Mathematical Functions, Characters, and Strings

CSE 114: Introduction to Object-Oriented Programming

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Contents

- Static vs. non-static methods
- The java.lang.Math Class API
  - Trigonometric methods
  - Exponent methods
  - Rounding methods
  - min, max, abs, and random methods
  - The random Method
- Characters
- The java.lang.String Type
  - Reading a String from the Console
  - Useful String functions
    - length, charAt, concat, substring, equals, compareTo, indexOf
  - Strings are immutable!
  - Comparing Strings
  - Interned Strings
  - Conversion between Strings and Numbers
- Formatting the Output

Static vs. non-static methods

- Remember the main method header?

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

  - What does **`static`** **mean?**
    - associates the method with the class

      (NOT objects instances of that class)
    - any method can call a **static method either:**
      - directly from within same class OR
      - using the class name from outside class (if the method is visible, e.g., **`public`**)
  - The Application Programming Interface (API) is the list of all public members of a class

Static vs. non-static methods

- Static methods:

```
public static int max(int x, int y){
   if(x>y) return x;
   return y;
}
System.out.println(max(2,3));//in same class
System.out.println(Test.max(2,3));//other
```

- Non-static methods:

```
String s1 = "Hello";
System.out.println( s1.length() ); // 5
System.out.println( s1.charAt(0) ); // H
String s2 = "Ola";
System.out.println( s2.length() );// 3
System.out.println( s2.charAt(0) );// O
```

The `Math` Class API

- Class constants (always static):
  - **`Math.PI`**
  - **`Math.E`**
- Class static methods:
  - Trigonometric methods
  - Exponent methods
  - Rounding methods
  - min, max, abs, and random methods

```
public class Test {
   public static void main(String[] args) {
      System.out.println( Math.PI );
      System.out.println( Math.E );
   }
}
```

```
Output:
3.141592653589793
2.718281828459045
```

Trigonometric Methods

- `Math.sin(double a)`
- `Math.cos(double a)`
- `Math.tan(double a)`
- `Math.acos(double a)`
- `Math.asin(double a)`
- `Math.atan(double a)`

Radians

- **Examples:**

```
Math.sin(0) returns 0.0
Math.sin(Math.PI / 6)
  returns ~0.5
Math.sin(Math.PI / 2)
  returns 1.0
Math.cos(0) returns 1.0
Math.cos(Math.PI / 6)
  returns ~0.866
Math.cos(Math.PI / 2)
  returns ~0
```

```
public class Test {
  public static void main(String[] args) {
    System.out.println( Math.sin(0) );
    System.out.println( Math.sin(Math.PI / 6) );
    System.out.println( Math.sin(Math.PI / 2) );
    System.out.println( Math.cos(0) );
    System.out.println( Math.cos(Math.PI / 6) );
    System.out.println( Math.cos(Math.PI / 2) );
  }
}
```

```
0.0
0.4999999999999994
1.0
1.0
0.8660254037844387
6.123233995736766E-17
```

Exponent Methods

- **`Math.exp(double a)`**
  Returns `e` raised to the power of `a`.
- **`Math.log(double a)`**
  Returns the natural logarithm of `a`.
- **`Math.log10(double a)`**
  Returns the 10-based logarithm of `a`.
- **`Math.pow(double a, double b)`**
  Returns `a` raised to the power of `b`.
- **`Math.sqrt(double a)`**
  Returns the square root of `a`.

- **Examples:**

```
Math.exp(1) returns 2.71
Math.log(2.71)
   returns 1.0
Math.pow(2, 3)
   returns 8.0
Math.pow(3, 2)
   returns 9.0
Math.pow(3.5, 2.5)
   returns 22.91765
Math.sqrt(4) returns 2.0
Math.sqrt(10.5)
   returns 3.24
```

```
public class Test {
  public static void main(String[] args) {
    System.out.println( Math.exp(1) );
    System.out.println( Math.log(2.71) );
    System.out.println( Math.pow(2, 3) );
    System.out.println( Math.pow(3, 2) );
    System.out.println( Math.sqrt(4) );
    System.out.println( Math.sqrt(10.5) );
  }
}
```

```
2.718281828459045
0.9969486348916096
8.0
9.0
2.0
3.24037034920393
```

Rounding Methods

- **`double ceil(double x)`**

  x rounded up to its nearest integer. This integer is returned as a double value.

