Object-Oriented Design & Patterns

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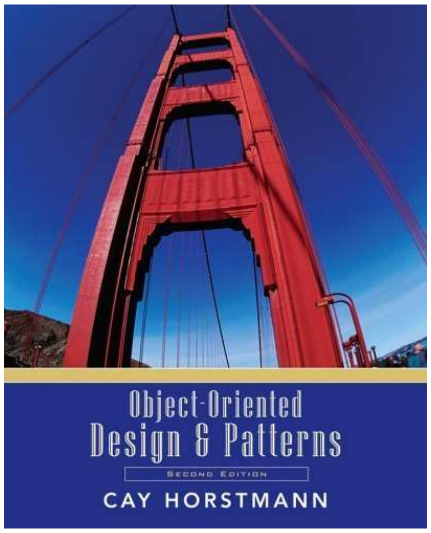
Chapter 1

A Crash Course in Java



Chapter Topics

"Hello, World" in Java

- Simple but typical class

  Ch1/helloworld/Greeter.java

- Features:
  - Constructor `Greeter(String aName)`
  - Method `sayHello()`
  - Instance field `name`
- Each feature is tagged `public` or `private`

```
/**
   A class for producing simple greetings.
*/

public class Greeter
{
   /**
      Constructs a Greeter object that can greet a person or
      entity.
      @param aName the name of the person or entity who should
      be addressed in the greetings.
   */
   public Greeter(String aName)
   {
      name = aName;
   }

   /**
      Greet with a "Hello" message.
      @return a message containing "Hello" and the name of
      the greeted person or entity.
   */
   public String sayHello()
   {
      return "Hello, " + name + "!";
   }

   private String name;
}
```

"Hello, World" in Java

- Construct new objects with `new` operator

  `new Greeter("World")`

- Can invoke method on newly constructed object

  `new Greeter("World").sayHello()`

- More common: store object reference in object variable

  `Greeter worldGreeter = new Greeter("World");`

- Then invoke method on variable:

  `String greeting = worldGreeter.sayHello();`

"Hello, World" in Java

- Construct separate class to test your class

  Ch1/helloworld/GreeterTester.java

- `main` method is called when program starts
- `main` is `static`: it doesn't operate on any objects
- There are no objects yet when `main` starts
- In OO program, `main` constructs objects and invokes methods

```
public class GreeterTester
{
   public static void main(String[] args)
   {
      Greeter worldGreeter = new Greeter("World");
      String greeting = worldGreeter.sayHello();
      System.out.println(greeting);
   }
}
```

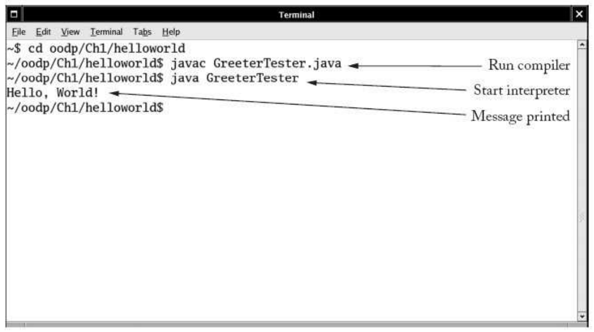
Using the SDK

- Create a new directory to hold your files
- Use a text editor to prepare files (Greeter.java, GreeterTest.java)
- Open a shell window
- `cd` to directory that holds your files
- Compile and run

  ```
  javac GreeterTest.javajava GreeterTest
  ```

  Note that Greeter.java is automatically compiled.
- Output is shown in shell window

Using the SDK

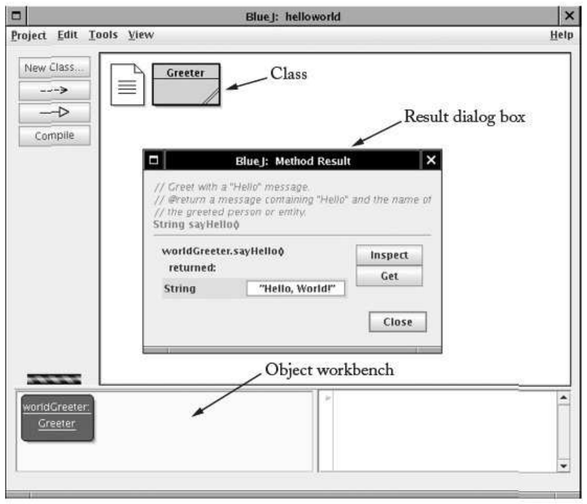


```
~$ cd oodp/Ch1/helloworld
~/oodp/Ch1/helloworld$ javac GreeterTester.java
~/oodp/Ch1/helloworld$ java GreeterTester
Hello, World!
~/oodp/Ch1/helloworld$
```

