SWEN20003
Object Oriented Software Development

Classes and Objects 1

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The Road So Far

Lectures

- Subject Introduction
- A Quick Tour of Java

Learning Outcomes

Upon completion of this topic, which includes three lectures, you will be able to:

- Explain the difference between a *class* and an *object*
- Create classes, give them *properties* and *behaviours*, implement and use simple classes
- Identify a series of well-defined classes from a *specification*
- Understand the role of *getters*, *setters* and *constructors*
- Understand the differences between *instance*, *static* and *local* variables
- Understand the role of *standard methods* in java
- Explain object oriented concepts: *abstraction, encapsulation, information hiding and delegation*
- Understand the role of *wrapper* classes

Overview

This topic will be delivered through three lectures (Lectures 3, 4 and 5) each covering the following subtopics.

Classes and Objects - 1

- Introducing Classes and Objects
- Defining Classes
- Using Classes

Classes and Objects - 2

- Getters, Setters and Constructors
- Static Attributes and Methods
- Standard Methods in Java

Classes and Objects - 3

- Introducing Java Packages
- Information Hiding
- Delegation through Association
- Wrapper Classes

Introducing Classes and Objects

Introduction

All programming languages support four basic concepts:

- Calculation: constants, variables, operators, expressions
- Selection: `if-else`, `switch`, `?`
- Iteration: `while`, `do`, `for`
- Abstraction: The process of creating self-contained units of software that allows the solution to be parameterized and therefore more general purpose

Abstraction is the fundamental concept that differentiates procedural programming languages such as C from Object Oriented languages such as Java, C++.

Abstraction in Procedural Languages

Abstraction in procedural languages is provided through *functions* or *procedures*.

Functions manipulate external data by performing operations on them.

Example of a function in C that calculates the average of two floating point numbers:

```
1       float calculate_average (float a, float b) {
2           float result;
3           result = (a + b)/2;
4           return result;
5       }
```

Abstraction in Object Oriented Languages

Abstraction in Object Oriented (OO) languages is provided through an *Abstract Data Type (ADT)*, which contains *data* and *functions* that operate on data.

In Java a **Class** is an implementation on an **Abstract Data Type**.

Classes

- A "generalization" of a real world (or "problem world") entity
  - A physical real world thing, like a student or book
  - An abstract real world thing, like a university subject
  - An even more abstract thing like a list or a string (data)
- Represents a template for things that have common properties
- Contains *attributes* and *methods*
- Defines a new **data type**

Keyword

Class: Fundamental unit of abstraction in *Object Oriented Programming*. Represents an "entity" that is part of a problem.

Objects

- Are *instances* of a class
- Contain **state**, or dynamic information
- "**X** is of type A", "**X** is an object of the class A", and "**X** is an instance of the class A" are all equivalent

Keyword

Object: A specific, concrete example of a class

Keyword

Instance: An object that exists in your code

Motivating Example

Throughout this topic we will be referring to the following specification:

Develop a system (a set of classes) for a simple Drawing Pad application. The application should allow drawing different types of shapes, such as circles, squares, rectangles, display their geometrical properties: e.g. area, circumference. It should also allow different types of actions such as moving, resizing to the performed on shapes.

How would you develop this, right now? What additional information do you need?

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Drawing Pad Application - Classes

What classes can we use for our example problem?

Fundamental:

- `Drawing Pad`
- `Circle`
- `Square`
- Other shapes

Additional:

- `Drawing Tool`
- `Paint Brush`
- `Fill Colour`
- `Fill Type`
- Many more

Identifying Attributes and Methods

Let us consider the `Circle` class.

Can you identify the *attributes* and *methods* of the class?

Attributes:

- `Centre`
- `Radius`
- `Fill Colour`, `Fill Type`
- Many more

Methods (Operations):

- `Compute Circumference`
- `Compute Area`
- `Move`
- `Resize`
- Many more

Object Oriented Features

Following are some key features of the object oriented design paradigm:

- Data Abstraction
- Encapsulation
- Information Hiding
- Delegation
- Inheritance
- Polymorphism

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- Data Abstraction
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- Inheritance
- Polymorphism

Data Abstraction

Keyword

Data Abstraction: The technique of creating new data types that are well suited to an application by defining new classes.

A class is a special kind of programmer-defined data type.

- For example, by creating classes such as `Circle`, `Drawing Pad`, you are creating new data types, that can be used in applications.

A class is somewhat close to a structure in C but have additional features - attributes and methods.

The class definition determines the types of data (attributes) that an object can contain, as well as the actions (methods) it can perform.

