Characters

Most of the time, if you are using a single character value, you will use the primitive `char` type. For example:

```
char ch = 'a';
// Unicode for uppercase Greek omega character
char uniChar = '\u039A';
// an array of chars
char[] charArray = { 'a', 'b', 'c', 'd', 'e' };
```

There are times, however, when you need to use a char as an object—for example, as a method argument where an object is expected. The Java programming language provides a *wrapper* class that "wraps" the `char` in a `Character` object for this purpose. An object of type `Character` contains a single field, whose type is `char`. This `Character` class also offers a number of useful class (i.e., static) methods for manipulating characters.

You can create a `Character` object with the `Character` constructor:

```
Character ch = new Character('a');
```

The Java compiler will also create a `Character` object for you under some circumstances. For example, if you pass a primitive `char` into a method that expects an object, the compiler automatically converts the `char` to a `Character` for you. This feature is called *autoboxing*—or *unboxing*, if the conversion goes the other way. For more information on autoboxing and unboxing, see Autoboxing and Unboxing.

Note: The `Character` class is immutable, so that once it is created, a `Character` object cannot be changed.

The following table lists some of the most useful methods in the `Character` class, but is not exhaustive. For a complete listing of all methods in this class (there are more than 50), refer to the `java.lang.Character` API specification.

Useful Methods in the `Character` Class

Method	Description
`boolean isLetter(char ch)` `boolean isDigit(char ch)`	Determines whether the specified char value is a letter or a digit, respectively.
`boolean isWhitespace(char ch)`	Determines whether the specified char value is white space.
`boolean isUpperCase(char ch)` `boolean isLowerCase(char ch)`	Determines whether the specified char value is uppercase or lowercase, respectively.

`char toUpperCase(char ch)` `char toLowerCase(char ch)`	Returns the uppercase or lowercase form of the specified char value.
`toString(char ch)`	Returns a `String` object representing the specified character value — that is, a one-character string.

Escape Sequences

A character preceded by a backslash (\) is an *escape sequence* and has special meaning to the compiler. The following table shows the Java escape sequences:

Escape Sequences

Escape Sequence	Description
`\t`	Insert a tab in the text at this point.
`\b`	Insert a backspace in the text at this point.
`\n`	Insert a newline in the text at this point.
`\r`	Insert a carriage return in the text at this point.
`\f`	Insert a formfeed in the text at this point.
`\'`	Insert a single quote character in the text at this point.
`\"`	Insert a double quote character in the text at this point.
`\\`	Insert a backslash character in the text at this point.

When an escape sequence is encountered in a print statement, the compiler interprets it accordingly. For example, if you want to put quotes within quotes you must use the escape sequence, \", on the interior quotes. To print the sentence

```
She said "Hello!" to me.
```

you would write

```
System.out.println("She said \"Hello!\" to me.");
```

Converting Between Numbers and Strings

Converting Strings to Numbers

Frequently, a program ends up with numeric data in a string object—a value entered by the user, for example.

The `Number` subclasses that wrap primitive numeric types (`Byte`, `Integer`, `Double`, `Float`, `Long`, and `Short`) each provide a class method named `valueOf` that converts a string to an object of that type. Here is an example, `ValueOfDemo` , that gets two strings from the command line, converts them to numbers, and performs arithmetic operations on the values:

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

        // this program requires two
        // arguments on the command line
        if (args.length == 2) {
            // convert strings to numbers
            float a = (Float.valueOf(args[0])).floatValue();
            float b = (Float.valueOf(args[1])).floatValue();

            // do some arithmetic
            System.out.println("a + b = " +
                               (a + b));
            System.out.println("a - b = " +
                               (a - b));
            System.out.println("a * b = " +
                               (a * b));
            System.out.println("a / b = " +
                               (a / b));
            System.out.println("a % b = " +
                               (a % b));
        } else {
            System.out.println("This program " +
                "requires two command-line arguments.");
        }
    }
}
```

The following is the output from the program when you use `4.5` and `87.2` for the command-line arguments:

```
a + b = 91.7
a - b = -82.7
a * b = 392.4
a / b = 0.0516055
a % b = 4.5
```

Note: Each of the `Number` subclasses that wrap primitive numeric types also provides a `parseXXXX()` method (for example, `parseFloat()`) that can be used to convert strings to primitive numbers. Since a primitive type is returned instead of an object, the `parseFloat()` method is more direct than the `valueOf()` method. For example, in the `ValueOfDemo` program, we could use:

```
float a = Float.parseFloat(args[0]);
float b = Float.parseFloat(args[1]);
```

Converting Numbers to Strings

Sometimes you need to convert a number to a string because you need to operate on the value in its string form. There are several easy ways to convert a number to a string:

```
int i;
// Concatenate "i" with an empty string; conversion is handled for you.
String s1 = "" + i;
```

or

```
// The valueOf class method.
String s2 = String.valueOf(i);
```

Each of the `Number` subclasses includes a class method, `toString()`, that will convert its primitive type to a string. For example:

```
int i;
double d;
String s3 = Integer.toString(i);
String s4 = Double.toString(d);
```

The `ToStringDemo` example uses the `toString` method to convert a number to a string. The program then uses some string methods to compute the number of digits before and after the decimal point:

```
public class ToStringDemo {

    public static void main(String[] args) {
        double d = 858.48;
        String s = Double.toString(d);

        int dot = s.indexOf('.');

        System.out.println(dot + " digits " +
            "before decimal point.");
        System.out.println( (s.length() - dot - 1) +
            " digits after decimal point.");
    }
}
```

The output of this program is:

```
3 digits before decimal point.
2 digits after decimal point.
```

Manipulating Characters in a String

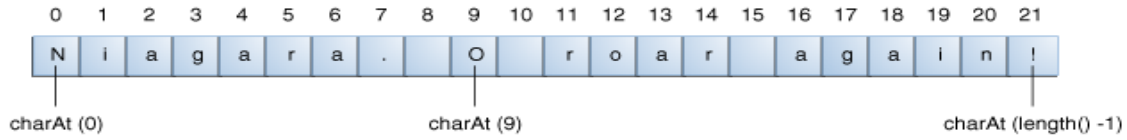
The `String` class has a number of methods for examining the contents of strings, finding characters or substrings within a string, changing case, and other tasks.

Getting Characters and Substrings by Index

You can get the character at a particular index within a string by invoking the `charAt()` accessor method. The index of the first character is 0, while the index of the last character is `length()-1`. For example, the following code gets the character at index 9 in a string:

```
String anotherPalindrome = "Niagara. O roar again!";
char aChar = anotherPalindrome.charAt(9);
```

Indices begin at 0, so the character at index 9 is 'O', as illustrated in the following figure:



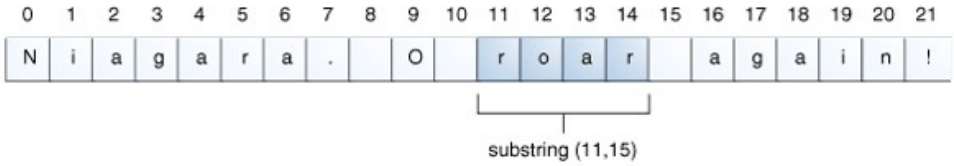
If you want to get more than one consecutive character from a string, you can use the `substring` method. The `substring` method has two versions, as shown in the following table:

The `substring` Methods in the `String` Class

Method	Description
`String substring(int beginIndex, int endIndex)`	Returns a new string that is a substring of this string. The first integer argument specifies the index of the first character. The second integer argument is the index of the last character - 1.
`String substring(int beginIndex)`	Returns a new string that is a substring of this string. The integer argument specifies the index of the first character. Here, the returned substring extends to the end of the original string.

The following code gets from the Niagara palindrome the substring that extends from index 11 up to, but not including, index 15, which is the word "roar":