Using BlueJ

- Download BlueJ from http://www.bluej.org
- No test program required
- Select Project->New and supply directory name
- Click on New Class... and type in Greeter class
- Compile the class
- Right-click the class to construct an object
- Right-click the object to invoke a method

Using BlueJ



```
// Greet with a "Hello" message.
// @return a message containing "Hello" and the name of
// the greeted person or entity.
String sayHello()

worldGreeter.sayHello()
  returned:
String    "Hello, World!"
```

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Documentation Comments

- Delimited by `/** ... */`
- First sentence = summary
- `@param` *`parameter` explanation*
- `@return` *explanation*
- Javadoc utility extracts HTML file

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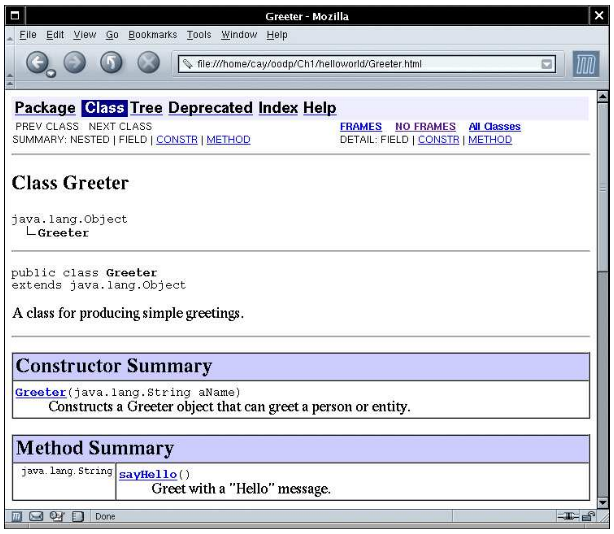
Documentation Comments - Summary


Greeter - Mozilla
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DETAIL: FIELD | CONSTR | METHOD
Done

Class Greeter

```
java.lang.Object
  └Greeter
```

```
public class Greeter
extends java.lang.Object
```

A class for producing simple greetings.

Constructor Summary

`Greeter(java.lang.String aName)`
Constructs a Greeter object that can greet a person or entity.

Method Summary

`java.lang.String`	`sayHello()` Greet with a "Hello" message.

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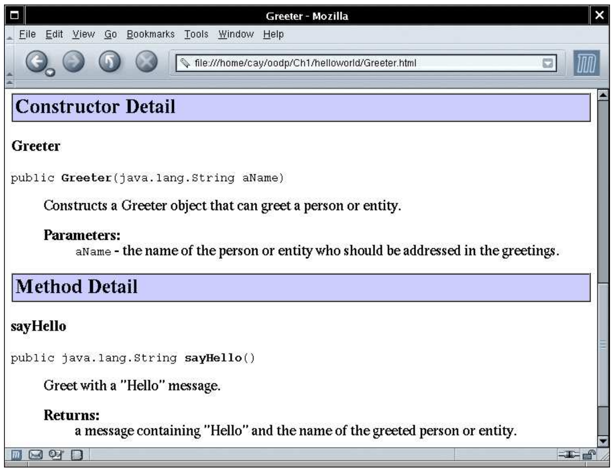
Documentation Comments - Detail


Greeter - Mozilla
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file:///home/cay/oodp/Ch1/helloworld/Greeter.html

Constructor Detail

Greeter

`public Greeter(java.lang.String aName)`

Constructs a Greeter object that can greet a person or entity.

Parameters:
`aName` - the name of the person or entity who should be addressed in the greetings.

Method Detail

sayHello

`public java.lang.String sayHello()`

Greet with a "Hello" message.

