



# Object-Oriented Programming in Java: More Capabilities

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## Topics in This Section

- **Overloading**
- **Best practices for “real” classes**
  - Encapsulation and accessor methods
  - JavaDoc
- **Inheritance**
- **Packages**
- **The toString method**
- **More iterations of the Person class**

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# Overloading



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## Overview

- **Idea**

- Classes can have more than one method with the same name, or more than one constructor
- The methods or constructors have to differ from each other by having different number or types of arguments

- **Syntax example**

```
public class MyClass {  
    public double randomNum() { ... }; // Range 1-10  
    public double randomNum(double range) { ... }  
}
```

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## Motivation

- **Overloading methods**

- Lets you have similar names for similar operations
  - MathUtils.arraySum(arrayOfInts)
  - MathUtils.arraySum(arrayOfDoubles)
  - MathUtils.log(number) // Assumes  $\log_e(\text{number})$
  - MathUtils.log(number, base) //  $\log_{\text{base}}(\text{number})$

- **Overloading constructors**

- Lets you build instances in different ways
  - new Ship(someName) // Default x, y, speed, direction
  - new Ship(someX, someY, someSpeed, someDirection, someName)

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## Ship Example: Overloading (ship4/Ship.java)

```
package ship4;

public class Ship {
    public double x=0.0, y=0.0, speed=1.0, direction=0.0;
    public String name;

    public Ship(double x, double y,
                double speed, double direction,
                String name) {
        this.x = x;
        this.y = y;
        this.speed = speed;
        this.direction = direction;
        this.name = name;
    }

    public Ship(String name) {
        this.name = name;
    }
}
```

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## Overloading (Continued)

...

```
public void move() {
    move(1);
}

public void move(int steps) {
    double angle = degreesToRadians(direction);
    x = x + steps * speed * Math.cos(angle);
    y = y + steps * speed * Math.sin(angle);
}

// degreesToRadians and printLocation as before
}
```

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## Ship Tester

```
package ship4;

public class ShipTest {
    public static void main(String[] args) {
        Ship s1 = new Ship("Ship1");
        Ship s2 = new Ship(0.0, 0.0, 2.0, 135.0, "Ship2");
        s1.move();
        s2.move(3);
        s1.printLocation();
        s2.printLocation();
    }
}
```

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## Overloading: Results

- **Compiling and running in Eclipse (common)**
  - Save Ship.java and ShipTest.java
  - R-click inside ShipTest.java, Run As → Java Application
- **Compiling and running manually (rare)**
  - > `javac ship4\ShipTest.java`
  - > `java ship4.ShipTest`
- **Output:**
  - Ship1 is at (1.0,0.0).
  - Ship2 is at (-4.24264...,4.24264...).

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# OOP Design: Best Practices

“Always code as if the guy who ends up maintaining your code  
will be a violent psychopath who knows where you live.”  
– John F. Woods

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## Overview

- **Ideas**

- Instance variables should *always* be private
  - And hooked to outside world with getBlah and/or setBlah
- From very beginning, put in JavaDoc-style comments

- **Syntax example**

```
/** Short summary. More detail. Can use HTML. */  
public class MyClass {  
    private String firstName;  
    public String getFirstName() { return(firstName); }  
    public void setFirstName(String s) { firstName = s; }  
}
```

## Motivation

- **Supports secondary goal of OOP**
  - Limits ripple effect, where changes to one class requires changes to the classes that use it, that require changes to the classes that use that, and so forth
    - Lets you make changes to internal representation of classes without changing its public interface
    - Makes code more maintainable

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## OOP Principles

- **Basic OOP principles**
  - Primary goal: avoid needing to repeat identical or almost-identical code
    - DRY: Don't Repeat Yourself
    - Code reuse
  - Secondary goal: limit ripple effect
    - Where changes to one piece of code requires changes to the pieces that use it
- **Advanced OOP principles**
  - SOLID
    - [http://en.wikipedia.org/wiki/SOLID\\_%28object-oriented\\_design%29](http://en.wikipedia.org/wiki/SOLID_%28object-oriented_design%29)
    - <http://williamdurand.fr/2013/07/30/from-stupid-to-solid-code/>

