
MAHARISHI UNIVERSITY of MANAGEMENT
Engaging the Managing Intelligence of Nature
Computer Science Department
CS390 Fundamental Programming Practices (FPP)
Professor Paul Corazza
& A. McCollum

Lecture 2: Fundamental Programming Structures In Java

Water the Root to Enjoy the Fruit

Wholeness of the Lesson

Java is an object-oriented programming language that supports both primitive and object data types. These data types make it possible to store data in memory and modify it or perform computations on it to produce useful output. Execution of a program is an example of the "flow of knowledge"—the intelligence that has been coded into the program has a chance to be expressed when the program executes.

Maharishi's Science of Consciousness locates three components to any kind of knowledge: the knower, the object of knowledge, and the process of knowing. These can be found in the structure of a Java program: the "knower" aspect of the program is the intelligence underlying the creation of Java objects—a Java *class*. The *data* that a program works on, which is stored in program variables of either primitive or object type, is the "object of knowledge." And the Java methods, which act on the data, are the "process of knowing."

Outline of Topics

- First Java program and the *Reference Example*
- Data Types:
  - The Primitive Types
  - Other data types at the basis of object creation
- Operators In Java
  - Arithmetic Operators
  - Increment and Decrement Operators
  - Relational And Boolean Operators
  - Bitwise Operators
- Java Strings
- Control Flow:
  - Conditional Logic
  - While Loops
  - For loops
  - The switch Statement
- Arrays

Introducing Java

- Begin by studying a simple example:

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

Things to understand (in upcoming lessons)

- public
- class
- static
- void
- main
- String[]
- System, System.out, System.out.println (vs System.out.print)
- delimiters: `;`, `}`, `{` (“blocks”)
- capitalization conventions

A Java Application

- Java applications are *object-oriented*. This means that, unlike C, a Java program works by invoking multiple objects that then interact to produce results
- We return to the Lesson 1 sample code to give a feeling for how a Java program works. More details about it will be explained in Lesson 3.
- See the code in the package

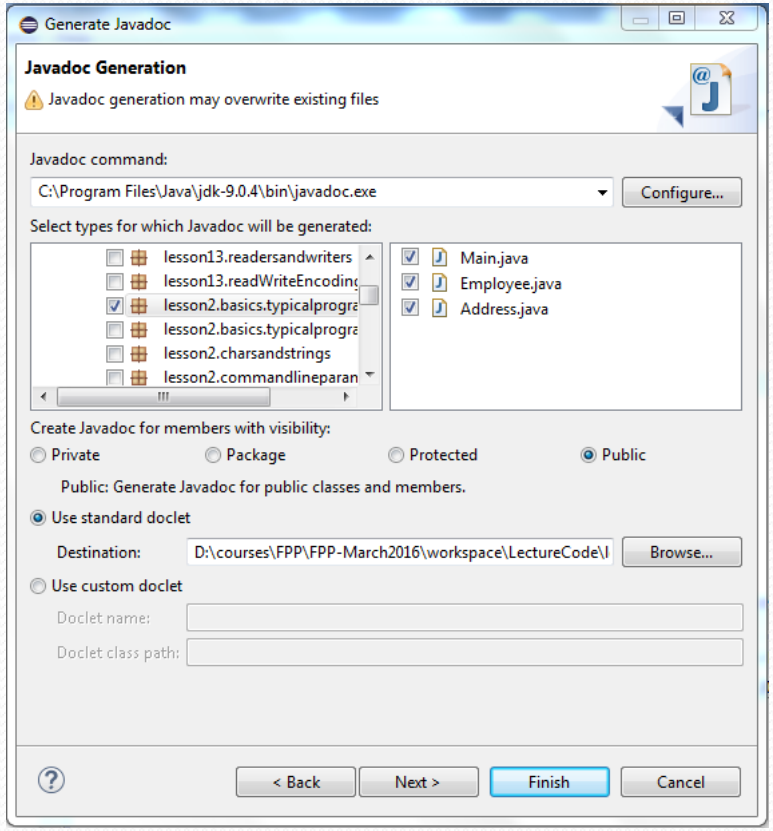
```
lesson2.basics.typicalprogram
```

This code will be referred to in future lessons as the ***reference example***

Comments In Java

- commenting out a line with //
- commenting out a block with /* … */
- commenting using javadoc format /** … */
- some javadoc keywords: @author, @since, @param @return
- ***Style:*** Every significant method you write should be documented with comments, javadoc style. (This is also true of every Java class you create.)
- Javadocs demo for reference application

  Right-click package > Export > Java > Javadoc



Data Types: The Primitive Types

- Every variable must have a declared type
- Eight primitive types: `int`, `short`, `long`, `byte`, `float`, `double`, `char`, `boolean`

Type	Storage Requirement	Range (Inclusive)
`int`	4 bytes	-2^{31} to $2^{31} - 1$
`short`	2 bytes	-2^{15} to $2^{15} - 1$
`long`	8 bytes	-2^{63} to $2^{63} - 1$
`byte`	1 byte	-2^{7} to $2^{7} - 1$ (-128 to 127)
`float`	4 bytes	6 - 7 significant (decimal) digits
`double`	8 bytes	15 significant (decimal) digits

- `boolean` has just 2 values: *true* and *false*. (Unlike C, not the same as 1 and 0.)

Exercise 2.1: Floats and Doubles in Java

1. Open JShell and at the prompt, type in the following 4 lines (hit enter after each line):

```
float x = 2.3456F
float y = 5.4193F
double x1 = 2.3456
double y1 = 5.4193
```

Then type the lines:

```
x * y
x1 * y1
```

Are the answers the same?

2. Continue working in JShell. First type

```
2 + 3 == 5
```

Note the return value of "true".

Then type in these lines:

```
double a = 0.7
double b = 0.9
double x = a + 0.1
double y = b - 0.1
```

Then type

```
x == y
```

Do you get a return value of "true"?

Floating Point Numbers in Java

- The `float` type in Java does not accurately represent numbers with more than 7 digits. See demo example in which the number 12.71151008 is represented as a `float` by 12.71151.
- Floating point numbers (`floats` and `doubles`) are represented internally in Java in *binary*. The result is that many (base-10) decimals are not precisely represented as a float or double – for instance, 0.1. For this reason, it is never safe to test whether two floating point numbers are equal, as in a test:

```
if(x == y) return true;
```

See the demo `lesson2.floatingpoint.FPArithmetic.java`

Examples of Floating Point Numbers in Binary

- Each floating point number *x* between 0 and 1 is translated into a finite sequence s1, s2, s3, . . . of 0's and 1's so that $s1/2 + s2/4 + s3/8 + \ldots \approx x$

s1	s2	s3	s4	. . .
1/2	1/4	1/8	1/16	. . .

- Example: Represent 0.625 in binary:
  0.625 = 0.5 + 0.125 = 1/2 + 0/4 + 1 / 8 => 1 0 1 0 ... 0

- Example: The binary form of 0.1 however requires infinitely many nonzero terms. Java uses just 23 of these terms (23 bits) to provide an approximation

  0.1 => 0 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1

  In the full representation of 0.1 in binary, the block **0011** repeats forever. Because the data types float and double have limited size (32 bits or 64 bits), this means that Java's binary representation of 0.1 is slightly smaller than the true value 0.1.