```
String anotherPalindrome = "Niagara. O roar again!";
String roar = anotherPalindrome.substring(11, 15);
```



Other Methods for Manipulating Strings

Here are several other `String` methods for manipulating strings:

Other Methods in the `String` Class for Manipulating Strings

Method	Description
`String[] split(String regex)` `String[] split(String regex, int limit)`	Searches for a match as specified by the string argument (which contains a regular expression) and splits this string into an array of strings accordingly. The optional integer argument specifies the maximum size of the returned array. Regular expressions are covered in the lesson titled "Regular Expressions."
`CharSequence subSequence(int beginIndex, int endIndex)`	Returns a new character sequence constructed from `beginIndex` index up until `endIndex` - 1.
`String trim()`	Returns a copy of this string with leading and trailing white space removed.
`String toLowerCase()` `String toUpperCase()`	Returns a copy of this string converted to lowercase or uppercase. If no conversions are necessary, these methods return the original string.

Searching for Characters and Substrings in a String

Here are some other `String` methods for finding characters or substrings within a string. The `String` class provides accessor methods that return the position within the string of a specific character or substring: `indexOf()` and `lastIndexOf()`. The `indexOf()` methods search forward from the beginning of the string, and the `lastIndexOf()` methods search backward from the end of the string. If a character or substring is not found, `indexOf()` and `lastIndexOf()` return -1.

The `String` class also provides a search method, `contains`, that returns true if the string contains a particular character sequence. Use this method when you only need to know that the string contains a character sequence, but the precise location isn't important.

The following table describes the various string search methods.

The Search Methods in the `String` Class

Method	Description
`int indexOf(int ch)` `int lastIndexOf(int ch)`	Returns the index of the first (last) occurrence of the specified character.
`int indexOf(int ch, int fromIndex)` `int lastIndexOf(int ch, int fromIndex)`	Returns the index of the first (last) occurrence of the specified character, searching forward (backward) from the specified index.
`int indexOf(String str)` `int lastIndexOf(String str)`	Returns the index of the first (last) occurrence of the specified substring.
`int indexOf(String str, int fromIndex)` `int lastIndexOf(String str, int fromIndex)`	Returns the index of the first (last) occurrence of the specified substring, searching forward (backward) from the specified index.
`boolean contains(CharSequence s)`	Returns true if the string contains the specified

	character sequence.

Note: `CharSequence` is an interface that is implemented by the `String` class. Therefore, you can use a string as an argument for the `contains()` method.

Replacing Characters and Substrings into a String

The `String` class has very few methods for inserting characters or substrings into a string. In general, they are not needed: You can create a new string by concatenation of substrings you have *removed* from a string with the substring that you want to insert.

The `String` class does have four methods for *replacing* found characters or substrings, however. They are:

Methods in the `String` Class for Manipulating Strings

Method	Description
`String replace(char oldChar, char newChar)`	Returns a new string resulting from replacing all occurrences of oldChar in this string with newChar.
`String replace(CharSequence target, CharSequence replacement)`	Replaces each substring of this string that matches the literal target sequence with the specified literal replacement sequence.
`String replaceAll(String regex, String replacement)`	Replaces each substring of this string that matches the given regular expression with the given replacement.
`String replaceFirst(String regex, String replacement)`	Replaces the first substring of this string that matches the given regular expression with the given replacement.

An Example

The following class, `Filename`, illustrates the use of `lastIndexOf()` and `substring()` to isolate different parts of a file name.

Note: The methods in the following `Filename` class don't do any error checking and assume that their argument contains a full directory path and a filename with an extension. If these methods were production code, they would verify that their arguments were properly constructed.

