CS101
Algorithms and Programming I

Week 3

24/06/2013

Outline

Creating Objects

- A variable holds either a primitive value or a *reference* to an object
- A class name can be used as a type to declare an *object reference variable*

Creating Objects

- Consider the following two declarations:

```
int num;
```

```
// integer variable exists
// but it is not initialized
```

```
String name;
```

```
// No String object actually
//  exists yet!
```

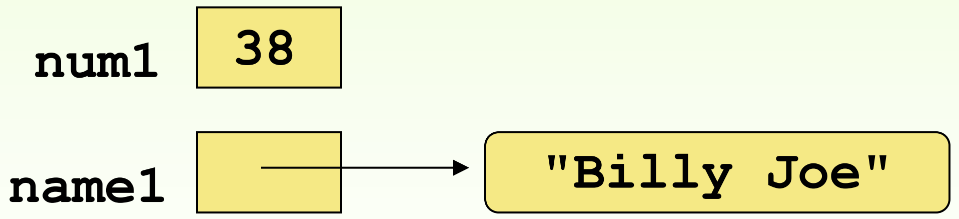
- The first declaration creates a variable that holds an integer value.

- The second declaration creates a String variable that holds a *reference* to a String object.

References

- A primitive variable contains the value itself, but an object variable contains the address of the object
- An object reference can be thought of as a pointer to the location of the object
- Consider the following two declarations:

```
int num1 = 38;
String name1 = new String("Billy Joe");
```



Memory for a String object

- Suppose that name1 contains the memory address AAA1000 in hexadecimal representation. Then, the following memory allocation is true:

Each character in Java is stored in 2 bytes

AAA1000	'B'
AAA1002	'i'
AAA1004	'l'
AAA1006	'l'
AAA1008	'y'
AAA100A	' '
AAA100C	'J'
AAA100E	'o'
AAA1010	'e'

Creating Objects

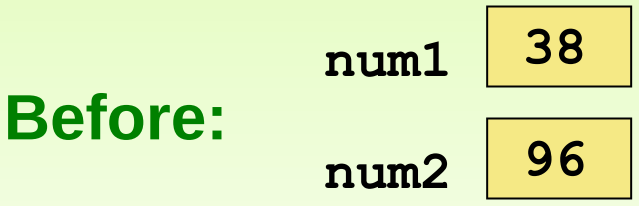
- We use the **`new`** operator to create an object
- Creating an object is called *instantiation*
- An object is an *instance* of a particular class

$$\texttt{name1 = }\underbrace{\texttt{new String ("Billy Joe")}}_{\text{This calls the String \textit{constructor}, which is a special method that sets up the object}}\texttt{;}$$

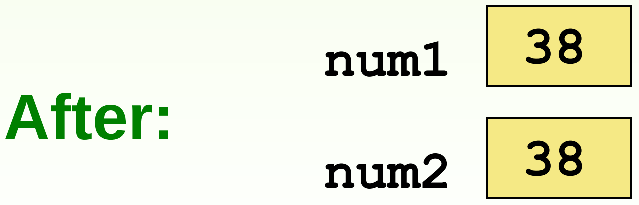
Assignment Revisited

- The act of assignment takes a copy of a value and stores it in a variable

- For primitive types:

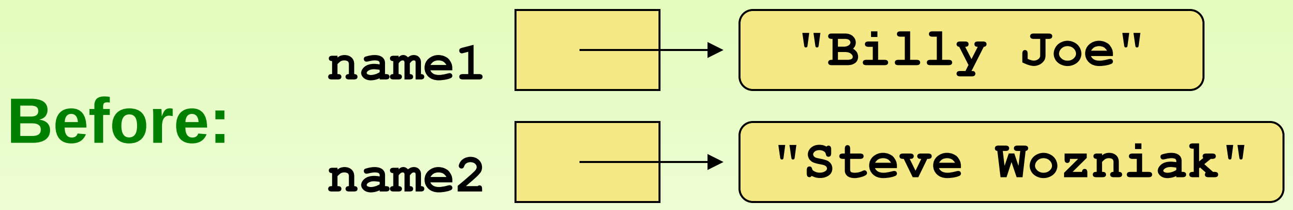


```
num2 = num1;
```

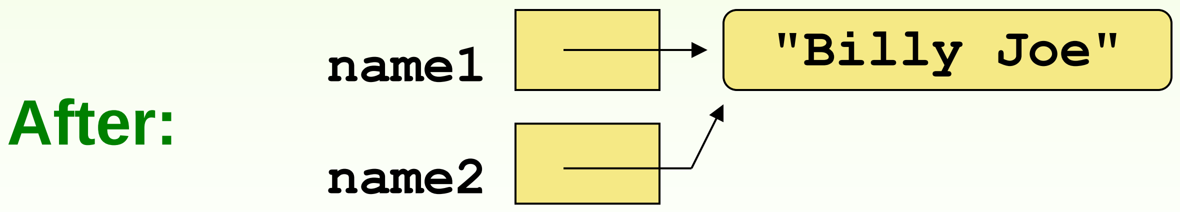


Reference Assignment

- For object references, assignment copies the address:



```
name2 = name1;
```



Aliases

- Two or more references that refer to the same object are called *aliases* of each other
- That creates an interesting situation: one object can be accessed using multiple reference variables
- Aliases can be useful, but should be managed carefully
- Changing an object through one reference changes it for all of its aliases, because there is really only one object

Outline

Class Libraries

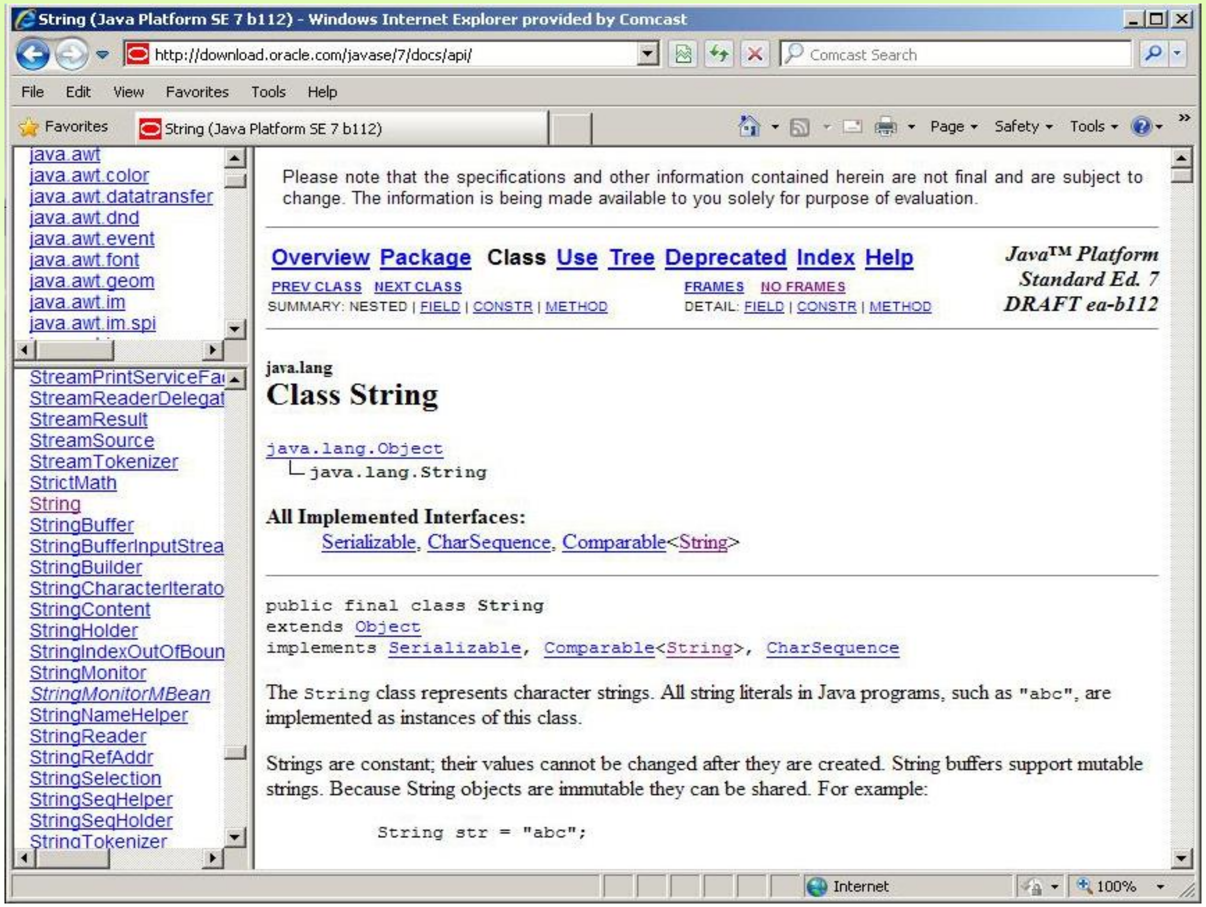
- A *class library* is a collection of classes that we can use when developing programs
- The *Java standard class library* is part of any Java development environment
- Various classes we've already used (`System` , `String`) are part of the Java standard class library

