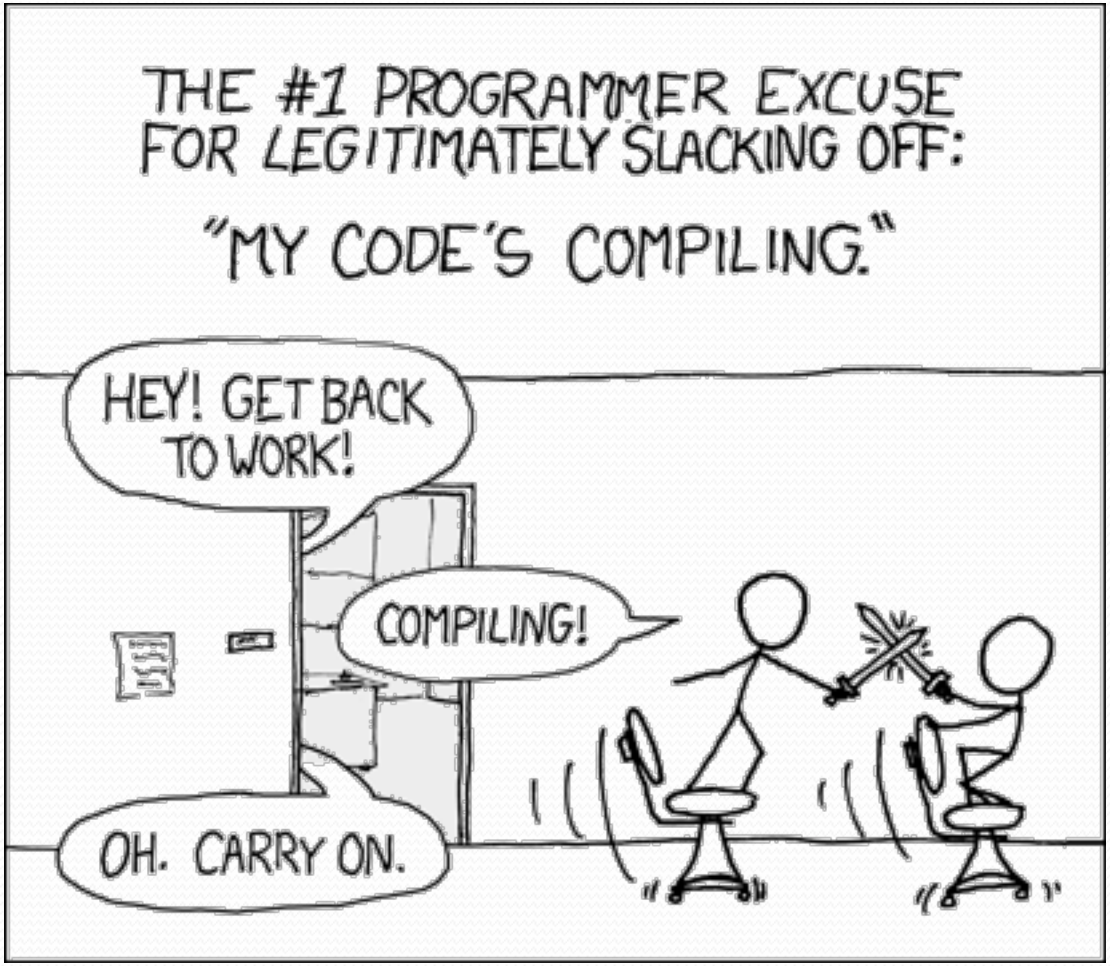


THE #1 PROGRAMMER EXCUSE FOR LEGITIMATELY SLACKING OFF:
"MY CODE'S COMPILING."
HEY! GET BACK TO WORK!
COMPILING!
OH. CARRY ON.

Building Java Programs

Arrays for Tallying; Text Processing; `ArrayList`

reading: 4.3, 7.6, 10.1

A multi-counter problem

- Problem: Write a method `mostFrequentDigit` that returns the digit value that occurs most frequently in a number.

