



Strings

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By: Mamoun Nawahdah (Ph.D.)
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Constructing **String** object

```
String newString = new String(stringLiteral);
```

```
String message = new String("Welcome to Java");
```

Since strings are used frequently, Java provides a short-hand **initializer** for creating a **string**:

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



Strings are **Immutable**

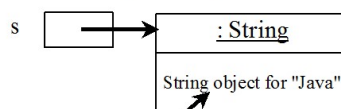


- ❖ A **String** object is immutable.
 - Its contents cannot be changed.
- ❖ Does the following code change the contents of the string **s**?

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

```
s = "HTML";
```

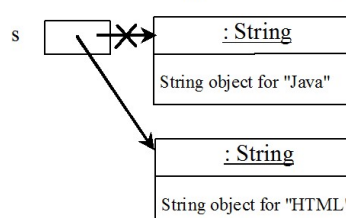
After executing `String s = "Java";`



Contents cannot be changed



After executing `s = "HTML";`



This string object is now unreferenced

Interned Strings

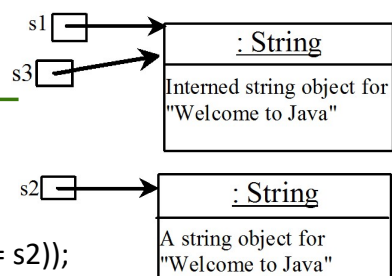
- ❖ Since strings are immutable and are frequently used, **to improve efficiency and save memory**, the **JVM** uses a **unique** instance for string literals with the same character sequence.
- ❖ Such an instance is called **interned**.



Example

```
String s1 = "Welcome to Java";
String s2 = new String("Welcome to Java");
String s3 = "Welcome to Java";
System.out.println("s1 == s2 is " + (s1 == s2));

System.out.println("s1 == s3 is " + (s1 == s3));
```



Display:

s1 == s2 is **false**
s1 == s3 is **true**

- ❖ A new object is created if you use the **new** operator.
- ❖ If you use the string **initializer**, no new object is created **if** the interned object is already created.



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String Comparisons

java.lang.String	
+equals(s1: Object): boolean	Returns true if this string is equal to string s1.
+equalsIgnoreCase(s1: String): boolean	Returns true if this string is equal to string s1 case-insensitive.
+compareTo(s1: String): int	Returns an integer greater than 0, equal to 0, or less than 0 to indicate whether this string is greater than, equal to, or less than s1.
+compareToIgnoreCase(s1: String): int	Same as compareTo except that the comparison is case-insensitive.
+regionMatches(toffset: int, s1: String, offset: int, len: int): boolean	Returns true if the specified subregion of this string exactly matches the specified subregion in string s1.
+regionMatches(ignoreCase: boolean, toffset: int, s1: String, offset: int, len: int): boolean	Same as the preceding method except that you can specify whether the match is case-sensitive.
+startsWith(prefix: String): boolean	Returns true if this string starts with the specified prefix.
+endsWith(suffix: String): boolean	Returns true if this string ends with the specified suffix.



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String Comparisons

```
String s1 = new String("Welcome");
String s2 = "Welcome";

if (s1.equals(s2)){
    // s1 and s2 have the same contents
}

if (s1 == s2) {
    // s1 and s2 have the same reference
}
```



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String Comparisons

compareTo(Object object)

```
String s1 = new String("Welcome");
String s2 = "Welcome";

if (s1.compareTo(s2) > 0) {
    // s1 is greater than s2
}

else if (s1.compareTo(s2) == 0) {
    // s1 and s2 have the same contents
}

else {
    // s1 is less than s2
}
```



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String Length, Characters, and Combining Strings

java.lang.String	
+length(): int	Returns the number of characters in this string.
+charAt(index: int): char	Returns the character at the specified index from this string.
+concat(s1: String): String	Returns a new string that concatenate this string with string s1.

Finding String Length

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

message = "Welcome to Java";

message.length(); // returns 15



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Retrieving Individual Characters in a String

- ❖ ~~Do not use message[0]~~
- ❖ Use **message.charAt(index)**
- ❖ Index starts from **0**

Indices	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
message	W	e	l	c	o	m	e		t	o		J	a	v	a

↑ message.charAt(0) message.length() is 15 message.charAt(14)



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String Concatenation

String s3 = s1.concat(s2);

String s3 = s1 + s2;

s1 + s2 + s3 + s4 + s5

same as

((s1.concat(s2)).concat(s3)).concat(s4)).concat(s5);



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Extracting Substrings

java.lang.String	
+substring(beginIndex: int): String	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 8.6.
+substring(beginIndex: int, endIndex: int): String	Returns this string's substring that begins at the specified beginIndex and extends to the character at index endIndex - 1, as shown in Figure 8.6. Note that the character at endIndex is not part of the substring.



