Program Fundamentals

```
/* HelloWorld.java
 * The classic “Hello, world!” program
 */

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

/* HelloWorld.java … <etc.> */

- /* … */ and // …
- These 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 colleagues, and anyone else that might want to understand your program

class HelloWorld {

- “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

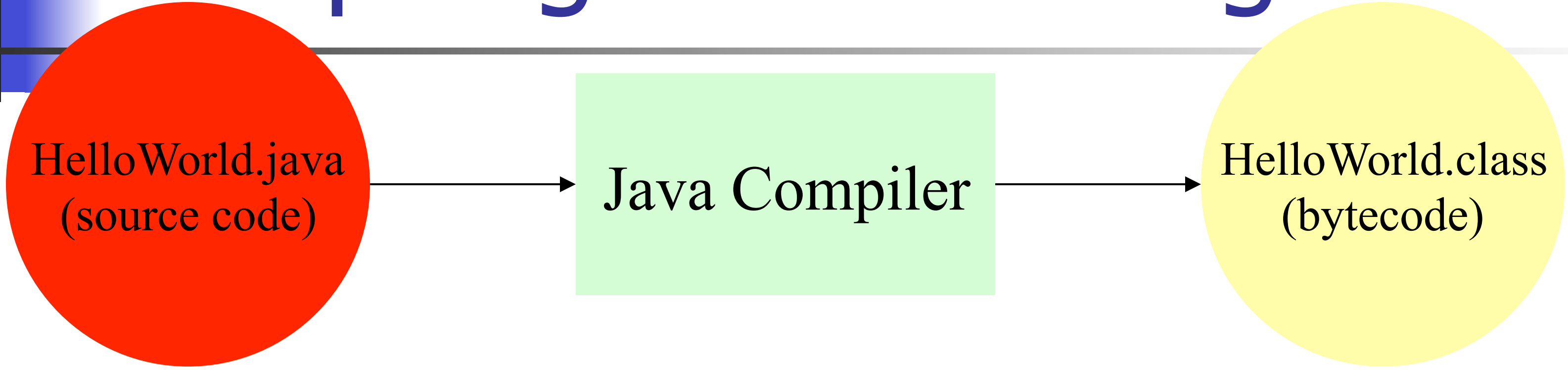
public static void main (String[] args) {

- main() is a java *method*
  - A method is a named set of operations within a class
  - The parentheses ( ) follow the name of the method
  - The braces surround the body of the method
  - Program vs. applets
  - Every program has a main( ) function
    - That’ s where the program starts executing

System.out.println(“Hello, world!”);

- This is the body of the main( ) method
- This is the instructions that run when main( ) is executed
- This code prints something on the screen
  - Whatever is between the quotes “ ”

Compiling and Running



HelloWorld.java
(source code)

Java Compiler

HelloWorld.class
(bytecode)

- Compiler translates human-readable code into machine-readable code
- The name of the .java file usually matches the name of the class it contains
- Java bytecode is machine independent
  - 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

Thrown out by the compiler

Converted into *tokens* by the compiler

White space

- Space, tab, and newline
- Separate tokens not otherwise separated by punctuation
- Make the code readable
- Can’t appear in 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
  - Ok: HelloWorld, println, data, first_name, a7, java
  - Not ok: 123, 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
  - char – ‘a’, ‘A’, ‘z’, ‘2’, ‘3’, ‘$’
  - 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
  - ; , ( ) { } .
- *Type*, *Precedence*, and *Associativity*
- By the way: ., !, *, #, $, &, ^, @, ~, |, /, ->

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>,
          <identifiern>;

Variable Initialization

- Examples

```
int age;
boolean flag1;
double hang_time; // C style identifier
String firstname;
Button clickToExit;  // Java style identifier
int first, second, third;
```

```
// HelloWorld2.java - simple variable declarations

class HelloWorld2 {
  public static void main(String[ ] args) {
    String word1, word2, sentence;

    word1 = “Hello, ”;
    word2 = “world!”;
    sentence = word1.concat(word2);
    System.out.println(sentence);
  }
}
```

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”;

```
// StringVsId.java – contrast Strings & Identifiers

class StringVsId {
  public static void main(String[ ] args) {
    String hello = “Hello, world!”;
    String stringVary;
    stringVary = hello;
    System.out.println(stringVary);
    stringVary = “hello”;
    System.out.println(stringVary);
  }
}
```

User Input

- Most interesting programs get input from the user
- Lots of ways to do this
- For now we will use Scanner

```java
// SimpleInput.java-read numbers from the keyboard
import java.util.*; // needed for Scanner

class SimpleInput {
  public static void main (String[] args) {
    int width, height, area;
    Scanner in = new Scanner(System.in);
    System.out.println("type two integers for" +
    " the width and height of a box");
    width = in.nextInt();
    height = in.nextInt();
    area = width * height;
    System.out.print("The area is ");
    System.out.println(area);
  }
}
```

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\nScott\n”);
  - Same as System.out.println(“Hi”);
  - And System.out.println(“Scott”);

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.println(“The value is: “ + a + b);
    prints out “The value is: 57”
  - System.out.println(“The value is: ” + (a+b));
    prints out “The value is: 12”
  - System.out.println(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 = 0,1,2,3 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

Type	Number of Bits	Range of Values
byte	8	-128 to 127
short	16	-32768 to 32767
char	16	0 to 65535
int	32	-2147483648 to 2147483647
long	64	-9223372036854775808 to 9223372036854775807

Floating point types

Type	Number of bits	Approximate Range of Values	Approximate Precision
float	32	+/-10^{-45} to +/-10^{+38}	7 decimal digits
double	64	+/-10^{-324} to +/-10^{+308}	15 decimal digits

Char

- char is a special integer type
  - Holds numeric values that represent Unicode characters
  - Examples:

‘a’	‘b’	‘c’	‘A’	‘B’	‘C’	‘0’	‘1’	‘9’	‘&’	‘*’	‘+’
97	98	99	65	66	67	48	49	57	38	42	43

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

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’

  0000000000110001 binary
- String “49” = ‘4’ + ‘9’ + 0 = 52 57 0 =

  00000000010100100000000001010111 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: (float)5, (long)a, 5.0, 4f
- Integer types storing floating point values will have the fractional part truncated
  - towards 0

```
// MakeChange.java - change in dimes and pennies
import java.util.*; // needed for Scanner

class MakeChange {
 public static void main (String[] args) {
   int price, change, dimes, pennies;
   Scanner in = new Scanner(System.in);
   System.out.println(”Type price (0:100):");
   price = in.nextInt();
   change = 100 - price; //how much change
   dimes = change / 10; //number of dimes
   pennies = change % 10; //number of pennies
   System.out.print("The change is : ");
   System.out.println(dimes + " dimes, " + pennies + “
   pennies");
 }
}
```

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: int z = 3.0/4.0;

Assignment Operators

- <variable> = <rightHandSide>;
- What happens?
  - Right hand side is evaluated
  - The result is placed in the variable <variable>
- Examples:

```
a = 0;
a = b + c;
a = in.nextInt( );
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 * 4) + 5;    // result: j = 17
j = 3 * (4 + 5);    // result: j = 27
```

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 * 5;    // result: x = 23
x = (3 + 4) * 5;  // 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, understandabilty, 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