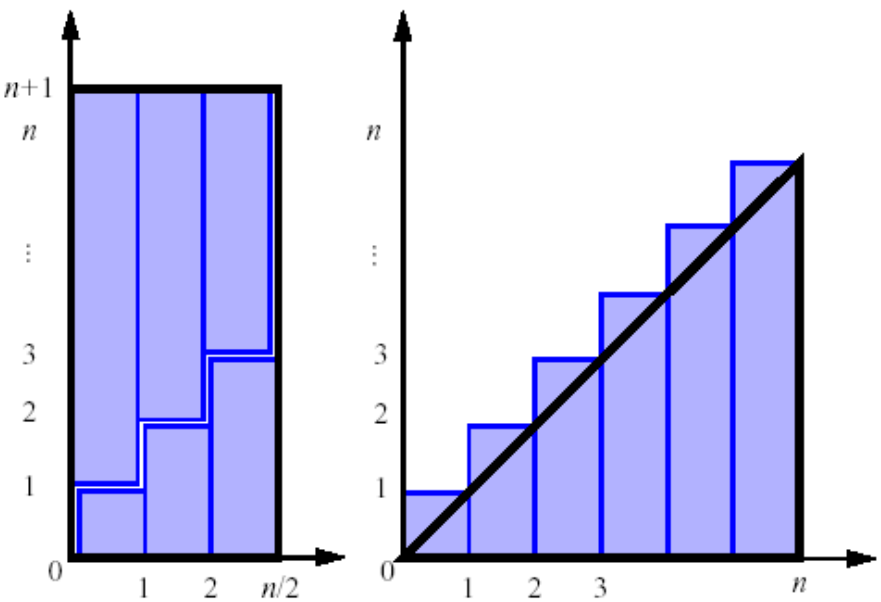
Online version

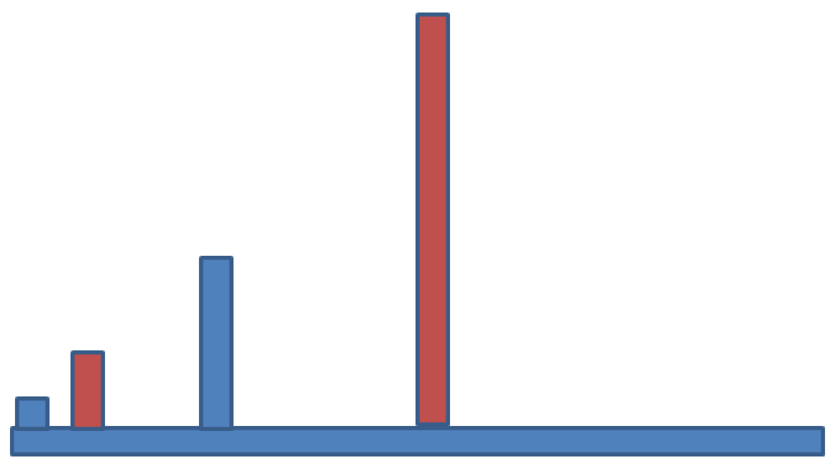
CSSE 230 Data Structures and Algorithm Analysis Day 1

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

- two visual representations



Brief Course Intro
Math Review
Growable Array Analysis



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

Introductions

Matthew Boutell (Rhymes with Math, You Now Tell)

Yes: CS & Math, teaching background

Please introduce yourself to me and your classmates on the discussion forum, e.g., what are your passions, your favorite food, your hobbies, types of work you've done, etc.

(5pts toward homework grade)

I'll do this too.