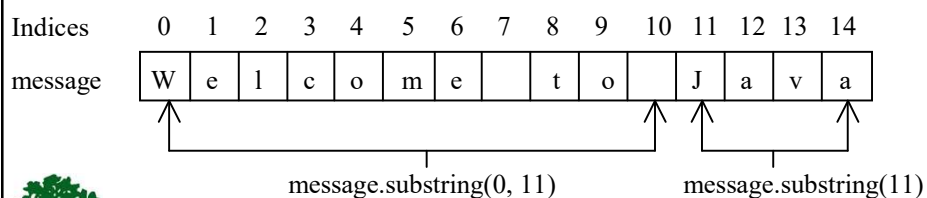
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Extracting Substrings

- ❖ You can extract a single character from a **string** using the **charAt** method.
- ❖ You can also extract a substring from a **string** using the **substring** method in the **String** class.

String s1 = "Welcome to Java";

String s2 = s1.**substring**(0, 11) + "HTML";



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Converting, Replacing, and Splitting Strings

java.lang.String
+toLowerCase(): String
+toUpperCase(): String
+trim(): String
+replace(oldChar: char, newChar: char): String
+replaceFirst(oldString: String, newString: String): String
+replaceAll(oldString: String, newString: String): String
+split(delimiter: String): String[]

- Returns a new string with all characters converted to lowercase.
- Returns a new string with all characters converted to uppercase.
- Returns a new string with blank characters trimmed on both sides.
- Returns a new string that replaces all matching character in this string with the new character.
- Returns a new string that replaces the first matching substring in this string with the new substring.
- Returns a new string that replace all matching substrings in this string with the new substring.
- Returns an array of strings consisting of the substrings split by the delimiter.



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Examples

"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".**replaceAll("e", "AB")**
returns a new string, **WABlcomAB**



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Splitting a String

```
String s1 = "Java#HTML#Perl";
String[] tokens = s1.split( "#");
for (int i = 0; i < tokens.length; i++)
    System.out.println( tokens[i] );
```

Displays:

Java
HTML
Perl



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Matching, Replacing and Splitting by Patterns

- ❖ You can **match**, **replace**, or **split** a string by specifying a pattern.
- ❖ This is an extremely useful and powerful feature, commonly known as **regular expression**.

```
"Java".matches("Java")
```

```
"Java".equals("Java")
```

```
"Java is fun".matches("Java.*")
```

```
"Java is cool".matches("Java.*")
```



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Matching, Replacing and Splitting by Patterns

- ❖ The **replaceAll**, **replaceFirst**, and **split** methods can be used with a regular expression.
- ❖ For example, the following statement returns a new string that **replaces** **\$**, **+**, or **#** in **"a+b\$#c"** by the string **123**.

```
String s = "a+b$#c".replaceAll("[${+}]", "123");
System.out.println(s);
```

Here the regular expression **[\${+}]** specifies a pattern that matches **\$**, **+**, or **#**.

So, the output is **a123b123123c**



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Matching, Replacing and Splitting by Patterns

❖ The following statement **splits** the string into an array of strings delimited by some punctuation marks:

```
String[] tokens = "Java,C?C#,C++".split("[.,:;?]");
for (int i = 0; i < tokens.length; i++)
    System.out.println(tokens[i]);
```

Java
C
C#
C++



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Finding a Character or a Substring in a String

java.lang.String	
+indexOf(ch: char): int	Returns the index of the first occurrence of ch in the string. Returns -1 if not matched.
+indexOf(ch: char, fromIndex: int): int	Returns the index of the first occurrence of ch after fromIndex in the string. Returns -1 if not matched.
+indexOf(s: String): int	Returns the index of the first occurrence of string s in this string. Returns -1 if not matched.
+indexOf(s: String, fromIndex: int): int	Returns the index of the first occurrence of string s in this string after fromIndex. Returns -1 if not matched.
+lastIndexOf(ch: int): int	Returns the index of the last occurrence of ch in the string. Returns -1 if not matched.
+lastIndexOf(ch: int, fromIndex: int): int	Returns the index of the last occurrence of ch before fromIndex in this string. Returns -1 if not matched.
+lastIndexOf(s: String): int	Returns the index of the last occurrence of string s. Returns -1 if not matched.
+lastIndexOf(s: String, fromIndex: int): int	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

```
String s = "Welcome to Java";
s.indexOf('W')           returns 0
s.indexOf('x')           returns -1
s.indexOf('o', 5)        returns 9
s.indexOf("come")        returns 3
s.indexOf("Java", 5)     returns 11
s.indexOf("java", 5)     returns -1
s.lastIndexOf('a')      returns 14
```



