Building Java Programs

Chapter 4
Lecture 4-3: Strings; `char`

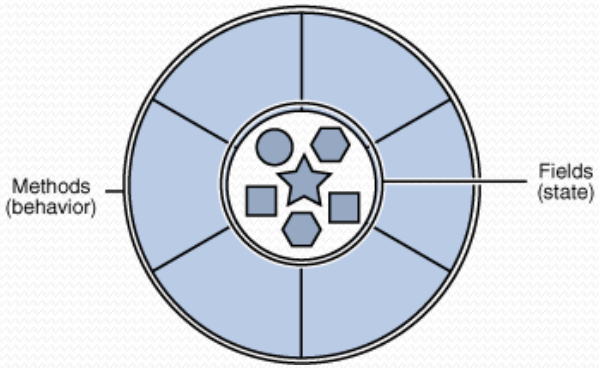
reading: 3.3, 4.3

Strings

reading: 3.3

Objects

- **object:** An entity that contains data and behavior.
  - *data*: variables inside the object
  - *behavior*: methods inside the object
    - You interact with the methods; the data is hidden in the object.
    - A **class** is a *type* of objects.



- Constructing (creating) an object:

```
Type objectName = new Type(parameters);
```

- Calling an object's method:

```
objectName.methodName(parameters);
```

Strings

- **string**: An object storing a sequence of text characters.
  - Unlike most other objects, a `String` is not created with `new`.

```
String name = "text";
String name = expression (with String value);
```

  - Examples:

```
String names = "Alice and Bob";
int x = 3;
int y = 5;
String point = "(" + x + ", " + y + ")";
```

Indexes

- Characters of a string are numbered with 0-based *indexes*:

```
String name = "M. Mouse";
```

index	0	1	2	3	4	5	6	7
character	M	.		M	o	u	s	e

  - First character's index : 0
  - Last character's index : 1 less than the string's length

  - The individual characters are values of type `char` (seen later)

`String` methods

Method name	Description
`indexOf(`**`str`**`)`	index where the start of the given string appears in this string (-1 if not found)
`length()`	number of characters in this string
`substring(`**`index1`**`, `**`index2`**`)` or `substring(`**`index1`**`)`	the characters in this string from *index1* (inclusive) to *index2* (exclusive); if *index2* is omitted, grabs till end of string
`toLowerCase()`	a new string with all lowercase letters
`toUpperCase()`	a new string with all uppercase letters

- These methods are called using the dot notation:

```
String starz = "Prince vs. Michael";
System.out.println(starz.length());   // 18
```

`String` method examples

```
// index      012345678901
String s1 = "Stuart Reges";
String s2 = "Marty Stepp";

System.out.println(s1.length());          // 12
System.out.println(s1.indexOf("e"));      // 8
System.out.println(s1.substring(7, 10)); // "Reg"

String s3 = s2.substring(1, 7);
System.out.println(s3.toLowerCase());     // "arty s"
```

- Given the following string:

```
// index        01234567890123456789
String book = "Building Java Programs";
```

  - How would you extract the word `"Java"` ?

Modifying strings

- Methods like `substring` and `toLowerCase` build and return a new string, rather than modifying the current string.

```
String s = "Mumford & Sons";
s.toUpperCase();
System.out.println(s);    // Mumford & Sons
```

- To modify a variable's value, you must reassign it:

```
String s = "Mumford & Sons";
s = s.toUpperCase();
System.out.println(s);    // MUMFORD & SONS
```

Strings as user input

- `Scanner`'s `next` method reads a word of input as a `String`.

```
Scanner console = new Scanner(System.in);
System.out.print("What is your name? ");
String name = console.next();
name = name.toUpperCase();
System.out.println(name + " has " + name.length() +
    " letters and starts with " + name.substring(0, 1));
```

Output:

```
What is your name? Bono
BONO has 4 letters and starts with B
```

- The `nextLine` method reads a line of input as a `String`.

```
System.out.print("What is your address? ");
String address = console.nextLine();
```

Name border

HELENE
HELEN
HELE
HEL
HE
H
HE
HEL
HELE
HELEN
HELENE
MARTIN
MARTI
MART
MAR
MA
M
MA
MAR
MART
MARTI
MARTIN

- Prompt the user for full name
- Draw out the pattern to the left
- This should be resizable. Size 1 is shown and size 2 would have the first name twice followed by last name twice

Strings question

- Write a program that outputs "The Name Game" with a person's first and last name.