The char Type

- Java allots **16 bits** for its `char` type.
- To represent a character literal in Java, for commonly used characters, simply place the character between single quotes: 'A' represents the letter A.

```
char c = 'A';
```

- Characters can also be represented using the *unicode* character map – this is useful for characters that cannot be typed directly from a keyboard.
- Unicode maps each character to a 21 bit number.

`https://unicode-table.com/en/#cjk-unified-ideographs`

Examples:

- the ordinary letter 'A' is represented in Java notation (a *code unit*) by `'\u0041'`
- the Chinese character 终 by `'\u7ec8'` (Zhōng)

- Examples (see lesson2.unicode) show how the most commonly used characters are represented in unicode with just 16 bits. Each of these characters can be represented by a Java code unit (as in the examples)

The Char Type (continued)

From your text book:

- "Unicode was invented to overcome the limitations of traditional character encoding schemes. Before Unicode, there were many different standards: ASCII in the United States, ISO 8859-1 for Western European languages, KOI-8 for Russian, GB18030 and BIG-5 for Chinese, and so on. This caused two problems. A particular code value corresponds to different letters in the different encoding schemes. Moreover, the encodings for languages with large character sets have variable length: Some common characters are encoded as single bytes, others require two or more bytes. Unicode was designed to solve these problems.
- …
- Now, the 16-bit char type is insufficient to describe all Unicode characters."

The Char Type (continued)

- Occasionally, a character can be represented only if two of Java's code units are concatenated together. Characters that require two code units are called *supplementary characters*, and typically show up only in very specialized applications.

  Example:

  The symbol for the set $\mathbb{Z}$ of integers in mathematics is represented by the pair "`\ud835\udd6b`"

  In the unicode character map, $\mathbb{Z}$ is mapped to the 20-bit number (in hex format): 1d56b. In unicode notation, this is written: U+ 1d56b

The char Type (continued)

- To compute the unicode value of a basic Java character, cast it to an int (and convert to hex notation)

```
char c = 'A';
int unicodeVal = (int)c;  // this is in base 10
String hexVal = Integer.toHexString(unicodeVal); //value = 41

char c = '终';
int unicodeVal = (int)c;  // this is in base 10
String hexVal = Integer.toHexString(unicodeVal); //value = 7ec8
```

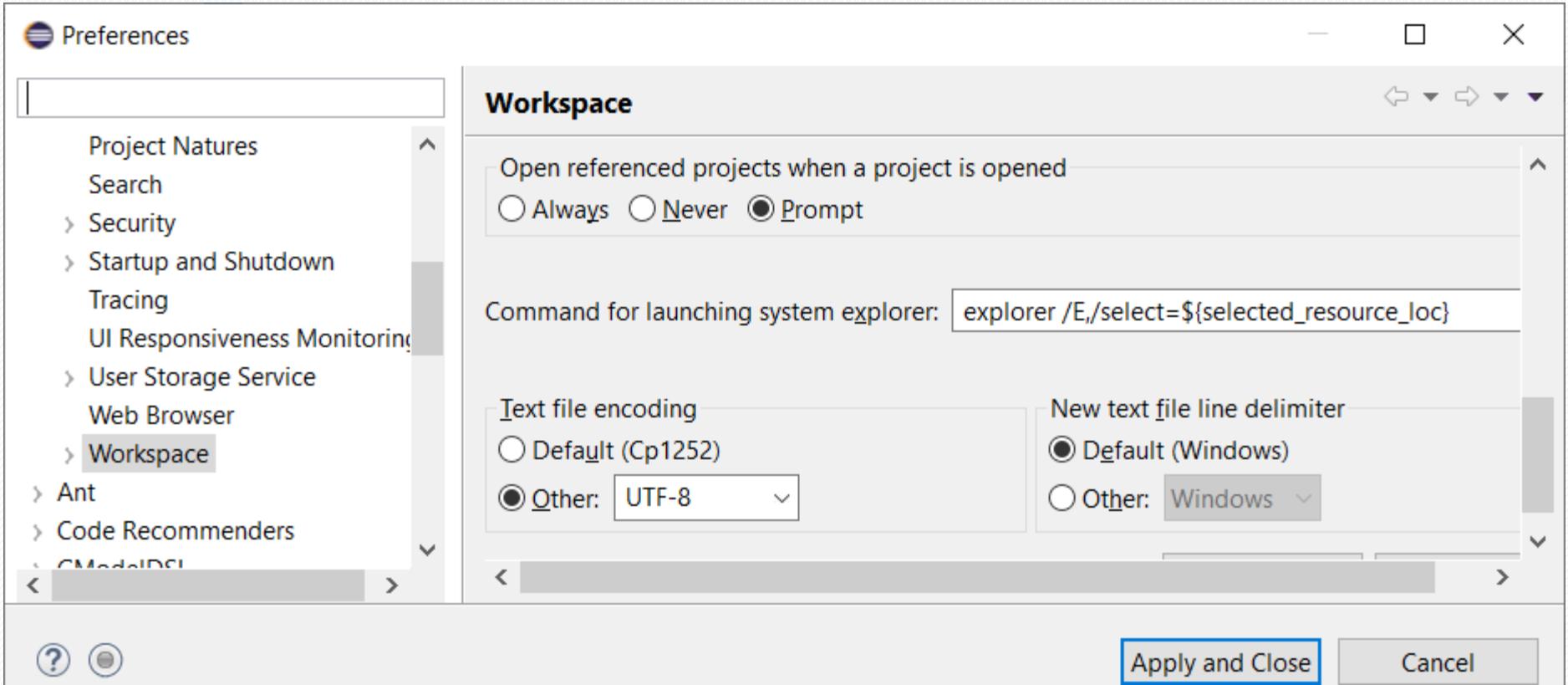
- To render a code as a character in output, pass in the Java unicode to `System.out.println( ).`

```
System.out.println('\u7ec8');  //output is 终
System.out.println("\ud835\udd6b"); //output is 𝕫
```

- See demo code: `lesson2.charsandstrings.Main`

Character Encoding in Eclipse

To change your project to an encoding that supports the Chinese characters in the lecture Code such as '终'. Go to Windows, Preferences, General, Workspace, Text file encoding, then select Other and choose UTF-8 as shown below.



Escape Characters

- \u is an example of an *escape character*. Other common escape characters are used to represent special characters:
  - \b – backspace
  - \t – tab
  - \n – newline
  - \r – carriage return
  - \" – double quote
  - \' – single quote
  - \\ - backslash

```
System.out.println("After waving, he said \"hello\"");
//output:  After waving, he said "hello"
```

Exercise 2.2: Escape Characters

- Working in jshell, define a string

```
String s =  xxxx
```

so that when you type

```
System.out.println(s);
```

the screen output is

Use "\t" to produce a tab.

