Introduction to Classes and Objects

CS102A Lecture 7

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Objectives

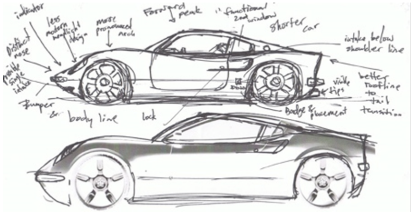
- Understand *classes*, *objects*, *instance variables*.
- Learn to declare a class and use it to create an object.
- Learn to declare non-static methods to implement the class’s behavior.
- Learn to declare instance variables to implement the class’s attributes.
- Learn to use a constructor to ensure that an object’s data is initialized when the object is created.

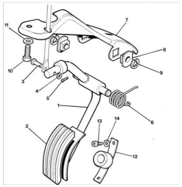
Introduction

- Typically, Java applications consist of one or more classes, each containing one or more methods.
  - E.g., `Welcome1`, `Welcome2`, `Addition`, `Comparison` ...
- In this chapter, we present a simple framework for organizing object-oriented applications in Java.
- We begin with an analogy to introduce classes and their contents.

Classes, objects, methods

- To drive a car and accelerate it by pressing down on its accelerator pedal.
  - Before you can drive a car, someone has to design it (engineering drawings/blueprints).
  - Including the design for an accelerator pedal.
  - A lot more designs, e.g., the brake pedal, the steering wheel.
  - **We don't need to know the complex mechanisms behind the design to drive the car.**





Classes, objects, methods

- We cannot drive a car’s engineering drawings.
  - Before we drive, it must be **built from the engineering drawings**.
  - Even building a car is not enough, the driver must **press the accelerator pedal** to perform the task of drive the car.
- Three key concepts in Java:
  - *class* – a car’s engineering drawings (blueprint),
  - *method* – designed to perform tasks (make a car move),
  - *object* – the car we drive.

Classes, objects, methods

- When programming Java, we begin by creating a program unit called `class`, just like we begin with engineering draws in the driving example.
- In a `class`, we provide one or more *methods* that are designed to perform the class' tasks. The method hides from its user the complex tasks that it performs, just like the accelerator pedal of a car hides from the driver the complex mechanisms that make the car move faster.

Classes, objects, methods

- We cannot drive a car's engineering drawings
- Similarly, we cannot "drive" a `class` to perform a task.
- Just as we have to build a car from its engineering drawings before driving it, we must *build an object* of a `class` before getting a program to perform tasks.
- This is one reason why Java is called an "object-oriented" programming language.

Classes, objects, methods

- When driving a car, pressing the accelerator pedal **sends a message to the car** to perform a task –- make the car go faster.
- Similarly, we **send a message to an object** –- implemented as a method call that tells a method of the object to perform its task.

Instance variables

- A car can have many *attributes*, such as its color, the number of doors, the amount of gas in its tank, its current speed, and the total miles driven.
  - These attributes are represented as part of a car's design in its engineering diagrams.
  - As you drive a car, **these attributes are always associated with the car** (not other cars of the same model).
  - Every car maintains its own attributes (e.g., knowing how much gas is left in its tank, but do not know about other cars).
- Similarly, an object has *attributes* that are carried with the *object* as it's used in a program.
  - These attributes are specified as the class' instance variables. E.g., a bank account object has a balance attribute (implemented as an instance variable) that represents the amount of money in that account.

The whole picture

- *Class* –a car's engineering drawings (a blueprint);
- *Method* –designed to perform tasks (e.g., making a car move);
- *Object* –the car we drive;
- *Method* call –perform the task (e.g., pressing the accelerator pedal)
- *Instance variable* –to specify the attributes (e.g., the amount of gas).

Declaring a `class`

- Every class declaration contains the keyword `class` + the class' name.
- The access modifier `public` indicates that the declared `class` is visible to all `class`es everywhere.

```java
public class GradeBook {
  // every class' body is enclosed in a pair of
  // left and right curly braces
}
```

Declaring a *method*

- A class usually consists of one or more *method*s.
- The access modifier `public` indicates that the method is "available to public", that is, can be called from the methods of other classes.

```java
public class GradeBook {
  // display welcome message to the user
  public void displayMessage() {
    System.out.println("Welcome to the Grade Book!");
  }
}
```

Object creation and method calling

```java
public class GradeBookTest {
  public static void main(String[] args) {
    // create a GradeBook object - assign it to myGradeBook
    GradeBook myGradeBook = new GradeBook();

    // call myGradeBook's displayMessage method
    myGradeBook.displayMessage();
  }
}
```

- `GradeBook myGradeBook`: define a variable of the type `GradeBook`. Note that each new class you create becomes a new type, this is why Java is an extensible language.