Example Output:

```
What is your name? James Joyce

James, James, bo-bames
Banana-fana fo-fames
Fee-fi-mo-mames
JAMES!

Joyce, Joyce, bo-boyce
Banana-fana fo-foyce
Fee-fi-mo-moyce
JOYCE!
```

Strings answer

```
// This program prints "The Name Game".
import java.util.*;

public class TheNameGame {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        System.out.print("What is your name? ");
        String name = console.nextLine();

        int spaceIndex = name.indexOf(" ");
        String firstName = name.substring(0, spaceIndex);
        String lastName = name.substring(spaceIndex + 1);

        singSong(firstName);
        singSong(lastName);
    }
```

Strings answer (cont.)

```
 public static void singSong(String name) {
        System.out.println();
        String allButLast = name.substring(1);
        System.out.println(name + ", " + name + ", bo-b" + allButLast);
        System.out.println("Banana-fana fo-f" + allButLast);
        System.out.println("Fee-fi-mo-m" + allButLast);
        System.out.println(name.toUpperCase() + "!");
    }
}
```

Comparing strings

- Relational operators such as < and == fail on objects.

```
Scanner console = new Scanner(System.in);
System.out.print("What is your name? ");
String name = console.next();
if (name == "Barney") {
    System.out.println("I love you, you love me,");
    System.out.println("We're a happy family!");
}
```

  - This code will compile, but it will not print the song.

  - == compares objects by *references* (seen later), so it often gives `false` even when two `String`s have the same letters.

The `equals` method

- Objects are compared using a method named `equals`.

```
Scanner console = new Scanner(System.in);
System.out.print("What is your name? ");
String name = console.next();
if (name.equals("Barney") {
    System.out.println("I love you, you love me,");
    System.out.println("We're a happy family!");
}
```

  - Technically this is a method that returns a value of type `boolean`, the type used in logical tests.

`String` test methods

Method	Description
`equals(`**str**`)`	whether two strings contain the same characters
`equalsIgnoreCase(`**str**`)`	whether two strings contain the same characters, ignoring upper vs. lower case
`startsWith(`**str**`)`	whether one contains other's characters at start
`endsWith(`**str**`)`	whether one contains other's characters at end
`contains(`**str**`)`	whether the given string is found within this one

```
String name = console.nextLine();
if (name.startsWith("Dr.")) {
    System.out.println("Will you marry me?");
} else if (name.equalsIgnoreCase("buTteRs")) {
    System.out.println("You're grounded, young man!");
}
```

String documentation: http://docs.oracle.com/javase/7/docs/api/java/lang/String.html

Strings question

- Write a program that reads two people's first names and suggests a name for their child.
  - The suggestion is the concatentation of the first halves of both names.

Example Output:

```
Parent 1 first name? Danielle
Parent 2 first name? John
Child gender? f
Suggested baby name: JODANI

Parent 1 first name? Danielle
Parent 2 first name? John
Child gender? Male
Suggested baby name: DANIJO
```

Strings answer

```
// Suggests a baby name based on parents' names.
import java.util.*;

public class BabyNamer {
   public static void main(String[] args) {
      Scanner s = new Scanner(System.in);
      System.out.print("Parent 1 first name? ");
      String name1 = s.next();
      System.out.print("Parent 2 first name? ");
      String name2 = s.next();
      System.out.print("Child gender? ");
      String gender = s.next();

      System.out.println("Suggested name: " +
                         suggestChildName(gender, name1, name2).toUpperCase());
   }

   ...
```

Strings answer (cont.)

```
   ...

   // Return the first half of the given name.
   public static String getHalfName(String name) {
      int halfIndex = name.length() / 2;
      return name.substring(0, halfIndex);
   }

   // Suggests a child's name (for a given gender) for parents with the given names.
   public static String suggestChildName(String gender, String name1, String name2) {
      String halfName1 = getHalfName(name1);
      String halfName2 = getHalfName(name2);
      String name;
      if (gender.toLowerCase().startsWith("f")) {
         name = halfName1 + halfName2;
      } else {
         name = halfName2 + halfName1;
      }
      return name;
   }
}
```

Another Strings question

- Prompt the user for two words and report whether they:
  - *"rhyme"* (end with the same last two letters)
  - *alliterate* (begin with the same letter)
  - Example output: (run #1)

```
Type two words: car STAR
They rhyme!
```