- **`double floor(double x)`**

  x is rounded down to its nearest integer. This integer is returned as a double value.

- **`double rint(double x)`**

  x is rounded to its nearest integer. If x is equally close to two integers, the even one is returned as a double.

- **`int round(float x)`**

  Return (int)Math.floor(x+0.5).

- **`long round(double x)`**

  Return (long)Math.floor(x+0.5).

Rounding Methods Examples

Math.ceil(2.1) returns 3.0
Math.ceil(2.0) returns 2.0
Math.ceil(-2.0) returns -2.0
Math.ceil(-2.1) returns -2.0
Math.floor(2.1) returns 2.0
Math.floor(2.0) returns 2.0
Math.floor(-2.0) returns -2.0
Math.floor(-2.1) returns -3.0
Math.round(2.6f) returns 3
Math.round(2.0) returns 2 (long)
Math.round(-2.0f) returns -2
Math.round(-2.6) returns -3 (long)

```
public class Test {
  public static void main(String[] args) {
    System.out.println( Math.ceil(2.1) );//3.0
    System.out.println( Math.ceil(2.0) );//2.0
    System.out.println( Math.ceil(-2.0) );//-2.0
    System.out.println( Math.ceil(-2.1) );//-2.0
    System.out.println( Math.floor(2.1) );//2.0
    System.out.println( Math.floor(2.0) );//2.0
    System.out.println( Math.round(2.6f) );//3
    System.out.println( Math.round(2.0) );//2
    System.out.println( Math.round(-2.0f) );//-2
    System.out.println( Math.round(-2.6) );//-3
  }
}
```

`min`, `max`, and `abs`

- **`Math.max(a, b)`** and **`Math.min(a, b)`**

  Returns the maximum or minimum of two parameters.

- **`Math.abs(a)`**

  Returns the absolute value of the parameter.

- **`Math.random()`**

  Returns a random `double` value in the range [0.0, 1.0).

- **Examples:**

```
Math.max(2, 3)
  returns 3
Math.max(2.5, 3)
  returns 3.0
Math.min(2.5,3.6)
  returns 2.5
Math.abs(-2)
  returns 2
Math.abs(-2.1)
  returns 2.1
```

```
public class Test {
  public static void main(String[] args) {
    System.out.println( Math.max(2, 3) );
    System.out.println( Math.max(2.5, 3) );
    System.out.println( Math.min(2.5, 3.6) );
    System.out.println( Math.min(2, 3) );
    System.out.println( Math.abs(-2) );
    System.out.println( Math.abs(-2.1) );
  }
}
```

```
3
3.0
2.5
2
2
2.1
```

The Math.**random** method

Generates a random **double** value greater than or equal to 0.0 and less than 1.0 (**0 <= Math.random() < 1.0**)

Examples:

```
(int)(Math.random() * 10)
```
→ Returns a random integer between 0 and 9.

```
50 + (int)(Math.random() * 50)
```
→ Returns a random integer between 50 and 99.