Object creation and method calling

```java
public class GradeBookTest {
  public static void main(String[] args) {
    // create a GradeBook object - assign it to myGradeBook
    GradeBook myGradeBook = new GradeBook();

    // call myGradeBook's displayMessage method
    myGradeBook.displayMessage();
  }
}
```

- `new GradeBook()`: class instance creation expression. The keyword `new` is used to create a new object of the specified class. Class name + `()` represent a call to a *constructor* (a special method used to initialize the object's data).

Object creation and method calling

```java
public class GradeBookTest {
  public static void main(String[] args) {
    // create a GradeBook object - assign it to myGradeBook
    GradeBook myGradeBook = new GradeBook();

    // call myGradeBook's displayMessage method
    myGradeBook.displayMessage();
  }
}
```

- We can use the variable `myGradeBook` to refer to the created object and that we call the method `displayMessage()`. The empty parentheses indicate "**provide no additional data (arguments) to the called method**".

More on instance variables

- An object has *attribute*s (e.g., the amount of gas of a car) that are carried with the object as it is used in a program.
- Such attributes exist before a method is called on an object and after the method completes execution.
- A class typically consists of one or more *method*s that manipulate the attributes that belong to a particular object of the class.
- Attributes are represented as variables in a class declaration.

More on instance variables

```java
public class GradeBook {
  private String courseName;
  public void displayMessage( String courseName ) {
    System.out.println("Welcome to the Grade Book for
    the course%s!\n", courseName);
  }
}
```

- Object attributes are represented as *variable*s (called *field*s) in a class declaration.
- Each *object* (*instance*) of the class has its own copy of an attribute in memory, the *field* that represents the attribute is also know as an instance variable.

Don’t confuse with local variables

```java
public class GradeBookTest {
  public static void main(String[] args) {
    // create a GradeBook object
    // assign it to myGradeBook
    GradeBook myGradeBook = new GradeBook();

    // call myGradeBook's displayMessage method
    myGradeBook.displayMessage();
  }
}
```

- Variables declared in the body of a particular method are known as *local variable*s and can be only used in that method.
- Instance variables are declared inside a class declaration, but outside the bodies of the class’ method declarations.

Declaring methods to manipulate instance variables

```java
public class GradeBook {
  private String courseName;
  // method to set the course name
  public void setCourseName(String name) {
    courseName = name;
  }
  // method to retrieve the course name
  public String getCourseName() {
    return courseName;
  }
}
```

- Most instance variables are declared to be `private` (*data hiding*). Variables (or methods) declared to be `private` are accessible only to methods of the class in which they are declared.

Using *getter* and *setter*

```
import java.util.Scanner;
public class GradeBookTest {
  public static void main(String[] args) {
    GradeBook myGradeBook = new GradeBook();
    Scanner input = new Scanner(System.in);
    System.out.printf("Enter course name: ");
    String theName = input.nextLine();
    myGradeBook.setCourseName(theName);
    myGradeBook.displayMessage();
  }
}
public class GradeBook {
  ...
  public void displayMessage() {
    System.out.printf("Welcome to the grade book
    for\n%s!\n", getCourseName());
  }
}
```

Initializing objects with constructors

```java
GradeBook myGradeBook = new GradeBook();
```

- Each class you declare can provide a special method called a *constructor* that can be used to initialize an object of a class when the object is created.
- Java requires a *constructor* call for every object that is created.
- Keyword `new` requests memory from the system to store an object, then calls the corresponding class's constructor to initialize the object.

Initializing objects with constructors

```java
GradeBook myGradeBook = new GradeBook();
```

- The empty parentheses after `new GradeBook` indicate a call to the class' constructor without arguments.
- The compiler provides a *default constructor* with no parameters in any class that does not explicitly include a constructor.
  - When a class has only the default constructor, its instance variables are initialized with default values (e.g., an `int` variable gets the value `0`).
- When you declare a class, you can provide your own constructor to specify custom initialization for objects of your class.

Initializing objects with constructors

```java
public class GradeBook {
  private String courseName; // course name of this Gradebook

  // constructor initialize
  public GradeBook( String name ) {
    courseName = name;
  } // end constructor
}
```

- The modified `GradeBook` class contain a constructor that receives an argument.
- Like a method, a constructor's parameter list specifies the data it requires to perform its task.

