Lecture Set 2: Starting Java

1. Java Concepts
2. Java Programming Basics
3. User output
4. Variables and types
5. Expressions
6. User input

This Course: Intro to Procedural Programming using Java

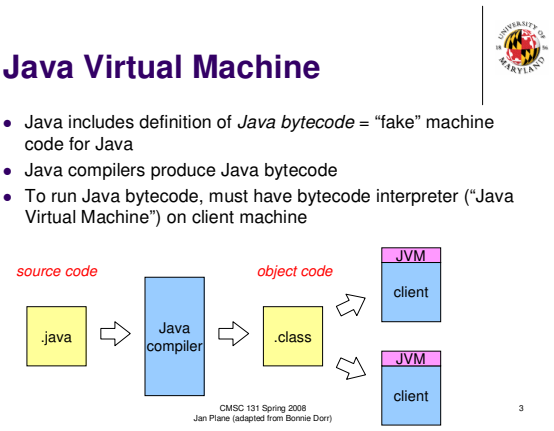
Why Java?

- Popular modern language
- Used in web, business, telecom applications
- Developed in 1990s, incorporates many features from earlier languages
  - *Object-orientation*
  - *Garbage collection*
  - *Portability of object code*

Portability of Object Code?

- Object code is 2GL (assembly) / 1GL (machine code)
- Last time we said that 2GL / 1GL is architecture-specific
- How can Java have portable object code?
  Answer: *Java Virtual Machine* (JVM)

Java Virtual Machine



- Java includes definition of *Java bytecode* = "fake" machine code for Java
- Java compilers produce Java bytecode
- To run Java bytecode, must have bytecode interpreter ("Java Virtual Machine") on client machine

Facts about JVMs

- For efficiency, JVMs often compile bytecode into native machine code
- There are also "native" Java compilers (these compile Java directly to machine code)

Method Headers

- main is a method = "operation"
  - Operations require operands = data to work on
  - Operations return new data (result)
  - Header gives information on form of operands, result for methods

    For main:
    - Operand is collection of Strings
    - Result is "void" (= unimportant)
  - More later on "public", "static"
- Every program must have exactly one "main" method (where execution begins)

Output and Comments

- Output to console
  - System.out.println
  - System.out.print
  - String Literals always use “quotation marks”
- Comments: explanations added by programmer
  - ignored by the compiler
  - read by other people looking at the code
  - Two styles
    - /* … */
    - // to end of line…
  - Comments are essential for good programming!

Objects

- Bundles of data (“instance variables”) and methods (“functions”)
- Created using classes as “templates”
- We’ll learn more later this semester

Java Program Organization

- Class
  - Structure around which all Java programs are based
  - A typical Java program consists of many classes
  - Each class resides in its own file, whose name is based on the class’s name
  - The class is delimited by curly braces { … }.

File name: **Example1.java**:

```
public class Example1a {
        … (contents of the class go here) …
}
```

A class consist of data (**variables**) and operations (**methods**)

example1b

- variables
  - declaration
  - initialization
  - assignment
  - value use
- mathematical expressions
  - calculated to take on a value
  - based on values of literals and variables

Java Program Organization

- Methods
  - Where most computation takes place
  - Each method has a name, a list of arguments enclosed in (…), and body (collection of *statements*) in {…}

```
public static void main( String[ ] args ) {
        … (contents of the main method go here) …
  }
```

- Variables
  - Storage locations that program can operate on
  - Variables can store data of different forms (integers, for example)

```
int secondsPerMinute = 60;
int minutesPerLecture = 50;
```


Java Program Organization

- Statements: Many different types
  - Declarations – specify variable types (and optionally initialize)

```
int x, y, z;           // three integer variables
String s = "Howdy";    // a character string variable
boolean isValid = true; // a boolean (true/false) variable
```

  - Assignments – assign variables new values

```
x = 13;
```

  - Method invocation – call other methods

```
System.out.println( "Print this message" );
```

  - Control flow – determine the order of statement execution. (These include **if-then-else**, **while**, **do-while**, **for**. More later.)
- Built-in Operators: For manipulating values (+, -, *, /, etc.)
  - **i.e. String Concatenation for output**