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## Ship Example: OOP Design and Usage (ship5/Ship.java)

```
/** Ship example to demonstrate OOP in Java. */

public class Ship {
    private double x=0.0, y=0.0, speed=1.0, direction=0.0;
    private String name;
    ...
    /** Get current X location. */

    public double getX() {
        return(x);
    }

    /** Set current X location. */

    public void setX(double x) {
        this.x = x;
    } ...
}
```

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## Ship Tester

```
package ship5;

/** Small example to test the Ship class.
 * <p>
 * From <a href="http://www.coreservlets.com/">the
 * coreservlets.com Java tutorials</a>.
 */
public class ShipTest {
    public static void main(String[] args) {
        Ship s1 = new Ship("Ship1");
        Ship s2 = new Ship(0.0, 0.0, 2.0, 135.0, "Ship2");
        s1.move();
        s2.move(3);
        s1.printLocation();
        s2.printLocation();
    }
}
```

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# Results

- **Compiling and running in Eclipse (common)**

- Save Ship.java and ShipTest.java
- R-click inside ShipTest.java, Run As → Java Application
- **Select project, go to Project menu and choose “Generate Javadoc”**
  - If it asks you where javadoc.exe is located, you can find it in the bin folder of your Java installation (e.g., C:\Program Files\Java\jdk1.8.0\_75\bin)

- **Compiling and running manually (rare)**

```
> javac ship5\ShipTest.java
> java ship5.ShipTest
> javadoc *.java
```

- **Output:**

```
Ship1 is at (1.0,0.0).
Ship2 is at (-4.24264...,4.24264...).
```

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# OOP Design: Testing and Results (Continued)

The screenshot shows the Eclipse IDE interface with the Javadoc for the `Ship` class displayed. The left sidebar shows the project structure with packages `people`, `ship4`, and `ship5`, and classes `Ship`, `ShipTest`, `Speedboat`, and `SpeedboatTest`. The main editor shows the Javadoc for the `Ship` class, including the package list, constructors, and method summary.

**Package List:**

Package	Description
people	
ship4	
ship5	

**Constructors:**

- `Ship(double x, double y, double speed, double direction, java.lang.String name)`  
Build a ship with specified parameters.
- `Ship(java.lang.String name)`  
Build a ship with default values (x=0, y=0, speed=1.0, direction=0.0).

**Method Summary:**

Modifier and Type	Method and Description
double	<code>getDirection()</code> Gets current heading (0=East, 90=North, 180=West, 270=South).
java.lang.String	<code>getName()</code> Gets Ship's name.
double	<code>getSpeed()</code> Gets current speed.
double	<code>getX()</code> Gets current X location.

**Annotation:** If you run Javadoc from within Eclipse (Project → Generate Javadoc), it puts the HTML in the "doc" folder.

## Major Points

- **Encapsulation**

- Lets you change internal representation and data structures *without users of your class changing their code*
- Lets you put constraints on values *without users of your class changing their code*
- Lets you perform arbitrary side effects *without users of your class changing their code*

- **Comments and Javadoc**

- Comments marked with `/** ... */` will be part of the online documentation
  - These should go before every public class, every public method, and every public constructor
- To build online documentation within Eclipse, do Project → Generate Javadoc
- To build the documentation from command line, use “`javadoc *.java`”

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## More Details on Getters and Setters

- **Eclipse will automatically build getters/setters from instance variables**

- R-click anywhere in code
- Choose Source → Generate Getters and Setters
- However, if you later click on instance variable and do Refactor → Rename, Eclipse will not automatically rename the accessor methods

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## More Details on Getters and Setters

- **There need not be both getters and setters**

- It is common to have fields that can be set at instantiation, but never changed again (immutable field). It is even quite common to have classes containing only immutable fields (immutable classes)

```
public class Ship {
    private final String shipName;

    public Ship(...) { shipName = ...; ... }

    public String getName() { return(shipName); }

    // No setName method
}
```

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## More Details on Getters and Setters

- **Getter/setter names need not correspond to instance var names**

- Common to do so if there is a simple correspondence, but this is not required
  - Notice on previous page that instance variable was “shipName”, but methods were “getName” and “setName”
- In fact, there doesn't even have to *be* a corresponding instance variable

```
public class Customer {
    ...
    public String getFirstName() { getFromDatabase(...); }
    public void setFirstName(...) { storeInDatabase(...); }
    public double getBonus() { return(Math.random()); }
}
```

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# Inheritance

Q: What is the object-oriented way of getting rich?  
A: Inheritance.