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Convert Character and Numbers to Strings

- ❖ The **String** class provides several static **valueOf** methods for converting a character, an array of characters, and numeric values to strings.
- ❖ These methods have the same name **valueOf** with different argument types **char**, **char[]**, **double**, **long**, **int**, and **float**.
- ❖ For example, to convert a **double** value to a **string**, use **String.valueOf(5.44)**. The return value is string consists of characters **'5'**, **'.'**, **'4'**, and **'4'**.



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The Character Class

java.lang.Character

+Character(value: char)	Constructs a character object with char value
+charValue(): char	Returns the char value from this object
+compareTo(anotherCharacter: Character): int	Compares this character with another
+equals(anotherCharacter: Character): boolean	Returns true if this character equals to another
+isDigit(ch: char): boolean	Returns true if the specified character is a digit
+isLetter(ch: char): boolean	Returns true if the specified character is a letter
+isLetterOrDigit(ch: char): boolean	Returns true if the character is a letter or a digit
+isLowerCase(ch: char): boolean	Returns true if the character is a lowercase letter
+isUpperCase(ch: char): boolean	Returns true if the character is an uppercase letter
+toLowerCase(ch: char): char	Returns the lowercase of the specified character
+toUpperCase(ch: char): char	Returns the uppercase of the specified character



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Examples

Character c = new Character('b');

c.compareTo(new Character('a'))	returns 1
c.compareTo(new Character('b'))	returns 0
c.compareTo(new Character('c'))	returns -1
c.compareTo(new Character('d'))	returns -2
c.equals(new Character('b'))	returns true
c.equals(new Character('d'))	returns false



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StringBuilder and StringBuffer

- ❖ The **StringBuilder/StringBuffer** class is an alternative to the **String** class.
- ❖ In general, a **StringBuilder/StringBuffer** can be used wherever a **String** is used.
- ❖ **StringBuilder/StringBuffer** is more **flexible** than **String**.
- ❖ You can **add**, **insert**, or **append** new contents into a string buffer, whereas the value of a **String** object is fixed once the string is created.



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StringBuilder Constructors

java.lang.StringBuilder

+StringBulder()

+StringBulder(capacity: int)

+StringBulder(s: String)

Constructs an empty string builder with capacity 16.

Constructs a string builder with the specified capacity.

Constructs a string builder with the specified string.



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Modifying Strings in the Builder

java.lang.StringBuilder	
+append(data: char[]): StringBuilder	Appends a char array into this string builder.
+append(data: char[], offset: int, len: int): StringBuilder	Appends a subarray in data into this string builder.
+append(v: aPrimitiveType): StringBuilder	Appends a primitive type value as a string to this builder.
+append(s: String): StringBuilder	Appends a string to this string builder.
+delete(startIndex: int, endIndex: int): StringBuilder	Deletes characters from startIndex to endIndex.
+deleteCharAt(index: int): StringBuilder	Deletes a character at the specified index.
+insert(index: int, data: char[], offset: int, len: int): StringBuilder	Inserts a subarray of the data in the array to the builder at the specified index.
+insert(offset: int, data: char[]): StringBuilder	Inserts data into this builder at the position offset.
+insert(offset: int, b: aPrimitiveType): StringBuilder	Inserts a value converted to a string into this builder.
+insert(offset: int, s: String): StringBuilder	Inserts a string into this builder at the position offset.
+replace(startIndex: int, endIndex: int, s: String): StringBuilder	Replaces the characters in this builder from startIndex to endIndex with the specified string.
+reverse(): StringBuilder	Reverses the characters in the builder.
+setCharAt(index: int, ch: char): void	Sets a new character at the specified index in this builder.



