# Advanced Java Programming

## Objects & Classes

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## Introduction to OOP

- One of the ideas of object-oriented software is to organized software in a way that matches the thinking style of our object-oriented brains.
- Of course, at the machine level nothing has changed - bit patterns are being changed by machine instructions. But we don't have to think about it that way.



## Characteristics of Objects

- An object has **identity** (it acts as a single whole).
- An object has **state** (it has various properties, which might change).
- An object has **behavior** (it can do things and can have things done to it).



## Software Objects

- Many programs are written to do things that are concerned the real world. It is convenient to have "software objects" that are similar to "real world objects."
- Software objects will have *identity*, *state*, and *behavior* just as do real world objects.
- In this context we use the terms "problem domain" and "software domain"



## Objects

- Software objects have identity because each is a separate chunk of memory.
- Software objects have state**.** Some of the memory that makes a software object is used for variables which contain values.
- Software objects have behavior**.** Some of the memory that makes a software object is used to contain *methods* that enable the object to "do things."



## Classes

- When a Java application is being run, objects are created and their methods are invoked.
- To create an object, there needs to be a description of it.
- A class is a description of a kind of object. A programmer may define a class using Java, or may use predefined classes that come in class libraries.

## Creating Objects

- A class is merely a plan for a possible object.
- When a programmer wants to create an object the `new` operator is used with the name of the class. Creating an object is called *instantiation*.



## Creating Objects – The new Operator

- `String name = new String("Yoav");`
- `Turtle leonardo = new Turtle();`
- `Point x = new Point (2,3);`



## Is Everything an Object?

- Java is almost pure object oriented. The only things which are not objects are primitive types (hence, the name):
  - **`byte, short, int, long, float, double, char, boolean`**
- However, Java includes special classes of similar names which are objects:
  - **`Byte, Short, Integer, Long, Float, Double, Chararcter, Boolean`**



## Primitive Data Types and Classes

- Java has *many* data types built into it, and you (as a programmer) can create as many more as you want.
- However, other than the primitive data types, *all the other data in a Java program will be represented as an object*.



## Two kinds of variables

- **Primitive variable**
  - Contains the actual data.
  - Used for primitive data types
- **Reference variable**
  - Contains information on how to find the object
  - Used for all Objects



## Reference Variables and Null

- Since objects are big, complicated, and vary in size you do not automatically get an object when you declare an object reference variable.

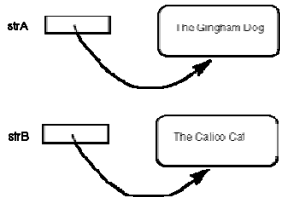
```
String name;
name = new String("Dana");
```

## Variables

| Kind of Variable | Information it Contains | When on the left of "=" |
|---|---|---|
| primitive variable | Contains actual data. | Previous data is replaced with new data. |
| reference variable | Contains information on how to find an object. | Old reference is replaced with a new reference |

## Several Objects of the same class

```
strA = new String( "The Gingham Dog" );
strB = new String( "The Calico Cat" );
```





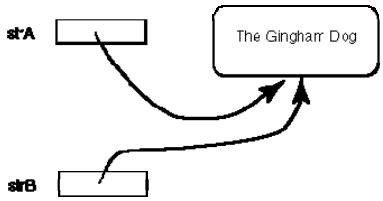

## Equality of reference

- The **==** operator is used to look at *the contents* of two reference variables. If the contents of both reference variables is the same, i.e, both variables refer to the same object then the result is *true*.
- The **==** operator *does **NOT** look at objects!* It only looks at references (information about where an object is)



## Alias

```
strA = new String( "The Gingham Dog" );
strB = strA;
```






## The equals method

- The `equals()` method is used to determine if two objects contain the same data.
- Two Strings that are == are always `equals()`
- This holds for any 2 objects




## Garbage Collection

- An Object which has no reference to it is called garbage.
- Since a garbage object can not be referred to, it is a waste of memory.
- The java virtual machine must clear that unused memory so it can be reused for creating other objects. This process is called ***Garbage Collection***

## Garbage Collection

- Garbage collection takes care of freeing the memory storage.
- The basic idea is storage reuse:
  - When an object is created the memory space is allocated for this object.
  - Later if the object or data are not used the memory is returned to the system for future reuse.
- The JVM performs the garbage collection periodically automatically.