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## Overview

- **Ideas**

- You can make a class that “inherits” characteristics of another class
  - The original class is called “parent class”, “super class”, or “base class”
  - The new class is called “child class”, “subclass”, or “extended class”
- The child class has access to all non-private methods of the parent class
  - No special syntax need to call inherited methods

- **Syntax example**

```
public class ChildClass extends ParentClass {  
    ...  
}
```

## Motivation

- **Supports primary goal of OOP**
  - Supports the key OOP principle of code reuse
    - I.e., don't write identical or nearly-identical code twice
  - You can design class hierarchies so that shared behavior is inherited by all classes that need it

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## Simple Example

- **Person**

```
public class Person {  
    public String getFirstName() { ... }  
    public String getLastName() { ... }  
}
```

- **Employee**

```
public class Employee extends Person {  
    public double getSalary() { ... }  
  
    public String getEmployeeInfo() {  
        return(getFirstName() + " " + getLastName() +  
            " earns " + getSalary());  
    }  
}
```

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## Ship Example: Inheritance

```
public class Speedboat extends Ship {
    private String color = "red";

    public Speedboat(String name) {
        super(name);
        setSpeed(20);
    }

    public Speedboat(double x, double y, double speed, double direction,
        String name, String color) {
        super(x, y, speed, direction, name);
        setColor(color);
    }

    @Override // Optional but useful -- discussed later
    public void printLocation() {
        System.out.print(getColor().toUpperCase() + " ");
        super.printLocation();
    }
    ...
}
```

## Inheritance Example: Testing

```
public class SpeedboatTest {
    public static void main(String[] args) {
        Speedboat s1 = new Speedboat("Speedboat1");
        Speedboat s2 = new Speedboat(0.0, 0.0, 2.0, 135.0,
            "Speedboat2", "blue");
        Ship s3 = new Ship(0.0, 0.0, 2.0, 135.0, "Ship1");
        s1.move();
        s2.move();
        s3.move();
        s1.printLocation();
        s2.printLocation();
        s3.printLocation();
    }
}
```

## Inheritance Example: Result

- **Compiling and running in Eclipse**

- Save SpeedBoatTest.java
- R-click, Run As → Java Application

- **Compiling and running manually**

- > `javac ship5\SpeedboatTest.java`
  - The above calls javac on Speedboat.java and Ship.java automatically
- > `java ship5.SpeedboatTest`

- **Output**

```
RED Speedboat1 is at (20,0).
BLUE Speedboat2 is at (-1.41421,1.41421).
Ship1 is at (-1.41421,1.41421).
```

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## Ship Inheritance Example: Major Points

- **Format for defining subclasses**

- And nomenclature (parent/child, super/sub, base/extended)

- **Using inherited methods**

- No special syntax required

- **Using `super(...)` for inherited constructors**

- *Only* when the zero-arg constructor is not OK
  - The most common case is to omit `super` and use zero-arg constructor of parent, but `super` is used moderately often

- **Using `super.someMethod(...)` for inherited methods**

- *Only* when there is a name conflict
  - Used rarely

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# Review of Packages

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## Overview

- **Idea**
  - Organize classes in groups.
- **Syntax**
  - Make folder called somepackage
    - In Eclipse, R-click on “src” and do New → Package
  - Put “package somepackage” at top of file
    - Automatic in Eclipse
  - To use code from another package
    - put “import somepackage.\*” below your package statement



## Motivation

- **Avoiding name conflicts**
  - Team members can work on different parts of project without worrying about what class names other teams use
- **Different versions for testing**
  - For example, in next section, I have three packages: shapes1, shapes1, shapes3. They have variations on ways to make shapes where you can sum their areas.
    - But I use same core class names (Circle, Rectangle, etc.) in each of the packages

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## Running Packaged Code that has “main”

- **From Eclipse**
  - Same as always: R-click, Run As → Application
- **From command line**
  - Go to top-level of package hierarchy, i.e., for simple packages, the folder above the one containing the Java code
  - Use the fully-qualified name, i.e., including package
    - > `java packagename.Classname ...`

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# The toString Method

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## Overview

- **Idea**

- If you give a class a toString method, that method is *automatically* called whenever
  - An object of that class is converted to a String
  - An object of that class is printed