Initializing objects with constructors

```java
public class GradeBookTest {
  public static void main( String[] args) {
    GradeBook gradeBook1 = new GradeBook("CS101");
    GradeBook gradeBook2 = new GradeBook("CS102");

    System.out.printf( "gradeBook1 course name is %s%n",
      gradeBook1.getCourseName() );
    System.out.printf( "gradeBook2 course name is %s%n",
      gradeBook2.getCourseName() );
  }
}
```

Initializing objects with constructors

- An important difference between constructors and methods is that constructors **cannot return values**, so they cannot specify a return type (not even `void`).
- Normally, constructors are declared `public`.
- If you declare any constructors for a class, the Java compiler will not create a default constructor for the class.

More on *default constructor*

- Can we write the following statement to create a GradeBook object?

```java
GradeBook myGradeBook = new GradeBook();
```

```java
public class GradeBook {
  // no constructor provided
  private String courseName;
  public void setCourseName(String
       name) {
    courseName = name;
  }
  public String getCourseName() {
    return courseName;
  }
  ...
}
```

```java
public class GradeBook {
  // this version has a constructor
  private String courseName;
  public GradeBook(String name) {
    courseName = name;
  }
  public void setCourseName(String
       name) {
    courseName = name;
  }
  ...
}
```

Case study: Account balances

- We define a class named `Account` to maintain the balance of a bank account.

```java
// Account class with a double instance variable balance and a
// constructor and deposit method that perform validation.
public class Account {
  private String name; // instance variable
  private double balance; // instance variable

  // Account constructor that receives two parameters
  public Account(String name, double balance)     {
      this.name = name; // assign name to instance variable name

      // validate that the balance is greater than 0.0; if it's not,
      // instance variable balance keeps its default initial value of 0.0
      if (balance > 0.0) // if the balance is valid
          this.balance = balance; // assign it to instance variable
  }
```

Case study: Account balances

```java
// method that deposits (adds) only a valid amount to the balance
public void deposit(double depositAmount) {
  if (depositAmount > 0.0) // if the depositAmount is valid
    balance += depositAmount; // add it to the balance
}

// method returns the account balance
public double getBalance() {
  return balance;
}
```

Case study: Account balances

```java
   // method that sets the name
   public void setName(String name) {
     this.name = name;
   }

   // method that returns the name
   public String getName() {
       return name; // give value of name back to caller
   } // end method getName
} // end class Account
```

Case study: Account balances

```java
// Inputting and outputting floating-point numbers with Account objects.
import java.util.Scanner;
public class AccountTest {
  public static void main(String[] args) {
    Account account1 = new Account("Jane Green", 50.00);
    Account account2 = new Account("John Blue", -7.53);

    // display initial balance of each object
    System.out.printf("%s balance: $%.2f\n",
      account1.getName(), account1.getBalance());
    System.out.printf("%s balance: $%.2f\n\n",
      account2.getName(), account2.getBalance());

    // create a Scanner to obtain input from the command window
    Scanner input = new Scanner(System.in);
```

Case study: Account balances

```
    System.out.print("Enter deposit amount for account1: "); // prompt
    double depositAmount = input.nextDouble(); // obtain user input

    System.out.printf("\nadding %.2f to account1 balance\n\n",
        depositAmount);
    account1.deposit(depositAmount); // add to account1's balance

    // display balances
    System.out.printf("%s balance: $%.2f\n",
      account1.getName(), account1.getBalance());
    System.out.printf("%s balance: $%.2f\n\n",
      account2.getName(), account2.getBalance());

    System.out.print("Enter deposit amount for account2: "); // prompt
    depositAmount = input.nextDouble(); // obtain user input
```

Case study: Account balances

```java
      System.out.printf("%nadding to account2 balance%n%n", depositAmount);
      account2.deposit(depositAmount); // add to account2 balance

      // display balances
      System.out.printf("%s balance: $%.2f\n",
        account1.getName(), account1.getBalance());
      System.out.printf("%s balance: $%.2f\n\n",
        account2.getName(), account2.getBalance());
   } // end main
} // end class AccountTest
```