## Invoking an Objects method

- Remember that an object consists of methods (recipes for behavior.)
- Java uses "dot notation" for invoking methods. To invoke the `length()` method of the object named `name` the following is used:

```
int len = name.length();
```



## Invoking an Objects method

```
Turtle leonardo = new Turtle();
leonardo.moveForward(50);
leonardo.turnRight(90);

Point p = new Point(0,0);
p.translate(2,3);
```

- How can we know which methods can be invoked for every object ?



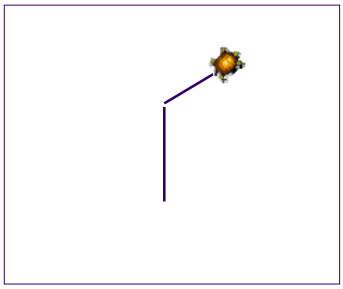
## API

**(Application Programming Interface)**

- The API is a Specification of methods and constructors in the class. It is the Documentation of the class.
- When we talk about defining are own classes we will see how to generate API documentation.

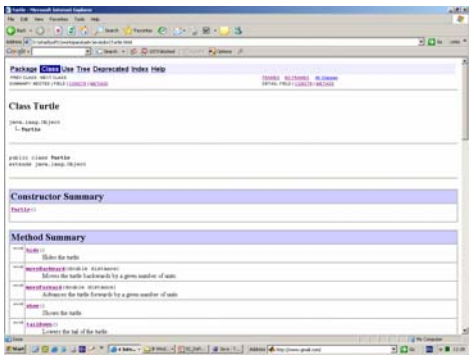


## LOGO Turtle





## Turtle Documentation



## Turtle Methods

- `show()` *Shows the turtle.*
- `hide()` *Hides the turtle.*
- `moveBackward(double)` *Moves the turtle backwards by a given number of units.*
- `moveForward(double)` *Advances the turtle forwards by a given number of units.*
- `tailDown()` *Lowers the tail of the turtle.*
- `tailUp()` *Raises the tail of the turtle.*
- `turnLeft(int)` *Turns the turtle counter-clockwise.*
- `turnRight(int)` *Turns the turtle clockwise.*



## Using the Turtle

```
public class TurtleDrawing {
    public static void main(String[] args) {
        Turtle leonardo = new Turtle();
        leonardo.tailDown();
        leonardo.moveForward(100);
        leonardo.turnLeft(90);
        leonardo.moveForward(100);
        // ...
    }
}
```



## Defining Classes

## Container vs. Definition Classes

- Container classes:
  - A collection of static methods that are not bound to any particular object.
  - These static methods usually have something in common.
  - Class as *Module*
- Definition classes:
  - These classes define new objects, in a way that we will soon see.
  - Class as *Type*



## Classes As New Types

- The class declaration is a way of defining new types for your program – extending your language "vocabulary".
- Once a class is declared you can use it to declare object variables.
- All those objects will be of the same type, they will have the same data and the same methods.



## Container Class

- The Math class is an example of the first kind. It is a container for math utility methods:

```
Math.sqrt()
Math.abs()
Math.max()
...
```

## Definition Class

- The class *Turtle* is an example of the second kind. It defines a new type of objects, *Turtle* objects.
- We will focus more on the second kind.



## Defining Classes - Abstraction

- Think of the object in its ideal form: what does it represent? What behaviors it should have?
- It is often useful to think of a real-world comparison, to help choose the name for the class and its methods.
- Often we include methods that we don't immediately need only because they make sense for the abstraction of the object.



## Objects and classes

A class is build of 4 parts:

1. **Definition** - class name;
2. **Properties** - instance and class variables;
3. **Constructors** - special methods for creating objects
4. **Methods** - instance and class methods



## Objects and Classes

- A ***class*** is a description of a possible object. The description is provided in code, therefore we can only write classes.
- An ***object*** is a unique runtime instance of a class. Objects are located in the memory and are created only when the program is executed.