Returns:
a message containing "Hello" and the name of the greeted person or entity.

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Documentation Comments

- Easy to keep documentation in sync with code
- You must document *all* classes and methods
- The pros do it--check out the API docs
- Install and bookmark the API docs *now*!

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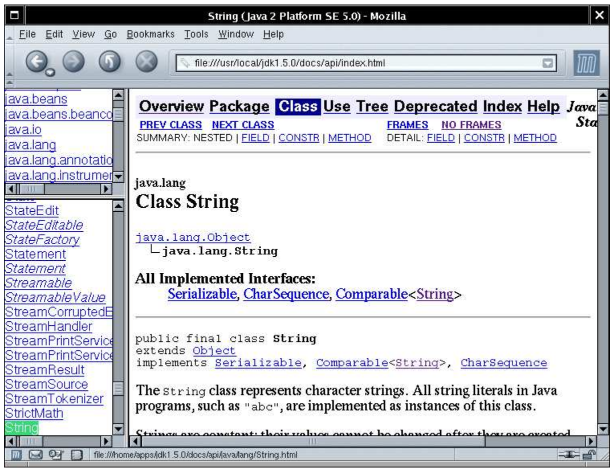
Documentation Comments - API Docs


String (Java 2 Platform SE 5.0) - Mozilla
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file:///home/apps/jdk1.5.0/docs/api/java/lang/String.html

java.lang
Class String

java.lang.Object
  └ java.lang.String

All Implemented Interfaces:
Serializable, CharSequence, Comparable<String>

```
public final class String
extends Object
implements Serializable, Comparable<String>, CharSequence
```

The `String` class represents character strings. All string literals in Java programs, such as `"abc"`, are implemented as instances of this class.

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Primitive Types

- 8 primitive types
- `int, long, short, byte`
- `double, float`
- `char`
- `boolean`
- suffixes L = long, F = float
- character constants `'a', '\n', '\x2122'`
- Casts `(int) x`, `(float) x`
- `Math` class has methods that operate on numbers:

```
y = Math.sqrt(x);
```

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Control Flow

- `if`
- `while`
- `do/while`
- `for`
- Variable can be declared in `for` loop:

```
for (int i = 1; i <= n; i++){ . . .}// i no longer defined here
```

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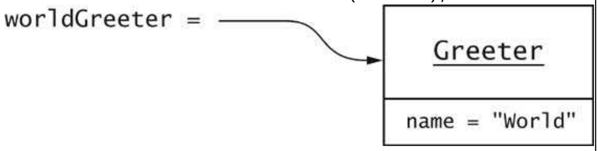
Object References

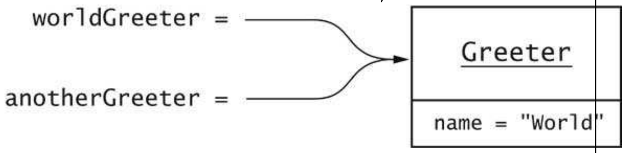
- Object variable holds a *reference*

```
Greeter worldGreeter = new Greeter("World");
```



- Can have multiple references to the same object

```
Greeter anotherGreeter = worldGreeter;
```



- After applying mutator method, all references access modified object

```
anotherGreeter.setName("Dave");// now worldGreeter.sayHello() returns "Hello, Dave!"
```

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The `null` Reference

- `null` refers to no object
- Can assign `null` to object variable:

```
worldGreeter = null;
```

- Can test whether reference is `null`

```
if (worldGreeter == null) . . .
```

- Dereferencing `null` causes `NullPointerException`

The `this` Reference

- Refers to implicit parameter of method call
- Example: Equality testing

```
public boolean equals(Greeter other){ if (this == other) return true; return name.equals(other.name);}
```

- Example: Constructor

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

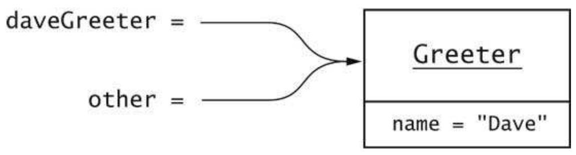
Parameter Passing

- Java uses "call by value":
  Method receives copy of parameter value
- Copy of object reference lets method modify object

```
public void copyNameTo(Greeter other){ other.name = this.name;}
```

-

```
Greeter worldGreeter = new Greeter("World");Greeter daveGreeter = new Greeter("Dave");worldGreeter.copyNameTo(daveGreeter);
```



