

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

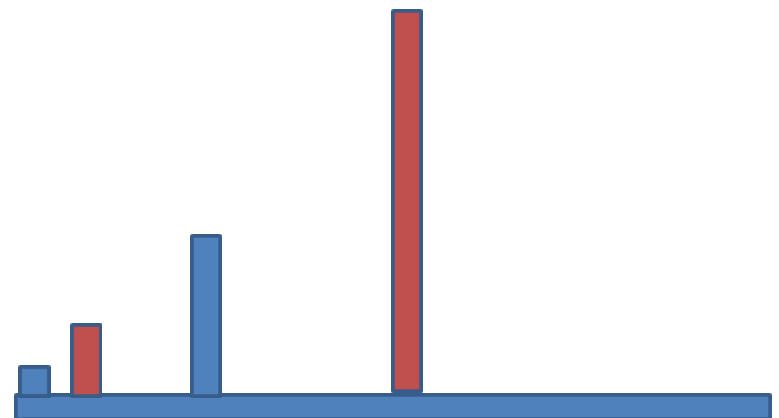
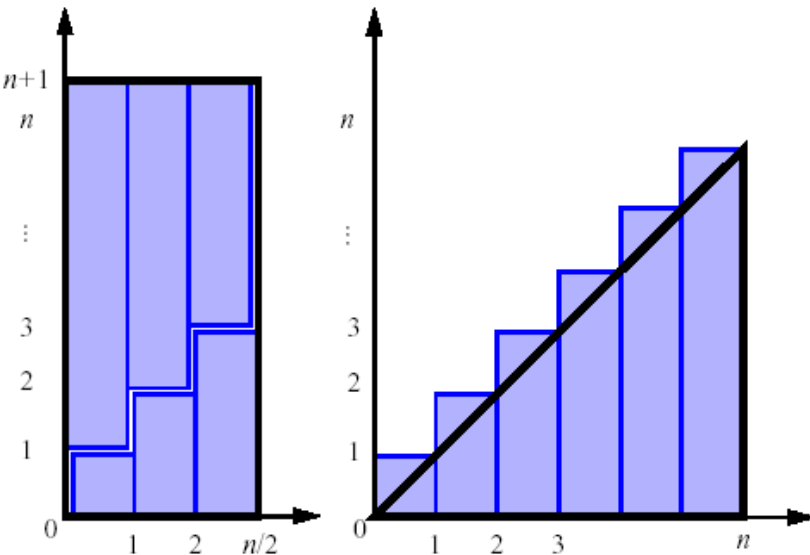
# CSSE 230 Data Structures and Algorithm Analysis Day 1

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

Brief Course Intro  
Math Review

Growable Array Analysis

- two visual representations



# Introductions

- ▶ Roll call
  - Introduce yourself to the person next to you
  - You'll share more with classmates on discussion forum, like what work you've done that you are most proud of.
- ▶ Dr. Chenette
  - At R-H since 2014. Math dept. 2014-16, now CSSE.
  - 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