Solution

```
String s = "Use \"\\t\" to produce a tab.";
```

Variables In Java

- Variables in Java store values, like strings, numbers, and other data
- A variable in Java always has a type; a variable is *declared* by displaying the type, followed by the variable name.
- Examples of declaring variables (see also the ***reference example***)

```
double salary;
int amount;
boolean found;
```

- Variable names consist of digits, letters and underscores, but may not begin with a digit. (More precise criteria are available in the documentation on the `isJavaIdentifierStart` and `isJavaIdentifierPart` methods of the `Character` class.)

Variables In Java

- *Variable Initialization*. A variable is initialized by using the *assignment operator* (=) to specify a value for a declared variable.

  Example:

  ```
  int sum;
  sum = 0;
  ```

  OR

  ```
  int sum = 0;
  ```

- *Coding Style:*
  - variable names begin with lower case letter
  - variable names composed of multiple words written so that each new word (except the first) begins with a capital letter, but all other letters are lower case
    Example:

    ```
    myExamScore
    ```

  - underscores should *not* be used typically in variable names
  - for *constants*, capitals and underscores are used (discussed later)

    ```
    CONSTANTS_LIKE_THIS
    ```

Introducing Other Data Types: Reading Console Input

- We have examined primitive data types (int, char, boolean, etc) and how variables are declared using these types. Most of the data types used in Java, however, are not built into the language, but are created through *class definitions*. This will be the topic of Lesson 3 – see the ***reference example*.**

- To introduce working with console input, we give another example of a class definition: the `Scanner` class.

Samples

- Scanner (as of j2se5.0)

```
//can think of Scanner as a special data type
Scanner sc = new Scanner(System.in);
System.out.print("Type your name: ");
System.out.println("you wrote: " + sc.nextLine());
System.out.print("Type your age: ");
System.out.println("your age: " + sc.nextInt());
sc.close();  //don't forget to close
```

```
//output
Type your name: Jim Stevens
you wrote:    Jim Stevens
Type your age: 36
your age: 36
```

See package lesson2.scannerandreader

- System.in and Readers (jdk1.1) (behaves like Scanner approach)

```
BufferedReader buf = null;
String input = null;
buf = new BufferedReader(new
    InputStreamReader(System.in));
System.out.print("Type your name: ");
input = buf.readLine();
System.out.println("You wrote " + input);
buf.close();
```

- JOptionPane (jdk1.2) (creates a GUI window for input)

```
String input =
    JOptionPane.showInputDialog("Type
        your name");
```

Main Point

Variables in Java are *declared* and *initialized* to provide space in RAM for the data that is to be stored. Using a variable name puts boundaries on memory, making it more specific. Similarly, unbounded pure consciousness becomes more concrete or specific when it is experienced by an individual. Unbounded pure consciousness can be expressed in an infinite number of ways through the human nervous system.

Operators In Java: Arithmetic Operators

- Standard binary operations represented in Java by `+, -, *, /`. Also the modulus operator `%`. Note: In Java, to compute `(-5)/2` (integer division) and `(-5) % 2`, remove the minus sign, compute, and then insert the minus sign again:

```
(-5)/2   = - (5/2) = -2
(-5) % 2 = - (5 % 2) = -1
```

Warning! This way of calculating modulus is an old mistake that is found in most procedural languages – the computation differs from the usual mathematical definition of modulus – in math, the modulus is always a nonnegative number.

=> **Java 8** corrects this with `Math.floorMod`:

```
Math.floorMod(-5, 2) = -5 (mod 2) = 1
Math.floorDiv(-5, 2) = floor(-5/2) = -3
```

See the `lesson2.modulus` package for this lesson.

Mathematical Definition: *n mod m is the nonnegative number r less than m for which there is a quotient q satisfying*

$n = m * q + r$

Therefore: -5 mod 2 is the nonnegative number r less than 2 (i.e. r is 0 or 1) satisfying

$-5 = 2 * q + r$ (for some q)

It follows

$q = -3,\ r = 1$

so

-5 mod 2 = 1

- Division by 0: for `int`s, an exception is thrown.
  For floating point numbers, the value is `NaN`

- The operators `+=, *=, /=, -=, %=`

Operators In Java: Increment and Decrement Operators

- Variables having primitive numeric type can be incremented and decremented using "++" and "--" respectively (char types can be incremented like this too, but it is not a good practice to do this)

- Example:

```
int k = 1;
k++;   //new value of k is 2 (postfix form)
++k;   //new value of k is 3 (prefix form)
```

- Difference between postfix and prefix forms arises when used in expressions – prefix form is evaluated *before* evaluation, postfix form *after* evaluation

Operators (continued)

- Example:

```
int k = 0;
int m = 3 * k++;  //m equals 0, k equals 1

int q = 0;
int n = 3 * ++q;  //n equals 3, q equals 1
```

- Commonly used in for loops (coming up soon) but also in traversing arrays (also coming up soon). These are standard uses; mostly this style should be avoided for the sake of readability.

Operators In Java: Relational And Boolean Operators

- **Relational:** == (equals), != (not equals), < (less than), <= (less than or equal to), > (greater than), >= (greater than or equal to)
- **Logical:** &&, ||, ! . Short-circuit evaluation.

&&	T	F
T	T	F
F	F	F

||	T	F
T	T	T
F	T	F

See demo: lesson2.shortcircuit.Main.

- **Ternary:** *condition* ? *expression1* : *expression2* – evaluates to expression1 if condition is true, expression2 otherwise
- Example:

```
CustomerStatus =
     (income > 100000) ?
           PLATINUM : SILVER;
```

is equivalent to this logic:

```
IF( income > 100000 )
       customerStatus = PLATINUM
ELSE
       customerStatus = SILVER
```

Operators In Java: Bitwise Operators

- & (and), | (or), ^ (xor), ~ (not), << (left shift), >> (arithmetic right shift), >>> (logical right shift)

&	1	0
1	1	0
0	0	0

|	1	0
1	1	1
0	1	0

^	1	0
1	0	1
0	1	0

(complement)

~1 = 0

~0 = 1

- Examples of << and >>. (>>> is same as >> for positive numbers)

0000 1111 >> 2 = 0000 0011 (right shift by 2 is same as dividing by 4)
[15 >> 2 = 15/4 = 3]

0000 1111 << 2 = 0011 1100 (left shift by 2 is same as multiplying by 4)
[15 << 2 = 15 * 4 = 60]

1111 1110 >> 1 = 1111 1111 (fill from left with 1s – right shift by 1 same as divide by 2 using floorDiv: -5 >> 1 = -3)

1111 1110 >>> 1 = 0111 1111 (fill from left with 0s)