In general,

```
a + Math.random() * b
```
→ Returns a random number between a and a + b, excluding a + b.

```
public class Test {
  public static void main(String[] args) {
    System.out.println( Math.random() * 10 );//[0,10)
    System.out.println( (int)(Math.random() * 10) );
                        // {0,1,2,3,4,5,6,7,8,9}
    System.out.println( 50 + (int)(Math.random() * 50) );
                        // {50, 51, …, 99}
    int a = 50, b = 50;
    System.out.println( a + (int)(Math.random() * b) );
                        // {a, a+1, …, a+b-1}
                        // {50, 51, …, 99}
  }
}
```

```
2.5056436465195766
7
58
69
```

Generating Random Characters

```
(char)((int)'a' + Math.random() * ((int)'z' - (int)'a' + 1))
```

- However, all numeric operators can be applied to the char operands
- The char operand is also cast into a higher number type if the other operand is a number
- So, the preceding expression can be simplified as follows:

```
(char)('a' + Math.random() * ('z' - 'a' + 1))
```

```
public class Test {
  public static void main(String[] args) {
    System.out.println( (char)((int)'a' +
      Math.random() * ((int)'z' - (int)'a' + 1)) );
    System.out.println( (char)('a' +
      Math.random() * ('z' - 'a' + 1)) );
  }
}
```

d

v

ASCII Code for Commonly Used Characters

Characters	Code Value in Decimal	Unicode Value
`'0'` to `'9'`	48 to 57	\u0030 to \u0039
`'A'` to `'Z'`	65 to 90	\u0041 to \u005A
`'a'` to `'z'`	97 to 122	\u0061 to \u007A

There is no need to remember them since we can do all mathematical operations with characters:

```
(char)('a' + Math.random() * ('z' - 'a' + 1))
```

```
'0' <= c && c <= '9'
```

Comparing and Testing Characters

```
if ('A' <= ch && ch <= 'Z')
  System.out.println(ch + " is an uppercase letter");

if ('a' <= ch && ch <= 'z')
  System.out.println(ch + " is a lowercase letter");

if ('0' <= ch && ch <= '9')
  System.out.println(ch + " is a numeric character");
```

Methods in the Character Class

Method	Description
`isDigit(ch)`	Returns true if the specified character is a digit.
`isLetter(ch)`	Returns true if the specified character is a letter.
`isLetterOrDigit(ch)`	Returns true if the specified character is a letter or digit.
`isLowerCase(ch)`	Returns true if the specified character is a lowercase letter.
`isUpperCase(ch)`	Returns true if the specified character is an uppercase letter.
`toLowerCase(ch)`	Returns the lowercase of the specified character.
`toUpperCase(ch)`	Returns the uppercase of the specified character.

Comparing and Testing Characters

```
if (Character.isUpperCase(ch))
  System.out.println(ch + " is an uppercase letter");

if (Character.isLowerCase(ch))
  System.out.println(ch + " is a lowercase letter");

if (Character.isDigit(ch))
  System.out.println(ch + " is a numeric character");
```

The String Type

- The **`char`** type only represents one character:

```
char ch = 'a';
```

- To represent a string of characters, use the data type called String.

String is a predefined class in the Java library just like the System class

http://java.sun.com/javase/8/docs/api/java/lang/String.html

- The String type is NOT a primitive type.
  - The String type is a *reference type*.
    - A String variable is a *reference variable*, an *address* (also called *pointer*) which points to an object storing the value or actual text

```
String message = "Welcome to Java";
```

Reading a String from the Console

```
Scanner input = new Scanner(System.in);
System.out.print("Enter three words separated by spaces:");
   // one two three
String s1 = input.next(); // "one"
String s2 = input.next(); // "two"
String s3 = input.next(); // "three"
System.out.println("s1 is " + s1);
System.out.println("s2 is " + s2);
System.out.println("s3 is " + s3);
```

Reading a String from the Console

```
Scanner input = new Scanner(System.in);
System.out.print("Enter a line:");
   // one two three
String s = input.nextLine();
    // "one two three"
System.out.println("s is " + s);
    // s is one two three
```

Reading a single Character from the Console

```
Scanner input = new Scanner(System.in);
System.out.print("Enter a character: ");

String s = input.nextLine();
char ch = s.charAt(0);
//charAt is not a static method
// it is invoked for a string s

System.out.print("The character entered is "+ch)
```

