## Java Review Slides

Test Format:

- One page of coding basics
- Four pages of interpretation
- Two pages of coding segments (Two problems will be pulled off of Hackerrank)
- One math proof and one page on program correctness

## Hello World Program

```
// HelloWorld
// Author: Chris Wilcox
// Date:   1/1/2015
// Class:  CS160
// Email:  wilcox@cs.colostate.edu

import java.lang.*;

public class HelloWorld
{
    public static void main(String[] args)
    {
        System.out.println( "Hello World!" );
    }
}
```



## Literals

- *Literals* are values that are directly recognized by Java:
  - numbers
    `237, 10, 9`
    `1.5, 5.8, 99.999`
    `50000L, 13.4F`
  - characters
    `'a', 'Z', '0', '$'`
  - Strings
    `"hello", "there"`
  - booleans
    true, false



## Java Identifiers

- An *identifier* is a name, such as the name of a variable.
- Identifiers may contain only
  - Letters
  - Digits (0 through 9)
  - The underscore character (_)
  - And the dollar sign symbol ($) which has a special meaning
- The first character cannot be a digit.

# Java Types

- In Java, there are two kinds of data types:
  - Primitive data types
    - Hold a single, indivisible piece of data
    - Pre-defined by the language
    - Examples: int, char, double, boolean
  - Classes (Reference Types)
    - Hold complex combinations of data
    - Programs may define new classes
    - Examples: String, System, Fraction, Pseudo



# Primitive Types

- Integer types: byte, short, int, and long
  - most common: int
- Floating-point types: float and double
  - most common: double
- Character type: char
- Boolean type: boolean



# Primitive Types

| Type Name | Kind of Value | Memory Used | Range of Values |
|---|---|---|---|
| `byte` | Integer | 1 byte | –128 to 127 |
| `short` | Integer | 2 bytes | –32,768 to 32,767 |
| `int` | Integer | 4 bytes | –2,147,483,648 to 2,147,483,647 |
| `long` | Integer | 8 bytes | –9,223,372,036,8547,75,808 to 9,223,372,036,854,775,807 |
| `float` | Floating-point | 4 bytes | $\pm 3.40282347 \times 10^{+38}$ to $\pm 1.40239846 \times 10^{-45}$ |
| `double` | Floating-point | 8 bytes | $\pm 1.79769313486231570 \times 10^{+308}$ to $\pm 4.94065645841246544 \times 10^{-324}$ |
| `char` | Single character (Unicode) | 2 bytes | All Unicode values from 0 to 65,535 |
| `boolean` | | 1 bit | True or false |



# Sample Expressions

| Ordinary Math | Java (Preferred Form) | Java (Parenthesized) |
|---|---|---|
| $rate^2 + delta$ | `rate * rate + delta` | `(rate * rate) + delta` |
| $2(salary + bonus)$ | `2 * (salary + bonus)` | `2 * (salary + bonus)` |
| $\frac{1}{time + 3mass}$ | `1 / (time + 3 * mass)` | `1 / (time + (3 * mass))` |
| $\frac{a-7}{t+9v}$ | `(a – 7) / (t + 9 * v)` | `(a – 7) / (t + (9 * v))` |

## Assignment Compatibilities

- A value of each following type can be assigned to a variable of type to the right:

  byte → short → int → long → float → double

  – This is called a type promotion

  – Have to type cast to assign variables to the left
- You can also assign a value of type char to a variable of type int.
- But you have to type cast to assign from int to char



## `if` Statement with `else`

- An **`if`** statement may have an optional **`else`** clause that will only be executed when the condition is false
- Example:

```
if ( wages <= 57600.0 )
    tax = 0.124 * wages;
else
    tax = 0.124 * 57600.0;
```

Give an example of when BOTH statements will execute?

NONE! One or the other must execute

Give an example of when NEITHER statement will execute?



## `boolean` Data Type

- boolean
- A primitive data type that can be set to:
  - `true`
  - `false`
- Example:

```
boolean correct = true;
```

Notice there are no quotation marks around true and false!



## Numeric Relational Operators

| Math | Java | description |
|---|---|---|
| < | < | Less than |
| > | > | Greater than |
| ≤ | <= | Less than or equal to |
| ≥ | >= | Greater than or equal to |
| = | == | Equal to |
| ≠ | != | Not equal to |

# `boolean` Operators

- Logical "and" (conjunction)
  - Java symbol **&&**
  - Math symbol ∧
  - true only when both expressions are true

```
(MIN_WAGE <= wages) && (wages <= MAX_WAGE)
```

- Logical inclusive "or" (disjunction)
  - Java symbol **||**
  - Math symbol ∨
  - true when either or both expressions are true

```
(wages < MIN_WAGE ) || (wages > MAX_WAGE )
```



