COMP 110-003
Introduction to Programming
Miscellaneous and More Arrays

April 02, 2013

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TR 11:00 – 12:15, SN 011
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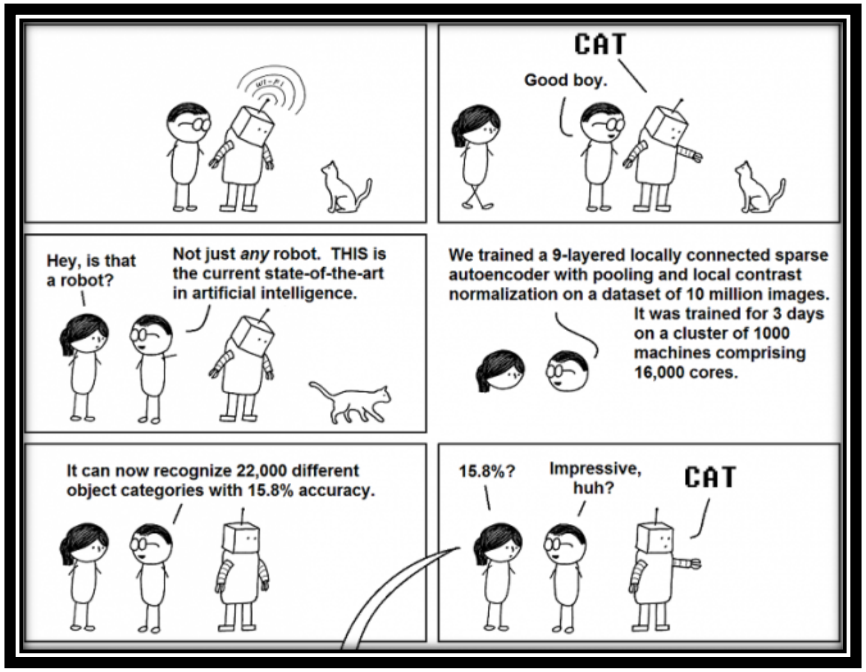
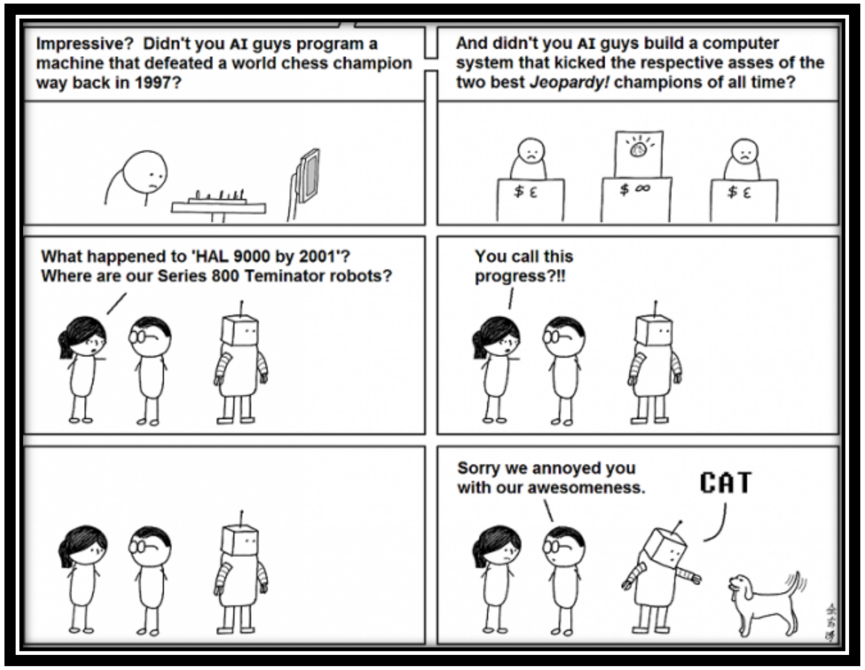
THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Daily Joke