Useful String functions

- **length, charAt, concat, substring, equals, equalsIgnoreCase, compareTo, compareToIgnoreCase, startsWith, endsWith, indexOf, lastIndexOf.**
  - **these are not static methods - they are invoked for String objects**

Finding a String Length

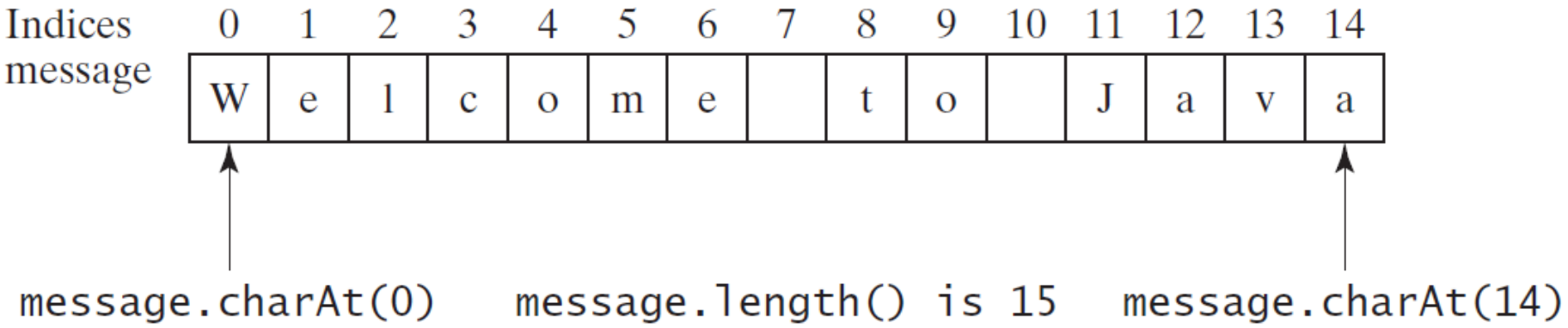
- Finding string length using the **`length()`** method:

```
String message = "Welcome to Java";
System.out.print( message.length());
   // prints 15
```

Getting Characters from a String

- Each character is stored at an index:

```
String message = "Welcome to Java";
```




```
System.out.println(
    "The first character in message is "
    + message.charAt(0));
```