No Reference Parameters

- Java has no "call by reference"
-

```
public void copyLengthTo(int n){ n = name.length(); } public void copyGreeterTo(Greeter other){ other = new Greeter(name);}
```

- Neither call has any effect after the method returns

```
int length = 0;worldGreeter.copyLengthTo(length); // length still 0worldGreeter.copyGreeterTo(daveGreeter) // daveGreeter unchanged
```

Packages

- Classes are grouped into packages
- Package names are dot-separated identifier sequences

```
java.utiljavax.swingcom.sun.miscedu.sjsu.cs.cs151.alice
```

- Unique package names: start with reverse domain name

Packages

- Add `package` statement to top of file

```
package edu.sjsu.cs.cs151.alice;public class Greeter { . . . }
```

- Class without package name is in "default package"
- Full name of class = package name + class name

```
java.util.ArrayListjavax.swing.JOptionPane
```

Importing Packages

- Tedious to use full class names
- `import` allows you to use short class name

```
import java.util.Scanner;. . .Scanner a; // i.e. java.util.Scanner
```

- Can import all classes from a package

```
import java.util.*;
```

Importing Packages

- Cannot import from multiple packages

```
import java.*.*; // NO
```

- If a class occurs in two imported packages, `import` is no help.

```
import java.util.*;import java.sql.*;. . .java.util.Date d; // Date also occurs in java.sql
```

- Never need to import `java.lang`.

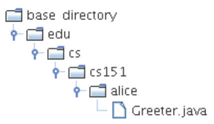
Packages and Directories

- Package name must match subdirectory name.

  ```
  edu.sjsu.cs.sjsu.cs151.alice.Greeter
  ```

  must be in subdirectory

  ```
  basedirectory/edu/sjsu/cs/sjsu/cs151/alice
  ```

- Always compile from the base directory

  ```
  javac edu/sjsu/cs/sjsu/cs151/alice/Greeter.java
  ```

  or

  ```
  javac edu\sjsu\cs\sjsu\cs151\alice\Greeter.java
  ```

- Always run from the base directory

  ```
  java edu.sjsu.cs.cs151.alice.GreeterTest
  ```

Exception Handling

- Example: `NullPointerException`

  ```
  String name = null;int n = name.length(); // ERROR
  ```

- Cannot apply a method to `null`
- Virtual machine *throws* exception
- Unless there is a handler, program exits with *stack trace*

  ```
  Exception in thread "main" java.lang.NullPointerException  at Greeter.sayHello(Greeter.java:25)  at GreeterTest.main(GreeterTest.java:6)
  ```

Checked and Unchecked Exceptions

- Compiler tracks only *checked* exceptions
- `NullPointerException` is not checked
- `IOException` is checked
- Generally, checked exceptions are thrown for reasons beyond the programmer's control
- Two approaches for dealing with checked exceptions
  - Declare the exception in the method header (preferred)
  - Catch the exception

Declaring Checked Exceptions

- Example: Opening a file may throw `FileNotFoundException`:

  ```
  public void read(String filename) throws FileNotFoundException{ FileReader reader = new FileReader(filename); . . .}
  ```

- Can declare multiple exceptions

  ```
  public void read(String filename) throws IOException, ClassNotFoundExceptionpublic static void main(String[] args) throws IOException, ClassNotFoundException
  ```

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Catching Exceptions

-

  ```
  try{ code that might throw an IOException}catch (IOException exception){ take corrective action}
  ```

- Corrective action can be:
  - Notify user of error and offer to read another file
  - Log error in error report file
  - In student programs: print stack trace and exit

    ```
    exception.printStackTrace();System.exit(1);
    ```

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The `finally` Clause

- Cleanup needs to occur during normal *and* exceptional processing
- Example: Close a file

  ```
  FileReader reader = null;try{ reader = new FileReader(name); ...}finally{ if (reader != null) reader.close();}
  ```