The Java API

- The Java class library is sometimes referred to as the Java API
- API stands for Application Programming Interface

The Java API

- Get comfortable navigating the online Java API documentation



String (Java Platform SE 7 b112) - Windows Internet Explorer provided by Comcast

http://download.oracle.com/javase/7/docs/api/

java.awt
java.awt.color
java.awt.datatransfer
java.awt.dnd
java.awt.event
java.awt.font
java.awt.geom
java.awt.im
java.awt.im.spi

StreamPrintServiceFa
StreamReaderDelegat
StreamResult
StreamSource
StreamTokenizer
StrictMath
String
StringBuffer
StringBufferInputStrea
StringBuilder
StringCharacterIterato
StringContent
StringHolder
StringIndexOutOfBoun
StringMonitor
StringMonitorMBean
StringNameHelper
StringReader
StringRefAddr
StringSelection
StringSeqHelper
StringSeqHolder
StringTokenizer

Please note that the specifications and other information contained herein are not final and are subject to change. The information is being made available to you solely for purpose of evaluation.

Overview Package **Class** Use Tree Deprecated Index Help

PREV CLASS NEXT CLASS — FRAMES NO FRAMES

SUMMARY: NESTED | FIELD | CONSTR | METHOD — DETAIL: FIELD | CONSTR | METHOD

Java™ Platform Standard Ed. 7 DRAFT ea-b112

java.lang

Class String

```
java.lang.Object
  └java.lang.String
```

All Implemented Interfaces:

Serializable, CharSequence, Comparable<String>

```
public final class String
extends Object
implements Serializable, Comparable<String>, CharSequence
```

The `String` class represents character strings. All string literals in Java programs, such as `"abc"`, are implemented as instances of this class.

Strings are constant; their values cannot be changed after they are created. String buffers support mutable strings. Because String objects are immutable they can be shared. For example:

```
     String str = "abc";
```

The Import Declaration

- When you want to use a class from a package, you could use its *fully qualified name*

```
java.util.Scanner
```

- Or you can *import* the class, and then use just the class name

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

- To import all classes in a particular package, you can use the * wildcard character

```
import java.util.*;
```

The String Class

- Because strings are so commonly used, Java treats a string literal as a `String` object. Thus the following statement is valid:

```
String title = "Billy Joe";
```

  instead of

```
String title = new String ("Billy Joe");
```

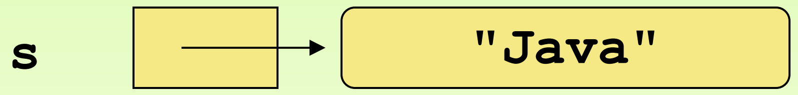
- This is a special syntax that works only for strings

- Each string literal (enclosed in double quotes) represents a **`String`** object

String Objects

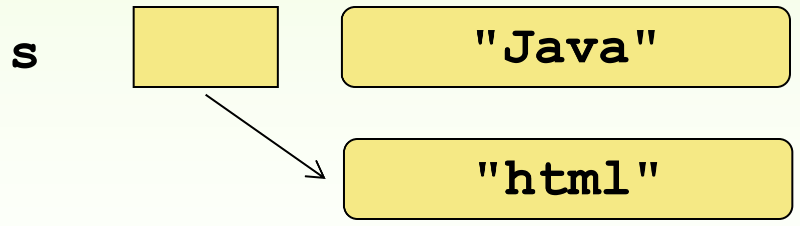
- A `String` object is *immutable; its contents cannot be changed.* Does the following code change the contents of the string?

```
String s = "Java";
```

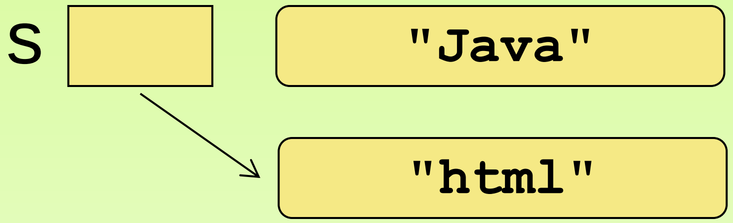


```
s = "html";
```

The answer is NO. Variable s now points to the new string object as shown:

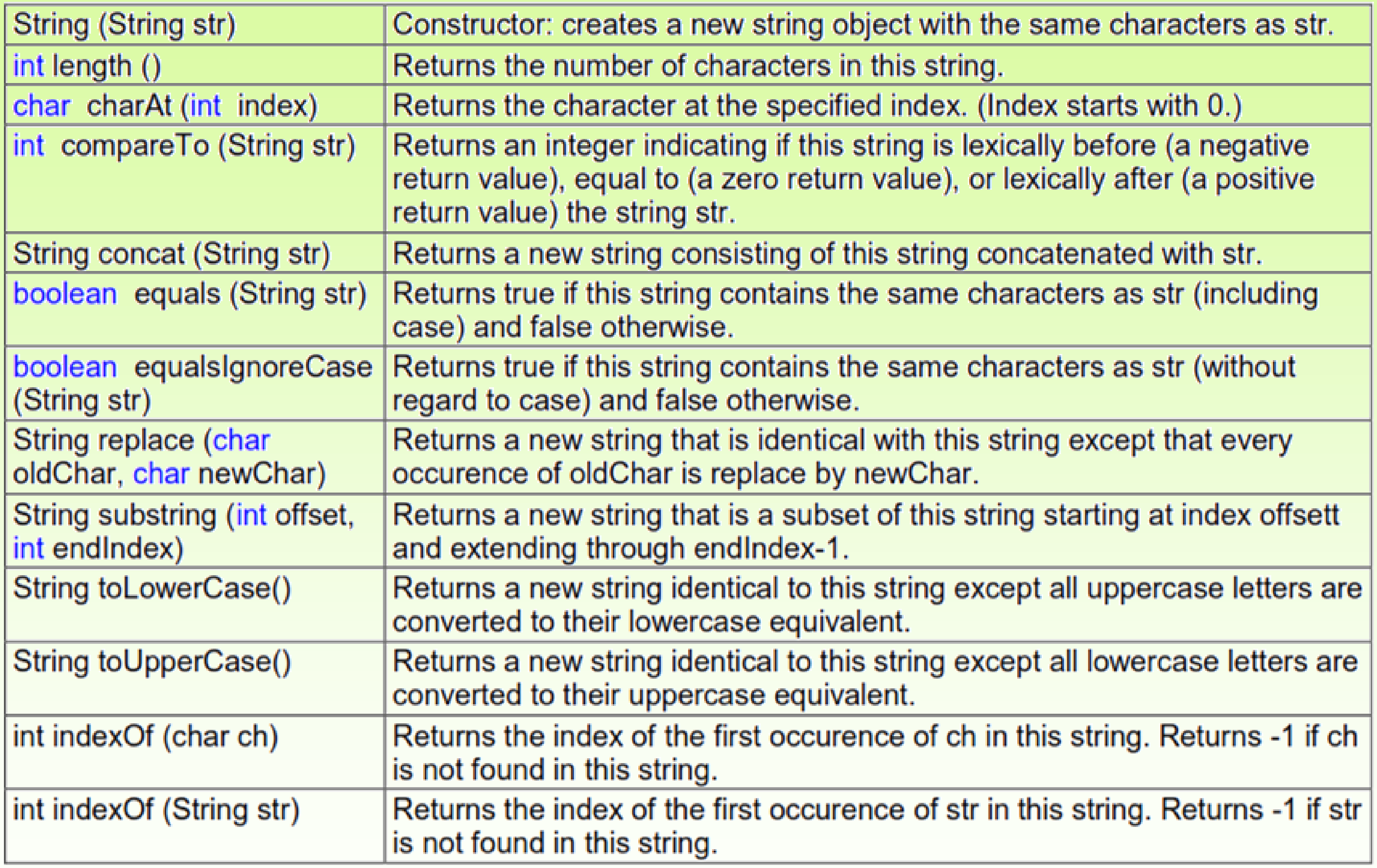


String Objects



The unreferenced String object becomes a garbage. Luckily Java collects its own garbage. The 8 bytes occupied by "Java" is brought back to free memory space.