# Introductions



# 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 ↓ Programming	Explain, show, do	Listen, follow, read, quiz	Homework sets Major programs	Tests 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  
    }  
    ...  
}
```

# 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
- ▶ 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

- ▶ <http://www.rose-hulman.edu/class/csse/csse230/201720/Schedule/>: schedule, assignments, room #s!
- ▶ [www.piazza.com](http://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.
  - Posting and answering posts is a factor in citizenship grade
- ▶ [moodle.rose-hulman.edu](http://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

$\lfloor x \rfloor =$  the largest integer  $\leq x$

- Ceiling

$\lceil x \rceil =$  the smallest integer  $\geq x$

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

# Summations

- Summations

- general definition:

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

- 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  $0 < a \neq 1$

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

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!

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

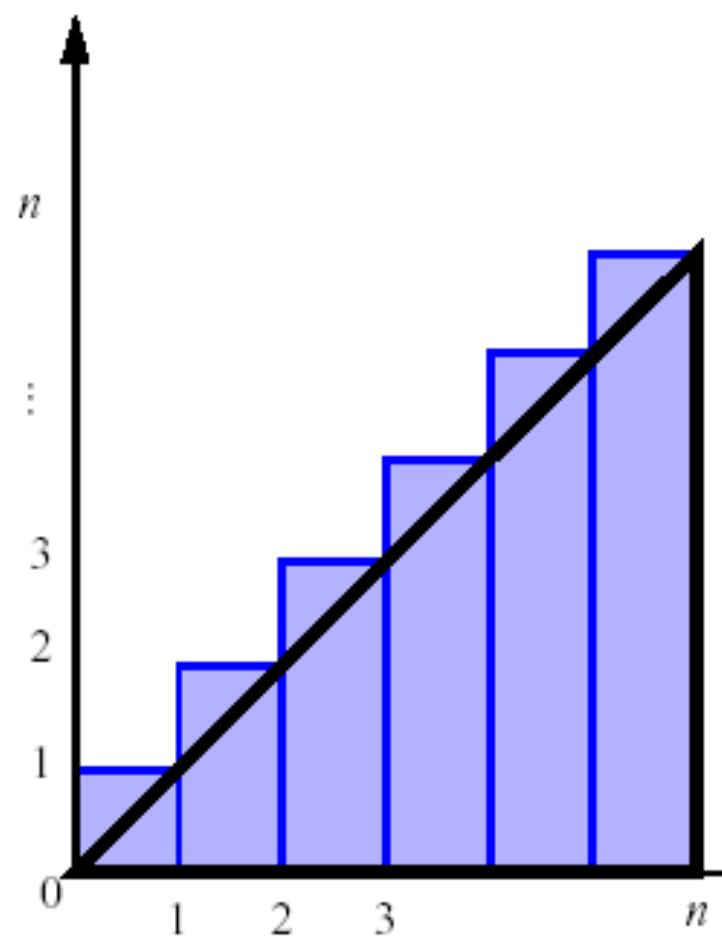
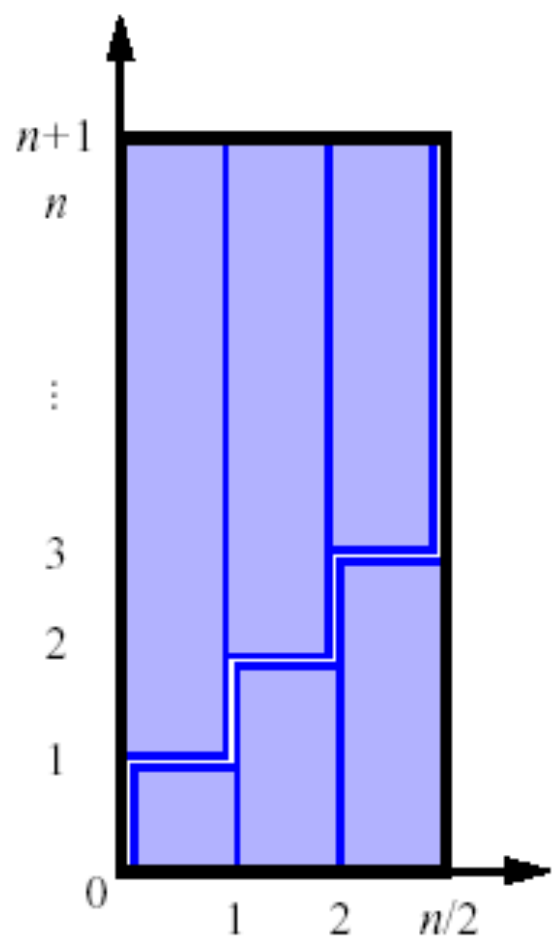
**Exercise:**  $\sum_{i=21}^{40} i$

Also useful for today's  
Growable Arrays exercise!

# Visual proofs of the summation formula

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

- 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”

# Growable Arrays

```
// Read an unlimited number of String; return a String [ ]
public static String [ ] getStrings( ) {
    Scanner in = new Scanner( System.in );
    String [ ] array = new String[ 5 ];
    int itemsRead = 0;
    System.out.println( "Enter any number of strings, one per line; " );
    System.out.println( "Terminate with empty line: " );

    while( in.hasNextLine( ) ) {
        String oneLine = in.nextLine( );
        if( oneLine.equals( "" ) )
            break;
        if( itemsRead == array.length )
            array = resize( array, array.length * 2 );
        array[ itemsRead++ ] = oneLine;
    }

    System.out.println( "Done reading" );
    return resize( array, itemsRead );
}
```

Original array size = 5

We don't know in advance how many strings there will be

Grow when necessary

How does `resize()` work?  
What is the main "overhead cost" of resizing?

# 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.