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Strings

- Sequence of Unicode characters
- (Technically, code units in UTF-16 encoding)
- `length` method yields number of characters
- `""` is the empty string of length 0, different from `null`
- `charAt` method yields characters:
  `char c = s.charAt(i);`

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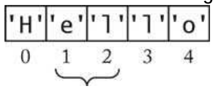
Strings

- `substring` method yields substrings:
  `"Hello".substring(1, 3)` is `"el"`
  

- Use `equals` to compare strings
  `if (greeting.equals("Hello"))`
- `==` only tests whether the object references are identical:
  `if ("Hello".substring(1, 3) == "el") ... // NO!`

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String concatenation

- `+` operator concatenates strings:

  ```
  "Hello, " + name
  ```

- If one argument of `+` is a string, the other is converted into a string:

  ```
  int n = 7;String greeting = "Hello, " + n; // yields "Hello, 7"
  ```

- `toString` method is applied to objects

  ```
  Date now = new Date();String greeting = "Hello, " + now;  // concatenates now.toString() // yields "Hello, Wed Jan 17 16:57:18 PST 2001"
  ```

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Converting Strings to Numbers

- Use static methods
  `Integer.parseInt`
  `Double.parseDouble`
- Example:

  ```
  String input = "7";int n = Integer.parseInt(input); // yields integer 7
  ```

- If string doesn't contain a number, throws a
  `NumberFormatException`(unchecked)

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Reading Input

- Construct `Scanner` from input stream (e.g. `System.in`)
  `Scanner in = new Scanner(System.in)`
- `nextInt`, `nextDouble` reads next `int` or `double`
  `int n = in.nextInt();`
- `hasNextInt`, `hasNextDouble` test whether next token is a number
- `next` reads next string (delimited by whitespace)
- `nextLine` reads next line
-

  Ch1/input/InputTester.java

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```
import java.util.Scanner;

public class InputTester
{
   public static void main(String[] args)
   {
      Scanner in = new Scanner(System.in);
      System.out.print("How old are you?");
      int age = in.nextInt();
      age++;
      System.out.println("Next year, you'll be " + age);
   }
}
```

The `ArrayList<E>` class

- Generic class: `ArrayList<E>` collects objects of type `E`
- `E` cannot be a primitive type
- `add` appends to the end

```
ArrayList<String> countries = new ArrayList<String>();countries.add("Belgium");countries.add("Italy");countries.add("Thailand");
```

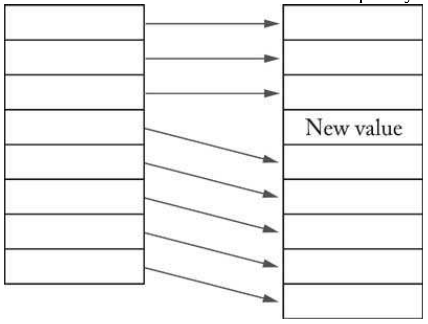
The `ArrayList<E>` class

- `get` gets an element; no need to cast to correct type:
  `String country = countries.get(i);`
- `set` sets an element
  `countries.set(1, "France");`
- `size` method yields number of elements
  `for (int i = 0; i < countries.size(); i++) . . .`
- Or use "for each" loop

```
for (String country : countries) . . .
```

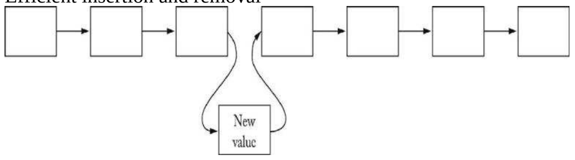
The `ArrayList<E>` class

- Insert and remove elements in the middle
  `countries.add(1, "Germany");`
  `countries.remove(0);`
- Not efficient--use linked lists if needed frequently



Linked Lists

- Efficient insertion and removal



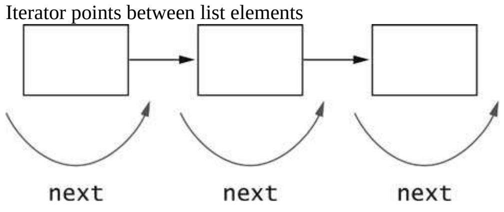
- `add` appends to the end