Case study: Account balances

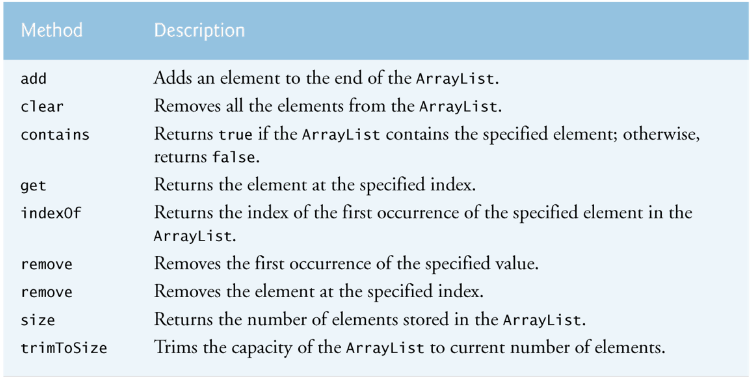
```
account1 balance: $50.00
account2 balance: $0.00

Enter deposit amount for account1: 25.53

adding 25.53 to account1 balance

account1 balance: $75.53
account2 balance: $0.00

Enter deposit amount for account2: 123.45

adding 123.45 to account2 balance

account1 balance: $75.53
account2 balance: $123.45
```

Introduction to *collections* and class `ArrayList`

- *Collections* provide efficient methods that organize, store and retrieve your data without requiring knowledge of how the data is being stored.
- The collection class `ArrayList<T>` (from package `java.util`) can dynamically change its size to accommodate more elements.
- The `T` is a placeholder – when declaring a new `ArrayList`, replace it with the type of elements that you want the `ArrayList` to hold.
- This is similar to specifying the type when declaring an array, except that only non-primitive types can be used with these collection classes.
- Classes with this kind of placeholder that can be used with any type are called *generic class*es.

```java
ArrayList<String> items = new ArrayList<String>();
```

Introduction to *collections* and class `ArrayList`



Method	Description
`add`	Adds an element to the end of the `ArrayList`.
`clear`	Removes all the elements from the `ArrayList`.
`contains`	Returns `true` if the `ArrayList` contains the specified element; otherwise, returns `false`.
`get`	Returns the element at the specified index.
`indexOf`	Returns the index of the first occurrence of the specified element in the `ArrayList`.
`remove`	Removes the first occurrence of the specified value.
`remove`	Removes the element at the specified index.
`size`	Returns the number of elements stored in the `ArrayList`.
`trimToSize`	Trims the capacity of the `ArrayList` to current number of elements.

Fig. 6.17 | Some methods and properties of class `ArrayList<T>`.

Introduction to *collections* and class `ArrayList`

```java
// Generic ArrayList<T> collection demonstration.
import java.util.ArrayList;
public class ArrayListCollection {
  public static void main(String[] args) {
    // create a new ArrayList of Strings with an initial capacity of 10
    ArrayList < String > items = new ArrayList < String > ();

    items.add("red"); // append an item to the list
    items.add(0, "yellow"); // insert "yellow" at index 0

    // header
    System.out.print("Display list contents with counter-controlled loop:
       ");

    // display the colors in the list
    for (int i = 0; i < items.size(); i++)
      System.out.printf(" %s", items.get(i));
```

Introduction to *collections* and class `ArrayList`

```java
    // display colors using enhanced for in the display method
    display(items, "%nDisplay list contents with enhanced for statement:"
        );

    items.add("green"); // add "green" to the end of the list
    items.add("yellow"); // add "yellow" to the end of the list
    display(items, "List with two new elements:");

    items.remove("yellow"); // remove the first "yellow"
    display(items, "Remove first instance of yellow:");

    items.remove(1); // remove item at index 1
    display(items, "Remove second list element (green):");

    // check if a value is in the List
    System.out.printf("\"red\" is %sin the list%n",
      items.contains("red") ? "" : "not ");
```

Introduction to *collections* and class `ArrayList`

```
    // display number of elements in the List
    System.out.printf("Size: %s%n", items.size());
  }

  // display the ArrayList's elements on the console
  public static void display(ArrayList < String > items, String header) {
    System.out.printf(header); // display header

    // display each element in items
    for (String item: items)
      System.out.printf(" %s", item);
    System.out.println();
  }
} // end class ArrayListCollection
```

Introduction to *collections* and class `ArrayList`

```
Display list contents with counter-controlled loop: yellow red
Display list contents with enhanced for statement: yellow red
List with two new elements: yellow red green yellow
Remove first instance of yellow: red green yellow
Remove second list element (green): red yellow
"red" is in the list
Size: 2
```