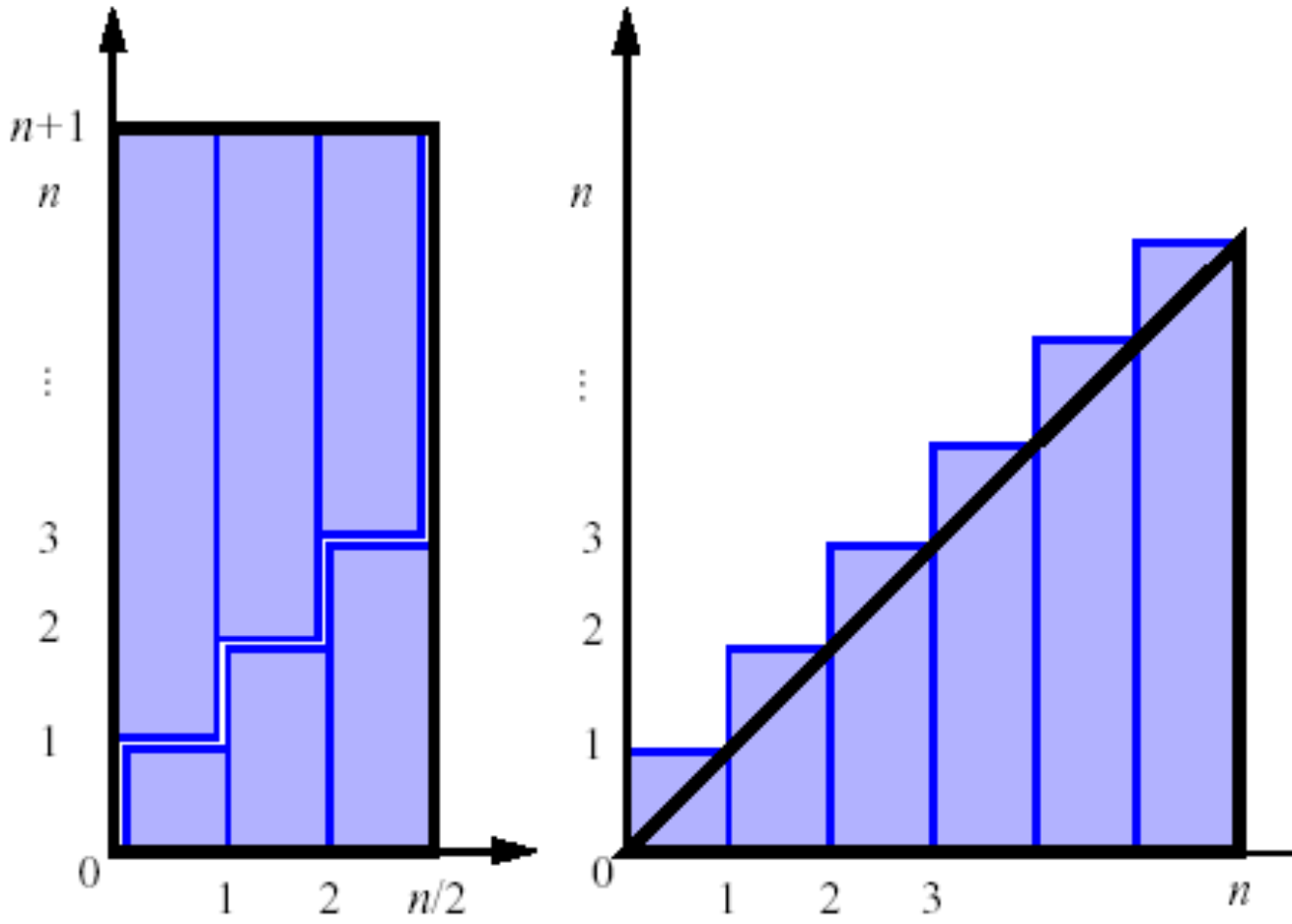
Exercise: $\sum_{i=21}^{40} i$

Also useful for today's Growable Arrays exercise!

Visual proofs of the summation formula

$$\sum_{i=1}^{n} i = 1 + 2 + 3 + \ldots + n = \frac{n^2 + n}{2}$$

- two visual representations



Application: Find exact and big-Oh runtime of Selection Sort

Q13-14, turn in

```
for (i=n-1; i>0; i--) {
    int maxPos = 0;
    for (int j = 0; j <=i; j++) {
        if (a[j] > a[maxPos]) {
            maxPos = j;
        }
    }
    swap a[maxPos] with a[i] ;
}
```

- How many comparisons of array elements are done?
  - Exact? Big-Oh?
- How many times are array elements copied?

Growable Array Analysis

An exercise in doubling, done by pairs of students

Arrays are ubiquitous

- Basis for ArrayLists, sorting, and hash tables
- Why? O(1) access to any position, regardless of the size of the array.

- Limitation:
  - Fixed capacity!
  - If it fills, you need to re-allocate memory and copy items
    - How efficient is this?
    - Consider two schemes: “add 1” and “double”

Work on Growable Array Exercise

- Work with a partner
- Hand in the document before you leave today if possible. Otherwise due start of day 2's class.
- Get help as needed from me and the assistants.