WI-FI
CAT
Good boy.
Hey, is that a robot?
Not just *any* robot. THIS is the current state-of-the-art in artificial intelligence.
We trained a 9-layered locally connected sparse autoencoder with pooling and local contrast normalization on a dataset of 10 million images.
It was trained for 3 days on a cluster of 1000 machines comprising 16,000 cores.
It can now recognize 22,000 different object categories with 15.8% accuracy.
15.8%?
Impressive, huh?
CAT


Impressive? Didn't you AI guys program a machine that defeated a world chess champion way back in 1997?
And didn't you AI guys build a computer system that kicked the respective asses of the two best *Jeopardy!* champions of all time?
$ ε
$ ∞
$ ε
What happened to 'HAL 9000 by 2001'? Where are our Series 800 Teminator robots?
You call this progress?!!
Sorry we annoyed you with our awesomeness.
CAT

Daily Joke – Behind the Scenes

- How powerful is a computer nowadays?
  - A computer can perform billions of arithmetical operations in every second
  - You've written a program computing π. In a millisecond, it computes so many digits on which many mathematicians spent their whole lives in 19th Century
- How smart is a computer nowadays?
  - You know, it's still hard for it to recognize a cat
  - If you know how to do it accurately, you can definitely become a professor in our department

You Wonder Why?

- Computers do things in a deterministic way!
  - The algorithms have to be precise and deterministic
    - Computer scientists don’t have tools significantly better than Java
  - When you see a cat, you know it is a cat, but you don’t know the rule for telling that truth
    - That’s your instinct, which is hard to be logical
  - Computer excels at board games because these games can be deterministic
    - You will write the logic behind it, and make people feel it smart
    - But still, it has only logic

Miscellaneous

- Initialization of instance variables
- Evaluation of boolean expressions
- **break** statement (and **return** statement)
- Random number generator

Initialization of Instance Variables

- In Lab 4, initialization was required
  - Many of you ignored this requirement
  - Those who did it didn't do it right

Initialization of Instance Variables

- You can declare default values for instance variables

```java
public class Rectangle
{
    public int width = 1;
    public int height = 1;
    public int area = 1;
    public void setDimensions(
        int newWidth,
        int newHeight){
        width = newWidth;
        height = newHeight;
        area = width * height;
    }
    public int getArea(){
        return area;
    }
}
```

```java
Rectangle box = new Rectangle();
System.out.println(box.getArea());

// Output: 1
```

Slide from Lecture 11

What’s the Point of Initialization

- When people call your methods, they won’t get an error
  - Because from outside of your class, they can not see implementation details
  - You must guarantee that every object in your class works, starting from it’s created

Common Solution without Initialing

```
public class Statistics {

    private int Goals_Made, Free_Throws, Three_Pointers,
            Goal_Attempts, Free_ThrowAttemp, Three_Attempts;

    public void setFieldGoalsMade(int FG_Made) {
        Goals_Made = FG_Made;
    }

    public double getFieldGoalPercent() {
        return (((double) Goals_Made) /
            ((double) Goal_Attempts)) * 100;
    }

}
```

If UNCStats Call It This Way

```
public static void main(String[] args) {
    Statistics unc = new Statistics();
    DecimalFormat df = new DecimalFormat("0.00");
    unc.setFieldGoalsMade(1);
    unc.setFieldGoalAttempts(2);

    int points = (int) unc.getTotalPoints();
    double field = unc.getFieldGoalPercent();
    double free = unc.getFreeThrowPercent();
    double three = unc.get3PointPercent();
    System.out.print("UNC has scored " + points + " points\n"
        + "UNC has a field-goal percentage of " + df.format(field)
        + "%\n" + "UNC has a free-throw percentage of "
        + df.format(free) + "%\n"
        + "UNC has a 3-point field-goal percentage of "
        + df.format(three) + "%\n");
}
```