(run #2)

```
Type two words: bare bear
They alliterate!
```

(run #3)

```
Type two words: sell shell
They alliterate!
They rhyme!
```

(run #4)

```
Type two words: extra strawberry
```

Another Strings answer

```
// Determines whether two words rhyme and/or alliterate.
import java.util.*;

public class Rhyme {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        System.out.print("Type two words: ");
        String word1 = console.next().toLowerCase();
        String word2 = console.next().toLowerCase();
        printIfRhyme(word1, word2);
        printIfAlliterate(word1, word2);
    }

    // print if two words "rhyme" (i.e., end with the same two letters)
    public static void printIfRhyme(String word1, String word2) {
        if (word2.length() >= 2 &&
            word1.endsWith(word2.substring(word2.length() - 2))) {
            System.out.println("They rhyme!");
        }
    }

    // print if two alliterate
    public static void printIfAlliterate(String word1, String word2) {
        if (word1.startsWith(word2.substring(0, 1))) {
            System.out.println("They alliterate!");
        }
    }
}
```

char

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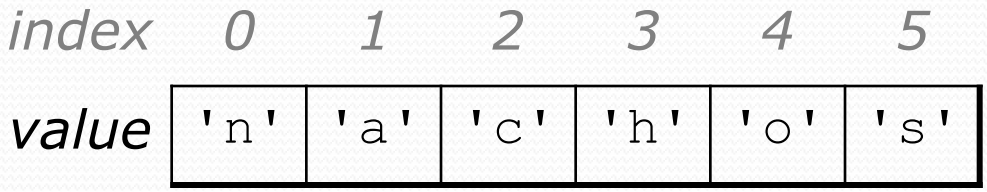
Type `char`

- **`char`** : A primitive type representing single characters.
  - A `String` is stored internally as an array of `char`

```
String s = "nachos";
```



  - It is legal to have variables, parameters, returns of type `char`
    - surrounded with apostrophes: `'a'` or `'4'` or `'\n'` or `'\''`

```
char initial = 'J';
System.out.println(initial);              // J
System.out.println(initial + " Joyce");   // J Joyce
```

The `charAt` method

- The `char`s in a `String` can be accessed using the `charAt` method.
  - accepts an `int` index parameter and returns the `char` at that index

```
String food = "cookie";
char firstLetter = food.charAt(0);    // 'c'
System.out.println(firstLetter + " is for " + food);
```

- You can use a `for` loop to print or examine each character.

```
String major = "CSE";
for (int i = 0; i < major.length(); i++) {     // output:
    char c = major.charAt(i);                  // C
    System.out.println(c);                     // S
}                                              // E
```

Comparing `char` values

- You can compare `char` values with relational operators:

  `'a' < 'b'` and `'X' == 'X'` and `'Q' != 'q'`

  - An example that prints the alphabet:

```
for (char c = 'a'; c <= 'z'; c++) {
    System.out.print(c);
}
```

- You can test the value of a string's character:

```
String word = console.next();
if (word.charAt(word.length() - 1) == 's') {
    System.out.println(word + " is plural.");
}
```

char vs. String

- "h" is a String, but 'h' is a char (they are different)
- A String is an object; it contains methods.

```
String s = "h";
s = s.toUpperCase();          // "H"
int len = s.length();         //  1
char first = s.charAt(0);     // 'H'
```

- A char is primitive; you can't call methods on it.

```
char c = 'h';
c = c.toUpperCase();                 // ERROR
s = s.charAt(0).toUpperCase();       // ERROR
```

  - What is s + 1 ? What is c + 1 ?
  - What is s + s ? What is c + c ?

`char` vs. `int`

- Each `char` is mapped to an integer value internally
  - Called an **ASCII value**

`'A'` is 65	`'B'` is 66	`' '` is 32
`'a'` is 97	`'b'` is 98	`'*'` is 42

  - Doing "math" on a `char` causes automatic conversion to `int`.
    `'a' + 10` is 107, `'A' + 'A'` is 130
  - To convert an `int` into the equivalent `char`, type-cast it.
    `(char) ('a' + 2)` is `'c'`

`String/char` question

- A *Caesar cipher* is a simple encryption where a message is encoded by shifting each letter by a given amount.
  - e.g. with a shift of 3, A → D, H → K, X → A, and Z → C

- Write a program that reads a message from the user and performs a Caesar cipher on its letters:

```
Your secret message: Computer science is awesome
Your secret key: 3
The encoded message: frpsxwhu vflhqfh lv dzhvrph
```