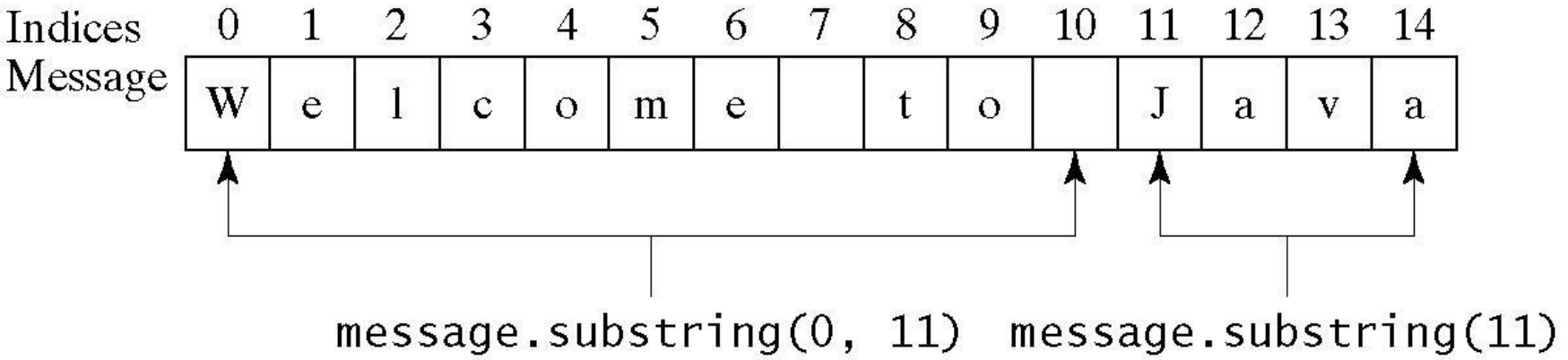
String Concatenation

- "+" is used for making a new string by concatenating strings:

```
// Three strings are concatenated
String message = "Welcome " + "to " + "Java";
// String Chapter is concatenated with number 2
String s = "Chapter" + 2; // s becomes Chapter2
// String Supplement is concatenated with character B
String s1 = "Supplement" + 'B';
     // s1 becomes SupplementB
String s2 = 1 + 2 + "ABC";
     // s2 become "3ABC"
String s2 = "" + 1 + 2 + "ABC";
     // s2 become "12ABC"
```

Obtaining Substrings

Method	Description
`substring(beginIndex)`	Returns this string's substring that begins with the character at the specified `beginIndex` and extends to the end of the string, as shown in Figure 4.2.
`substring(beginIndex, endIndex)`	Returns this string's substring that begins at the specified `beginIndex` and extends to the character at index `endIndex - 1`, as shown in Figure 9.6. Note that the character at `endIndex` is not part of the substring.

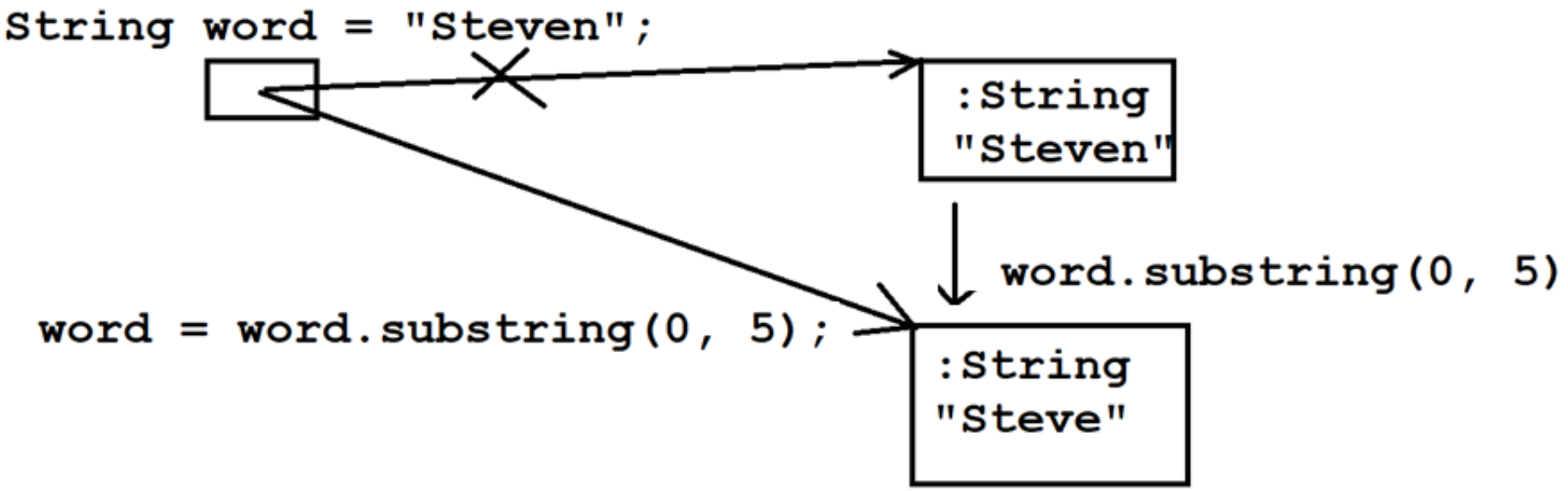


Strings are immutable!

