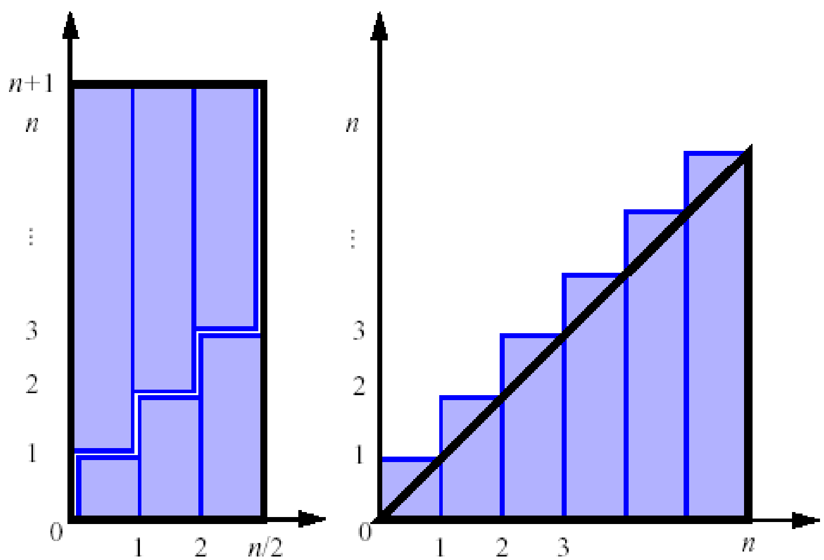
Pick up an in-class quiz from the table near the door

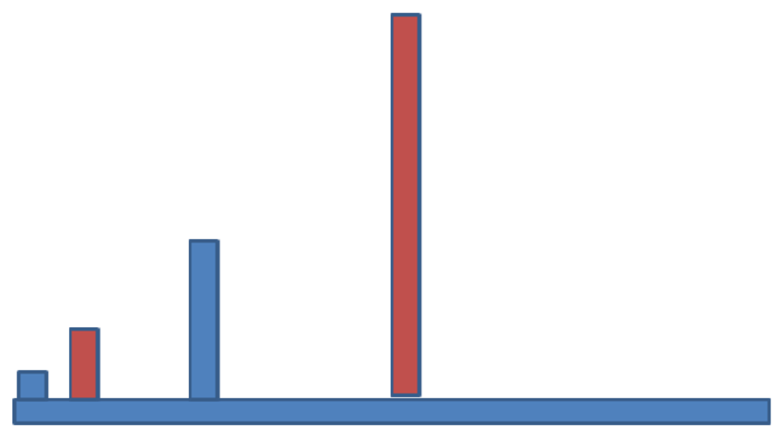
CSSE 230 Data Structures and Algorithm Analysis Day 1

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

- 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
  - I'll soon post an assignment to Moodle that asks you to share more with classmates on a Piazza discussion forum, e.g., what's your favorite food, what are your hobbies, types of work you've done, etc.