If UNCStats Call It This Way

- In a game with only two field attempts, what is the free throw and three pointer percentage?
  - It should be 0.0% (or 100.0% if you want to)
- The uninitialized version outputs:

```
Exception in thread "main" java.lang.ArithmeticException: / by zero
at Statistics.getFreeThrowPercent(Statistics.java:87)
at UNCStats2.main(UNCStats2.java:15)
```

  - Divide-by-zero run-time error

If UNCStats Call It This Way

- Obviously, the problem is you are calculating 0/0
- For both integer and floating-point instance variables, the initial value is always 0
  - For boolean variables, it is always **false**
  - Actually, it makes no difference if you initialize everything as 0
  - You have to initialize variables so that there is no error

Correct Initialization

```
public class Statistics {

    private int Goals_Made = 0, Free_Throws = 0, Three_Pointers = 0,
        Goal_Attempts = 0, Free_ThrowAttemp = 0, Three_Attempts = 0;
    private double Goal_Percent = 0, Free_Percent = 0, Three_Percent = 0;
    // The methods will be in charge of checking values
}
```

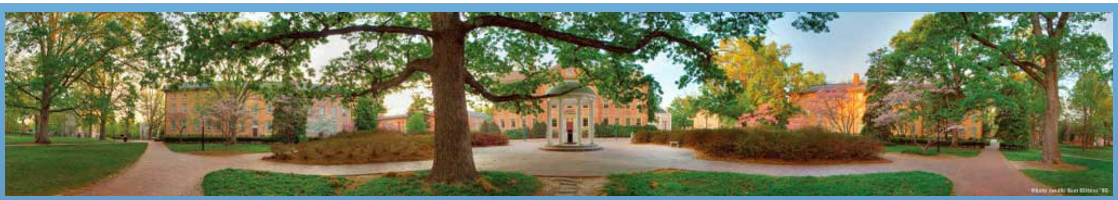
```
public class Statistics {

    private int Goals_Made = 0, Free_Throws = 0, Three_Pointers = 0,
        Goal_Attempts = 1, Free_ThrowAttemp = 1, Three_Attempts = 1;
    // Only works when you don't have
    // methods like makeAShot() and missAShot()

}
```

Key Point of Initialization

- You class should work as long as an object is created
  - You should try your best to cover all cases
  - If it can't be done, we will learn "constructor method" in next week, which pushes the responsibility to the user

Evaluation of Boolean Expressions

- Logical operators
  - &&: be false if **ONE** expression is false
  - ||: be true if **ONE** expression is true
- Java doesn't evaluate all subexpressions if the result is known
  - a && b && c && d
    - The evaluation stops when one subexpression is **false**
  - a || b || c || d
    - The evaluation stops when one subexpression is **true**



Evaluation of Boolean Expressions

- The following code will have a run-time error

```
if (3 == 3 && 3 / 0 == 1) {
    System.out.println("Something");
}
```

- The following code will print "Something"

```
if (3 == 3 || 3 / 0 == 1) {
    System.out.println("Something");
}
```

Why is This Useful?

- In certain circumstances, we can make things short

```
if (i >= 1) {
    if (num[i - 1] > currentValue) {
        num[i - 1] = num[i];
    }
}
```

```
if (i >= 1 && num[i - 1] > currentValue) {
    num[i - 1] = num[i];
}
```

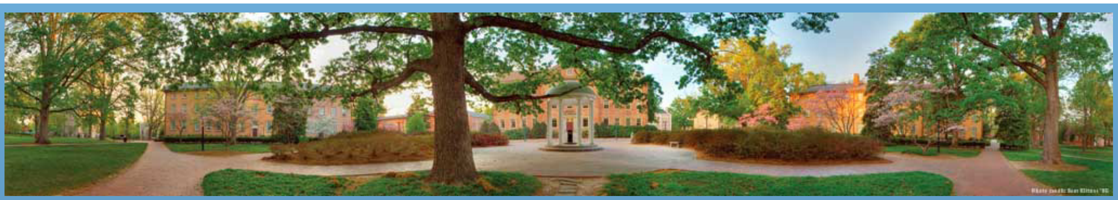
  - The second version won't have an out-of-bound problem