  - Example: The number 669260267 contains:
    one 0, two 2s, four 6es, one 7, and one 9.

    `mostFrequentDigit(669260267)` returns 6.

  - If there is a tie, return the digit with the lower value.

    `mostFrequentDigit(57135203)` returns 3.

A multi-counter problem

- We could declare 10 counter variables ...

```
int counter0, counter1, counter2, counter3, counter4,
    counter5, counter6, counter7, counter8, counter9;
```

- But a better solution is to use an array of size 10.
  - The element at index *i* will store the counter for digit value *i*.
  - Example for 669260267:

index	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
value	1	0	2	0	0	0	4	1	0	1

  - How do we build such an array? And how does it help?

Creating an array of tallies

```
// assume n = 669260267
int[] counts = new int[10];
while (n > 0) {
    // pluck off a digit and add to proper counter
    int digit = n % 10;
    counts[digit]++;
    n = n / 10;
}
```

index	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
value	1	0	2	0	0	0	4	1	0	0

Tally solution

```
// Returns the digit value that occurs most frequently in n.
// Breaks ties by choosing the smaller value.
public static int mostFrequentDigit(int n) {
    int[] counts = new int[10];
    while (n > 0) {
        int digit = n % 10;  // pluck off a digit and tally it
        counts[digit]++;
        n = n / 10;
    }

    // find the most frequently occurring digit
    int bestIndex = 0;
    for (int i = 1; i < counts.length; i++) {
        if (counts[i] > counts[bestIndex]) {
            bestIndex = i;
        }
    }

    return bestIndex;
}
```

Section attendance question

- Read a file of section attendance (*see next slide*):

```
yynyyynayayynyyyayanyyyaynayyayyanayyyanyayna
ayyanyyyyayanaayyanayyyananayayaynyayayynynya
yyayaynyyayyanynnyyyayyanayaynannnyyayyayayny
```

- And produce the following output:

```
Section 1
Student points: [20, 16, 17, 14, 11]
Student grades: [100.0, 80.0, 85.0, 70.0, 55.0]

Section 2
Student points: [16, 19, 14, 14, 8]
Student grades: [80.0, 95.0, 70.0, 70.0, 40.0]

Section 3
Student points: [16, 15, 16, 18, 14]
Student grades: [80.0, 75.0, 80.0, 90.0, 70.0]
```

  - Students earn 3 points for each section attended up to 20.

Section input file

```
student     123451234512345123451234512345123451234512345
week          1    2    3    4    5    6    7    8    9
section 1   yynyyynayayynyyyayanyyyaynayyayyanayyyanyayna
section 2   ayyanyyyyayanaayyanayyyananayayaynyayayynynya
section 3   yyayaynyyayyanynnyyyayyanayaynannnyyayyayayny
```

- Each line represents a section.
- A line consists of 9 weeks' worth of data.
  - Each week has 5 characters because there are 5 students.
- Within each week, each character represents one student.
  - `a` means the student was absent (+0 points)
  - `n` means they attended but didn't do the problems (+1 points)
  - `y` means they attended and did the problems (+3 points)

String traversals

- The `char`s in a `String` can be accessed using the `charAt` method.
  - accepts an `int` index parameter and returns the `char` at that index

```
String food = "cookie";
char firstLetter = food.charAt(0);   // 'c'
System.out.println(firstLetter + " is for " + food);
```

- You can use a `for` loop to print or examine each character.

```
String major = "CSE";
for (int i = 0; i < major.length(); i++) {    // output:
    char c = major.charAt(i);                 // C
    System.out.println(c);                    // S
}                                             // E
```