- There are no methods to change them once they have been created
  - a new assignment will assign a new String reference to the old variable

```
String word = "Steven";
word = word.substring(0, 5);
```

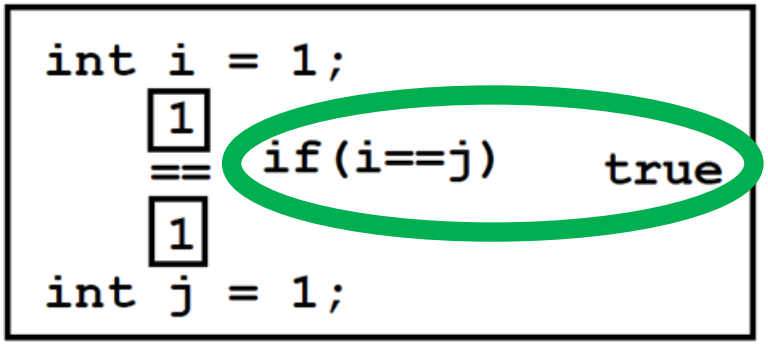
  - the variable **word** is now a reference to a **new String** that contains "**Steve**"

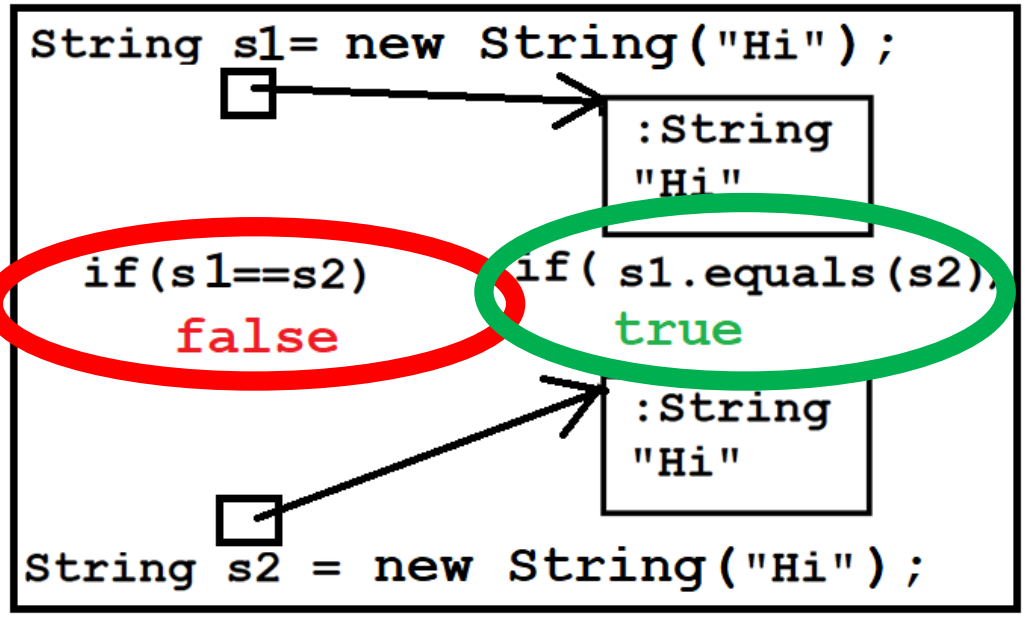


Comparing Strings

- Don't use '==' to compare Strings
  - it compares their memory addresses and not actual strings (character sequences)
- Instead use the **`equals`** method supplied by the String class:
  - **`s.equals(t)`**
    - **returns `true` if `s` and `t` have same characters in the same sequence**
    - **`false` otherwise**

== for Primitive vs. equals for Reference Types





Comparing Strings

```
String word1 = new String("Hello");
String word2 = new String("Hello");
if (word1 == word2){
  System.out.println(true);
} else {
  System.out.println(false);
}
```

false

Two different references/addresses

Comparing Strings

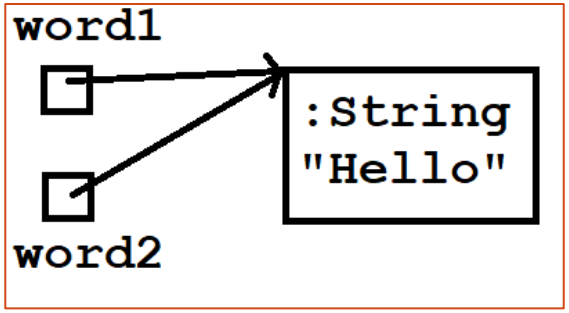
```
String word1 = new String("Hello");
String word2 = new String("Hello");
if (word1.equals(word2)){
  System.out.println(true);
} else {
  System.out.println(false);
}
```

true

compares the contents: "Hello" with "Hello"