Mathematical Constants And Functions

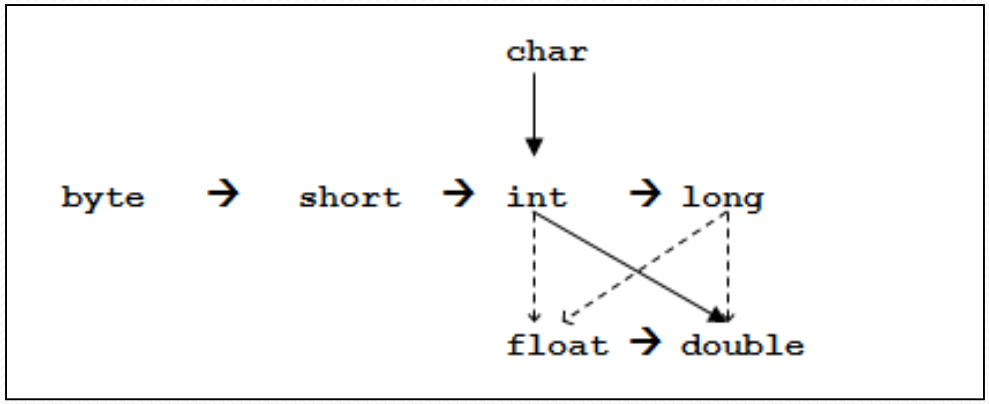
- Special math functions and constants are available in Java by using the syntax
  `Math.<constant>` and `Math.<function>`
- Examples:

```
Math.PI   (the number pi – approximately 3.14159)

Math.pow(a,x)  (the number a raised to the power x)

Math.sqrt(x)  (the square root of x)
```

- For this course, we have a `RandomNumbers` class (which uses the Java Random class). Its methods can be accessed in the same way the methods of `Math` class can.
- Examples: (see demo lesson2.random.RandomNumbers)

```
//produces a randomly generated int
int n = RandomNumbers.getRandomInt();

//produces a randomly generated int in the range 3..11, inclusive.
int m = RandomNumbers.getRandomInt(3,11);
```

Conversions Between Numeric Types



- Solid arrows indicate automatic type conversions that do not entail information loss
- Dotted arrows -- `int` to `float`, `long` to `float`, and `long` to `double` -- indicate automatic conversions also, but may lose precision (however, they always preserve number of digits to left of decimal):

Example:

```
int n = 123456789;
float f = n;  //f is 123456792.000000,
```

See `lesson2.datatypeconversion.DataConversion`

- When values of different type are combined (via addition, multiplication or other operations), a type conversion occurs to arrive at just one common type.

  Most important cases:
  - a double combined with another primitive numeric type results in a double
  - an int combined with a smaller type (byte, short) results in an int.

- A complete list of rules is given on p. 60 of Core Java, Vol 1, 10th ed.

- Other conversions can be "forced" by casting.

  Example:

```
double x = 9.997;
int y = (int) x;  //y has value 9
```

- "Rounding" is usually preferable to casting and is done by using the round function of the Math class:

```
Example:
double x = 9.997;
int n = (int)Math.round(x); //round returns a long,
 //so cast is necessary
```

- It is possible to cast a `long` to an `int`, an `int` to a `byte`, and so forth. In such cases, casting is accomplished by removing as many high-order bits as necessary to produce a number of the narrower type.

```
Example:
int x = 130;            ( = 000. . .00 1000 0010 as an int)
byte b = (byte)x;       ( = 1000 0010 as a byte = -126)
```

The bytes -128 to -1 are represented by bit strings that begin with 1.
Examples:

-1 = 1111 1111, -127 = 1000 0001, -128 = 1000 0000.

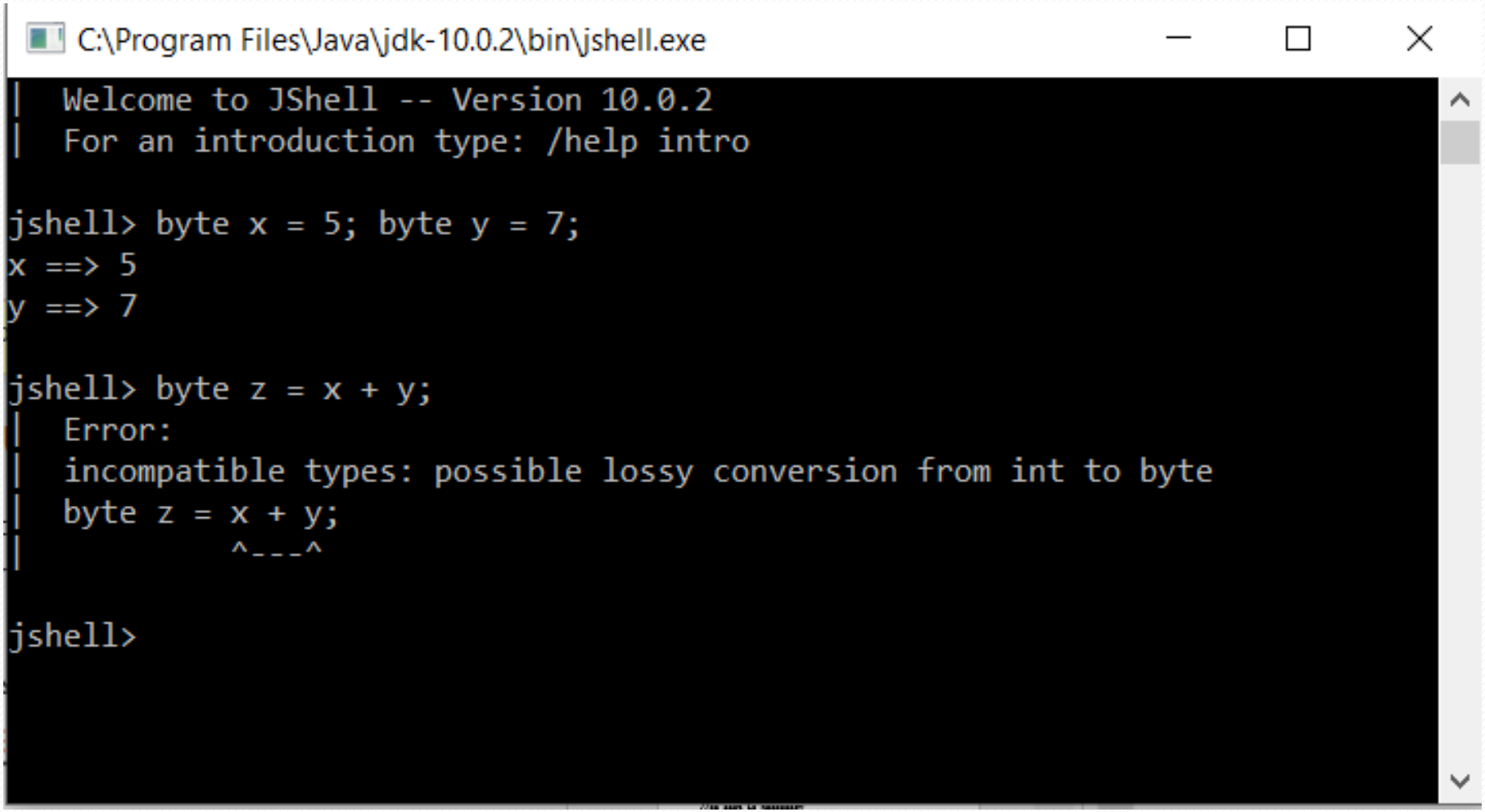
Notice -126 = -127 + 1 = 1000 0010

- *Automatic promotion of integral types.* When a binary operation (like +, *, or any shift operator) is applied to values of type `byte` or `short`, the types are promoted to `int` before the computation is carried out.