Built-in (Primitive) Types

	Type name	Size (bytes)
Integers	`byte`	1
	`short`	2
	`int`	4
	`long`	8
Reals	`float`	4
	`double`	8
Other	`char`	2
	`boolean`	1

String Type

- Elements of String type are sequences of characters
  "abc" "Call me Ishmael" etc.
- String type is *not* built-in
- We will use it a lot
- Useful operation: *concatenation* (+)
  "abc" + "def" = "abcdef"

Writing Programs in Java

1. EXPRESSIONS: computations that carry a value
2. OPERATORS: symbols like +, *, -, etc.
3. Statements end with a semicolon
4. Types of statements:
   a) DECLARATION (where a variable is created)
   b) ASSIGNMENT (where a variable is given a value)
   c) METHOD INVOCATIONS (where another method is called)
   d) others - later
5. You can put blank lines in anytime you want
6. Proper indenting helps readability

Variables …

- … are named storage locations

Variable	Value
x	5

- Recall that memory is a sequence of bits
- Question: How much memory to allocate for a variable's value?
- Answer: A variable must have a *type* specifying how much storage to allocate.

Recall Java Built-in Types

	Type name	Size (bytes)
Integers	`byte`	1
	`short`	2
	`int`	4
	`long`	8
Reals	`float`	4
	`double`	8
Other	`char`	2
	`boolean`	1

Primitive Data Types In Detail

Integer Types:

byte	1 byte	Range: -128 to +127
short	2 bytes	Range: -32,000 to +32,000
int	4 bytes	Range: -2 billion to +2 billion
long	8 bytes	Range: -9 quintillion to +9 quintillion

Floating-Point Types:

float	4 bytes	-3.4×10^{38} to 3.4×10^{38}, 7 digits of precision
double	8 bytes	-1.7×10^{308} to 1.7×10^{308}, 15 digits of prec.

Other types:

boolean	1 byte	true, false
char	2 bytes	A single (Unicode) character

Primitive-Type Constants

- Constants are also called literals
- **Integer types:**
  - **byte**, **short**, **int**: optional sign and digits (0-9): 12 -1 +234 0 1234567
  - **long**: Same as above, but followed by 'L' or 'l': -1394382953L

Avoid this lowercase L. It looks too much like the digit '1'

- **Floating-point types**:
  - **double**: Two allowable forms:
    - **Decimal notation**: 3.14159 -234.421 0.0042 -43.0
    - **Scientific notation**: (use E or e for base 10 exponent)
      - **3.145E5** = 3.145 x 10^5 = 314500.0
      - **1834.23e-6** = 1834.23 x 10^{-6} = 0.00183423
  - **float**: Same as double, but followed by 'f' or 'F': 3.14159F -43.2f

Note: By default, integer constants are **int**, unless 'L'/'l' is used to indicate they are **long**. Floating constants are **double**, unless 'F'/'f' is used to indicate they are **float**.

Character and String Constants

- **Char constants**: Single character in single quotes ('…') including:
  - **Letters and digits**: 'A', 'B', 'C', …, 'a', 'b', 'c', …, '0', '1', …, '9'
  - **Punctuation symbols**: '*', '#', '@', '$' (except ' and backslash '\')
  - **Escape sequences**: (see below)
- **String constants**: 0 or more characters in double quotes ("…")
- **Escape sequences**: Allows inclusion of special characters:
  - `\"` double quote
  - `\'` single quote
  - `\\` backslash
  - `\n` new-line character (start a new line)
  - `\t` tab character
- **Examples**: `char x = '\'';` → (x contains a single quote)
  String s1=`"\"Hi there!\"";` → s1 contains `"Hi there!"`
  String s2= `"C:\\WINDOWS";` → s2 contains `C:\WINDOWS`

Common Numeric Operators

- **Arithmetic operators**:
  - Unary negation: `-x`
  - Addition/subtraction: `x+y` `x-y`
  - Multiplication/division: `x*y` `x/y`
    - Division between integer types **truncates** to integer: `23/4` → `5`
    - `x%y` returns the **remainder** of `x` divided by `y`: `23%4` → `3`
    - Division with real types yields a real result: `23.0/4.0` → `5.75`
- **Comparison operators**:
  - Equality/inequality: `x == y` `x != y`
  - Less than/greater than: `x < y` `x > y`
  - Less than or equal/greater than or equal: `x <= y` `x >= y`

These comparison operators return a **boolean** value: **true** or **false**.