Break Statement

- We saw it in switch statement
- It can also be used in loops
  - The syntax is very simple
    - **break;**
  - It means: to jump out of current loop
- It is used when
  - You don't want to execute the remaining loop
  - **You must stop executing the remaining loop**

Break Statement

```
public boolean equalStrings(String a, String b) {
    boolean result = true;
    if (a.length() != b.length()) {
        result = false;
    } else {
        for (int i = 0; i < a.length(); i++) {
            if (a.charAt(i) != b.charAt(i)) {
                result = false;
                break; // jump out of the loop immediately
            }
        }
    }
    return result;
}
```



Break Statement

- You can only jump out one loop
  - There is no way to jump out a nested loop using break

```
System.out.println("All
    possible dice combinations no greater than 8 are:");
for (int i = 1; i <= 6; i++) {
    for (int j = 1; j <= 6; j++) {
            if (i + j >= 8)
                break;
            System.out.print("(" + i + "," + j + "), ");
        }
    System.out.println();
}
```

Break Statement

- You can run the code by yourself
- The results are:

```
All possible dice combinations no greater than 8 are:
(1,1), (1,2), (1,3), (1,4), (1,5), (1,6),
(2,1), (2,2), (2,3), (2,4), (2,5),
(3,1), (3,2), (3,3), (3,4),
(4,1), (4,2), (4,3),
(5,1), (5,2),
(6,1),
```

Jump Out of All Loops

- The only way is to use **return** statement in a method
- An example question:
  - Given an array, does it include 3 numbers that add up to 0?
  - For example, if the array is
    - int[] nums = { 3, 2, 4, 9, -3, -3, -2, -11 };
    - You should output: 2+9+-11=0
  - If the array is
    - int[] nums = { 3, 2, 4, 9, -3, -3, -2, -10 };
    - You should output: No such three numbers

Solution

```
public static void main(String[] args) {
    int[] nums = { 3, 2, 4, 9, -3, -3, -2, -10 };
    threeSumZero(nums);
}
private static void threeSumZero(int[] num) {
    for (int i = 0; i < num.length; i++)
        for (int j = 0; j < num.length; j++)
            for (int k = 0; k < num.length; k++)
                if (i != j && i != k && j != k
                    && num[i] + num[j] + num[k] == 0) {
                        System.out.println(num[i] + "+"
                            + num[j] + "+" + num[k] + "=0");
                        return; // JUMP OUT OF EVERYTHING
                    }
    System.out.println("No such three numbers");
}
```

Random Number Generator

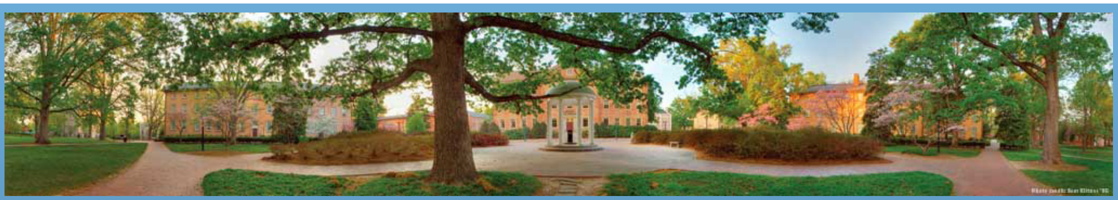
- It is very similar to Scanner

```
int N = 10, print = 5;
Random generator = new Random();
for (int i = 0; i < print; i++) {
    int randomNum = generator.nextInt(N);
    System.out.println(randomNum);
}
```