```
LinkedList<String> countries = new LinkedList<String>();countries.add("Belgium");countries.add("Italy");countries.add("Thailand");
```

- Use iterators to edit in the middle

List Iterators

- Iterator points between list elements



List Iterators

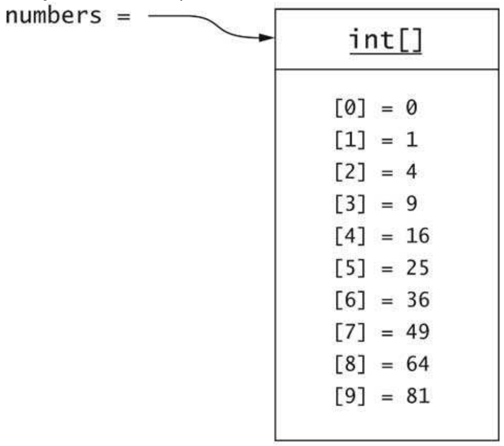
- `next` retrieves element and advances iterator

```
ListIterator<String> iterator =
countries.listIterator();
while (iterator.hasNext())
{
   String country = iterator.next();
   . . .
}
```

- Or use "for each" loop:
  `for (String country : countries)`
- `add` adds element before iterator position
- `remove` removes element returned by last call to `next`

Arrays

- Drawback of array lists: can’t store numbers
- Arrays can store objects of any type, but their length is fixed
  `int[] numbers = new int[10];`
- Array variable is a *reference*



Arrays

- Array access with `[]` operator:
  `int n = numbers[i];`
- `length` member yields number of elements

```
for (int i = 0; i < numbers.length; i++)
```

- Or use "for each" loop
  `for (int n : numbers) . . .`

Arrays

- Can have array of length 0; *not* the same as `null`:

```
numbers = new int[0];
```

- Multidimensional array

```
int[][] table = new int[10][20];int t = table[i][j];
```

Command-Line Arguments

- `void main(String[] args)`
- `args` parameter of `main` is initialized with command-line arguments
- Example:
  `java GreeterTest Mars`
- `args.length` is 1
  `args[0]` is `"Mars"`

Static Fields

- Shared among all instances of a class
- Example: shared random number generator

```
public class Greeter{ . . . private static Random generator;}
```

- Example: shared constants

```
public class Math{ . . . public static final double PI = 3.14159265358979323846;}
```

Static Methods

- Don’t operate on objects
- Example: `Math.sqrt`
- Example: *factory method*

```
public static Greeter getRandomInstance(){ if (generator.nextBoolean()) // note: generator is static field return new Greeter("Mars"); else return new Greeter("Venus");}
```

- Invoke through class:

```
Greeter g = Greeter.getRandomInstance();
```

- Static fields and methods should be rare in OO programs

Programming Style: Case Convention

- variables, fields and methods:
  start with lowercase, use caps for new words:

  ```
  namesayHello
  ```

- Classes:
  start with uppercase, use caps for new words:

  ```
  GreeterArrayList
  ```

- Constants:
  use all caps, underscores to separate words

  ```
  PIMAX_VALUE
  ```

Programming Style: Property Access

- Common to use `get/set` prefixes:

  ```
  String getName()void setName(String newValue)
  ```

- Boolean property has `is/set` prefixes:

  ```
  public boolean isPolite()public void setPolite(boolean newValue)
  ```

Programming Style: Braces

- "Allman" brace style: braces line up

  ```
  public String sayHello(){ return "Hello, " + name + "!";}
  ```

- "Kernighan and Ritchie" brace style: saves a line

  ```
  public String sayHello() { return "Hello, " + name + "!";}
  ```

Programming Style: Fields

- Some programmers put fields before methods:

  ```
  public class Greeter{ private String name; public Greeter(String aName) { . . . } . . .}
  ```

- From OO perspective, it is better to list the `public` interface first
- All fields should be `private`
- Don’t use default (package) visibility

Programming Style: Miscellaneous

- Spaces around operators, after keywords, but not after method names

  ```
  Good: if (x > Math.sqrt(y))Bad: if(x>Math.sqrt (y))
  ```

- Don’t use C-style arrays:

  ```
  Good: int[] numbersBad: int numbers[]
  ```

- No magic numbers

  ```
  Good: h = HASH_MULTIPLIER * h + val[off];Bad: h = 31 * h + val[off];
  ```