Interned Strings

String interning is a method of storing only one copy of each distinct string value, i.e., the distinct values are stored in a pool of unique strings - All compile-time constant strings in Java are automatically interned using this method.




```
String word1 = "Hello";
String word2 = "Hello";
if (word1 == word2){
  System.out.println(true);
} else {
  System.out.println(false);
}
```

true

- Interned Strings: only one instance of "Hello" is stored
  - so word1 and word2 will have the same address

Interned Strings

- **equals** still works as it is supposed to work:

```
String word1 = "Hello";
String word2 = "Hello";
if (word1.equals(word2)){
  System.out.println(true);
} else {
  System.out.println(false);
}
```

Also **true**

So, we always use equals.

Interned Strings

```
String word1 = new String("Hello");
String word2 = "Hello";
if (word1.equals(word2)){
  System.out.println(true);
} else {
  System.out.println(false);
}
```

```
true
```

Interned Strings

```
String word1 = "Hello";
String word2 = new String("Hello");
if (word1.equals(word2)){
  System.out.println(true);
} else {
  System.out.println(false);
}
```

```
true
```

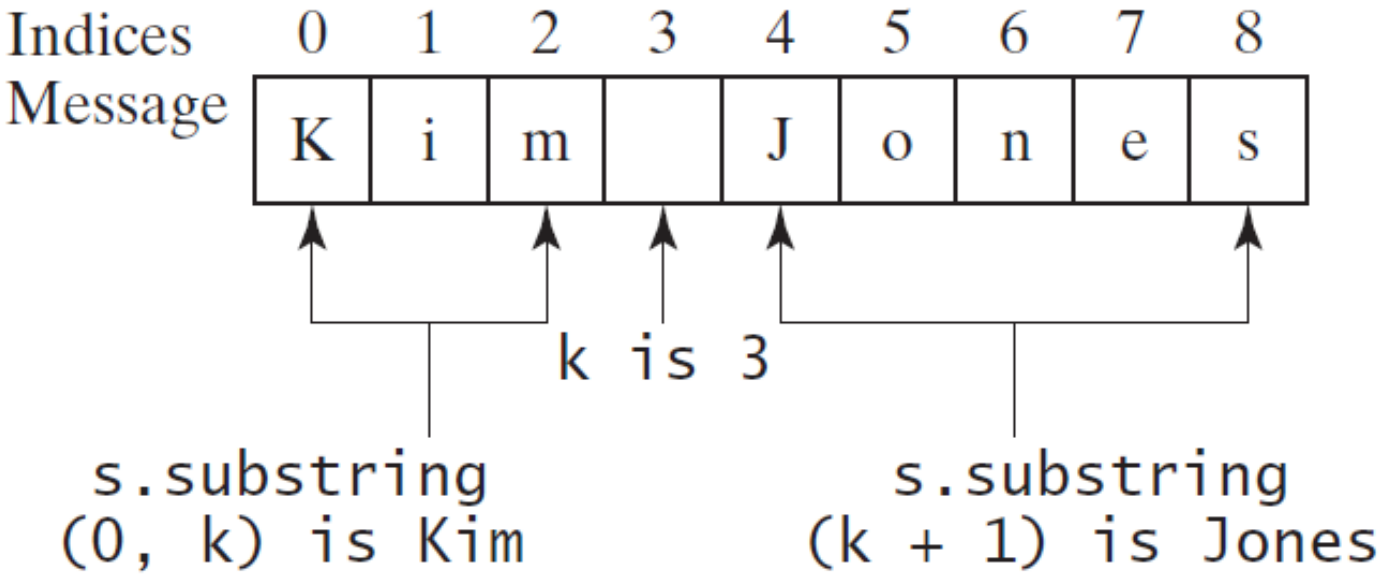
Comparing Strings

Method	Description
`equals(s1)`	Returns true if this string is equal to string `s1`.
`equalsIgnoreCase(s1)`	Returns true if this string is equal to string `s1`; it is case insensitive.
`compareTo(s1)`	Returns an integer greater than `0`, equal to `0`, or less than `0` to indicate whether this string is greater than, equal to, or greater than `s1`.
`compareToIgnoreCase(s1)`	Same as `compareTo` except that the comparison is case insensitive.
`startsWith(prefix)`	Returns true if this string starts with the specified prefix.
`endsWith(suffix)`	Returns true if this string ends with the specified suffix.

Finding a Character or a Substring in a String

Method	Description
`indexOf(ch)`	Returns the index of the first occurrence of `ch` in the string. Returns `-1` if not matched.