Some Useful Methods in String Class



String (String str)	Constructor: creates a new string object with the same characters as str.
int length ()	Returns the number of characters in this string.
char charAt (int index)	Returns the character at the specified index. (Index starts with 0.)
int compareTo (String str)	Returns an integer indicating if this string is lexically before (a negative return value), equal to (a zero return value), or lexically after (a positive return value) the string str.
String concat (String str)	Returns a new string consisting of this string concatenated with str.
boolean equals (String str)	Returns true if this string contains the same characters as str (including case) and false otherwise.
boolean equalsIgnoreCase (String str)	Returns true if this string contains the same characters as str (without regard to case) and false otherwise.
String replace (char oldChar, char newChar)	Returns a new string that is identical with this string except that every occurence of oldChar is replace by newChar.
String substring (int offset, int endIndex)	Returns a new string that is a subset of this string starting at index offsett and extending through endIndex-1.
String toLowerCase()	Returns a new string identical to this string except all uppercase letters are converted to their lowercase equivalent.
String toUpperCase()	Returns a new string identical to this string except all lowercase letters are converted to their uppercase equivalent.
int indexOf (char ch)	Returns the index of the first occurence of ch in this string. Returns -1 if ch is not found in this string.
int indexOf (String str)	Returns the index of the first occurence of str in this string. Returns -1 if str is not found in this string.

Other String Class Methods in Java

int `lastIndexOf(char ch)` *or* `lastIndexOf(String str)` Returns the index of the last match of the argument, or −1 if none exists.
boolean `startsWith(String str)` Returns `true` if this string starts with `str`.
boolean `endsWith(String str)` Returns `true` if this string starts with `str`.
String `trim()` Returns a copy of this string with leading and trailing whitespace
String `toLowerCase()` Returns a copy of this string with all uppercase characters changed to lowercase.
String `toUpperCase()` Returns a copy of this string with all lowercase characters changed to uppercase

Checking Strings for Equality

- Many applications will require you to test whether two strings are *equal*, in the sense that they contain the same characters.

- Although it seems natural to do so, you cannot use the == operator for this purpose. While it is legal to write

  ~~`if (s1 == s2) . . .`~~

  the if test will not have the desired effect. When you use == on two objects, it checks whether the objects are *identical*, which means that the references point to the same address.

- What you need to do instead is call the **equals** method:

```
if (s1.equals(s2)) . . .
```

String Class **`equals`**

Checking equality of two Strings

```
import java.util.*;
public class Program {
  public static void main(String[] args) {

           String physicist1 = "Albert Einstein";
           String physicist2 = "Max Planck";
           String physicist3 = "Albert Einstein";

           // Are any of the above Strings equal to one another?
           boolean equals1 = physicist1.equals(physicist2);
           boolean equals2 = physicist1.equals(physicist3);

           // Display the results of the equality checks.
           System.out.println("\"" + physicist1 + "\" equals \""  + physicist2 + "\"? "
                                 + equals1);
           System.out.println("\"" + physicist1 + "\" equals \""  + physicist3 + "\"? "
                                 + equals2);

           // Compare == with equals method
           Scanner scan = new Scanner (System.in);
           String physicist4 = scan.nextLine();
           System.out.println("\"" + physicist1 + "\" == \""  + physicist3 + "\"? " +
                                 (physicist1 == physicist3));
           System.out.println("\"" + physicist1 + "\" == \""  + physicist4 + "\"? " + (
                                 physicist1 == physicist4));

  }
}
```

String Class

Checking equality

Sample Run

```
"Albert Einstein" equals "Max Planck"? false
"Albert Einstein" equals "Albert Einstein"? true
Albert Einstein
"Albert Einstein" == "Albert Einstein"? true
"Albert Einstein" == "Albert Einstein"? false
```

```
import java.util.*;
public class Program {
  public static void main(String[] args) {

           String physicist1 = "Albert Einstein";
           String physicist2 = "Max Planck";
           String physicist3 = "Albert Einstein";

           // Are any of the above Strings equal to one another?
           boolean equals1 = physicist1.equals(physicist2);
           boolean equals2 = physicist1.equals(physicist3);

           // Display the results of the equality checks.
           System.out.println("\"" + physicist1 + "\" equals \""  + physicist2 + "\"? "
                                 + equals1);
           System.out.println("\"" + physicist1 + "\" equals \""  + physicist3 + "\"? "
                                 + equals2);

           // Compare == with equals method
           Scanner scan = new Scanner (System.in);
           String physicist4 = scan.nextLine();
           System.out.println("\"" + physicist1 + "\" == \""  + physicist3 + "\"? " +
                                  (physicist1 == physicist3));
           System.out.println("\"" + physicist1 + "\" == \""  + physicist4 + "\"? " + (
                                 physicist1 == physicist4));


  }
}
```

String Class `equalsIgnoreCase`

```
public class Program2 {
    public static void main(String[] args) {

        String physicist1 = "Albert Einstein";
        String physicist2 = "Max Planck";
        String physicist3 = "albert einstein";

        // Are any of the above Strings equal to one another?
        boolean equals1 = physicist1.equalsIgnoreCase(physicist2);
        boolean equals2 = physicist1.equalsIgnoreCase(physicist3);

        // Display the results of the equality checks
        System.out.println("\"" + physicist1 + "\" equals \"" +
                                   physicist2 + "\"? " + equals1);

        System.out.println("\"" + physicist1 + "\" equals \"" +
                                   physicist3 + "\"? " + equals2);

    }
}
```

String Class equalsIgnoreCase

The **char** at the gi

```
public class Program2 {
    public static void main(String[] args) {

        String physicist1 = "Albert Einstein";
        String physicist2 = "Max Planck";
        String physicist3 = "albert einstein";

        // Are any of the above Strings equal to one another?
        boolean equals1 = physicist1.equalsIgnoreCase(physicist2);
        boolean equals2 = physicist1.equalsIgnoreCase(physicist3);

        // Display the results of the equality checks
        System.out.println("\"" + physicist1 + "\" equals \"" +
                                    physicist2 + "\"? " + equals1);

        System.out.println("\"" + physicist1 + "\" equals \"" +
                                    physicist3 + "\"? " + equals2);

    }
}
```

Sample Run

```
"Albert Einstein" equals "Max Planck"? false
"Albert Einstein" equals "albert einstein"? true
```

Comparing Two Strings

- The compareTo method can also be used to compare two strings:

```
s1.compareTo(s2)
```

returns:

0 if s1 is equal to s2

<0 if s1 is lexicographically less than s2

>0 if s1 is lexicographically greater than s2

Converting, Replacing

`"Welcome".toLowerCase()` returns a new string, **`"welcome"`**

`"Welcome".toUpperCase()` returns a new string, **`"WELCOME"`**

`" Welcome ".trim()` returns a new string, **`"Welcome"`**

`"Welcome".replace('e','A')` returns a new string, **`"WAlcomA"`**

`"Welcome".replaceFirst("e","AB")` returns a new string, **`"WABlcome"`**

`"Welcome".replace("e","AB")` returns a new string, **`"WABlcomAB"`**

`"Welcome".replace("el","AB")` returns a new string, **`"WABcome"`**

String Indexes

- It is helpful to refer to a particular character within a string
- This can be done by specifying the character's numeric *index*
- The indexes begin at zero in each string
- In the string `"Hello"`, the character `'H'` is at index 0 and the `'o'` is at index 4

String Class `charAt`

The **char** at the given index within the String.

```
public class Program3
{
   public static void main(String[] args)
   {
      String str = "Hello, World!";

      // Get the character at positions 0 and 12.
      char ch1 = str.charAt(0);
      char ch2 = str.charAt(12);

     // Print out the results
     System.out.println("The character at position 0 is " + ch1);
     System.out.println("The character at position 12 is " + ch2);

  }
}
```

String Class `charAt`

The **char** at the given index within the String.

```
public class Program3
{
   public static void main(String[] args)
   {
      String str = "Hello, World!";

      // Get the character at positions 0 and 12.
      char ch1 = str.charAt(0);
      char ch2 = str.charAt(12);

     // Print out the results
     System.out.println("The character at position 0 is " + ch1);
     System.out.println("The character at position 12 is " + ch2);

  }
}
```

Sample Run

```
The character at position 0 is H
The character at position 12 is !
```

How to get a char from the user using Scanner class?

