Program Fundamentals

/* HelloWorld.java
 * The classic "Hello, world!" program
 * orig. Author: Kernighan and Ritchie?, 1978
 */

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

In C:

/* HelloWorld.java ...
 * The classic "Hello, world!" program
 * orig. Author: Kernighan and Ritchie?, 1978
 */

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

• /* and */ are comments
• Everything between /* and */ or after // is ignored by the compiler
• They explain the program and its parts to humans
  – You, me, the TA, your teammate, your colleagues, and
  anyone else that might want to understand your
  program

• “class” is a java keyword
  – keywords are words with special meaning in a
    programming language
• A class is a named collection of
  – data objects, and
  – operations on those data objects
• Note how this matches our design!
  – This is object oriented programming!
• The braces { } surround the things in the class

• main() is a java method
  – A named set of operations within a class
  – "Procedure" or "function" in other languages
  – parentheses ( ) follow the name of the method
  – The braces surround the body of the function
  – Every program has a main( ) function
    • That’s where the program starts executing

• The very simple body of the main( ) method
• The instructions executed when main( ) is run
• This code prints something on the screen
  – Whatever is between the quotes " "

System.out.println("Hello, world!");
Compiling and Running

- Compiler translates human-written source code into more machine-friendly code
- The name of the .java file usually matches the name of the class it contains
- Java bytecode is machine independent (interpreted)
  - machine code, binaries, and executables are not

Lexical Elements

- Composed of characters
- The lowest-level components of a program
  - White space
  - Comments
  - Keywords
  - Identifiers
  - Literals
  - Operators
  - Punctuation
  - For Humans, not compiler
  - Converted into tokens by the compiler

White space

- Space, tab, and newline
- Needed to separate tokens not separated by punctuation
- Make the code (human) readable
- Can’t appear in the middle of a keyword, identifier, or literal
- Otherwise ignored by the compiler

Comments

- Provide additional information to a person reading the code
- Separates tokens like white space
- Single-line comment: // …
- Multi-line comment: /* … */
- Ignored by the compiler
- Important part of any good program!

Keywords (aka Reserved words)

- Special words that can’t be used for anything else
- abstract, boolean, byte, case, catch, char, class, const, continue, default, do, double, else, extends, final, finally, float, for, goto, if, implements, import, instanceof, int, interface, long, native, new, package, private, protected, public, return, short, static, super, switch, synchronized, this, throw, throws, transient, try, void, volatile, while
- null, true, false – predefined like literals

Identifiers

- Names for different elements of a java program: classes, methods, and variables
- Defined by the programmer
- Any sequence of letters and digits starting with a letter (including $ and _)
  - Except Java keywords and null, true, and false
- Examples
  - Good: HelloWorld, println, data, first_name, a7, java
  - Bad: 345, x+y, int, data?, first name
Literals

- **Constants** – primitive program elements with a fixed value
- Five types of constants in java
  - int – 1, 79, -23, 0
  - double – 1.5, 2.7, 3.14159, -0.3
  - boolean – true, false
  - String – “Hello”, “foo”, “123”, “123(*&T^%”

Operators and Punctuation

- **Operators** specify an action to take on data
  - +, -, *, /, %, ++, --, etc.
  - Really just shorthand for specific methods on that data
- **Punctuation** separates or encloses program elements or parts
  - ; , ( ) { } .
- For later: ., !, *, #, $, &, ^, @, ~, |, /, ->

Data Types and Variable Declarations

- Every data object has an associated **type** that specifies
  - What it is
  - What operations it supports
- **Primitive types**
  - Numeric: byte, short, int, long, float, double – numbers in different sizes and formats
  - Character: char - characters
  - Logical: boolean – true, or false
  - Can be created using literals or as the result of operations (17, 2+3, etc.)

Data Types and Variable Declarations (cont.)