Common String Operators

- **String Concatenation**: The '+' operator **concatenates** (joins) two strings.
  - `"Go" + "Terps"` → `"GoTerps"`

    Note: Concatenation does not add any space
  - When a string is concatenated with another type, the other type is first evaluated and **converted** into its string representation.

    `(8*4) + "degrees"` → `"32degrees"` `(1 + 2) + "5"` → `"35"`
- **String Comparison**: Strings have special comparison functions.
  - `s.equals(t)` : returns true if `s` and `t` have the same characters.
  - `s.compareTo(t)` : compares strings **lexicographically** (dictionary order)

    result < 0 if `s` precedes `t`
    result == 0 if `s` is equal to `t`
    result > 0 if `s` follows `t`

    `"dilbert".compareTo( "dogbert" )` → `-1` **(which is < 0)**

Both functions are case-sensitive.

User Input in Java

- We've done output (System.out); what about input?
- Java 5.0 includes the Scanner class feature
  - Can use Scanner to create "scanner objects"
  - Scanner objects convert user input into data
- To use Scannner need to *import* a library:

```
import java.util.Scanner;
```


Example5.java

```
import java.util.Scanner;

public class Example5 {

    public static void main(String[] args) {
        int i;
        double d;
        String s;

        Scanner sc = new Scanner(System.in);

        System.out.print("Enter an integer: ");
        i = sc.nextInt();
        System.out.print("Enter a floating point value: ");
        d = sc.nextDouble();
        System.out.print("Enter a string: ");
        s = sc.next();

        System.out.println("Here is what you entered: ");
        System.out.println(i);
        System.out.println(d);
        System.out.println(s);
    }
}
```

Include the definition of the Scanner utility

Create new scanner object to read from keyboard

Input an integer

Input a double

Input a string (up to white space)

Scanner Class Details

- To create a scanner object:
  `new Scanner(input_source);`
  - Input source can be keyboard (`System.in`), files, etc.
  - Object must be assigned to a variable (e.g. `sc`)
- Operations
  - `nextBoolean()`
  - `nextByte()`
  - `nextDouble()`
  - `nextFloat()`
  - `nextInt()`
  - `nextLong()`
  - `nextShort()`

  Returns value of indicated type (reports error if type mismatch

  - `next()` Returns sequence of characters up to next whitespace (space, carriage return, tab, etc.)
  - `nextLine()` Returns sequence of characters up to next carriage return

Objects

- From Example 5:
  `Scanner sc = new Scanner(System.in);`
  - `sc` is a variable
  - Its type is …`Scanner`?
- What's going on?
  - `Scanner` is a class defined in `java.util.Scanner`
  - `System.in` is a predefined *object* for keyboard input
  - `new Scanner(System.in)` creates a new *object* in the `Scanner` class and assigns it to `sc`
- Object?
  - A bundle of data (*instance variables*) and operations (*methods*)
  - A class defines both instance variables and methods for objects
  - A class is also a type for objects
  - `new` creates new objects in the given class
- We will learn (much) more about objects later

Debugging Java Programs

- Types of errors
  - "Compile time": caught by Eclipse / Java compiler
    - *Syntax* errors
    - disobeys the rules of the language; violates language's grammar
    - *Type* errors: misuse of variables
  - "Run time": appear during program execution
    - Semantic errors
    - obeys the rules of the language but does not express them meaning you intended;
    - division by 0
    - crash or hang or wrong outputs (because of mistakes in programming)
- Eclipse helps catch compile time errors
  - Red: error
  - Yellow: warning
- Debugging
  - process of finding and fixing problems
  - to minimize debugging frustration – use "unit" testing
    - write a small part, thoroughly test it, cycle back

Example3.java – find the errors

```
public class Example3 {

    public static void main(String[] args) {
        int x = 7;
        int y = 12;
        double d = 72.33;
        boolean b = true;
        char c;
        String s;

        x = y + 24;
        y = 17.3;
        d = x;
        b = 17;
        c = "cow";
        s = "Here is something weird " + x + y;
    }
}
```