As mentioned earlier, the Scanner class does not have a method that returns a char alone. Use the following to extract the first character from a String of 1 (or more..) characters:

```
char ch = scan.next().charAt(0);
```

- See `StringMutation.java`

```java
//********************************************************************
//  StringMutation.java       Author: Lewis/Loftus
//
//  Demonstrates the use of the String class and its methods.
//********************************************************************

public class StringMutation
{
   //-----------------------------------------------------------------
   //  Prints a string and various mutations of it.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      String phrase = "Change is inevitable";
      String mutation1, mutation2, mutation3, mutation4;

      System.out.println ("Original string: \"" + phrase + "\"");
      System.out.println ("Length of string: " + phrase.length());

      mutation1 = phrase.concat (", except from vending machines.");
      mutation2 = mutation1.toUpperCase();
      mutation3 = mutation2.replace ('E', 'X');
      mutation4 = mutation3.substring (3, 30);
```

continued

continued

```
      // Print each mutated string
      System.out.println ("Mutation #1: " + mutation1);
      System.out.println ("Mutation #2: " + mutation2);
      System.out.println ("Mutation #3: " + mutation3);
      System.out.println ("Mutation #4: " + mutation4);

      System.out.println ("Mutated length: " + mutation4.length());
   }
}
```

Output

```
Original string: "Change is inevitable"
Length of string: 20
Mutation #1: Change is inevitable, except from vending machines.
Mutation #2: CHANGE IS INEVITABLE, EXCEPT FROM VENDING MACHINES.
Mutation #3: CHANGX IS INXVITABLX, XXCXPT FROM VXNDING MACHINXS.
Mutation #4: NGX IS INXVITABLX, XXCXPT F
Mutated length: 27
```

```
      System.out.println ("Mutated length: " + mutation4.length());
   }
}
```

Quick Check

What output is produced by the following?

```
String str = "Space, the final frontier.";
System.out.println (str.length());
System.out.println (str.substring(7));
System.out.println (str.toUpperCase());
System.out.println (str.length());
```

Quick Check

What output is produced by the following?

```
String str = "Space, the final frontier.";
System.out.println (str.length());
System.out.println (str.substring(7));
System.out.println (str.toUpperCase());
System.out.println (str.length());
```

```
26
the final frontier.
SPACE, THE FINAL FRONTIER.
26
```

Extracting Substring

- The `substring` method makes it possible to extract a piece of a larger string by providing index numbers that determine the extent of the substring.
- The general form of the `substring` call is

```
str.substring(p1, p2);
```

  where `p1` is the first index position in the desired substring and `p2` is the index position immediately following the last position in the substring.

- As an example, if you wanted to select the substring `"ell"` from a string variable `str` containing `"hello, world"` you would make the following call:

```
str.substring(1, 4);
```

String Example

- Reverse a string
  - Take input from the user
  - Reverse the input
  - Print out the user input and the reversed version of the string

<u>Output</u>

```
Please type the original text:Cs114
The reversed text:  411sC
```

See ReverseString.java

Searching within a String: `indexOf`

`int indexOf(char ch)`

Returns the index of the first occurrence of **`char ch`** in this string. Returns -1 if not matched.

`int indexOf(char ch, int fromIndex)`

Returns the index of the first occurrence of **`char ch`** in this string after **`fromIndex`**. Returns -1 if not matched.

`int indexOf(String s)`

Returns the index of the first occurrence of **`String cs`** in this string. Returns -1 if not matched.

`int indexOf(String s, int fromIndex)`

Returns the index of the first occurrence of **`String s`** in this string after **`fromIndex`**. Returns -1 if not matched.

Searching within a String: `lastIndexOf`

`int lastIndexOf(char ch)`

Returns the index of the last occurrence of **`char ch`** in this string. Returns -1 if not matched.

`int lastIndexOf(char ch, int fromIndex)`

Returns the index of the last occurrence of **`char ch`** in this string before **`fromIndex`**. Returns -1 if not matched.

`int lastIndexOf(String s)`

Returns the index of the last occurrence of **`String cs`** in this string. Returns -1 if not matched.

`int lastIndexOf(String s, int fromIndex)`

Returns the index of the last occurrence of **`String s`** in this string before **`fromIndex`**. Returns -1 if not matched.

Searching within a string

```
  0   3   5   9 11
```

"Welcome to Java".`indexOf('W')` returns **0**.

"Welcome to Java".`indexOf('o')` returns **4**.

"Welcome to Java".`indexOf('o', 5)` returns **9**.

"Welcome to Java".`indexOf("come")` returns **3**.

"Welcome to Java".`indexOf("Java", 5)` returns **11**.

"Welcome to Java".`indexOf("java", 5)` returns **-1**.

"Welcome to Java".`lastIndexOf('W')` returns **0**.

"Welcome to Java".`lastIndexOf('o')` returns **9**.

"Welcome to Java".`lastIndexOf('o', 5)` returns **4**.

"Welcome to Java".`lastIndexOf("come")` returns **3**.

"Welcome to Java".`lastIndexOf("Java", 5)` **returns -1.**

"Welcome to Java".`lastIndexOf("Java")` **returns 11.**

String Class Example

- How would you replace a word within a String with another one? (Without using replace method)

- See ReplaceOccurence.java

String Class Examples

- How would you replace a word within a String with another one? (Without using replace method)
- See ReplaceOccurence.java
- Or you could use the replace method of String class:

```
str.replace(repFrom, repTo);
```

Outline

Useful Methods in the **`Character`** Class

`static boolean isDigit(char ch)` Determines if the specified character is a digit.
`static boolean isLetter(char ch)` Determines if the specified character is a letter.
`static boolean isLetterOrDigit(char ch)` Determines if the specified character is a letter or a digit.
`static boolean isLowerCase(char ch)` Determines if the specified character is a lowercase letter.
`static boolean isUpperCase(char ch)` Determines if the specified character is an uppercase letter.
`static boolean isWhitespace(char ch)` Determines if the specified character is whitespace (spaces and tabs).
`static char toLowerCase(char ch)` Converts `ch` to its lowercase equivalent, if any. If not, `ch` is returned
`static char toUpperCase(char ch)` Converts `ch` to its uppercase equivalent, if any. If not, `ch` is returned unchanged.

Character Class

`See` `CharacterLowerCaseExample.java`

Character Class

```java
public class CharacterLowerCaseExample {
    public static void main(String[] args)    {

        char c1 = 'A';
        char c2 = 'a';

        boolean b1 = Character.isLowerCase(c1);
        boolean b2 = Character.isLowerCase(c2);

        if(b1 == true){
           System.out.println(c1 + " is lowercase.");
        }
        else{
           System.out.println(c1 + " is not lowercase.");
        }
        if(b2 == true){
           System.out.println(c2 + " is lowercase.");
        }
        else{
           System.out.println(c2 + " is not lowercase.");
        }
    }
}
```

Outline

The Random Class

- The **`Random`** class is part of the **`java.util`** package
- It provides methods that generate pseudorandom numbers
- A **`Random`** object performs complicated calculations based on a *seed value* to produce a stream of seemingly random values
- See **`RandomNumbers.java`**

```
//********************************************************************
//  RandomNumbers.java       Author: Lewis/Loftus
//
//  Demonstrates the creation of pseudo-random numbers using the
//  Random class.
//********************************************************************

import java.util.Random;

public class RandomNumbers
{
   //-----------------------------------------------------------------
   //  Generates random numbers in various ranges.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      Random generator = new Random();
      int num1;
      float num2;

      num1 = generator.nextInt();
      System.out.println ("A random integer: " + num1);

      num1 = generator.nextInt(10);
      System.out.println ("From 0 to 9: " + num1);
```

continued

continued

```
      num1
      Syst

      num1
      Syst

      num1
      Syst
```

Sample Run

```
A random integer: 672981683
From 0 to 9: 0
From 1 to 10: 3
From 20 to 34: 30
From -10 to 9: -4
A random float (between 0-1): 0.18538326
From 1 to 6: 3
```

```
      num2 = generator.nextFloat();
      System.out.println ("A random float (between 0-1): " + num2);

      num2 = generator.nextFloat() * 6;  // 0.0 to 5.999999
      num1 = (int)num2 + 1;
      System.out.println ("From 1 to 6: " + num1);
   }
}
```

Quick Check

Given a **`Random`** object named **`gen`**, what range of values are produced by the following expressions?

```
gen.nextInt(25)

gen.nextInt(6) + 1

gen.nextInt(100) + 10

gen.nextInt(50) + 100

gen.nextInt(10) – 5

gen.nextInt(22) + 12
```

Quick Check

Given a **`Random`** object named **`gen`**, what range of values are produced by the following expressions?