`indexOf(ch, fromIndex)`	Returns the index of the first occurrence of `ch` after `fromIndex` in the string. Returns `-1` if not matched.
`indexOf(s)`	Returns the index of the first occurrence of string `s` in this string. Returns `-1` if not matched.
`indexOf(s, fromIndex)`	Returns the index of the first occurrence of string `s` in this string after `fromIndex`. Returns `-1` if not matched.
`lastIndexOf(ch)`	Returns the index of the last occurrence of `ch` in the string. Returns `-1` if not matched.
`lastIndexOf(ch, fromIndex)`	Returns the index of the last occurrence of `ch` before `fromIndex` in this string. Returns `-1` if not matched.
`lastIndexOf(s)`	Returns the index of the last occurrence of string `s`. Returns `-1` if not matched.
`lastIndexOf(s, fromIndex)`	Returns the index of the last occurrence of string `s` before `fromIndex`. Returns `-1` if not matched.

Finding a Character or a Substring in a String




```
int k = s.indexOf(' ');  //3
String firstName = s.substring(0, k);
String lastName = s.substring(k + 1);
```

Conversion between Strings and Numbers

```
String intString = "15";
String doubleString = "56.77653";

int intValue =
    Integer.parseInt(intString);
double doubleValue =
    Double.parseDouble(doubleString);

String s1 = "" + intValue;
String s2 = "" + doubleValue;
```

Formatting the Output

The printf statement:

```
System.out.printf(format, items);
```

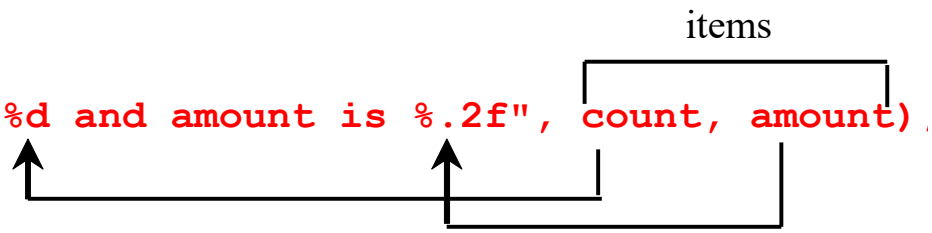
format is a string that may consist of substrings and format **specifiers:**

- A format specifier begins with a percent sign (%) and specifies how an item should be displayed: a numeric value, character, boolean value, or a string

Frequently-Used Specifiers

Specifier	Output	Example
%b	a boolean value	true or false
%c	a character	'a'
%d	a decimal integer	200
%f	a floating-point number	45.460000
%e	a number in standard scientific notation	4.556000e+01
%s	a string	"Java is cool"

```
int count = 5;
double amount = 45.561899;
System.out.printf("count is %d and amount is %.2f", count, amount);
```



Displays: `count is 5 and amount is 45.56`