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

```java
/**
 * 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

Q2-3

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/csse230/201930/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
- Talk to and work with others
  - Don't be the "lone ranger"
- But never give or use someone else's answers

Tools

- https://www.rose-hulman.edu/class/csse/csse230/201930/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

Q9-10

- 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

Q11-12

- Arithmetic progressions:
  - An example

Memorize this formula!

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

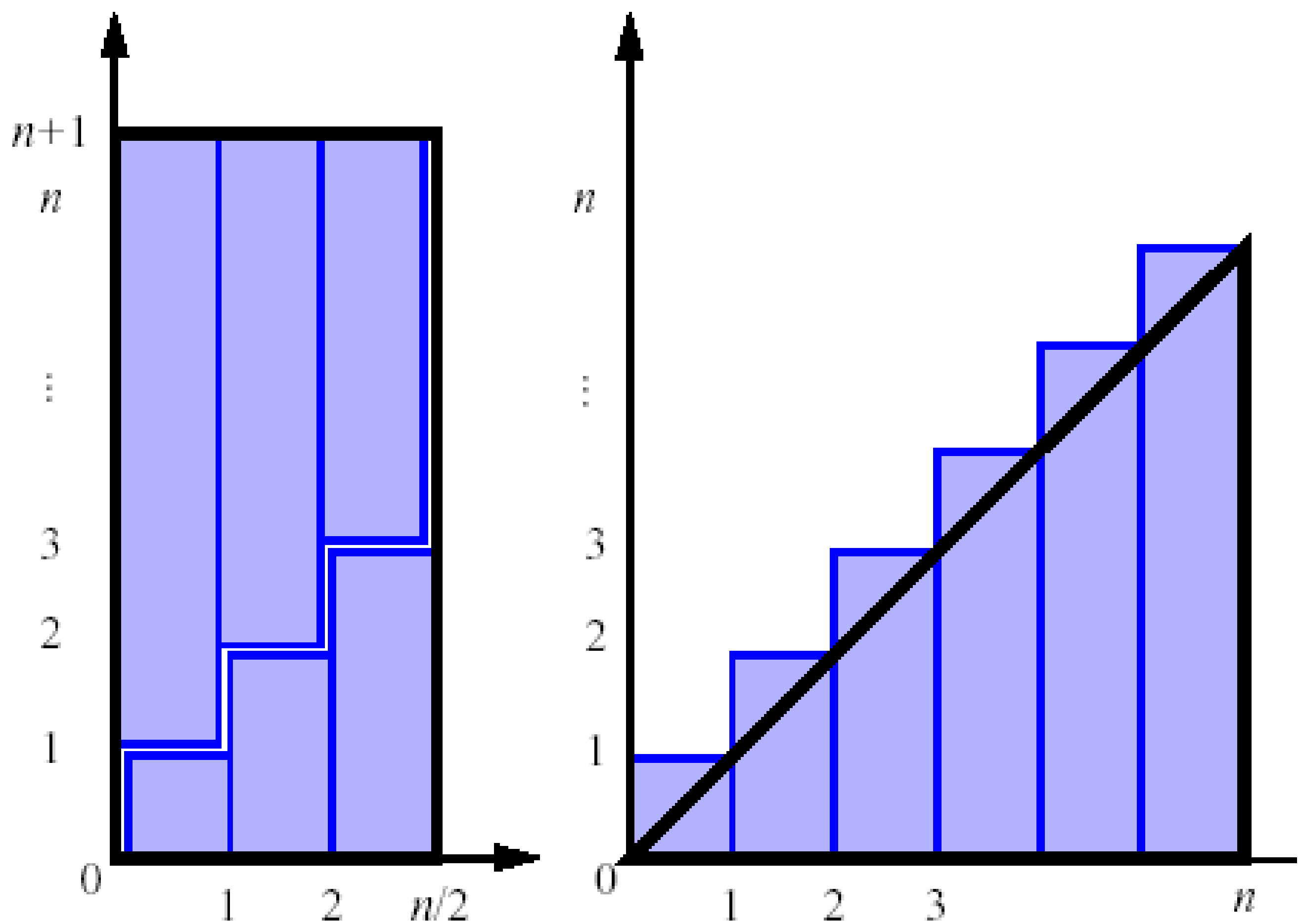
Exercise: $\sum_{i=21}^{40} i$

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: Runtime of Selection Sort

```
for (int 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] ;
}
```

Selection Sort

- Basic idea:
  - Think of the array as having a sorted part (at the beginning) and an unsorted part (the rest)

0	1	2	3	4	5	6	7	8	9
38	44	87	2033	99	1500	100	90	239	748

  - Find the smallest value in the unsorted part
  - Move it to the end of the sorted part (making the sorted part bigger and the unsorted part smaller)

Repeat until unsorted part is empty

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

```
1 for (int i = n-1; i > 0; i--) {
2    int maxPos = 0;
3    for (int j = 0; j <= i; j++) {
4         if (a[j] > a[maxPos]) {
5              maxPos = j;
6         }
7    }
8    swap a[maxPos] with a[i] ;
9 }
```

- On what line is comparison performed?
- How many comparisons of array elements are executed? 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 of ArrayLists:
  - 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.

Handy for Growable Arrays HW

Properties of logarithms

$$log_b(xy) = log_b(x) + log_b(y)$$

$$log_b(x/y) = log_b(x) - log_b(y)$$

$$log_b(x^{\alpha}) = \alpha log_b(x)$$

$$log_b(x) = \frac{log_a(x)}{log_a(b)}$$

$$a^{log_b(n)} = n^{log_b(a)}$$

Properties of exponents

$$a^{(b+c)} = a^b a^c$$

$$a^{bc} = \left(a^b\right)^c$$

$$a^b/a^c = a^{(b-c)}$$

$$b = a^{log_a(b)}$$

$$b^c = a^{c*log_a(b)}$$