## Object Oriented Programming

- The programmer defines classes that describe future objects that the program will use when it is running.
- As the program runs, The program does its work by creating objects and activating their methods.
- Each class description can be used to create many objects of the same type. A class is a blue print for creating objects.



## Syntax of class definition

```
class ClassName {
  // description of variables
  // constructors
  // methods
}
```

## Methods

- A Java class contains one or more methods.
- Each method is defined by its:
  - Visibility - (public / private / protected)
  - Return value (int / double / Point / void)
  - Arguments



## Constructors

- Objects must be initialized before they can be used .We must specify what is the initial state of the object before we can use it.
- We specify the way an object is initialized using a constructor, which is a special method which is invoked every time we create a new object.



## Constructors

- Each class has a constructor. It is the first thing that is executed when creating an object.
- Constructors do not have a return type.
- The constructor has the same name as the class name.
- It is possible to have more than one constructor in a class, each constructor differs in its arguments.



## Calling the Constructor

```
Point p1 = new Point();
Point p2 = new Point(1,1);
Point p3 = new Point(p2);
```



## Examples

- Point
- Segment
- Complex
- LinearFunction
- Circle



## Class Vs. Objects

- Most of the data and methods reside and work on specific objects of a class. The class is only a blueprint used as object definition.
- This view is not totally correct. There are situations in which data and/or methods reside in the class itself.

## Static Data Members

- Only one instance of a static variable exists for the whole class. The value of the variable is one for all instances.
- The variable exist even before any objects of the class are instantiated.
- By default static variables are initialized to 0 or null.



## Static Methods

- Static methods can operate only on static variables or call other static methods.
- They are not connected to a specific instance and therefore cannot use '`this`' reference.
- Instance methods can access static variables!



## Static Method Call

- The access to a static method is not done through an object but through the class name itself:

```
float i = Math.random();
String s = String.valueOf(i);
```

- If a static method calls another static method of the same class than the class-name can be omitted.



## The Main Method

- The *`main`* method is static; it is invoked by the system without creating an instance object!

```
public static void main(String[] args);
```



## A Collection of Static Methods

- Even if no static variables exist static methods can still be used to implement general functionality. They just encapsulate a given task, a given algorithm.
- We can write a class that is a collection of static methods. Such a class isn't meant to define new type of objects.
- This class is more of a *namespace* or a *module*



## `java.lang.Math`

```
/**
 * A library of mathematical methods.
 */
public class Math {
    // Computes the trigonometric sine of an angle.
    public static double sin(double x) {
        // ...
    }

    // Computes the logarithm of a given number.
    public static double log(double x) {
        // ...
    }
    // ...
}
```

## Use of Math Methods

- It is just used as a library for utilities that are related in some way:

```
double x = Math.sin(alpha);
int c = Math.max(a,b);
double y = Math.random();
```



## API Documentation
## Javadoc

## Interface Definition

- Your classes are often intended to be used by other programmers. Even when we hide implementation, we need to describe what a class can do.
- Programmers that use your class are not interested in the implementation. They want to use it as a whole and are only interested in **what it does** and **how to use it**.



## API Documentation

- API (Application Programmer Interface) documentation is a description of the interface of the class intended for the application programmer who wants to use it.
- To use the class, we need not (and should not) look at the code. All that is needed is the class API.



## Javadoc

- The JDK contains a special tool for the generation of API documentation for your classes, called **`javadoc`**.




## Javadoc Process

- **`javadoc`** takes as input Java programs and automatically generates documentation using:
  - The `public` method signatures
  - Any documentation which is part of the interface begins with /** (double asterisk) and ends with */
- The output is an HTML file which can be viewed by an internet browser.