Example: The following produces a compiler error. Why?

```
byte x = 5;
byte y = 7;
byte z = x + y;
```

Problem Soving Technique: Try it out in JShell


C:\Program Files\Java\jdk-10.0.2\bin\jshell.exe
| Welcome to JShell -- Version 10.0.2
| For an introduction type: /help intro
jshell> byte x = 5; byte y = 7;
x ==> 5
y ==> 7
jshell> byte z = x + y;
| Error:
| incompatible types: possible lossy conversion from int to byte
| byte z = x + y;
| ^---^
jshell>

Operator Precedence and Association Conventions

Examples:

`a && b || c` means `(a && b) || c` (operator precedence)

`a += b += c` means `a += (b += c)` (association to the right)

- See the chart on the next slide for a list of all the rules
- Important precedence rules to know:
  - *, / , % precede + and –
  - ++ and -- have almost the highest precedence
  - = (assignment) associates to the right: `a = b = c` means `a = (b = c)`
  - *Tip:* be able to use the chart on the next page to read syntax

Precedence and Association Table

Table 3-4. Operator precedence	
Operators	**Associativity**
[] . () (method call)	left to right
! ~ ++ +(unary) -(unary) ()(cast) new	right to left
* / %	left to right
+ -	left to right
<< >> >>>	left to right
< <= > >= instanceof	left to right
== !=	left to right
&	left to right
^	left to right
|	left to right
&&	left to right
||	left to right
?: (ternary operator)	right to left
= += -= *= /= %= &= |= ^= <<= >>= >>>=	right to left

Evaluate: `11 - 2 * 3 == 5`

Solution: `(11 - (2 * 3)) == 5 resolves to true`

Evaluate: `2 + x++ == 5, where x = 3`

Solution: `(2 + (x++)) == 5 also resolves to true`

Table 3-4. Operator precedence

Operators	Associativity
`[]  .  ()  (method call)`	left to right
`!  ~  ++  +(unary)  -(unary)  ()(cast)  new`	right to left
`*  /  %`	left to right
`+  -`	left to right
`<<  >>  >>>`	left to right
`<  <=  >  >=  instanceof`	left to right
`==  !=`	left to right
`&`	left to right
`^`	left to right
`|`	left to right
`&&`	left to right
`||`	left to right
`?:  (ternary operator)`	right to left
`=  +=  -=  *=  /=  %=  &=  |=  ^=  <<=  >>=  >>>=`	right to left

Example. Use the precedence rules table (below and on p.53) to evaluate:

```
7 & 13 >> 2 | 8
```

Solution:

Apply precedence rules with parenthesis:	(7 & (13 >> 2))	| 8	[13 is 1101 in binary]
Operate on inner parenthesis first:	(7 & 3)	| 8	
Change operation in parenthesis to bits:	(00000111 & 00000011)	| 8	
Result from parenthesis in bits:	(00000011)	| 00001000	
End result in bits:	00001011		
End result in decimal:	11		

Table 3-4. Operator precedence

Operators	Associativity
`[]  .  () (method call)`	left to right
`!  ~  ++  +(unary)  -(unary)  ()(cast)  new`	right to left
`*  /  %`	left to right
`+  -`	left to right
`<<  >>  >>>`	left to right
`<  <=  >  >=  instanceof`	left to right
`==  !=`	left to right
`&`	left to right
`^`	left to right
`|`	left to right
`&&`	left to right
`||`	left to right
`?: (ternary operator)`	right to left
`=  +=  -=  *=  /=  %=  &=  |=  ^=  <<=  >>=  >>>=`	right to left

Main Point

Variables of primitive type can be combined to form expressions through the use of *operators* (like +, *, &&, ||). The Java syntax requires one to observe rules for forming expressions – precedence rules, type conversion rules, and others. Pure consciousness, likewise, also has laws that govern its self-combining. The self-combining dynamics of pure consciousness – like the self-interacting dynamics of the unified field – give rise to "everything": All thoughts, all knowledge, all manifest existence. This is why contact with this source of manifest existence through meditation practice enhances success and achievement in life.

Java Strings

- A `String` is a sequence (technically, an array) of characters – therefore, formally, "String" is not a built-in data type (unlike `int` and `float`)

- A `String` can be created using a string literal.

  Example:

```
String name = "Jennifer";
String emtpy = "";
```

- Java `Strings` are *immutable*. This means that it is <u>not possible to change the values of the characters</u> within a `String`.

Java Strings: `charAt()` Method

- Thinking of a Java `String` as a sequence of characters, the `charAt` method extracts the character (code unit) at a specified position in this sequence:
  - `"Hello".charAt(1)  //value is 'e'`
  - For special characters, care is needed. For example: Suppose a `String expr` is defined like this:

```
expr = "ℤ is the set of integers"
```

In this case, the expression

```
expr.charAt(1)
```

has value `'\uDD6B'` since it is the second character of the pair `\ud835\uDD6B` of code units that represents the character ℤ.

Java Strings: `length()` Method

- The `length()` method returns the number of Java characters in a `String`. When only basic characters are present, the length is just the number of characters. But care is needed with *special* characters.
  - The value of

    ```
    "Hello".length()
    ```

    is 5
  - However, the value of "𝕫_𝕫".length()

    is 5, not 3.

String Functions: `substring`, `indexOf`, `startsWith`, `+`, `equals`

- **`substring(m,n)`** returns the subsequence of characters starting at position m up to position n-1
- **`indexOf(char c)`** returns position of (first occurrence of) char c in the String if present, -1 otherwise
- **`indexOf(String s)`** returns position of (first occurrence of) o^{th} character in s in the String if present, -1 otherwise
- **`startsWith(String s)`** returns true if String begins with the String s, false otherwise
- **`+`** concatenates two strings
- **`equals(String s)`** returns true if the character sequence that composes the string is identical to the character sequence that composes s.

Exercise 2.3: String Functions

- Type the following lines into JShell and record the answers that you get
  - `substring`

```
String name = "Robert";
name.substring(0,3);
name.substring(0,name.length());
name.substring(0,1);
name.substring(0,0);
```

  - `indexOf`

```
String name = "Robert";
name.indexOf('t');
name.indexOf("bert");
```

(continued)

- startsWith

```
String name = "Robert";
name.startsWith(“Rob");
name.startsWith("R");
name.startsWith("bert");
```

- + (concatenation) – creates a new String

```
String name = "Robert";
String space = " ";
String lastName = "Stevens";
name + space + lastName;
```

- equals

```
String name = "Robert";
name.equals("Robert");
name == "Robert";
String newName = new String("Robert");
newName == "Robert";
newName.equals("Robert");
```

String Functions: substring, indexOf, startsWith, +, equals, StringJoiner

- Examples of how the `String` functions are used:
  - `substring`

```
String name = "Robert";
String nickname = name.substring(0,3);// "Rob"
String whole = name.substring(0,name.length()); //"Robert"
String first = name.substring(0,1); //"R"
String empty = name.substring(0,0);  // ""
```

  - `indexOf`

```
String name = "Robert";
int posOfT = name.indexOf('t'); //5
int posOfSubstr = name.indexOf("bert"); //2
```

- `startsWith`

```
String name = "Robert";
boolean result = name.startsWith(“Rob");//true
boolean result2 = name.startsWith("R"); //true
boolean result3 = name.startsWith("bert"); //false
```

- `+ (concatenation) – creates a new String`

```
String name = "Robert";
String space = " ";
String lastName = "Stevens";
String fullname = name + space + lastName;// "Robert Stevens"
```

- `equals`

```
String name = "Robert";
boolean equal = name.equals("Robert"); //true
boolean refEqual = (name == "Robert");  //true, but be careful
String newName = new String("Robert");
refEqual = (newName == "Robert");  //false!
refEqual = (newName.equals("Robert")); //true
```

Note: `equals` and + are illustrated in the ***Reference Example***

StringJoiner

- This relative of the `String` class can be used to produce a formatted sequence of `String`s.
- Constructor for `StringJoiner` is `StringJoiner`(*delimiter, prefix, suffix*). The delimiter separates the `Strings` that are added to the joiner; the prefix is the initial part of the output `String`, the suffix is the final part of the output `String`.