- **Class types**
  - String, Button, Point, etc.
  - Composed of other class types and primitive types
  - Created with the class keyword
  - Over 1500 classes in standard Java

Variables

- Data objects
  - Have a specified type
  - Have a value of that type
- Variable declaration
  `<type> <identifier>;`
  `<type> <identifier1>, <identifier2>, <identifieri>;`

Example Declarations

- Examples
  int age;
  boolean flag1;
  double hang_time; // C style identifier
  String firstname;
  Button clickToExit; // Java style identifier
  int first, second, third;
Strings vs. Strings vs. Identifiers vs. Variables

• *string* – a particular data value that a program can manipulate
• *String* – a Java type - data objects of this type can contain strings
• *Variable* – a data object, has an identifier, a type, and a value
• *Identifier* – the name of a particular class, variable, or method
• Example: *String animal = “elephant”*;

User Input

• Most interesting programs get input from the user
• Lots of ways to do this
• For now we will use tio (terminal I/O)
  – If this doesn’t work, see http://www.cse.ucsc.edu/~charlie/java/tio/doc/install.html

Calling Predefined Methods

• A *method* is a named group of instructions
• We’ve seen *main( )* , *System.out.println( )* , …
• We execute a method by *calling* it
• We call a method by putting its name in the program where we want it to be executed
• Method names don’t have to be unique
  – Identified by the object name - *System.out.println( )*  
• *function* is another name for method
Passing Parameters to Methods

• Many methods take inputs: parameters
• Parameters are passed to the method by placing them between the parentheses
• Example: System.out.println(“Hello”);
  – “Hello” is the parameter passed to System.out.println( )
• Multiple parameters are separated by commas

print( ) and println( )

• System.out.print( ) and System.out.println( ) print out strings and the primitive types
• Difference: println( ) puts a newline at the end
• Explicit newline is represented by ‘\n’, as in System.out.print(“Hi\n”);
  – Same as System.out.println(“Hi”);

More on print( ) and println( )

• Concatenation with ‘+’
  – ‘+’ allows multiple things in a print( ) statement
  – System.out.print(“The value is: ” + value);
• Be careful with numeric types
  – Given int a = 5, b = 7;
  – System.out.print(“The value is: ” + a + b); prints out “The value is: 57”
  – System.out.print(“The value is: ” + (a+b)); prints out “The value is 12”
  – System.out.print(a + b); prints out “12”

Number Types

• Two basic representations for numbers
  – Integer: whole numbers
  – Floating point: fractional numbers and very big numbers
• Bit
  – The smallest element of storage in a computer
  – Can be either 0 or 1
  – Bigger numbers are stored as a sequence of bits

Representing Numbers with Bits

• A sequence of bits is interpreted as a binary number
  – 00, 01, 10, 11 binary = 1, 2, 3, 4 in decimal
  – Read Appendix A
• A byte is 8 bits
  – Smallest addressable unit in a computer
  – Can contain any number between –128 and 127

Integer Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Bits</th>
<th>Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>8</td>
<td>-128 to 127</td>
</tr>
<tr>
<td>short</td>
<td>16</td>
<td>-32768 to 32767</td>
</tr>
<tr>
<td>char</td>
<td>16</td>
<td>0 to 65536</td>
</tr>
<tr>
<td>int</td>
<td>32</td>
<td>-2147483648 to 2147483647</td>
</tr>
<tr>
<td>long</td>
<td>64</td>
<td>-9223372036854775808 to 9223372036854775807</td>
</tr>
</tbody>
</table>
Floating point types

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of bits</th>
<th>Approximate Range of Values</th>
<th>Approximate Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Float</td>
<td>32</td>
<td>+/-10^{-45} to +/-10^{38}</td>
<td>7 decimal digits</td>
</tr>
<tr>
<td>Double</td>
<td>64</td>
<td>+/-10^{-324} to +/-10^{308}</td>
<td>15 decimal digits</td>
</tr>
</tbody>
</table>

Char

- char is a special integer type
  - Holds numeric values that represent Unicode characters
  - Examples:
    - 97, 98, 99, 65, 66, 67, 48, 49, 57, 38, 42, 43

- Special characters
  - ‘
    ’, ’\r’, ’\t’, ’\n’, ’\b’

Numeric Literals

- Integer literals
  - Default to type int
  - Can be specified as long by ending with ‘L’
  - 24, 1003, 123887699888L
  - Octal: begin with ‘0’, as in 0217
  - Hex: begin with “0x” as in 0xB3D
- Floating point literals
  - Default to type double
  - Can be specified as float with ‘F’
  - 3.7, 2.9, 3.1416F, 1358494.34792098