```
public class Filename {
    private String fullPath;
    private char pathSeparator,
                 extensionSeparator;

    public Filename(String str, char sep, char ext) {
        fullPath = str;
        pathSeparator = sep;
        extensionSeparator = ext;
    }
```

```
    public String extension() {
        int dot = fullPath.lastIndexOf(extensionSeparator);
        return fullPath.substring(dot + 1);
    }

    // gets filename without extension
    public String filename() {
        int dot = fullPath.lastIndexOf(extensionSeparator);
        int sep = fullPath.lastIndexOf(pathSeparator);
        return fullPath.substring(sep + 1, dot);
    }

    public String path() {
        int sep = fullPath.lastIndexOf(pathSeparator);
        return fullPath.substring(0, sep);
    }
}
```

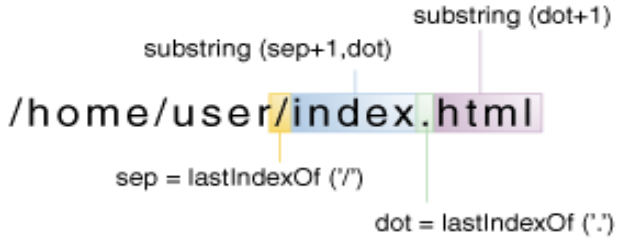
Here is a program, `FilenameDemo`, that constructs a `Filename` object and calls all of its methods:

```
public class FilenameDemo {
    public static void main(String[] args) {
        final String FPATH = "/home/user/index.html";
        Filename myHomePage = new Filename(FPATH, '/', '.');
        System.out.println("Extension = " + myHomePage.extension());
        System.out.println("Filename = " + myHomePage.filename());
        System.out.println("Path = " + myHomePage.path());
    }
}
```

And here's the output from the program:

```
Extension = html
Filename = index
Path = /home/user
```

As shown in the following figure, our `extension` method uses `lastIndexOf` to locate the last occurrence of the period (.) in the file name. Then `substring` uses the return value of `lastIndexOf` to extract the file name extension — that is, the substring from the period to the end of the string. This code assumes that the file name has a period in it; if the file name does not have a period, `lastIndexOf` returns -1, and the substring method throws a `StringIndexOutOfBoundsException`.



Also, notice that the `extension` method uses `dot + 1` as the argument to `substring`. If the period character (.) is the last character of the string, `dot + 1` is equal to the length of the string, which is one larger than the largest index into the string (because indices start at 0). This is a legal argument to `substring` because that method accepts an index equal to, but not greater than, the length of the string and interprets it to mean "the end of the string."

Comparing Strings and Portions of Strings

The `String` class has a number of methods for comparing strings and portions of strings. The following table lists these methods.

Methods for Comparing Strings

Method	Description
`boolean endsWith(String suffix)` `boolean startsWith(String prefix)`	Returns `true` if this string ends with or begins with the substring specified as an argument to the method.
`boolean startsWith(String prefix, int offset)`	Considers the string beginning at the index `offset`, and returns `true` if it begins with the substring specified as an argument.
`int compareTo(String anotherString)`	Compares two strings lexicographically. Returns an integer indicating whether this string is greater than (result is > 0), equal to (result is = 0), or less than (result is < 0) the argument.
`int compareToIgnoreCase(String str)`	Compares two strings lexicographically, ignoring differences in case. Returns an integer indicating whether this string is greater than (result is > 0), equal to (result is = 0), or less than (result is < 0) the argument.
`boolean equals(Object anObject)`	Returns `true` if and only if the argument is a `String` object that represents the same sequence of characters as this object.
`boolean equalsIgnoreCase(String anotherString)`	Returns `true` if and only if the argument is a `String` object that represents the same sequence of characters as this object, ignoring differences in case.
`boolean regionMatches(int toffset, String other, int ooffset, int len)`	Tests whether the specified region of this string matches the specified region of the String argument. Region is of length `len` and begins at the index `toffset` for this string and `ooffset` for the other string.
`boolean regionMatches(boolean ignoreCase, int toffset, String other, int ooffset, int len)`	Tests whether the specified region of this string matches the specified region of the String argument. Region is of length `len` and begins at the index `toffset` for this string and `ooffset` for the other string.

	The boolean argument indicates whether case should be ignored; if true, case is ignored when comparing characters.
`boolean matches(String regex)`	Tests whether this string matches the specified regular expression. Regular expressions are discussed in the lesson titled "Regular Expressions."

The following program, `RegionMatchesDemo`, uses the `regionMatches` method to search for a string within another string:

```
public class RegionMatchesDemo {
    public static void main(String[] args) {
        String searchMe = "Green Eggs and Ham";
        String findMe = "Eggs";
        int searchMeLength = searchMe.length();
        int findMeLength = findMe.length();
        boolean foundIt = false;
        for (int i = 0;
             i <= (searchMeLength - findMeLength);
             i++) {
           if (searchMe.regionMatches(i, findMe, 0, findMeLength)) {
              foundIt = true;
              System.out.println(searchMe.substring(i, i + findMeLength));
              break;
           }
        }
        if (!foundIt)
            System.out.println("No match found.");
    }
}
```

The output from this program is `Eggs`.

The program steps through the string referred to by `searchMe` one character at a time. For each character, the program calls the regionMatches method to determine whether the substring beginning with the current character matches the string the program is looking for.

The StringBuilder Class

`StringBuilder` objects are like `String` objects, except that they can be modified. Internally, these objects are treated like variable-length arrays that contain a sequence of characters. At any point, the length and content of the sequence can be changed through method invocations.

Strings should always be used unless string builders offer an advantage in terms of simpler code (see the sample program at the end of this section) or better performance. For example, if you need to concatenate a large number of strings, appending to a `StringBuilder` object is more efficient.

Length and Capacity

The `StringBuilder` class, like the `String` class, has a `length()` method that returns the length of the character sequence in the builder.

Unlike strings, every string builder also has a *capacity*, the number of character spaces that have been allocated. The capacity, which is returned by the `capacity()` method, is always greater than or equal to the length (usually greater than) and will automatically expand as necessary to accommodate additions to the string builder.

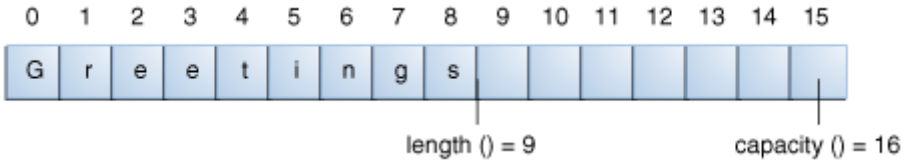
`StringBuilder` Constructors

Constructor	Description
`StringBuilder()`	Creates an empty string builder with a capacity of 16 (16 empty elements).
`StringBuilder(CharSequence cs)`	Constructs a string builder containing the same characters as the specified `CharSequence`, plus an extra 16 empty elements trailing the `CharSequence`.
`StringBuilder(int initCapacity)`	Creates an empty string builder with the specified initial capacity.
`StringBuilder(String s)`	Creates a string builder whose value is initialized by the specified string, plus an extra 16 empty elements trailing the string.

For example, the following code