	Range
`gen.nextInt(25)`	`0 to 24`
`gen.nextInt(6) + 1`	`1 to 6`
`gen.nextInt(100) + 10`	`10 to 109`
`gen.nextInt(50) + 100`	`100 to 149`
`gen.nextInt(10) – 5`	`-5 to 4`
`gen.nextInt(22) + 12`	`12 to 33`

Quick Check

Write an expression that produces a random integer in the following ranges:

Range

`0 to 12`

`1 to 20`

`15 to 20`

`-10 to 0`

Quick Check

Write an expression that produces a random integer in the following ranges:

Range	
`0 to 12`	`gen.nextInt(13)`
`1 to 20`	`gen.nextInt(20) + 1`
`15 to 20`	`gen.nextInt(6) + 15`
`-10 to 0`	`gen.nextInt(11) – 10`

Outline

The Math Class

- The `Math` class is part of the `java.lang` package
- The `Math` class contains methods that perform various mathematical functions
- These include:
  - absolute value
  - square root
  - exponentiation
  - trigonometric functions

The Math Class

- The methods of the `Math` class are *static methods* (also called *class methods*)

- Static methods are invoked through the class name – no object of the `Math` class is needed

```
value = Math.cos(90) + Math.sqrt(delta);
```

- We discuss static methods further in Chapter 7

- See `Quadratic.java`

```
//********************************************************************
//  Quadratic.java       Author: Lewis/Loftus
//
//  Demonstrates the use of the Math class to perform a calculation
//  based on user input.
//********************************************************************

import java.util.Scanner;

public class Quadratic
{
   //-----------------------------------------------------------------
   //  Determines the roots of a quadratic equation.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      int a, b, c;  // ax^2 + bx + c
      double discriminant, root1, root2;

      Scanner scan = new Scanner (System.in);

      System.out.print ("Enter the coefficient of x squared: ");
      a = scan.nextInt();
```

continued

continued

```
      System.out.print ("Enter the coefficient of x: ");
      b = scan.nextInt();

      System.out.print ("Enter the constant: ");
      c = scan.nextInt();

      // Use the quadratic formula to compute the roots.
      // Assumes a positive discriminant.

      discriminant = Math.pow(b, 2) - (4 * a * c);
      root1 = ((-1 * b) + Math.sqrt(discriminant)) / (2 * a);
      root2 = ((-1 * b) - Math.sqrt(discriminant)) / (2 * a);

      System.out.println ("Root #1: " + root1);
      System.out.println ("Root #2: " + root2);
   }
}
```

Useful Methods in the `Math` Class

`Math.abs(`*x*`)`	Returns the absolute value of *x*
`Math.min(`*x*`,` *y*`)`	Returns the smaller of *x* and *y*
`Math.max(`*x*`,` *y*`)`	Returns the larger of *x* and *y*
`Math.sqrt(`*x*`)`	Returns the square root of *x*
`Math.log(`*x*`)`	Returns the natural logarithm of *x* ($\log_e x$)
`Math.exp(`*x*`)`	Returns the inverse logarithm of *x* (e^x)
`Math.pow(`*x*`,` *y*`)`	Returns the value of *x* raised to the *y* power (x^y)
`Math.sin(`*theta*`)`	Returns the sine of *theta,* measured in radians
`Math.cos(`*theta*`)`	Returns the cosine of *theta*
`Math.tan(`*theta*`)`	Returns the tangent of *theta*
`Math.asin(`*x*`)`	Returns the angle whose sine is *x*
`Math.acos(`*x*`)`	Returns the angle whose cosine is *x*
`Math.atan(`*x*`)`	Returns the angle whose tangent is *x*
`Math.toRadians(`*degrees*`)`	Converts an angle from degrees to radians
`Math.toDegrees(`*radians*`)`	Converts an angle from radians to degrees

Math Example

- The following code provides examples on the use of most of the Math methods.
- Notice how we invoke the methods (without using a Math object)

`HW: Study MathExample.java`

Other Exercises

- See Converter.java

Outline

Formatting Output

- It is often necessary to format output values in certain ways so that they can be presented properly
- The Java standard class library contains classes that provide formatting capabilities
- The `NumberFormat` class allows you to format values as currency or percentages
- The `DecimalFormat` class allows you to format values based on a pattern
- Both are part of the `java.text` package

Formatting Output

- The `NumberFormat` class has static methods that return a formatter object

```
getCurrencyInstance()

getPercentInstance()
```

- Each formatter object has a method called `format` that returns a string with the specified information in the appropriate format
- See `Purchase.java`

```
//********************************************************************
//  Purchase.java       Author: Lewis/Loftus
//
//  Demonstrates the use of the NumberFormat class to format output.
//********************************************************************

import java.util.Scanner;
import java.text.NumberFormat;

public class Purchase
{
   //-----------------------------------------------------------------
   //  Calculates the final price of a purchased item using values
   //  entered by the user.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      final double TAX_RATE = 0.06;  // 6% sales tax

      int quantity;
      double subtotal, tax, totalCost, unitPrice;

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

continued

continued

```
      NumberFormat fmt1 = NumberFormat.getCurrencyInstance();
      NumberFormat fmt2 = NumberFormat.getPercentInstance();

      System.out.print ("Enter the quantity: ");
      quantity = scan.nextInt();

      System.out.print ("Enter the unit price: ");
      unitPrice = scan.nextDouble();

      subtotal = quantity * unitPrice;
      tax = subtotal * TAX_RATE;
      totalCost = subtotal + tax;

      // Print output with appropriate formatting
      System.out.println ("Subtotal: " + fmt1.format(subtotal));
      System.out.println ("Tax: " + fmt1.format(tax) + " at "
                          + fmt2.format(TAX_RATE));
      System.out.println ("Total: " + fmt1.format(totalCost));
   }
}
```

continued

```
      NumberFormat f
      NumberFormat f

      System.out.pri
      quantity = sca

      System.out.print ("Enter the unit price: ");
      unitPrice = scan.nextDouble();

      subtotal = quantity * unitPrice;
      tax = subtotal * TAX_RATE;
      totalCost = subtotal + tax;

      // Print output with appropriate formatting
      System.out.println ("Subtotal: " + fmt1.format(subtotal));
      System.out.println ("Tax: " + fmt1.format(tax) + " at "
                          + fmt2.format(TAX_RATE));
      System.out.println ("Total: " + fmt1.format(totalCost));
   }
}
```

```
tance();
ance();
```

Sample Run

```
Enter the quantity: 5
Enter the unit price: 3.87
Subtotal: $19.35
Tax: $1.16 at 6%
Total: $20.51
```

Formatting Output

- The `DecimalFormat` class can be used to format a floating point value in various ways
- For example, you can specify that the number should be truncated to three decimal places
- The constructor of the `DecimalFormat` class takes a string that represents a pattern for the formatted number
- See `CircleStats.java`

```
//********************************************************************
//  CircleStats.java       Author: Lewis/Loftus
//
//  Demonstrates the formatting of decimal values using the
//  DecimalFormat class.
//********************************************************************

import java.util.Scanner;
import java.text.DecimalFormat;

public class CircleStats
{
   //-----------------------------------------------------------------
   //  Calculates the area and circumference of a circle given its
   //  radius.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      int radius;
      double area, circumference;