## From Source File

```
/**
* A clock representation class. Clock instances represent a point of
* time during the day in a precision of seconds.
*/

public class Clock {
    // the hours, minutes and seconds read
        private int hours, minutes, seconds;
        /**
         * Constructs a new clock, sets the clock to the time 00:00:00.
         */
        public Clock() {
                hours = 0;
                minutes = 0;
                seconds = 0;
        }
        /**
         * Constructs a new clock, sets the clock to the specified time.
         * @param hours The hours to be set (0-23)
         * @param minutes The minutes to be set (0-59)
         * @param seconds The seconds to be set (0-59)
         */
        public Clock(int hours, int minutes, int seconds) {
                setTime(hours,minutes,seconds);
        }
        // ...
}
```

javadoc



## To HTML Output

Class Clock

java.lang.Object
  |
  +--Clock

public class **Clock**
extends java.lang.Object

A clock representation class. Clock instances represent a point of time during the day in a precision of seconds.

**Field Summary**

| | |
|---|---|
| protected int | hours |
| protected int | minutes |
| protected int | seconds |

**Constructor Summary**

| | |
|---|---|
| Clock() | Constructs a new clock, sets the clock to the time 00:00:00. |
| Clock(int hours, int minutes, int seconds) | Constructs a new clock, sets the clock to the specified time. |



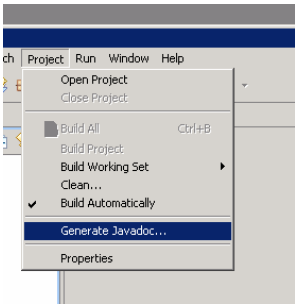
## Clock Class Documentation

**Method Summary**

| | |
|---|---|
| boolean | equals(Clock compareClock) Returns true if parameter clock is equal to this clock. |
| int | getHours() Returns the hours read |
| int | getMinutes() Returns the minutes read. |
| int | getSeconds() Returns the seconds read. |
| void | hourElapsed() Advances the clock by one hour. |
| void | minuteElapsed() Advances the clock by one minute. |
| void | secondElapsed() Advances the clock by one second. |
| void | setTime(int hours, int minutes, int seconds) Sets the clock to the specified time. |
| java.lang.String | toString() Returns a string description of the time represented by the clock in the format hh:mm:ss. |



## Directly from Eclipse






## What Should You Comment?

- You should put a documentation comment for any member of the class which is part of its interface and for the class itself.
- All public constructors and methods should documentation comments.
- Private methods are not part of the interface of the class, thus `javadoc` skips them by default
- You may ask `javadoc` to include also non-public parts of the class



## API Documentation Purpose

- Documentation comments are written for programmers who use your class as a whole.
- They should describe only
  - What the class does,
  - How to use it.

## API Documentation Style

- Documentation comments should not describe how a class is implemented.
- Documentation comments should be
  - Short and descriptive,
  - Written in a simple language (ENGLISH),
  - Accurate.
- Assume that the reader doesn't know anything about your class



## API Documentation Tags

- Documentation comments can also include *tagged paragraphs* that give a standard way to document several features of the interface such as method parameters, return values, etc.
- A tagged paragraph begins with the symbol @ followed with a tag keywords. Tags: **`@see`**, **`@author`**, **`@version`**, **`@param`**, **`@return`**, **`@exception`**.
- Documentation comments text can include HTML tags (not relevant for those who don't know HTML).



## Using Tags

- `@param` to document every parameter in the method signature: description, range limitiations, etc.
- `@return` if the method returns a value:

```
/**
  * Reads the next line in the file.
  * @return A string containing the next line in the file,
  * not including newline character at end (if exists).
 */
public String nextLine() {
   // ...
}
```

- `@exception` to document exceptions (later).



## Naming

- The names you use for your class and for its public methods are part of the class API.
- Good descriptive naming are crucial for a clear API.
- Read the style guidelines!



## Changing the Implementation

- Encapsulation allows us to change an implementation of a class without affecting other parts of the program.
- Without encapsulation changes to implementation might "break" the program and lead to many further changes.
- Why would we want to change the implementation?
  - Different implementations have different tradeoffs (e.g., Space conservation, efficiency etc.).



## Non-API Comments

- Java still uses the // and /* … */ style comments
- Those comments wouldn't be included in the documentation – and they are used to clarify certain parts of the code

If you have a complicate part in your code, don't document it – simplify it !