  - If you run the code many times, the output varies
    - 7,6,6,1,9/5,6,8,8,5/5,6,7,3,9/6,7,4,0,2
  - **nextInt(N)** generates integers in [0,N)
    - Like arrays, 0 is included but N is not
    - You can get 0 but not 10 in this program

Random Number Generator

- Like scanners, using one generator is sufficient
- You can use it in many ways
  - Create a random size array with random increasing elements
    - The size can be from 10 to 19
    - The values starts from 0 to 100
  - Sample outputs:
    - The array has a size 17. The elements are:
      - 3,7,8,11,15,16,21,24,26,30,33,38,41,42,45,46,51.
    - The array has a size 15. The elements are:
      - 2,3,7,8,10,12,18,21,24,30,35,40,46,47,50.



Random Number Generator

```
int lowSize = 10, highSize = 20, valueRange = 100;
Random generator = new Random();
int size = lowSize + generator.nextInt(highSize - lowSize);
System.out.println("The array has a size " + size
        + ". The elements are:");
int[] array = new int[size];
array[0] = generator.nextInt(valueRange / size);
for (int i = 1; i < size; i++) {
    array[i] = array[i - 1]
            + generator.nextInt(valueRange / size) + 1;
    System.out.print(array[i - 1] + ",");
}
System.out.print(array[size - 1] + ".");
```

Avoid "Magic Numbers"

- Magic numbers means
  - It is there. It works. But you don't know what it is.

```
int size = 10 + generator.nextInt(10);
```

- Use variables instead

```
int lowSize = 10, highSize = 20, valueRange = 100;
int size = lowSize + generator.nextInt(highSize - lowSize);
```

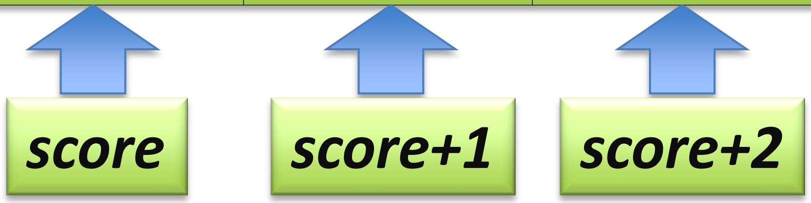
  - If you want to change it, you know what to do

Back to Arrays

- `int[] scores = new int[5];`
- This is like declaring 5 strangely named variables of type int:
  - scores[0]
  - scores[1]
  - scores[2]
  - scores[3]
  - scores[4]
- Especially, you can use **score[i]** to locate a single one

Review: Array and Index

var name	score[0]	score[1]	score[2]	score[3]	score[4]
data	62	51	88	70	74
m address	25131	25132	25133	25134	25135



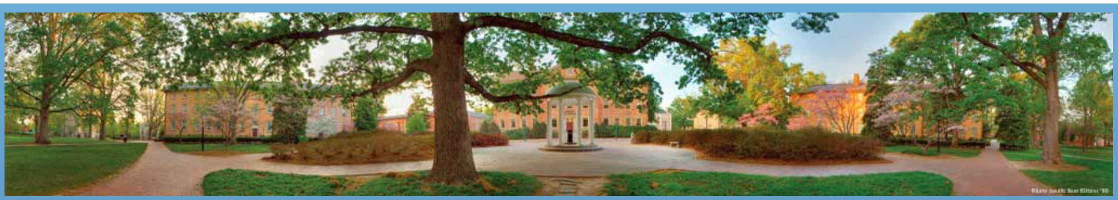
- Index numbers start with **0**. They do NOT start with 1 or any other number.
- he array name represents a memory address, and the ith element can be accessed by the address plus i

Review: Creating an Array

- Create an array with given length saved in constants
  - **public static final int NUMBER_OF_READINGS** = 100;
  - **int**[] pressure = **new int**[**NUMBER_OF_READINGS**];
- Create an array with user input length
  - System.out.println("How many scores?");
  - **int numScores** = keyboard.nextInt();
  - **int**[] scores = **new int**[**numScores**];

Review: Don’t be OUT OF BOUNDS!