Example. The `String`

`"[George:Sally:Fred]"`

may be constructed as follows:

```
StringJoiner sj = new StringJoiner(":", "[", "]");
sj.add("George").add("Sally").add("Fred");
String desiredString = sj.toString();
```

String Functions: `compareTo`

- The natural ordering on Strings is *alphabetical order*. In that ordering, for example, "Bob" comes before "Charles". The `compareTo` method on `Strings` specifies this ordering on `Strings`:

```
int compareTo(String t)
```

- `s.compareTo(t)` returns
  - `a positive integer if s is "greater than" t`
  - `a negative integer is s is "less than" t`
  - `zero, if s and t are equal as Strings`
- Examples

```
public static void main(String[] args) {
    System.out.println("a".compareTo("b"));
    System.out.println("b".compareTo("a"));
    System.out.println("a".compareTo("a"));
}
```

//output:

-1

1

0

- The `compareTo` method is used to sort `Strings` (see the section on Arrays)

Formatted Console Output

- j2se5.0 introduced C-like formatting features with `System.out.printf` and `String.format`
- Use `System.out.printf` to print formatted output directly to the console
- Use `String.format`, with the same formatting options, to store formatted String in memory, perhaps to be sent to the console or a file (for example) at a later time
- Can be combined with `Date` formatting
- For jdk1.4 and before, the `MessageFormat` class is used for formatting `Strings` – see sample code below
- A complete list of format specifiers (like s, d) can be found on p. 83, Core Java, 10th edition.

Samples

```
System.out.printf("You owe me $%f \n", 195.50f);
System.out.printf("You owe me $%.2f \n", 195.50f); //.2 is precision specifier
System.out.printf("You owe me $%7.2f \n", 195.50f); //7 is width specifier
```

You owe me $195.500000
You owe me $195.50
You owe me $ 195.50

```
String name = "Bob";
int age = 30;
System.out.printf("Happy birthday %s. I can't believe you're
%d.",name,age);
```

Happy birthday Bob. I can't believe you're 30.

```
String oweMe = String.format("You owe me %.2f dollars", 196f);
String oweMe2 = String.format("You owe me %d dollars", 196);
System.out.println(oweMe);
System.out.println(oweMe2);
```

You owe me 196.00 dollars
You owe me 196 dollars

Samples

```
String date = String.format("Today's date: %tD", new Date());
System.out.println(date);
```

Today's date: 09/09/05

```
//formatting in jdk1.4 - uses arrays, explained soon
Object [] params = {"animal", "dog"};
String stringWithParameter =
    "Look at that {0} -- it looks like a {1}.";
System.out.println("original string: " + stringWithParameter);
System.out.println("formatted string: " +
MessageFormat.format(stringWithParameter,params));
```

original string: "Look at that {0} -- it looks like a {1}."
formatted string: Look at that animal -- it looks like a dog.

Control Flow: Conditional Logic

- The conditional statement in Java has the following form:

```
if(condition) statement
```

Here, condition is any boolean statement (statement that evaluates to true of false)

- The *statement* may in fact be an entire block of code, in this form:

```
if(condition) {
        statement1;
        statement2;
        …
}
Example:

        if(sales >= target) {
                performance = "Satisfactory";
                bonus = 100;
        }
```

Control Flow: Conditional Logic

- Another form of conditionals is the *"if...else"* form:

```
if(condition) statement1
else statement2
```

Example:

```
    if(sales >= target) {
          performance = "Satisfactory";
          bonus = 100;
    } else {  //this is the preferred formatting
          performance = "Unsatisfactory";
          bonus = 0;
    }
```

See the ***reference example*** (the Main class).

- Can have repeated “else if”s .

Example:

```
if(sales >= 2 * target) {
          performance = "Excellent";
          bonus = 100;
}
else if (sales >= target {
          performance = "Satisfactory";
          bonus = 50;
}
else { //sales < target
          performance = "Unsatisfactory";
          bonus = 0;
}
```

An “else” is associated with nearest previous “if”. Therefore, these statements are read by the compiler as:

```
if(sales >= 2 * target) {
          performance = "Excellent";
          bonus = 100;
}
else {
          if (sales >= target) {
                    performance = "Satisfactory";
                    bonus = 500;
          }
          else { //sales < target
                    performance = "Unsatisfactory";
                    bonus = 0;
          }
}
```

Control Flow: While Loops

- The general form of a `while` loop is

  `while (`*`condition`*`)` *`statement`*

  where *condition* is a boolean expression.

- The general form of a `do…while` loop is

  ```
  do statement while (condition)
  ```

- Typically, `do…while` is used in place of `while` when it is necessary for `statement` to execute at least once (even if `condition` is always false).

Examples

```
//while loop
while(balance < goal) {
  balance += payment;
  double interest
     = balance * interestRate/100;
  balance += interest;
  years++;
}
System.out.println(years + "
years");
```

```
//do..while loop
Scanner sc = new Scanner(System.in);
do{
  System.out.print("Payment amount? ");
  payment = sc.nextDouble();
  balance += payment;
  double interest = balance * interestRate / 100;
  balance += interest;
  years++;
  System.out.println("Your balance: " +
     balance);
  System.out.println(
      "Make another payment? (Y/N)");
  input = sc.next();
}
while(input.equals("Y"));
```

Examples – the while(true) Construct

- Use the `while(true)` form when the `statement` requires processing before a condition can be evaluated. To exit the loop, use a `break` statement.

Example:

```
Scanner sc = new Scanner(System.in);
while(true) {
    System.out.print ("Enter a positive number: ");
    int value = sc.nextInt();
    if(value <= 0){
        break;
    }
}
System.out.println("The value you enter must be
positive.");
```

while(true) - continued

- Also used sometimes in creating a server (for a client/server system); in this case, the while loop never stops (until the server itself stops):
- *Using* `break` *in while loops.* When a `break` statement occurs, the while loop is exited and execution resumes as it would if the condition in the while loop had just failed. When possible, use `while` *without* a `break` statement (by selecting the condition for the `while` loop carefully) – sometimes though `break` statements are necessary.