Section attendance answer

```
import java.io.*;
import java.util.*;

public class Sections {
    public static void main(String[] args) throws FileNotFoundException {
        Scanner input = new Scanner(new File("sections.txt"));
        int section = 1;
        while (input.hasNextLine()) {
            String line = input.nextLine();      // process one section
            int[] points = new int[5];
            for (int i = 0; i < line.length(); i++) {
                int student = i % 5;
                int earned = 0;
                if (line.charAt(i) == 'y') {     // c == 'y' or 'n' or 'a'
                    earned = 3;
                } else if (line.charAt(i) == 'n') {
                    earned = 1;
                }
                points[student] = Math.min(20, points[student] + earned);
            }

            double[] grades = new double[5];
            for (int i = 0; i < points.length; i++) {
                grades[i] = 100.0 * points[i] / 20.0;
            }

            System.out.println("Section " + section);
            System.out.println("Student points: " + Arrays.toString(points));
            System.out.println("Student grades: " + Arrays.toString(grades));
            System.out.println();
            section++;
        }
    }
}
```

Data transformations

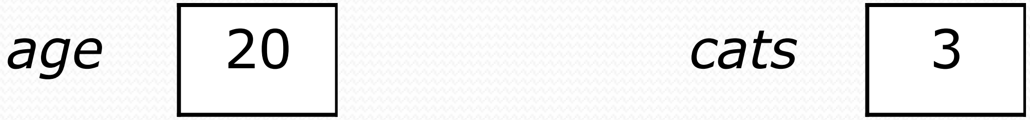
- In many problems we transform data between forms.
  - Example: digits → count of each digit → most frequent digit
  - Often each transformation is computed/stored as an array.
  - For structure, a transformation is often put in its own method.

- Sometimes we map between data and array indexes.
  - by position (store the *i* th value we read at index *i*)
  - tally (if input value is *i*, store it at array index *i*)
  - explicit mapping (count `'J'` at index 0, count `'X'` at index 1)

- *Exercise:* Modify our Sections program to use static methods that use arrays as parameters and returns.

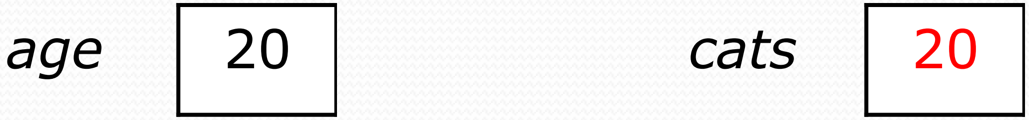
Value/Reference Semantics

- Variables of primitive types store values directly:

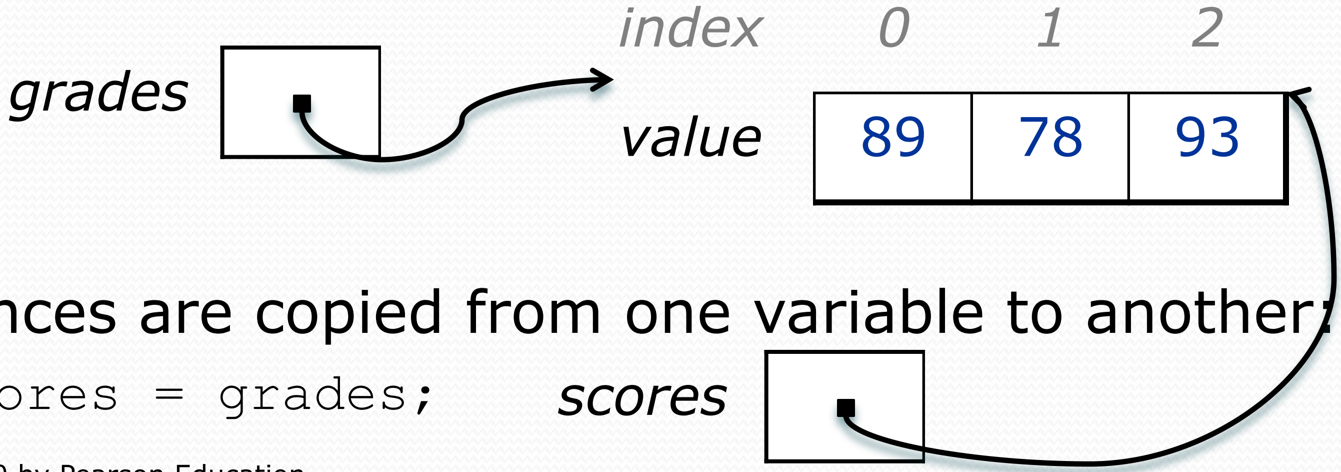


- Values are copied from one variable to another:

```
cats = age;
```



- Variables of object types store references to memory:



- References are copied from one variable to another:

```
scores = grades;
```

Array param/return answer

```java
// This program reads a file representing which students attended
// which discussion sections and produces output of the students'
// section attendance and scores.

import java.io.*;
import java.util.*;

public class Sections2 {
    public static void main(String[] args) throws FileNotFoundException {
        Scanner input = new Scanner(new File("sections.txt"));
        int section = 1;
        while (input.hasNextLine()) {
            // process one section
            String line = input.nextLine();
            int[] points = countPoints(line);
            double[] grades = computeGrades(points);
            results(section, points, grades);
            section++;
        }
    }

    // Produces all output about a particular section.
    public static void results(int section, int[] points, double[] grades) {
        System.out.println("Section " + section);
        System.out.println("Student scores: " + Arrays.toString(points));
        System.out.println("Student grades: " + Arrays.toString(grades));
        System.out.println();
    }

    ...
```

Array param/return answer

```
    ...
    // Computes the points earned for each student for a particular section.
    public static int[] countPoints(String line) {
        int[] points = new int[5];
        for (int i = 0; i < line.length(); i++) {
            int student = i % 5;
            int earned = 0;
            if (line.charAt(i) == 'y') {     // c == 'y'  or  c == 'n'
                earned = 3;
            } else if (line.charAt(i) == 'n') {
                earned = 2;
            }
            points[student] = Math.min(20, points[student] + earned);
        }
        return points;
    }

    // Computes the percentage for each student for a particular section.
    public static double[] computeGrades(int[] points) {
        double[] grades = new double[5];
        for (int i = 0; i < points.length; i++) {
            grades[i] = 100.0 * points[i] / 20.0;
        }
        return grades;
    }
}
```

Problems with arrays

- We need to know the size when we declare an array, and we can’t change it later
  - Can’t add more elements
  - Can’t shrink the array to avoid wasting space
    - Could get around this with Arrays.copyOf
- No method to find the index of a given object in an array
    - Could use Arrays.sort and Arrays.binarySearch, but this could be inefficient
- No method to add/remove from the middle of the list without overwriting a given element
    - We’d have to write our own methods

ArrayLists

- Arrays that dynamically resize themselves to accommodate adding or removing elements

- Works the same as a Python list

`ArrayList` declaration

```
Arrays:    type[]          name = new type[length];
ArrayList: ArrayList<type> name = new ArrayList<type>();
```

- Example:

```
ArrayList<String> words = new ArrayList<String>();
```

- Need to import `java.util.*;`

Primitives and `ArrayList`

```
ArrayList<type> name = new ArrayList<type>();
```

- **type** must be an object type

- Primitive types have wrapper classes that allow them to be put in `ArrayList`s.

Primitive	Wrapper
`boolean`	`Boolean`
`int`	`Integer`
`double`	`Double`
`char`	`Character`

- Autoboxing converts primitives to their wrapper type and back in almost all places.

ArrayList Methods

Method name	Description
add(**obj**)	Adds obj to the end of the list
add(**index**, **obj**)	Adds obj at the specified index, shifting higher-index elements to make room
contains(**obj**)	Whether the list contains obj
get(**i**)	Get the object at index i
indexOf(**obj**)	Find the lowest index of obj in the list, -1 if not found
lastIndexOf(**obj**)	Find the highest index of obj in the list, -1 if not found
remove(**i**)	Remove the element at index i
remove(**obj**)	Remove the lowest index occurrence of obj
set(**i**, **obj**)	Set the element at index i to obj
size()	The number of elements in the list