- Indices MUST be in bounds
  - double[] entries = new double[**5**]; // from [0] to [4]
  - entries[**5**] = 3.7; // ERROR! Index out of bounds
- Your code will compile if you are using an index that is out of bounds, but it will give you a run-time error!



Arrays as Instance Variables

- Quite straight forward

```
public class Weather {
    private double[] temperature;
    private double[] pressure;

    public void initializeTemperature(int len) {
        temperature = new double[len];
    }
}
```

Arrays of Objects

- When you create an array of objects like this:

```
Student[] students = new Student[35];
```

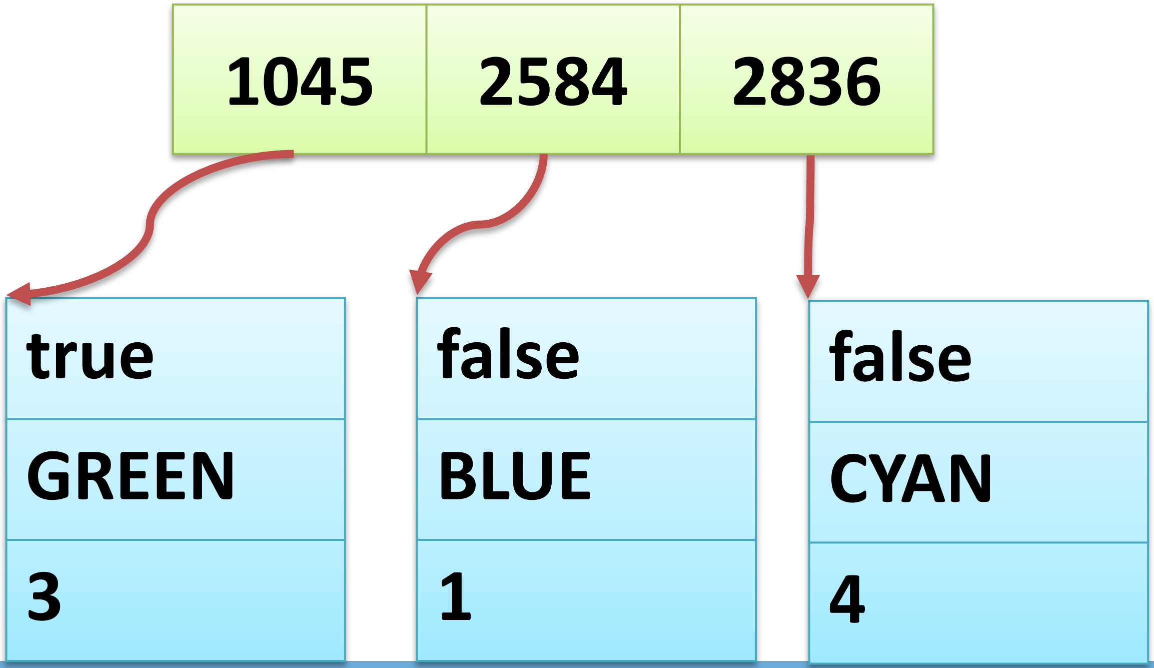
- Each of the elements of *students* is not yet an object
- You have to instantiate each individual one

```
students[0] = new Student();
students[1] = new Student();
```