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Examples

```

StringBuilder sb = new StringBuilder("Welcome to ");
sb.append("Java");
sb.insert(11, "HTML and ");
sb.delete(8, 11);
sb.deleteCharAt(8);
sb.reverse();
sb.replace(11, 15, "HTML");
sb.setCharAt(0, 'w');

```

Welcome to Java**Welcome to HTML and Java****Welcome HTML and Java****Welcome TML and Java****avaJ dna LMT emocleW****avaJ dna LMHTMLocleW****wvaJ dna LMHTMLocleW**

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The toString, capacity, length, setLength, and charAt Methods

java.lang.StringBuilder	
+toString(): String	Returns a string object from the string builder.
+capacity(): int	Returns the capacity of this string builder.
+charAt(index: int): char	Returns the character at the specified index.
+length(): int	Returns the number of characters in this builder.
+setLength(newLength: int): void	Sets a new length in this builder.
+substring(startIndex: int): String	Returns a substring starting at startIndex.
+substring(startIndex: int, endIndex: int): String	Returns a substring from startIndex to endIndex-1.
+trimToSize(): void	Reduces the storage size used for the string builder.



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What are the results of the following expressions?

Suppose that **s1**, **s2**, **s3**, and **s4** are four strings, given as follows:

```
String s1 = "Welcome to Java";
String s2 = s1;
String s3 = new String("Welcome to Java");
String s4 = "Welcome to Java";
```

- | | |
|--|--------------------|
| a. s1 == s2 | a. true |
| b. s1 == s3 | b. false |
| c. s1 == s4 | c. true |
| d. s1.equals(s3) | d. true |
| e. s1.equals(s4) | e. true |
| f. "Welcome to Java".replace("Java", "HTML") | f. Welcome to HTML |
| g. s1.replace('o', 'T') | g. WelcTme tT Java |
| h. s1.replaceAll("o", "T") | h. WelcTme tT Java |
| i. s1.replaceFirst("o", "T") | i. WelcTme to Java |
| j. s1.toCharArray() | j. [] |



Problem: Checking Palindromes

Ignoring Non-alphanumeric Characters

```
/** Return true if a string is a palindrome */
public static boolean isPalindrome(String s) {
    // Create a new string by eliminating non-alphanumeric chars
    String s1 = filter(s);

    // Create a new string that is the reversal of s1
    String s2 = reverse(s1);

    // Compare if the reversal is the same as the original string
    return s2.equals(s1);
}
```



```
/** Create a new string by eliminating non-alphanumeric chars */
public static String filter(String s) {
    // Create a string builder
    StringBuilder stringBuilder = new StringBuilder();

    // Examine each char in the string to skip alphanumeric char
    for (int i = 0; i < s.length(); i++) {
        if (Character.isLetterOrDigit(s.charAt(i))) {
            stringBuilder.append(s.charAt(i));
        }
    }

    /** Create a new string by reversing a specified string */
    public static String reverse(String s) {
        StringBuilder stringBuilder = new StringBuilder(s);
        stringBuilder.reverse(); // Invoke reverse in StringBuilder
        return stringBuilder.toString();
    }
}
```



Regular Expression Syntax



Regular Expression	Matches	Example
x	a specified character x	Java matches Java
.	any single character	Java matches J..a
(ab cd)	ab or cd	ten matches t(en im)
[abc]	a, b, or c	Java matches Ja[uvw]a
[^abc]	any character except a, b, or c	Java matches Ja[^ars]a
[a-z]	a through z	Java matches [A-M]av[a-d]
[^a-z]	any character except a through z	Java matches Jav[^b-d]
[a-e[m-p]]	a through e or m through p	Java matches [A-G[I-M]]av[a-d]
[a-e&&[c-p]]	intersection of a-e with c-p	Java matches [A-P&&[I-M]]av[a-d]
\d	a digit, same as [0-9]	Java2 matches "Java[\d]"
\D	a non-digit	\$Java matches "[\D][\D]ava"
\w	a word character	Java1 matches "[\w]ava[\w]"
\W	a non-word character	\$Java matches "[\W][\w]ava"
\s	a whitespace character	"Java 2" matches "Java[\s2]"
\S	a non-whitespace char	Java matches "[\S]Java"
p*	zero or more occurrences of pattern p	aaaabb matches "a*bb" ababab matches "(ab)*"
p+	one or more occurrences of pattern p	a matches "a+b*" able matches "(ab)+.*"
p?	zero or one occurrence of pattern p	Java matches "J?Java" Java matches "J?ava"
p{n}	exactly n occurrences of pattern p	Java matches "Ja{1},.*" Java does not match ".{2}"
p{n,}	at least n occurrences of pattern p	aaaa matches "a{1,}" a does not match "a{2,}"
p{n,m}	between n and m occurrences (inclusive)	aaaa matches "a{1,9}" abb does not match "a{2,9}bb"