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

continued

continued

```
      System.out.print ("Enter the circle's radius: ");
      radius = scan.nextInt();

      area = Math.PI * Math.pow(radius, 2);
      circumference = 2 * Math.PI * radius;

      // Round the output to three decimal places
      DecimalFormat fmt = new DecimalFormat ("0.###");

      System.out.println ("The circle's area: " + fmt.format(area));
      System.out.println ("The circle's circumference: "
                          + fmt.format(circumference));
   }
}
```

continued

```
      System.ou
      radius =

      area = Math.PI * Math.pow(radius, 2);
      circumference = 2 * Math.PI * radius;

      // Round the output to three decimal places
      DecimalFormat fmt = new DecimalFormat ("0.###");

      System.out.println ("The circle's area: " + fmt.format(area));
      System.out.println ("The circle's circumference: "
                          + fmt.format(circumference));
   }
}
```

Sample Run

```
Enter the circle's radius: 5
The circle's area: 78.54
The circle's circumference: 31.416
```

Using Locale class

- What if you want to display Euro symbol, but not the default money symbol on your computer?
- The answer is to use a country that uses Euro as the currency symbol as the parameter for the getCurrencyInstance method of the NumberFormat class.
- You can also generete your own Locale like tr in the following example
- See EuroSymbol.java

Using useLocale() method

- Have you ever encountered the run-time error, InputMismatchException when you have tried to input a floating-point number with an incorrect decimal point symbol?
- Would you not prefer to make sure that you can use the . as the decimal point ?
- See ReadingInUSLocale.java

Outline

Scanner

- In our examples Scanner was reading input from System.in
- Example:

```
Scanner scan = new Scanner (System.in);
int i = scan.nextInt();
```

This example reads a single int from System.in

We will now change the parameter, `System.in`

Reading File: The `File` Class

- How are we going to get a reference to a file on our disk?

```
// Need to import to use File class
import java.io.*;

String myFilename = "example.txt “;
File myfile = new File(myFilename);
```

The Scanner class

Pass the File object as a parameter to the Scanner class

```
String myFilename = "example.txt “;
File myFile = new File( myFilename );
Scanner input = new Scanner( myFile );
```

Compiler Error with Files

- Would the following program compile?

```
import java.io.*;       // for File
import java.util.Scanner;   // for Scanner
public class ReadFile {
     public static void main(String[] args) {

         String myFilename = “data.txt”;
         File myFile = new File(myFilename);
         Scanner input = new Scanner(myFile);

         String text = input.next();
         System.out.println(text);

         input.close();
     }
 }
```

Compiler Error with Files

- The following program does not compile:

```
import java.io.*;       // for File
import java.util.Scanner;   // for Scanner
public class ReadFile {
     public static void main(String[] args) {

         String myFilename = “data.txt”;
         File myFile = new File(myFilename);
         Scanner input = new Scanner(myFile);

         String text = input.next();
         System.out.println(text);

         input.close();
     }
 }
```

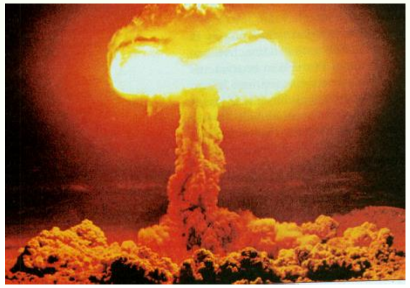
- The following error occurs:

```
ReadFile.java:6: unreported exception java.io.FileNotFoundException;
must be caught or declared to be thrown
        Scanner input = new Scanner(new File("data.txt"));
                        ^
```

Exceptions

- **Exception**: An object representing a runtime error.
    - dividing an integer by 0
    - calling charAt on a String with a large index
    - trying to read the wrong type of value from a Scanner
    - trying to read a file that does not exist

- A program with an error "*throws*" an exception.
- It is also possible to "*catch*" (handle or fix) an exception.



The `throws` Clause

- **`throws` clause**: Keywords on a method's header that state that it may generate an exception.
- Like saying, "I hereby announce that this method might throw an exception, and I accept the consequences if it happens."

- **Syntax:**

```
public static type name(params) throws type {
```

- **Example:**

```
public class ReadFile {
    public static void main(String[] args)
            throws IOException{
```

Reading an Entire File

- Suppose we want our program to process the entire file; for instance find the sum of all numbers stored in a file regardless of the number of values stored in a file.

- How can we achieve this?

Testing for Valid Input: hasNext Methods

- Scanner hasNext Methods are useful to see what input is coming, and to avoid crashes

Method	Description
`boolean hasNext()`	returns true if there are any more tokens of input to read *(always true for console input)*
`boolean hasNextInt()`	returns true if there is a next token and it can be read as an int
`boolean hasNextDouble()`	returns true if there is a next token and it can be read as a double
`boolean hasNextLine()`	returns true if there is a next line of input

- These methods do not consume input; they just give information about the next token.

How to iterate until the end of file?

EchoFile2.java

EchoFileNumbers.txt

- Find the number of lines in a given input file
- See `FindNumberOfLines.java`

File Reading Example

Find the number of space (' '), comma (',') and dot ('.') in each line and in the file and report it to the user.

- Check out `CountPunctuationSpace.java`

Example

- Check this one at home: `SearchFile.java`

Outline

Writing Text Files

- We have to create `PrintWriter` objects for writing text to any file using `print`, `println` and `printf` methods.

- The close() method of the `PrintWriter` class must be used to close the file. If this method is not invoked the data may not be saved properly in the file.

Writing Text Files

Write a Java program that generates 10 random numbers per line for 10 lines and stores these numbers in a text file.

- See `TestData.java`

```
//********************************************************************
//  TestData.java       Author: Lewis/Loftus
//
//  Demonstrates I/O exceptions and the use of a character file
//  output stream.
//********************************************************************

import java.util.Random;
import java.io.*;

public class TestData
{
   //-----------------------------------------------------------------
   //  Creates a file of test data that consists of ten lines each
   //  containing ten integer values in the range 10 to 99.
   //-----------------------------------------------------------------
   public static void main (String[] args) throws IOException
   {
      final int MAX = 10;

      int value;
      String file = "ourtest.dat";

      Random rand = new Random();
```

continue

continue

```
     PrintWriter outFile = new PrintWriter (file);

       for (int line=1; line <= MAX; line++)
       {
          for (int num=1; num <= MAX; num++)
          {
             value = rand.nextInt (90) + 10;
             outFile.print (value + "   ");
          }
          outFile.println ();
       }

       outFile.close();
       System.out.println ("Output file has been created: " + file);
    }
 }
```

continue

```
      FileW
      PrintWriter outFile = new PrintWriter (fw);

      for (int line=1; line <= MAX; line++)
      {



      }

      ou
      Sy                                                         );
   }
}
```

Output

```
Output file has been created: test.dat
```

Sample ourtest.dat File

```
77    46    24    67    45    37    32    40    39
10
90    91    71    64    82    80    68    18    83
89
25    80    45    75    74    40    15    90    79
59
44    43    95    85    93    61    15    20    52
86
60    85    18    73    56    41    35    67    21
42
93    25    89    47    13    27    51    94    76
13
33    25    48    42    27    24    88    18    32
17
71    10    90    88    60    19    89    54    21
```

File Read and Write

Modify the `CountPunctuationSpace.java` such that the output is written on file

- Check out **`CountPunctuationSpace2.java`**

Outline

We used many methods up to now

`int lastIndexOf(char ch)` *or* `lastIndexOf(String str)`
Returns the index of the last match of the argument, or −1 if none exists.

`boolean equalsIgnoreCase(String str)`
Returns `true` if this string and `str` are the same, ignoring differences in

`boolean startsWith(String str)`
Returns `true` if this string starts with `str`.

`boolean endsWith(String str)`
Returns `true` if this string starts with `str`.

`String replace(char c1, char c2)`
Returns a copy of this string with all instances of `c1` replaced by `c2`.