- …or do this in a loop

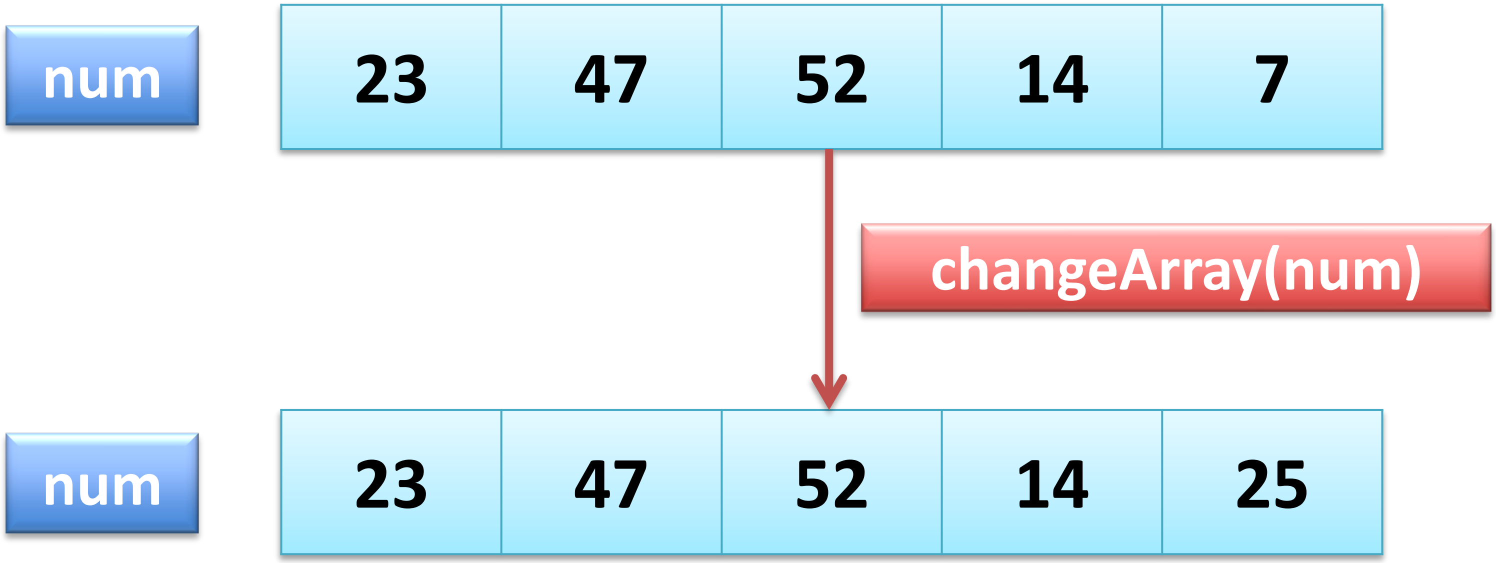
Arrays of Objects

```
Smiley[] smilies = new Smiley[3];
for (int i = 0; i < smilies.length; i++) {
    smilies[i] = new Smiley();
}
```



Arrays as Parameters

```
public void changeArray(int[] arr) {
    int len = arr.length;
    arr[len – 1] = 25;
}
```



Arrays as Return Types

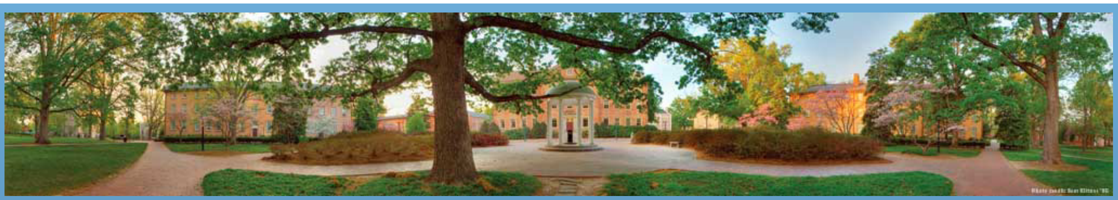
- Create an array and return it

```
public double[] buildArray(int len) {
    double[] retArray = new double[len];
    for (int i = 0; i < retArray.length; i++) {
        retArray[i] = i * 1.5;
    }
    return retArray;
}
```