- **Example**

```
public class Person {
    // Main code covered earlier

    @Override
    public String toString() {
        return("PERSON: " + getFullName());
    }
}
```

## Preview of @Override

- **Oddities of toString**

- We write the method, but we never call it
- If we spell method wrong, we don't know until run time
  - @Override useful for both issues; more details later

- **What will be printed on final line below?**

```
public class Person {  
    ...  
    public void toString() { return(getFullName()); }  
}  
...  
Person p = new Person(...);  
System.out.println(p);
```

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# Example: Person Class

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## Iterations of Person

- **Last lecture: four iterations of Person**

- Instance variables
- Methods
- Constructors
- Constructors with “this” variable

- **This lecture**

- Person class
  - Change instance vars to private, add accessor methods
  - Add Javadoc comments
  - Use toString
- Employee class
  - Make a class based on Person that has all of the information of a Person, plus new data

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## Person Class (Part 1)

```
/** A class that represents a person's given name
 * and family name.
 */
public class Person {
    private String firstName, lastName;

    public Person(String firstName,
                  String lastName) {
        this.firstName = firstName;
        this.lastName = lastName;
    }
}
```

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## Person Class (Part 2)

```
/** The person's given (first) name. */

public String getFirstName() {
    return (firstName);
}

public void setFirstName(String firstName) {
    this.firstName = firstName;
}
```

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## Person Class (Part 3)

```
/** The person's family name (i.e., last name or surname). */

public String getLastName() {
    return (lastName);
}

public void setLastName(String lastName) {
    this.lastName = lastName;
}

/** The person's given name and family name, printed
 * in American style, with given name first and
 * a space in between.
 */
public String getFullName() {
    return(firstName + " " + lastName);
}
```

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## Employee Class (Part 1)

```
/** Represents people that work at a company. */  
  
public class Employee extends Person {  
    private int employeeId;  
    private String companyName;  
  
    public Employee(String firstName, String lastName,  
                    int employeeId, String companyName) {  
        super(firstName, lastName);  
        this.employeeId = employeeId;  
        this.companyName = companyName;  
    }  
}
```

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## Employee Class (Part 2)

```
/** The ID of the employee, with the assumption that  
 * lower numbers are people that started working at  
 * the company earlier than those with higher ids.  
 */  
public int getEmployeeId() {  
    return (employeeId);  
}  
  
public void setEmployeeId(int employeeId) {  
    this.employeeId = employeeId;  
}
```

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## Employee Class (Part 3)

```
/** The name of the company that the person
 * works for.
 */
public String getCompanyName() {
    return (companyName);
}

public void setCompanyName(String companyName) {
    this.companyName = companyName;
}
}
```

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# Wrap-Up

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## Java OOP References

- **Online**

- “OOP Concepts” section in Oracle Java Tutorial. See also “Classes and Objects” and “Interfaces and Inheritance”.
  - <http://docs.oracle.com/javase/tutorial/java/>

- **Books**

- *Murach’s Java SE* (Murach, Steelman, and Lowe)
  - Excellent Java intro for beginners to Java (but not first-time programmers). Very good OOP section.
- *Thinking in Java* (Bruce Eckel)
  - Perhaps not quite as good as Murach’s book in general, but possibly the best OOP coverage of any Java programming book.
- *Effective Java, 2<sup>nd</sup> Edition* (Josh Bloch)
  - In my opinion, by far the best Java best-practices book ever written. Fantastic coverage of OOP best practices.
    - However, very advanced. Other than the OOP chapter, you won’t understand much unless you have been doing Java fulltime for at least a year.
    - Even experts will learn a lot from this book.

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## Summary

- **Overloading**

- You can have multiple methods or constructors with the same name. They must differ in argument signatures

- **Best practices**

- Make *all* instance variables private. Hook them to the outside with getBlah and/or setBlah
- Use JavaDoc-style comments from the very beginning

- **Inheritance**

- `public class Subclass extends Superclass { ... }`
  - Non-private methods available with no special syntax

- **Organization**

- Put all code in packages
- Make output more readable by implementing toString

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# Questions?

More info:

<http://courses.coreservlets.com/Course-Materials/java.html> – General Java programming tutorial

<http://www.coreservlets.com/java-8-tutorial/> – Java 8 tutorial

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