Numbers vs. Chars vs. Strings

- The number 49 is different from the char 49 is different from the string “49”
- int or literal 49 = 32 bit binary number
  - 00000000000000000000000000110001 binary
- char 49 = 16 bit binary number and represents the Unicode character ‘1’
  - 0000000000000000110001 binary
- String “49” = ‘4’ + ‘9’ + 0 =
  - 00000000010100100000000000101111
  - 0000000000000000 binary

Arithmetic Expressions

- Operators:
  - Addition: +
  - Subtraction: -
  - Multiplication: *
  - Division: /
  - Modulus (remainder): %
- Types: char, byte, short, int, long, float, double

Rules of Mixed-Mode Arithmetic

1. An arithmetic operation on objects of the same type yields a result of that type
2. An arithmetic operation on objects of different types first promotes smaller types to larger type
   - Any operand is a double ⇒ promoted to double
   - Otherwise, any float ⇒ promoted to float
   - Otherwise, any long ⇒ promoted to long
   - Otherwise, any int ⇒ promoted to int
   - And then rule 1 applies
Details

- Any result value that is too big for the result type will be undefined
  - Solution: force promotion when necessary by using a variable or literal of the larger type or by casting one operand to a suitably larger type
  - Example: \((\text{float})5, \ (\text{long})a, 5.0, 4f\)
- Integer types storing floating point values will have the fractional part truncated
  - towards 0

Type Conversion

- Implicit (in mixed-mode arithmetic)
- Explicit (casting)
- Widening
  - From “smaller” to “larger type”
  - All information is retained
- Narrowing
  - From “larger” to “smaller” type
  - Information may be lost
  - Result may be meaningless
- Common mistake: \(\text{int z} = 3.0/4.0;\)

Assignment Operators

- \(<\text{variable}> = <\text{rightHandSide}>;\)
- What happens?
  - Right hand side is evaluated
  - The result is placed in the variable \(<\text{variable}>\)
- Examples:
  - \(a = 0;\)
  - \(a = b + c;\)
  - \(a = \text{Console.in.readInt();}\)
  - \(a = b = c;\)

More Assignment Operators

- \(= , \+= , -= , *= , /= , \%= , >>= , <<= , &= , ^= , |=\)
- \(+= \) is pronounced “plus equals”, etc.
- All but ‘=‘ are shorthand
- Example:
  - \(a += b;\) is shorthand for \(a = a + b;\)
- The others work the same way

Increment and Decrement Operators

- \(++ \) is shorthand for “add one to the variable”
  - ++i; and ++i; are shorthand for \(i = i + 1;\)
- -- is shorthand for “subtract one from the variable”
  - --i; and --i; are shorthand for \(i = i - 1;\)
- Location determines order of evaluation
  - int a, b=0;
  - \(a = ++b; \) // result: \(a = 1\) and \(b = 1;\)
  - \(a = b++; \) // result: \(a = 0\) and \(b = 1;\)
Order of Evaluation

- In expressions with multiple operators, order matters!
- Example:
  
  \[ j = (3 \times 4) + 5; \quad // result: j = 17 \]
  
  \[ j = 3 \times (4 + 5); \quad // result: j = 27 \]

  What is \(3 + 2 \times 3\) ? \(2 - 2 - 1\) ?

Precedence and Associativity

- **Precedence** specifies which operators are evaluated first
- **Associativity** specifies order when operators have equal precedence
- Parentheses ( ) override these
  - They force whatever is inside to be evaluated as a unit
- Example:
  
  \[ x = 3 + 4 \times 5; \quad // result: x = 23 \]
  
  \[ x = (3 + 4) \times 5; \quad // result: x = 35 \]

  *Look at Appendix B for details*

Programming Style

- Comments
  - At the top of every file
  - At the top of every class definition
  - At the top of every method definition
  - At the top of every non-trivial block of instructions
- Identifiers should be short and meaningful
- Readability, understandability, clarity, elegance

Java Naming Conventions

1. Class names start with uppercase and embedded words are capitalized, e.g. HelloWorld
2. Methods and variables start with lowercase and embedded words are capitalized, e.g. readInt, data, toString, loopIndex
3. $ should not be used and _ marks you as an old C programmer