```
// creates empty builder, capacity 16
StringBuilder sb = new StringBuilder();
// adds 9 character string at beginning
sb.append("Greetings");
```

will produce a string builder with a length of 9 and a capacity of 16:



The `StringBuilder` class has some methods related to length and capacity that the `String`

class does not have:

Length and Capacity Methods

Method	Description
`void setLength(int newLength)`	Sets the length of the character sequence. If `newLength` is less than `length()`, the last characters in the character sequence are truncated. If `newLength` is greater than `length()`, null characters are added at the end of the character sequence.
`void ensureCapacity(int minCapacity)`	Ensures that the capacity is at least equal to the specified minimum.

A number of operations (for example, `append()`, `insert()`, or `setLength()`) can increase the length of the character sequence in the string builder so that the resultant `length()` would be greater than the current `capacity()`. When this happens, the capacity is automatically increased.

StringBuilder Operations

The principal operations on a `StringBuilder` that are not available in `String` are the `append()` and `insert()` methods, which are overloaded so as to accept data of any type. Each converts its argument to a string and then appends or inserts the characters of that string to the character sequence in the string builder. The append method always adds these characters at the end of the existing character sequence, while the insert method adds the characters at a specified point.

Here are a number of the methods of the `StringBuilder` class.

Various `StringBuilder` Methods

Method	Description

`StringBuilder append(boolean b)`
`StringBuilder append(char c)`
`StringBuilder append(char[] str)`
`StringBuilder append(char[] str, int offset, int len)`
`StringBuilder append(double d)`
`StringBuilder append(float f)`
`StringBuilder append(int i)`
`StringBuilder append(long lng)`
`StringBuilder append(Object obj)`
`StringBuilder append(String s)`
	Appends the argument to this string builder. The data is converted to a string before the append operation takes place.

`StringBuilder delete(int start, int end)` `StringBuilder deleteCharAt(int index)`	The first method deletes the subsequence from start to end-1 (inclusive) in the `StringBuilder`'s char sequence. The second method deletes the character located at `index`.

`StringBuilder insert(int offset, boolean b)`
`StringBuilder insert(int offset, char c)`
`StringBuilder insert(int offset, char[] str)`
	Inserts the second argument into the string builder. The first integer argument indicates the index before which the data is to be inserted. The data is converted to a string before the insert operation takes place.

`StringBuilder insert(int index, char[] str, int offset, int len)`
`StringBuilder insert(int offset, double d)`
`StringBuilder insert(int offset, float f)`
`StringBuilder insert(int offset, int i)`
`StringBuilder insert(int offset, long lng)`
`StringBuilder insert(int offset, Object obj)`
`StringBuilder insert(int offset, String s)`	

`StringBuilder replace(int start, int end, String s)` `void setCharAt(int index, char c)`	Replaces the specified character(s) in this string builder.
`StringBuilder reverse()`	Reverses the sequence of characters in this string builder.
`String toString()`	Returns a string that contains the character sequence in the builder.

Note: You can use any `String` method on a `StringBuilder` object by first converting the string builder to a string with the `toString()` method of the `StringBuilder` class. Then convert the string back into a string builder using the `StringBuilder(String str)` constructor.

An Example

The `StringDemo` program that was listed in the section titled "Strings" is an example of a program that would be more efficient if a `StringBuilder` were used instead of a `String`.

`StringDemo` reversed a palindrome. Here, once again, is its listing:

```
public class StringDemo {
    public static void main(String[] args) {
        String palindrome = "Dot saw I was Tod";
        int len = palindrome.length();
        char[] tempCharArray = new char[len];
        char[] charArray = new char[len];

        // put original string in an
        // array of chars
        for (int i = 0; i < len; i++) {
            tempCharArray[i] =
                palindrome.charAt(i);
        }

        // reverse array of chars
        for (int j = 0; j < len; j++) {
            charArray[j] =
```

```
                tempCharArray[len - 1 - j];
        }

        String reversePalindrome =
            new String(charArray);
        System.out.println(reversePalindrome);
    }
}
```

Running the program produces this output:

```
doT saw I was toD
```

To accomplish the string reversal, the program converts the string to an array of characters (first `for` loop), reverses the array into a second array (second `for` loop), and then converts back to a string.

If you convert the `palindrome` string to a string builder, you can use the `reverse()` method in the `StringBuilder` class. It makes the code simpler and easier to read:

```
public class StringBuilderDemo {
    public static void main(String[] args) {
        String palindrome = "Dot saw I was Tod";

        StringBuilder sb = new StringBuilder(palindrome);

        sb.reverse();  // reverse it

        System.out.println(sb);
    }
}
```

Running this program produces the same output:

```
doT saw I was toD
```

Note that `println()` prints a string builder, as in:

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

because `sb.toString()` is called implicitly, as it is with any other object in a `println()` invocation.

Note: There is also a `StringBuffer` class that is *exactly* the same as the `StringBuilder` class, except that it is thread-safe by virtue of having its methods synchronized. Threads will be discussed in the lesson on concurrency.