# Java Logical and Arithmetic Operator Precedence Rules

1. **!** - (unary)
2. *** / %**
3. **+ -**
4. **< <= > >=**
5. **== !=**
6. **^ & |**
7. **&&**
8. **||**



# Program example: find divisors

```
public class foo {
    public static void main(String[] args) {
        int number = Integer.parseInt(args[0]);
        int divisor = 2;
        while (divisor < number ) {
            if ((number % divisor) == 0) {
                System.out.print(divisor + " ");
            }
            divisor = divisor + 1;
        }
    }
}
```



# Temperature Conversion Program

```
System.out.println("\tDEGREES C\tDEGREES F");


for (int cent = 50; cent <= 100; cent++)
{
  double fahr = (9.0 / 5.0) * cent + 32.0;
  System.out.print("\t" + cent);
  System.out.println("\t" + fahr);
}
```

# Method Examples

- `public double sin(double angle)`
- `public double cos(double angle)`
- `public char charAt(int index)`
- `public int indexOf(char c)`
- `public static int minimum(int i, int j)`
- `public static String toLower(String s)`
- `public int[] getArray()`



# public and private

- **public**
  - Can access the class, method, or data by name outside defining class
- **private**
  - Can access the class, method, or data by name only inside defining class
- Classes generally specified as **public**
- Instance variables usually are **private**
- Methods can be **public** or **private**



# Caution: Pass by value

- What do you expect this to print?

```
public class PassByValue {
  public static void main(String[] args) {
    int number = 100;
    increment(number);
    System.out.println("Number: " + number);
  }
  public static void increment(int n) {
      n++;
  }
}
```

- The value of the argument is copied, so no change to number! This is true of ALL Primitive Types.



# Caution: Pass by "reference"

- What do you expect this to print?

```
public class PassMyArray {
  public static void main(String[] args) {
    int [] number = {10, 20, 30, 40, 50};
    changeArray(number);
    System.out.println(Arrays.toString(number));
  }
  public static void changeArray(int n) {
      n[0] = 15;
        n[3] = 1;
  }
}
```

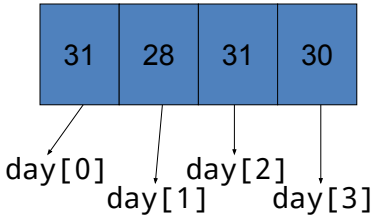
- Reference types like arrays and objects pass in a memory location so

[15, 20, 40, 1, 50] is printed (notice the formatting for Arrays.toString!

# Arrays

- An array is a set of variables *of the same type* accessed by their index

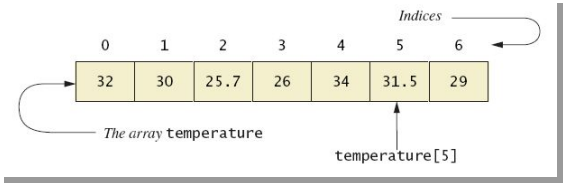
```
int[] day = new int[4];
```






# Creating and Accessing Arrays

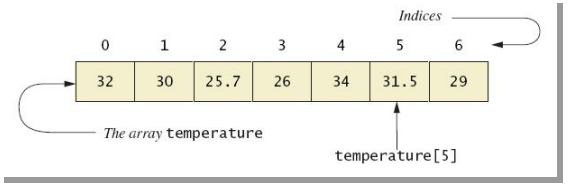
- Figure 7.1 A common way to visualize an array






# Creating and Accessing Arrays

- Figure 7.1 A common way to visualize an array






# Java's Representation of Multidimensional Arrays

- Multidimensional array represented as several one-dimensional arrays
- Given
  `int [][] table = new int [10][6];`
- Array table is actually 1 dimensional of type `int[]`
  - It is an array of arrays
- Important when sequencing through multidimensional array

# File class in Java

- Programmers refer to input/output as "I/O".
- Input is received from the keyboard, mouse, files. output is sent to the console, monitor, files, …
- The **File** class represents files as objects, and is defined in the **java.io** package.
- Creating a **File** object allows you to get information about a file (on the hard disk or optical drive).
- Creating a **File** object does NOT create a new file on your disk.

```
File f = new File("example.txt");
if (f.exists() && f.length() > 1000) {
    f.delete();
}
```



# Handling Exceptions

- When doing file I/O, we use **IOException**.

```
public static void main(String[] args) {
    Scanner scan = null;
  try {
    Scanner scan = new Scanner(new File("input.txt"));
    String firstLine = scan.nextLine();
        ...
    } catch (IOException e) {
        System.out.println("Unable to open input.txt");
        System.exit(-1);
    }
}
```