Encapsulation

Keyword

Encapsulation: The ability to group data (attributes) and methods that manipulate the data to a single entity though defining a class.

A class encapsulates data and the methods that operate on the data into a single unit.

This method of encapsulation is unique to OO programming and is not provided by the procedural programming paradigm.

Defining a Class

Defining a Class

Syntax:

```
<visibility modfier> class <ClassName> {
    <attribute declarations>
    <method declarations>
}
```

A bare bone class:

```
// Circle.java - Circle class definition
public class Circle {

}
```

Defining a Class - Adding Attributes

Attribute Syntax:

```
<visibility modifier> <type> <variable name>;
```

Adding attributes (also called data, fields) to the `Circle` class.

```
// Circle.java - Circle class definition
public class Circle {
    public double centreX; //centre x coordinate
    public double centreY; //centre y coordinate
    public double radius;  //radius
}
```

Defining a Class - Adding Attributes

The attributes added to the `Circle` class in the above example are referred to as *instance variables*.

- these attributes maintain the state of the object; i.e. by giving values to `centreX, centreY, radius` we define a Circle object with particular size and position.

Keyword

Instance Variable: A **property** or **attribute** that is unique to each *instance (object)* of a class.

Defining a Class - Adding Methods

Method Syntax:

```
1       <visibility modifier> <void or typeReturned> myMethod(paramList)
2       {
3           variable declarations
4           statements
5       }
```

- If the method returns data, the data type must be specified in the method definition, otherwise, it is defined as `void`.
- If the method returns data, the method body must contain a return statement, which returns a variable of the specified return type.
- Variables can be declared inside the method - such variables are called *local variables*.
  Note: Local variables are inside the method as opposed to the instance variables (introduced earlier) which are outside the method declaration.

Defining a Class - Adding Methods

Adding methods to `Circle` class.

```
1       // Circle.java
2       public class Circle {
3           public double centreX;
4           public double centreY;
5           public double radius;
6
7           public double computeCircumference () {
8               double circum = 2 * Math.PI * radius;
9               return circum;
10          }
11          public double computeArea () {
12              double area = Math.PI * radius * radius;
13              return area;
14          }
15          public void resize (double factor) {
16              radius = radius * factor;
17          }
18      }
19
```

Using a Class

Using the `Circle` class

Follow the steps below to use the `Circle` class we just created.

- Create a file `Circle.java` and write the code.
  Note: the file name should match the class name.
- You can use an Integrated Development Environment (IDE), such a IntelliJ for this (will be introduced in the workshops), but in this instance use a text editor such as `notepad, wordpad, vim, kate etc.`
- Compile the class using the following command:

  ```
  javac Circle.java
  ```

  This creates a file `Circle.class`
- `Circle` becomes a derived data type that can be used in a Java program.

Using the Circle class

By creating the Circle class, you have created a new data type Circle - **Data Abstraction**.

- Variables of type Circle can be now defined in a program
- Circle is a **Derived Data Type** (as opposed to a Primitive Data Type such as int, float)

Example:

```
1  /* CircleTest.java: A test program to test the Circle class */
2  public class CircleTest {
3      public static void main(String args[]) {
4          Circle aCircle;
5          Circle bCircle
6      }
7  }
```

Using the `Circle` class

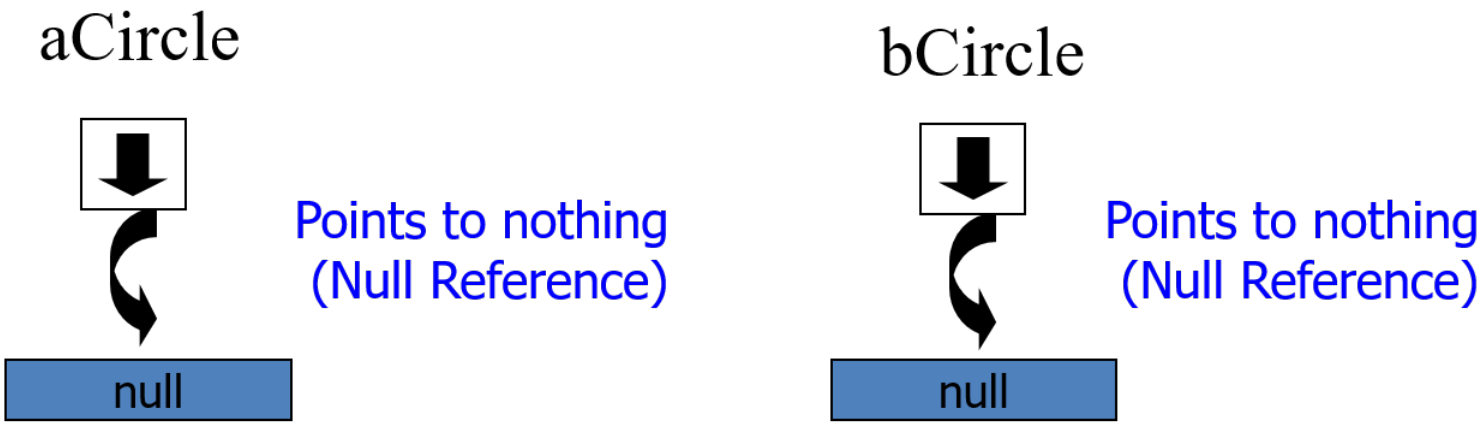
The declarations:

```
Circle aCircle;
Circle bCircle;
```