`String trim()`
Returns a copy of this string with leading and trailing whitespace

`String toLowerCase()`
Returns a copy of this string with all uppercase characters changed to

`String toUpperCase()`
Returns a copy of this string with all lowercase characters changed to
uppercase

Useful Methods in the **`Math`** Class

`Math.abs(`*x*`)`	Returns the absolute value of *x*
`Math.min(`*x*`, `*y*`)`	Returns the smaller of *x* and *y*
`Math.max(`*x*`, `*y*`)`	Returns the larger of *x* and *y*
`Math.sqrt(`*x*`)`	Returns the square root of *x*
`Math.log(`*x*`)`	Returns the natural logarithm of *x* ($\log_e x$)
`Math.exp(`*x*`)`	Returns the inverse logarithm of *x* (e^x)
`Math.pow(`*x*`, `*y*`)`	Returns the value of *x* raised to the *y* power (x^y)
`Math.sin(`*theta*`)`	Returns the sine of *theta*, measured in radians
`Math.cos(`*theta*`)`	Returns the cosine of *theta*
`Math.tan(`*theta*`)`	Returns the tangent of *theta*
`Math.asin(`*x*`)`	Returns the angle whose sine is *x*
`Math.acos(`*x*`)`	Returns the angle whose cosine is *x*
`Math.atan(`*x*`)`	Returns the angle whose tangent is *x*
`Math.toRadians(`*degrees*`)`	Converts an angle from degrees to radians
`Math.toDegrees(`*radians*`)`	Converts an angle from radians to degrees

Divide and Conquer

- Break large programs into a series of smaller methods:
  - Helps manage complexity
  - Makes it easier to build large programs
  - Makes is easier to debug programs
  - Reusability

Methods

- Local variables
  - Declared in method declaration
- Parameters
  - Communicates information into the methods
- Return value
  - Communicates information to the outside of the method

Methods

Write a java method, maximum instead of using Math.max(x,y)

See MyMax.java

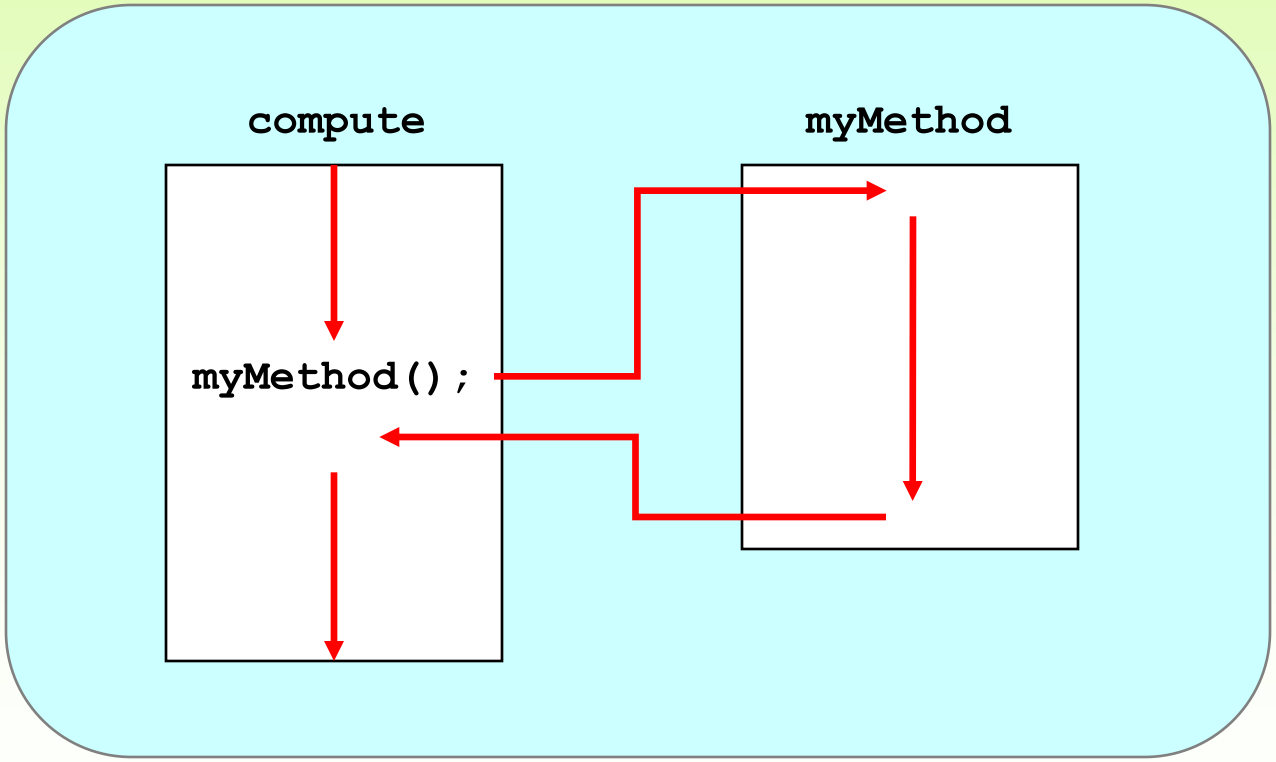
Now we'll learn how to write such methods.

Method Declarations

- A *method declaration* specifies the code that will be executed when the method is invoked (called)
- When a method is invoked, the flow of control jumps to the method and executes its code
- When complete, the flow returns to the place where the method was called and continues
- The invocation may or may not return a value, depending on how the method is defined

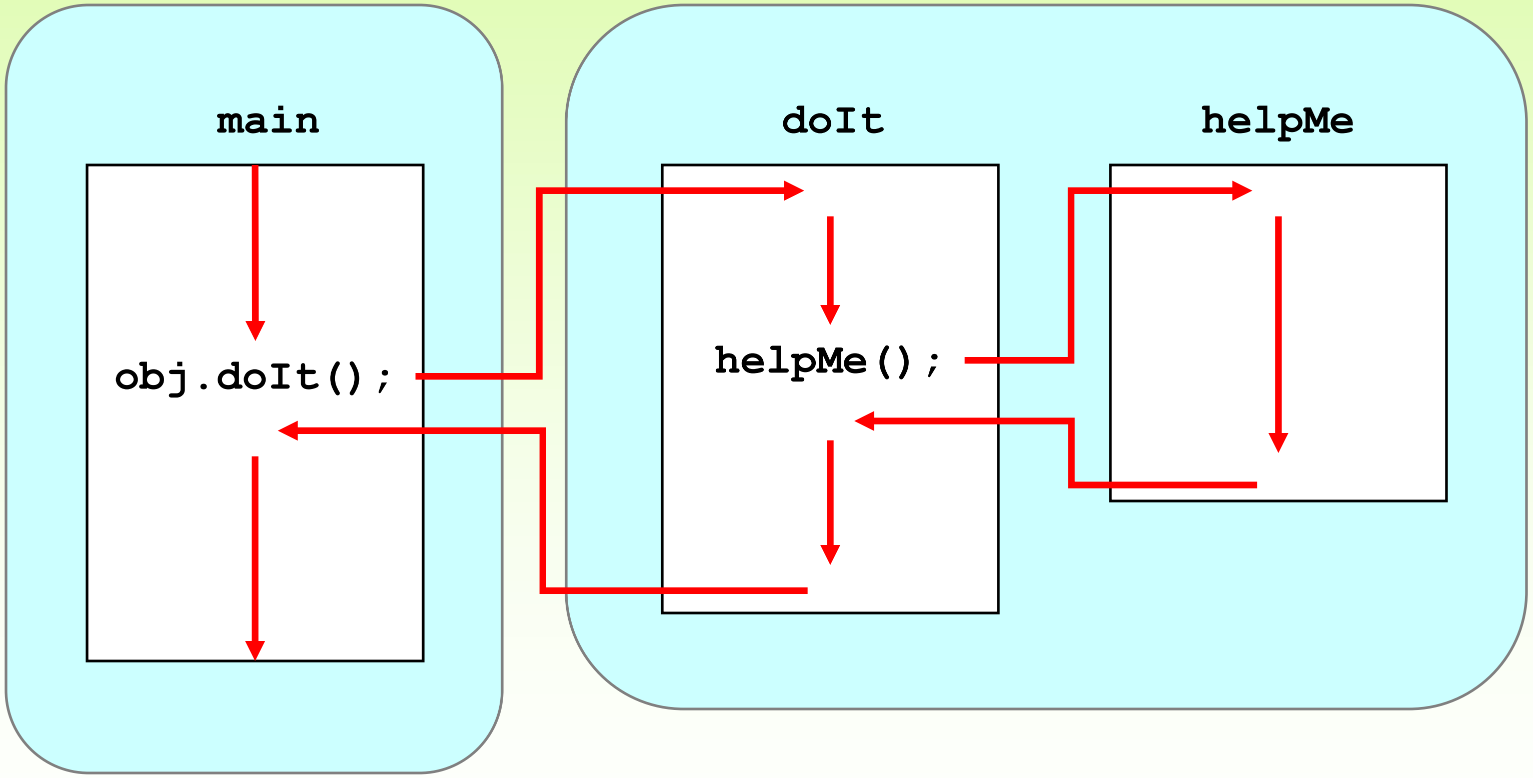
Control Flow on Invoking a Method

- If the called method is in the same class, only the method name is needed



Control Flow on Invoking a Method

- The called method is often part of another class or object



Methods Header

- What information can you learn about a method from its header?

```
public static void calc (int num1, String  message)
```