Strings answer 1

```
// This program reads a message and a secret key from the user and
// encrypts the message using a Caesar cipher, shifting each letter.

import java.util.*;

public class SecretMessage {
   public static void main(String[] args) {
      Scanner console = new Scanner(System.in);

      System.out.print("Your secret message: ");
      String message = console.nextLine();

      System.out.print("Your secret key: ");
      int key = console.nextInt();

      System.out.println("The encoded message: " +
                         encode(message, key));
   }

   ...
```

Strings answer 2

```
    // This method encodes the given text string using a Caesar
    // cipher, shifting each letter by the given number of places.
    public static String encode(String text, int shift) {
        text = text.toLowerCase();
        String result = "";
        for (int i = 0; i < text.length(); i++) {
            char letter = text.charAt(i);
            result += encodeLetter(letter, shift);
        }
        return result;
    }

    // Encodes a single letter using a Caesar cipher.  Shifts only
    // letters (leaves other characters alone).  Assumes letter is
    // lowercase.
    public static char encodeLetter(char letter, int shift) {
        if (letter >= 'a' && letter <= 'z') {
            letter = (char)(letter + shift);
            // may need to wrap around
            if (letter > 'z') {
                letter = (char)(letter - 26);
            } else if (letter < 'a') {
                letter = (char)(letter + 26);
            }
        }

        return letter;
    }
}
```

(Optional) `printf`

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Formatting text with `printf`

```
System.out.printf("format string", parameters);
```

- A format string can contain *placeholders* to insert parameters:
  - `%d` integer
  - `%f` real number
  - `%s` string
    - these placeholders are used instead of + concatenation
  - Example:

```
int x = 3;
int y = -17;
System.out.printf("x is %d and y is %d!\n", x, y);
                  // x is 3 and y is -17!
```

    - `printf` does not drop to the next line unless you write `\n`

printf width

- %**W**d integer, **W** characters wide, right-aligned
- %-**W**d integer, **W** characters wide, *left*-aligned
- %**W**f real number, **W** characters wide, right-aligned
- ...

```
for (int i = 1; i <= 3; i++) {
    for (int j = 1; j <= 10; j++) {
        System.out.printf("%4d", (i * j));
    }
    System.out.println();   // to end the line
}
```

Output:

```
   1   2   3   4   5   6   7   8   9  10
   2   4   6   8  10  12  14  16  18  20
   3   6   9  12  15  18  21  24  27  30
```

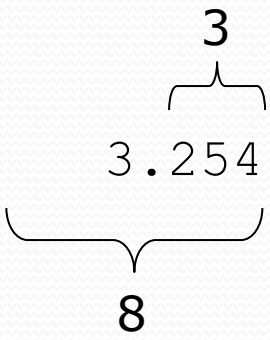
`printf` precision

- `%.`**`D`**`f` real number, rounded to **D** digits after decimal
- `%`**`W`**`.`**`D`**`f` real number, **W** chars wide, **D** digits after decimal
- `%-`**`W`**`.`**`D`**`f` real number, **W** wide (left-align), **D** after decimal

```
double gpa = 3.253764;
System.out.printf("your GPA is %.1f\n", gpa);
System.out.printf("more precisely: %8.3f\n", gpa);
```

Output:

```
your GPA is 3.3
more precisely:    3.254
```



`printf` question

- Modify our `Receipt` program to better format its output.
  - Display results in the format below, with 2 digits after .

- Example log of execution:

```
How many people ate? 4
Person #1: How much did your dinner cost? 20.00
Person #2: How much did your dinner cost? 15
Person #3: How much did your dinner cost? 25.0
Person #4: How much did your dinner cost? 10.00

Subtotal:   $70.00
Tax:        $5.60
Tip:        $10.50
Total:      $86.10
```

printf answer (partial)

```
...
    // Calculates total owed, assuming 8% tax and 15% tip
    public static void results(double subtotal) {
        double tax = subtotal * .08;
        double tip = subtotal * .15;
        double total = subtotal + tax + tip;

        // System.out.println("Subtotal: $" + subtotal);
        // System.out.println("Tax: $" + tax);
        // System.out.println("Tip: $" + tip);
        // System.out.println("Total: $" + total);

        System.out.printf("Subtotal: $%.2f\n", subtotal);
        System.out.printf("Tax:      $%.2f\n", tax);
        System.out.printf("Tip:      $%.2f\n", tip);
        System.out.printf("Total:    $%.2f\n", total);
    }
}
```