in the previous example did not create `Circle` objects.

`aCircle` and `bCircle` are simply **references** to `Circle` objects (not objects):

- Currently they point to nothing, hence **null references**.



The `null` Reference

Keyword

null: The Java keyword for "no object here". Null objects can't be "accessed" to get variables or methods, or used in any way.

Instantiating a Class

Objects are **null** until they are *instantiated*.

Keyword

Instantiate: To create an object of a class

```
1          // Instantiate an Circle object
2          Circle circle_1 = new Circle();
```

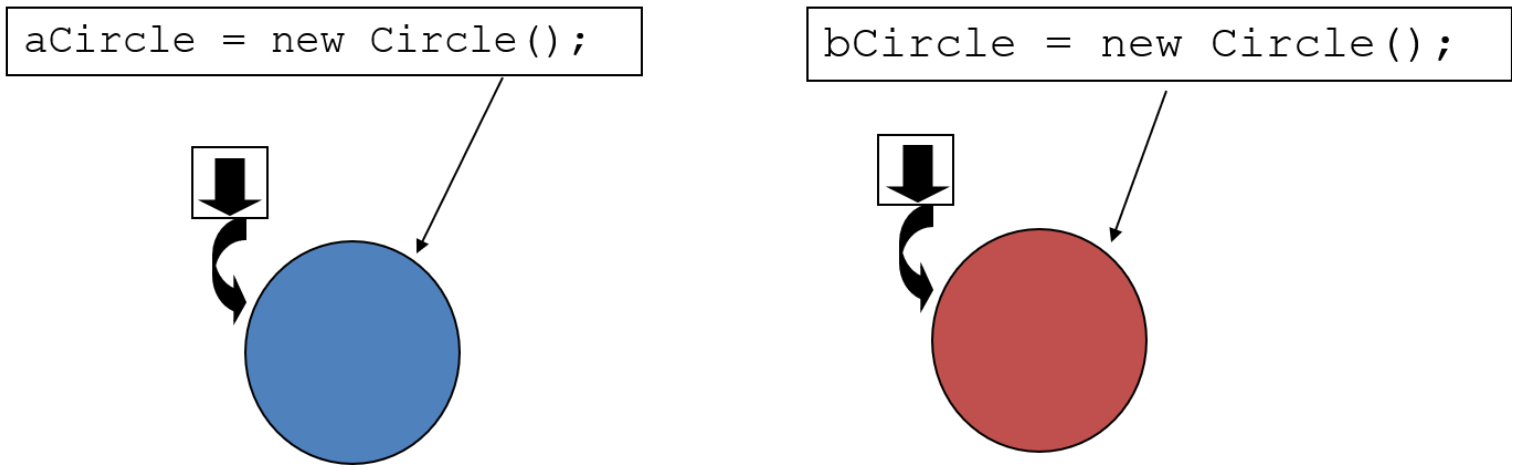
Keyword

new: Directs the JVM to allocate memory for an object, or *instantiate* it

Creating Objects

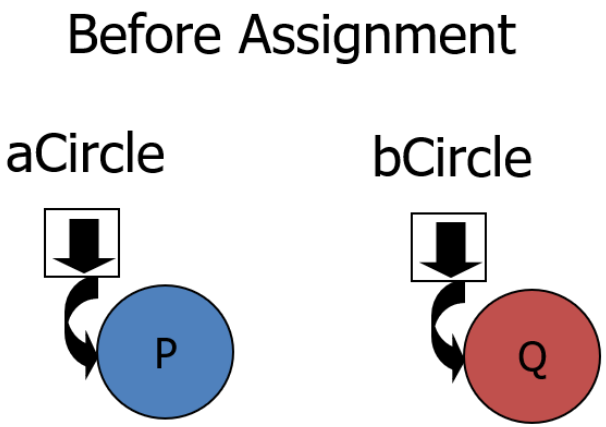
Objects are created dynamically using the `new` keyword.