# Opening a file for writing

- Same story as reading, we must handle exceptions:

```
public static void main(String[] args) {
   PrintWriter output  = null;
    try {
            PrintWriter output = new PrintWriter(new File("output.txt"));
            output.println("Integer number: " + 987654);
...
    } catch (IOException e) {
        System.out.println("Unable to write output.txt");
        System.exit(-1);
    }
```



# Java Bitwise Operators

- Java has six bitwise operators:

| Symbol | Operator |
|---|---|
| & | Bitwise AND |
| \| | Bitwise OR |
| ^ | Bitwise XOR |
| ~ | Bitwise NOT |
| << | LEFT SHIFT |
| >> | RIGHT SHIFT |

## Wrapper Classes

- Character, Integer, Double, Arrays, etc.
  - Character.isUpperCase(char c);
  - Integer.parseInt(String s);
  - Double.parseDouble(String s);
  - Arrays.toString(int array[]);
  - Arrays.sort(int array[]);
  - Date date = **new** Date();



## Date Class

- Methods to manipulate dates and times:
- Example code and output:

```
String myFormat = ”dd/MM/yyyy (HH:mm:ss)”;
SimpleDateFormat dateFormat =
    new SimpleDateFormat(myFormat);
Date date = new Date();
System.out.println(dateFormat.format(date));
```

*19/11/2013 (21:17:27)*



## Enumerated Types

- General Form:

```
public enum DayOfWeek { SUNDAY, MONDAY,
TUESDAY, WEDNESDAY, THURSDAY, FRIDAY,
SATURDAY  }
```

- Example Usage:

```
DayOfWeek day = THURSDAY;
switch (day) {
   case MONDAY:
   case TUESDAY:
   ...
```



## Classes

- Classes are Reference Types
- Classes are the basis of object-oriented (OO) programming.
- What can classes be used for? Classes have many different uses, for example:
  - Data Structures
  - Code Libraries
  - Java Programs
  - Complex Objects

## Static (versus non-Static): Data

- Local data resides in a method, class and instance data resides in the class.
- Data defined in the class can be of two types:
  - Data may belong to the class (only one copy that has the same value for all objects of that class)
  - Data may belong to the object (separate storage and different values for each instance)
- Class data is identified by `static`
- Instance data is not `static`



## Static (versus non-Static): Methods

- All methods can access `static` (class) data, no instantiation is required, e.g. Math.PI.
- Should call `static` methods with class name, e.g. Math.sqrt(), not required within class.
- Must call `non-static` methods with an instance, e.g. string.length().
- Only non-static (instance) methods can access `non-static` data, hidden `this` parameter.
- Using an instance to access `static` (class) data or methods produces a warning.



## Constructors

- Q: How to initialize instance data when creating an object? A: Use a constructor.
- Constructors are used to create objects and send them data.
- Always named after the class, arbitrary parameters, but no return value!
- Example:

```
Scanner s = new Scanner(System.in);
```



## Pre and Post Conditions (20)

```
public static int foo(int x) {
    // Precondition: -4 <= x <= 2
    return (x * x + 2 * x - 5);
    // Postcondition -6 <= return <= 3
}
```

f(-5) = 10, f(-4) = 3, f(-3) = -2, f(-2) = -5,
f(-1) = -6, f(0) = -5, f(1) = -2, f(2) = 3, f(3) = 10

# Loop Invariants (21)

```
int x = 1, y = 2, z = -5;
while (x <= 5) {
    z += y;
    x++;
}
// Loop invariants
y = 2, 1 <= x <= 6, -5 <= z <= 5
y = 2, 1 <= x <= 6, z = -5 + 5y     (stronger alternative)
```



# Contrapositive Proof (22)

**Contrapositive proof**: Use a contrapositive proof to show that if a and b are integers, and 5ab is even, then a is even or b is even. **Note:** Use as many steps as necessary.

| | **Step** | **Reason** |
|---|---|---|
| 1. | Even(5ab) → Even(a) V Even(b) | **Hypothesis** |
| 2. | ¬(Even(a) V Even(b)) → ¬Even(5ab) | **Contrapositive** |
| 3. | ¬Even(a) ^ ¬Even(b)) → ¬Even(5ab) | **De Morgan's Law** |
| 4. | Odd(a) ^ Odd(b) → Odd(5ab) | **¬even == odd** |
| 5. | a = 2j + 1, b = 2k +1 | Odd definition |
| 6. | 5ab = 5(2j + 1) (2k + 1) | Substitution |
| 7. | = (20 jk + 10 j + 10 k + 5) | Algebra |
| 8. | = 2(10jk + 5j + 5k + 2) + 1 | Algebra |
| 9. | Odd(2(10jk + 5j + 5k + 3 + 1)) = true | Odd definition |
| 10. | (5ab) is odd | Proves contrapositive |