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(
            NodeInfo info) {
            // Set pointers and balance codes
…
```

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

How to succeed in CSSE230

- Take initiative in learning
  - Search Javadocs, Google, textbook, come for help
  - Re-do CSSE220 stuff as needed to make sure your foundations (recursion and linked lists) are strong
- Focus while in this class
  - Laptops can distract from learning (11/26/2017 NYT)
- Start early and plan ahead
  - Five things due each week: 2 assignments (1 homework set and 1 major program) and 3 quizzes
  - No all-nighters
- Talk to and work with others
  - Don't be the "lone ranger"
  - I want you to share ideas with classmates!
- But never give or use someone else's answers

Tools for online success

- Moodle:
  - Videos, in-class quizzes (ICQ), pdf turnin, including quiz's "clear/muddy" survey, gradebook, homework pdf turn-in, solutions.
- Course webpage->Moodle
  - Schedule of lessons, HW/program assignments, slides.
  - Read the **Syllabus**: Tomorrow's quiz will start with questions about it.
- Microsoft Teams
  - Online office hours and video calls
- CampusWire
  - Has direct messaging and public discussion forum when you have homework questions.
  - I'll use it to summarize each session's
  - You can set it to auto-email you whenever there is a post.
- Eclipse
  - Demo of checking out WarmUpAndStretching from git

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: $\lfloor x \rfloor$ = the largest integer $\leq x$
- Ceiling: $\lceil x \rceil$ = the largest integer $\geq x$
  - `java.lang.Math` provides methods `floor()` and `ceil()`

- Summations

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

  - f is a function
  - s is the start index
  - t is the end index

Geometric sums

- Geometric sequence: each term is a constant multiple of the previous term
  - The sequence exhibits exponential growth
  - $1, a, a^2, a^3, a^4, \ldots$

- Geometric sum. Index is in the *exponent*

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

(for $n \geq 0,\ a \neq 1$)

Memorize this formula!

- Exercise. Compute

$$\sum_{i=2}^{6} 3^i$$

Arithmetic sums

- Arithmetic sequence: each term is a constant (often 1) added to the previous term
  - 2,6,10,14,18, ...
  - 1,2,3,4,5,6, ...

- Arithmetic sum

$$\sum_{i=1}^{n} i = 1 + 2 + 3 + \cdots + n = \frac{n(n+1)}{2}$$

Memorize this formula!

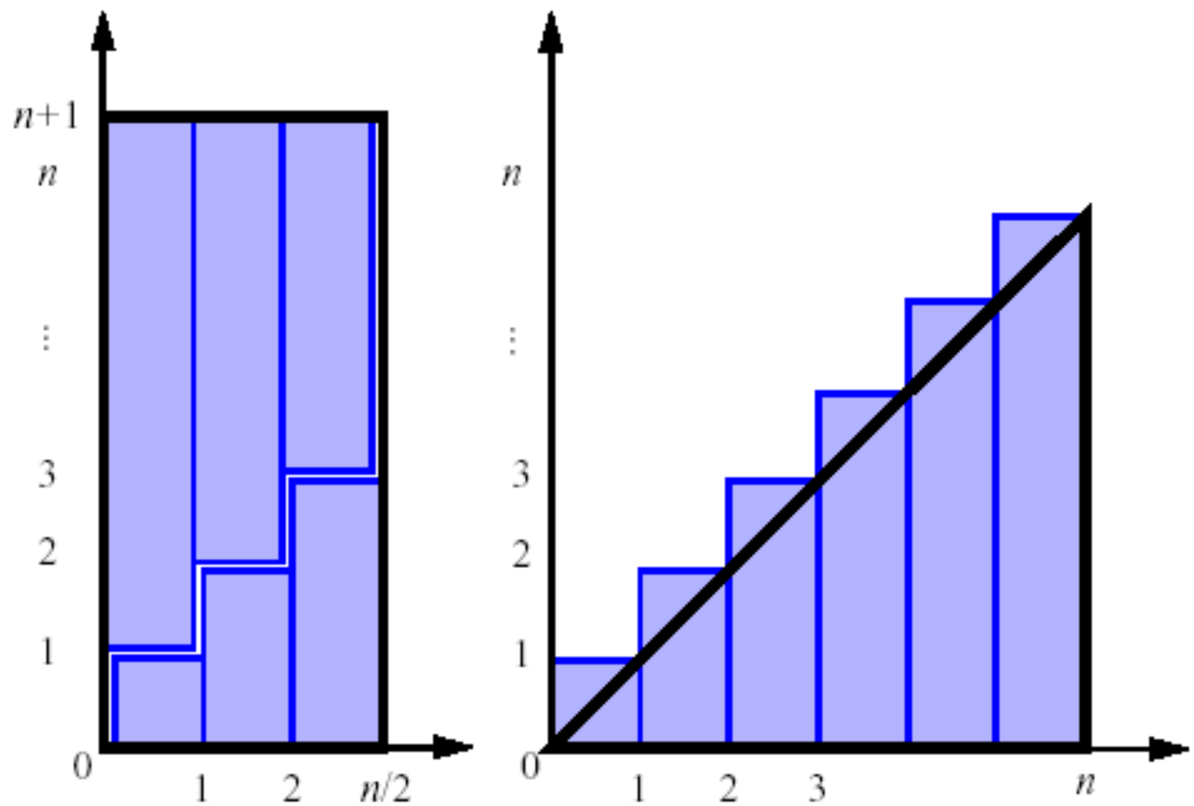
- Exercise. Compute

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

Visual proof of the arithmetic sum formula

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

- two visual representations



Application: Analysis of Selection Sort

- Selection sort basic idea:
  - Think of the array as having an unsorted part, then a sorted part

0	1	2	3	4	5	6	7	8	9
7	388	310	438	79	10	121	537	974	1391

  - Find the *largest* value in the unsorted part
  - Swap it to the *beginning* of the sorted part (making the sorted part bigger and the unsorted part smaller)

Repeat until unsorted part is empty

- Pseudocode:

```
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] ;
}
```

Q10

Application: Analysis 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] ;
}
```

How many times does the most-frequently-run line of code run, as a function of n?

Tabulate all values of index variables.

i	j	Count
n-1	0,1,2,…,n-1	n
n-2	0,1,2,…,n-2	n-1
n-3	0,1,2,…,n-3	n-2
…	…	…
2	0,1,2	3
1	0,1	2

Add up counts!

$$\sum_{i=2}^{n} i = \quad ?$$

Note: not the same i as before…

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”

- GrowableArray demo

Work on Growable Array Exercise

- You may work with a partner
- See hints if you get stuck

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

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

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

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

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

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