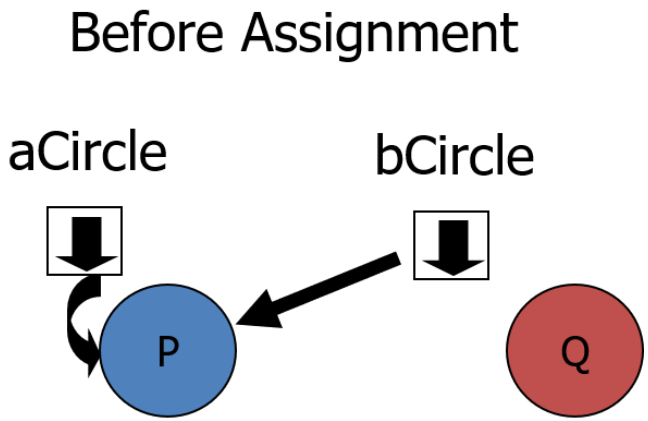
```
1  // CircleTest.java: A test program to test the Circle class
2  public class CircleTest {
3      public static void main(String args[]) {
4          Circle aCircle, bCircle;
5          aCircle = new Circle(); //aCircle now points to an object
6          bCircle = new Circle(); //bCircle now points to an object
7      }
8  }
```



Assigning References of a Class

```
1  // CircleTest.java: A test program to test the Circle class
2  public class CircleTest {
3      public static void main(String args[]) {
4          Circle aCircle, bCircle;
5          aCircle = new Circle(); //aCircle now points to an object
6          bCircle = new Circle(); //bCircle now points to an object
7          bCircle = aCircle; // Assining a class reference
8      }
9  }
```





Garbage Collection in Java

- In the previous example, object **Q** does not have a valid reference and, therefore, cannot be used in future.
- The object becomes a candidate for **Java Automatic Garbage Collection**.
  - Java automatically collects garbage periodically, and frees the memory of unused objects and makes this memory available for future use; you do not have to do this explicitly in the program.

Using Instance Variables and Methods

Syntax:

```
1       <objectName>.<varibaleName>;
2       <objectName>.<methodName>(<arguments>);
```

Syntax is similar to C syntax for accessing data defined in a structure.

Example:

```
1       Circle aCircle = new Circle();
2       double area;
3
4       // Initialize centre and radius
5       aCircle.centreX = 2.0;
6       aCircle.centreY = 2.0;
7       aCircle.radius = 1.0;
8
9       //Invoking methods or sending a "message" to methods
10      area = aCircle.computeArea();
11      aCircle.resize(2.0);
12
```

Using the Circle Class - Example

```java
// CircleTest.java - Test program to test the Circle class
public class CircleTest {
  public static void main(String args[]) {
    Circle aCircle = new Circle();
    aCircle.centreX = 10.0;
    aCircle.centreY = 20.0;
    aCircle.radius = 5.0;
    System.out.println("Radius = " + aCircle.radius);
    System.out.println("Circum: = " + aCircle.computeCircumference());
    System.out.println("Area = " + aCircle.computeArea());
    aCircle.resize(2.0);
    System.out.println("Radius = " + aCircle.radius);
  }
}
```

Program Output:

```
    Radius = 5.0
    Circum: = 31.41592653589793
    Area = 78.53981633974483
    Radius = 10.0
```

Back to the `main` method

- A program in Java is just a class that has a `main` method.
- When you give a command to run a Java program, the run-time system invokes the `main` method.
- The `main` is a `void` method, as indicated by its heading:

```
1          public static void main(String[] args) {
2
3          }
```

- `static` - it is still to come - please wait!

Learning Outcomes:

Topics covered in this lecture:

- Introducing Classes and Objects
- Defining Classes
- Using Classes

Learning Outcomes:

Upon completion of this lecture you will be able to:

- Explain the difference between a *class* and an *object*
- Create classes, give them *properties* and *behaviours*, implement and use simple classes
- Identify a series of well-defined classes from a *specification*
- Explain object oriented concepts: *abstraction and encapsulation*

References

- Absolute Java by Water Savitch (Fourth Edition), Chapters 4 & 5