Indexed Variables as Arguments

- The same as a regular variable

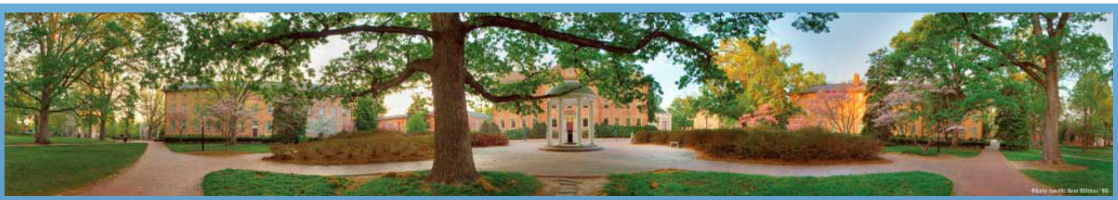
```
public void printNum(int num) {
    System.out.println(num);
}

public void doStuff() {
    int[] scores = { 15, 37, 95 };
    for (int index = 0; index < scores.length; index++) {
        printNum(index);
        printNum(scores[index]);
    }
}
```



2D Arrays

- Arrays having more than one index are often useful
  - Tables
  - Grids
  - Board games

	0: Open	1: High	2: Low	3: Close
0: Apple Inc.	99.24	99.85	95.72	98.24
1: Walt Disney Co.	21.55	24.20	21.41	23.36
2: Google Inc.	333.12	341.15	325.33	331.14
3: Microsoft Corp.	21.32	21.54	21.00	21.50



Declaring and Creating 2D Arrays

- Two pairs of square brackets means 2D
  - **int[][] table = new int[3][4];**
- or
  - **int[][] table;**
  - **table = new int[3][4];**

Declaring and Creating 2D Arrays

- Array (or 1D array) gives you a list of variables
  - int[] score = new int[5] gives you score[0], score[1], … , score[5]
- 2D array gives you a table of variables
  - int[][] table = new int[3][4];

table[0][0]	**table[0][1]**	**table[0][2]**	**table[0][3]**
table[1][0]	**table[1][1]**	**table[1][2]**	**table[1][3]**
table[2][0]	**table[2][1]**	**table[2][2]**	**table[2][3]**

Using a 2D Array

- We use a loop to access 1D arrays

```
for (int i = 0; i < 5; i++) {
   scores[i] = keyboard.nextInt();
   scoreSum += scores[i];
}
```

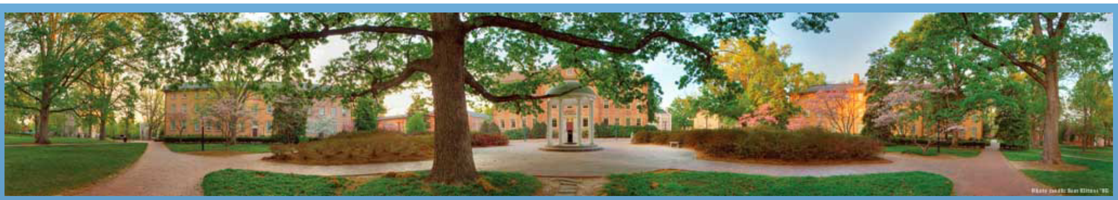
Using a 2D Array

- We use nested loops for 2D arrays

```
int[][] table = new int[4][3];
for (int i = 0; i < 4; i++) {
   for (int j = 0; j < 3; j++) {
      table[i][j] = i * 3 + j;
      System.out.println(table[i][j]);
   }
}
```

Multidimensional Arrays

- You can have more than two dimensions
  - int[][][] cube = new int[4][3][4];
- Use more nested loops to access all elements
  - for (int i…)
    - for (int j…)
      - for (int k…)



Announcement

- Those who haven't done the make-up assignment, today is the deadline
  - InsertionSort.java will be online tomorrow