Control Flow: for Loops

- General form of the `for` loop:

  for(*initialization*; *condition*; *increment*) *statement*

- Sample code: see the *reference example*, `Main` class.
- All three parts of the `for` expression are optional. The expression

  `for( ; ; )` *statement*

  means the same as

  `while(true)` *statement*

Examples

```
//standard
for(int i = 0; i < max; ++i) {
     //do something
}
```

Note: Since `i` is declared in the for expression, it cannot be referenced outside of the for block. If you need to use it outside the block, this code should be used:

```
int i;
for(i = 0; i < max; ++i) {
     //do something
}
//now i can be referenced here
```

or, equivalently,

```
int i=0;
for( ; i < max; ++i) {
     //do something
}
//now i can be referenced here
```

Examples - continued

More than one variable can be initialized, and more than one increment statement can be used; commas separate such statements.

```
for(int i = 1, j = max; i * j <= balance; i++, j--) {
     //do something
}
```

Complex conditions are allowed in the condition slot:

```
for(int i = 0; (i+1) * value > min && i * value < max; i = i + 2) {
 //do something
}
```

Exercise 2.4

- In the main method provided in the Main class in lesson2.exercise_4 in InClassExercises, do the following:

  Ask the user to type in his name and then output the number of occurrences of the letter 'e' that you find in his name.

Solution

```
package lesson2.exercise_4;

import java.util.Scanner;

public class Main {
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        System.out.println("Type your name");
        String nextLine = sc.nextLine();
        int count = 0;
        for(int i = 0; i < nextLine.length(); ++i) {
            if(nextLine.charAt(i) == 'e') {
                count++;
            }
        }
        sc.close();
        System.out.println(count);
    }
}
```

Nested for loops – example

```
for(int i = 0; i < n; ++i){
    for(int j = 0; j < n; ++j){
          System.out.printf("%-3s","*");

    }
    System.out.println();
}
// '-' flag means "left justify" within field
//  3 is the width for each string
// s is the type of data to be printed

Here is the output for n = 5

* * * * *
* * * * *
* * * * *
* * * * *
* * * * *
```

Examples - continued

```
for(int i = 0; i < n; ++i){
    for(int j = 0; j <= i; ++j){
          System.out.printf("%-3s","*");
    }
    System.out.println();

}

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

//output for n = 5

*
* *
* * *
* * * *
* * * * *
```

Control Flow: The switch Statement

- The `switch` statement is a convenient shorthand for writing "`if..else`" statements, when the values being tested are `int`s, `char`s, `String`s, or `enum`s. (Note: `enum`s will be discussed in Lesson 3.) [Demo: lesson2.switchdemo]
- General form of the `switch` statement:

```
switch(val) {
     case x:
               statement_x;
               break;
     case y:
               statement_y;
               break;
     …

     default:
               default_statement;
}
```

- The `break` in each case ensures that only one case is exectuted. If you forget to insert the break, later cases will continue to be tested and executed.
- A `default` case should typically be provided, to handle all cases not specified in the case statements.

“Fall-through” Behavior

- “Fallthrough behavior” occurs when break statements are omitted: Cases are examined and, as soon as a match is found, the corresponding statement is executed, and all subsequent case statements are also executed, until a break is encountered. If no matches are found, then the default statement is executed if there is one.
- Example of “fallthrough behavior”:

```
Scanner sc = new Scanner(System.in);
System.out.print("Pick an integer in the range 1..9");
int val = sc.nextInt();
System.out.println();
switch(val) {
    case 2:
    case 4:
    case 6:
    case 8:
        System.out.println("You chose an even number.");
        break;
    default:
        System.out.println("You chose an odd number.");
}
```

Main Point

Control flow is supported in Java using the language elements: *if..else, for, while, do..while, switch* [and also *for each*]. Loops are a pattern that we see in the self-referral consciousness at the source of the thinking process, the field of pure Creative Intelligence. And branching logic (if, then, else, switch) mirrors the tree-like hierarchy of natural laws that guide the activity in each layer of creation (examples in Unified Field Charts).

Arrays

An array is a data structure that stores a collection of values of the same type and that supports *random access* of its elements (the element at position `i` in an array `arr` is retrieved using the syntax `arr[i]`).

- *Declaration of arrays*

```
int[] arr;
```

- *Initialization of arrays*

```
int[] arr = new int[100];
```

100 cells, numbered 0 to 99, are created and by default, each cell contains the value 0. All numeric arrays (for primitive types) are filled with their own version of 0 when initialized. String arrays (and arrays of objects of other kinds) are filled with the value `null` (more on this later).

Arrays

- *Setting values in an array*

```
arr[5] = 30;
```

- *Retrieving values in an array*

```
int positionFour = arr[4];
```

- *Length of an array.* This is the size determined at initialization and may not be changed.

```
int len = arr.length;  // len is 4
```

- Note: Arrays are used in the ***Reference Example***

Application of Arrays-the split function of the String class

- Use `split` to break up a `String` into `tokens` based on a set of *delimiters*.
- The statement

```
String[] parsedVals =  s.split(",");
```

will split the String s into tokens, using "," as delimiter, and will place the tokens in the array `parsedVals`

Example:

```
String s = "hello,how,are,you,today";
String[] parsedVals =  s.split(",");
```

The elements of `parsedVals` are:

```
hello
how
are
you
today
```

- .

Exercise 2.5

- If you want to use more than one separator in a split, separate them with a pipe ('|'), as in

  "hello there,Bob".split(" |,")

  To indicate a dot, use \\. instead of just .

Working in JShell, think of the right separators to use in a split to extract the array

```
["Hello", "strings", "can", "be", "fun", "They", "have", "many", "uses"]
```

from the String

```
"Hello,strings can be fun. They have many uses."
```

Solution

```
String t = "Hello,strings can be fun. They have many uses."
String[] result = t.split(",| |\\. |\\.")

//output
["Hello", "strings", "can", "be", "fun", "They", "have",
"many", "uses"]
```

The *for each* Loop

```
int [] arr = {4, 5, 12, 25};
for(int x: arr) {
        System.out.println(x);
}
```

- Syntax:

  for(*variable* : *collection*) *statement*

  (As with ordinary for loops, the variable declaration can occur inside or outside the for expression)

  The *collection* must either be an array or an instance of a class that implements the `Iterable` interface (more on this later)

- ***Best Practice:*** Whenever there is a choice, use a *for each* loop in place of an ordinary *for* loop. The syntax is easier to read and doesn't rely on irrelevant information. (For instance, in this example, the *index* of each element in the array is not relevant for the task of printing the array elements)

Array Initializers and Anonymous Arrays

- When first created, can initialize an array like this (called an *array initializer*):

```
int[] somePrimes = {2, 3, 5, 7, 9, 11};

String[] names = {"Bob", "Harry", "Sue"};
```

But, the following is not legal:

```
String[] favoriteTeams = new String[2];
favoriteTeams = {"Sonics", "Mets"};  //compiler error
```

- Anonymous arrays

```
new int[] { 17, 19, 23, 29 };
```

One application: permits initialization like an array initializer even after an array has been declared:

```
String[] favoriteTeams = new String[2];
favoriteTeams = new String[]{"Sonics", "Mets", "Bulls"}; //change in size is ok
```

Array Copying and Sorting

To copy the cells from one array to another array, create a new (empty) array of the same size (or larger), and use `System.arraycopy`. To sort, use the `Arrays.sort` function.