Method Body

- The method header is followed by the *method body*

```
public static char calc (int num1, int num2, String message)
  {
     int sum = num1 + num2;
     char result = '*';

     if (sum>=0 && sum < message.length() )
        result = message.charAt (sum);

     return result;
  }
```

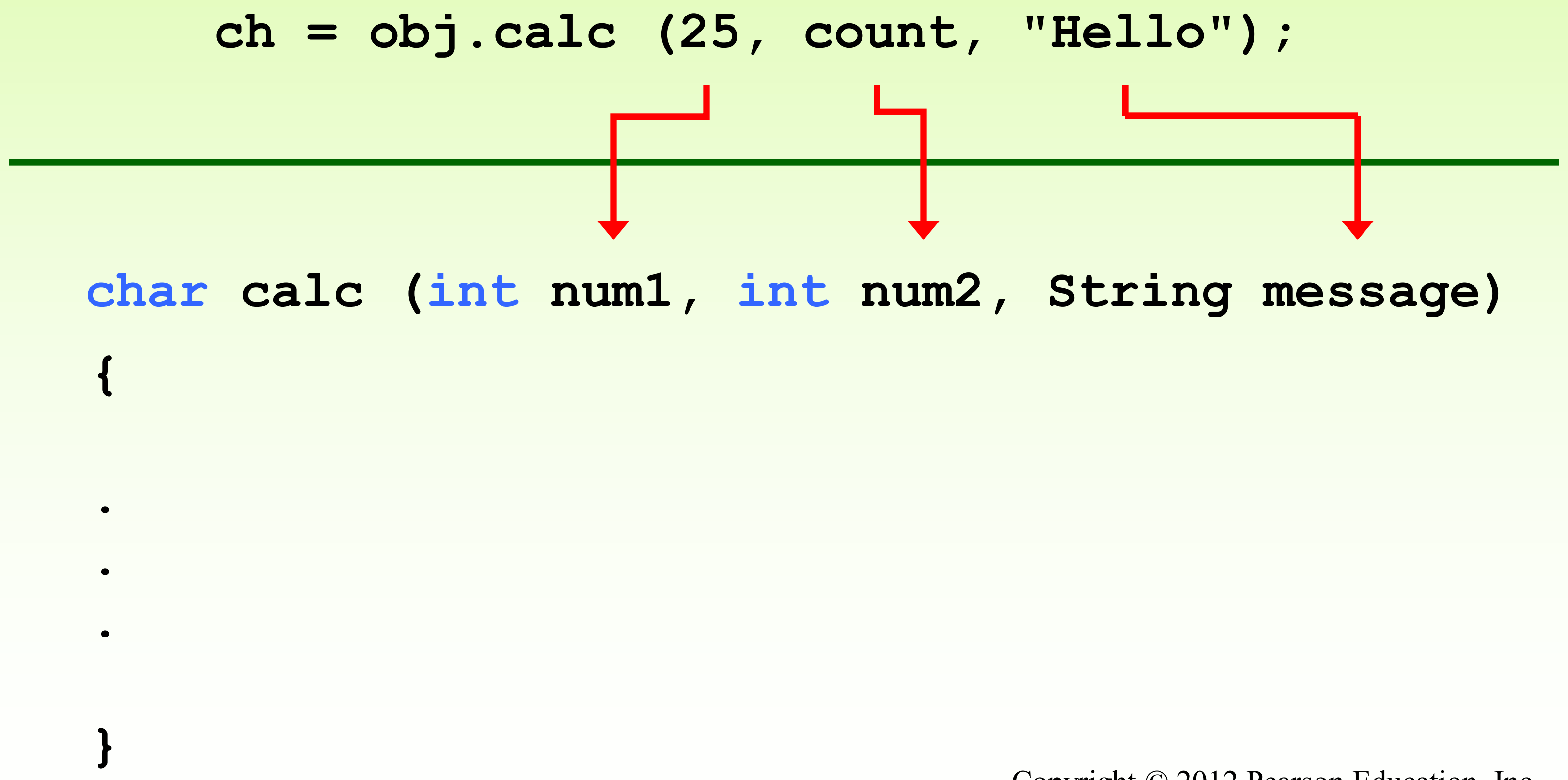
The return expression must be consistent with the return type

`sum` **and** `result` **are local data**

They are created each time the method is called, and are destroyed when it finishes executing

Parameters

- When a method is called, the *actual parameters* in the invocation are copied into the *formal parameters* in the method header



```
ch = obj.calc (25, count, "Hello");
```

```
char calc (int num1, int num2, String message)
{

.
.
.

}
```

Parameter Data Types

- You can pass as many parameters as you like.
- To pass more than one parameter, you need to separate the parameters with commas.

```
public static int maximum (int x, int y)
{
  /*body*/
}
```

No Parameters

- You can also have a method that accepts no parameters. The parameter list is empty:

```
public static int rollDie ()

public static void printIntro ()
```

The return Statement

- The *return type* of a method indicates the type of value that the method sends back to the calling location
- A method that does not return a value has a `void` return type
- A *return statement* specifies the value that will be returned

```
              return expression;
```

- Its expression must conform to the return type

Return Value Types

- You may have multiple return statement expressions (through if, nested if, switch etc)
- You can only return at most one value from a method.

Modify MyMax.java program to find the maximum among 3 numbers.

- See `MyMax3.java`

- Exercise: Modify the **`Palindrome.java`** such that it includes a **`isPalindrome`** method

- See **`Palindrome2.java`**

Returning `void`

- `void`: means nothing
- A method that returns void returns nothing.

  ```
  public static void printIntro (int n)
  ```

- void methods can optionally use a return statement with no value:
  - `return;`
  - There is no need for the optional return statement. But occasionally you might need it to force the program for an early exit from the method.

Methods That Don’t Return Anything

```
public static void printIntro() {
    System.out.println("Welcome to CS114");
    System.out.println("It's the best part of my day :P");
}
```

Local Data

- Local variables can be declared inside a method
- The formal parameters of a method create *automatic local variables* when the method is invoked
- When the method finishes, all local variables are destroyed (including the formal parameters)

The static Modifier

- We declare static using the `static` modifie
- Static method is one that can be invoked through its class name as opposed to an object of the class
- Static methods are sometimes called *class methods*
- For example, the methods of the `Math` class are static:

```
result = Math.sqrt(25)
```

Static Methods

- There is no need to instantiate an object of the class in order to invoke the method.

$$\begin{tikzcd}
\texttt{ClassName.} \arrow[d] & \texttt{methodName} \arrow[d] & \texttt{(args)} \arrow[d] \\
\texttt{Math.} & \texttt{sqrt} & \texttt{(28);}
\end{tikzcd}$$

- All the methods of the Math class are static.

Static Methods

```
public static int max(int val1, int val2) {

   if (val1 > val2) {
      return val1;
   }
   else {
      return val2;
   }
}
```

Let’s say this belongs to a class named Calculator

```
int myMax = Calculator.max(9, 2);
```

Static Methods

```
public class Helper
{
   public static int cube (int num)
   {
      return num * num * num;
   }
}
```

- Because it is declared as static, the cube method can be invoked through the class name:

```
value = Helper.cube(4);
```

- By convention visibility modifiers come first (private, or public determines visibility)

Main Method

- Recall that the `main` method is static – it is invoked by the Java interpreter without creating an object

```
public static void main (String[] args )
```

Exercise

- Modify the following code according to the comments
- See `Circle.java`