Signatures:

```
System.arraycopy(from, fromIndex, to, toIndex, count)
Arrays.sort(arr)
```

Examples:

```
int[] smallPrimes = { 2, 3, 5, 7, 11};
int[] copy = new int[5];
System.arraycopy(smallPrimes, 0, copy, 0, 5);

int[] smallPrimes = { 2, 3, 5, 7, 11};
int[] luckyNums = {350, 400, 150, 200, 250};
System.arraycopy(smallPrimes, 1, luckyNums, 3, 2);

//luckyNums is now [350, 400, 150, 3, 5]
//now sort
Arrays.sort(luckyNums);
//luckyNums is now [3, 5, 150, 350, 400]
```

Sorting Strings

When you used Arrays.sort on an array of Strings, the JVM automatically uses the compareTo method to compare Strings and to put them in alphabetical order.

- Example:

```
public static void main(String[] args) {
    String[] names = {"Steve", "Joe", "Alice", "Tom"};
    //sorts the array in place
    Arrays.sort(names);
    System.out.println(Arrays.toString(names));
}
```

//output

```
[Alice, Joe, Steve, Tom]
```

- See package lesson2.stringcompareto

Commandline Parameters

The `main` method is designed to read input from the user when the program is executed.

```
class ParameterExample {
      public static void main(String[] args) {
                int len = 0;
                if(args != null) len = args.length;
                for(int i = 0; i < len; ++i) {
                    System.out.println("position " + i + ": " + args[i]);
                }
      }
}
```

Sample run of this code:

```
java ParameterExample Hello Goodbye
//output
position 0: Hello
position 1: Goodbye
```

Commandline parameters can be inserted into a Run Configuration in Eclipse.
Right click class > Run As > Run Configurations, set name of configuration, add Program Arguments in Arguments tab. See demo in package: lesson2.commandlineparams

Introduction to Static Methods

- We have seen that the `main` method in a Java class is static and have discussed briefly what this means.
- In Java, static methods can call other static methods. Static methods are *utility methods* – designed to do some computation or processing, accepting inputs returning outputs, which support the main flow of the application. They can be used whether or not an instance of their enclosing class has been created. We will discuss static methods, and methods generally, in Lesson 3.

Example: See the `StringGame` demo in

`lesson2.staticdemo`

Avoiding Costly Concatenation of Strings with StringBuilder

- **Example**: You are writing an application that will receive an unknown number of `Strings` as command-line arguments. These `Strings`, when pieced together, will form a sentence. Your job is to concatenate all these `Strings` and output to console the final sentence, with the correct sentence structure. (Since we are assuming just one sentence is formed, the only adjustments we need to make to the input are to put spaces between the words and a period at the end.)

First Try

```
public static void main(String[] args) {
    if(args == null || args.length == 0) {
        System.out.println("<no input>");
    }
    String finalSentence = "";
    len = args.length;
    for(int i = 0; i < len-1; ++i) {
        finalSentence += (args[i] + " ");  //inefficient
    }
    finalSentence += (args[len-1] + ".");
    System.out.println(finalSentence);
}
//NOTE: couldn't do this with a "for each" loop
```

Problem: Concatenation becomes very slow with many arguments because each concatenation creates a new `String` (which requires allocating new memory for the new object), and compared to other steps, this is a costly operation.

Solution: `StringBuilder`

StringBuilder represents a "growable String" – can append characters and `Strings` without significant cost.

Note: `StringBuilder` is designed to be used for single-threaded applications – it is not thread-safe. This means that a single `StringBuilder` instance must not be shared between two or more competing threads. If multithreaded access is needed, a class with the same method names, `StringBuffer`, can be used, but it is less efficient in the single-threaded case.

Better Solution

```
public static void main(String[] args) {
    if(args == null || args.length == 0) {
        System.out.println("<no input>");
    }
    StringBuilder finalSentence = new StringBuilder();
    len = args.length;
    for(int i = 0; i < length-1; ++i) {
        finalSentence.append(args[i]);
        finalSentence.append(" ");  //much more efficient
    }
    finalSentence.append(args[len-1]);
    finalSentence.append(".");

    // Convert the StringBuilder to a String at the end.
    String finalSentenceAsString = finalSentence.toString();
    System.out.println(finalSentenceAsString);
}
```

Multidimensional Arrays

- Declaration:

```
int[][] twoD;
```

- Initialization:

```
int[][] twoDspecified = new int[3][5];  //3 int[] arrays
// each with 5 elements

int[][] twoDunspecified = new  int[3][]; //3 int[] arrays
//each of unspecified length

//ragged array
twoDunspecified[0] = new int[2];
twoDunspecified[1] = new int[3];
twoDunspecified[2] = new int[5];
```

- Array initializers

```
String[][] teams = {
    {"Joe", "Bob", "Frank", "Steve"},
    {"Jon", "Tom","David","Ralph"},
    {"Tim", "Bev","Susan","Dennis"}
};

//specifies a 3 x 4 array
//teams.length is 3
//teams[i].length is 4 (whenever 0<= i <= 2)
//teams[1][2] has value “David” (row 1,
//column 2, start counting from 0)
```

Main Point

Arrays in Java support storage of multiple objects of the same type. Java supports multi-dimensional and ragged arrays; array copy and sort functions (accessible through the System and Arrays classes); and supports convenient forms of declaration and initialization. The data structures mirror the "existence" aspect of consciousness – the nervous system – whereas the *contents* of these structures mirrors the "intelligence" aspect; the pure potentiality of a data structure is as if brought to life by filling it with real data.

Summary

- We introduced the *Reference Example,* which shows how a Java program is composed of objects interacting with each other. More explanation of syntax will be given in Lesson 3.
- Java uses variables to store data, and all variables are given a *type.* The built-in types in Java are the primitive types (char, boolean, int, byte, short, double, float) together with more complex *object* types, to be discussed more in Lesson 3.Data Types:
- Data having primitive type can be manipulated using Java's operators, like +, * (arithmetic), &&, || (logical), and &, | (bitwise)
- An important data type in Java is a String, which provides many string manipulation operations, like `substring, +, indexOf, startsWith, charAt`.
- Procedural flow in a Java program is controlled by conditional logic (if..then..else, switch, and the ternary operator) and loops (for, forEach, while, do..while)
- Data in a Java program is stored in memory using *arrays,* which can be one- or multi-dimensional

Connecting the Parts of Knowledge With the Wholeness of Knowledge

1. In Java, variables of primitive type can be combined using operators to form expressions, which may be evaluated to produce well-defined output values.

2. On a broader scale, objects in Java are "combined“ by objects interacting with other objects, collectively resulting in the behavior of a Java application.

---

3. **Transcendental Consciousness:** Pure consciousness is the field beyond type and interaction; it is the field of *unbounded awareness* and *infinite silence*.
4. **Wholeness moving within itself**: In Unity Consciousness, one observes that this unbounded silent quality of awareness is spontaneously present at all levels of action in the world, and not just relegated to the transcendental field.