

# Java Language Overview

## Key Terms and Concepts

- Java is an Object Oriented Programming (OOP) language.
- Programs in Java are organized around **classes**. You can think of classes a bit like blueprints that specify how an object is to be created.
- Related classes are grouped together into **packages**.
- An **object** is created when we **instantiate** a class. We do this using the keyword “new”, which calls the class **constructor**.
  - For example, `new Cat("Ziggy")` would call the constructor for the `Cat` class. Doing this *instantiates* a new `Cat` object.
  - **instantiate** - to make an instance of
- Classes can **extend** other classes, which means that they inherit all the functionality from those other classes (but they can also overwrite some of the functionality). In this case we call the extended class the *superclass* and the extending class the *subclass*.
  - For example, the `Cat` class may extend a `Pet` class. It may have some same functionality, e.g. weight, number of legs, age fields and accessors, but it may also have its own methods, e.g. `purr`.
- An **interface** is a set of **method signatures** (i.e., function prototypes). A class can **implement** an interface if it has implementations for all the methods indicated in the interface.
  - A good example of that is Java’s `List` interface<sup>1</sup>. It contains specifications for a rich set of operations revolving around maintaining a list of elements. But it does not provide any implementation for these operations; the implementing subclasses do that.
- The keyword `this` can be used in a method to refer to the object itself, and to provide access to the object’s **data fields**. If there is no ambiguity, you can also refer to the data fields directly.
- As an OOP language, much of Java programming boils down to calling object **methods**, or in pure OOP terms “*passing messages to objects*”.

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<sup>1</sup><https://docs.oracle.com/javase/8/docs/api/java/util/List.html>

## Access Modifiers

The **scope** of a class, method, or variable refers to the part of the program where the class/method/variable is *visible* and can be accessed. In Java, the scope of a class and the scope of each class attribute (method or data field) is specified using the following **access modifiers**:

**public** Can be accessed anywhere.

**private** Can be accessed only by objects of the class that contains them.

**package-private** Can be accessed by classes within the same package; also the default, if no access modifier is given.

**protected** Can be accessed only by subclasses of the class.

The scope is the first thing specified when a class or class attribute is being defined. In the example below, objects of type `Foo` can be created anywhere in the program. The `Foo` class methods are also public, which means these methods can be called on `Foo` objects anywhere in the program. However, The variable `xBar` is private, so the only place this variable can be accessed is inside of class `Foo`.

```
package fragile;
public class Foo {

    private int xBar = 42;

    public int getXBar() {
        return xBar;
    }

    public void addToXBar(int y) {
        xBar += y;
    }
}
```

## Variables

**Variables** are identifiers in a program that hold values. Java employs several different kinds of variables, which vary in terms of their scope.

**Instance variables** Typically called **data fields** or just **fields**. Instance variables are part of a class's definition. They are created when an object is instantiated; each *object* is created with its own independent copy of the instance variables. All methods of an object can access the object's instance variables. If needed, instance variables may be referenced within an object through the `this` keyword; for example, `this.x = x` where the `x` on the left is the instance variable and the `x` on the right is a parameter or local variable.

**Static variables** Typically called **static fields**. Static variables are part of a class's definition. They are used to represent properties associated with a *class*. A single copy of each static variable is shared amongst all object instances of that class. Static variables can be used even if no class instances have been created; they are always referenced through the name of the class. For example, if class `Zip` has a static variable called `numObjects`, throughout the class the variable would be referenced as `Zip.numObjects`.

**Local variables** Typically just called **variables**. Local variables are variables defined inside of methods. They may only be referenced within the innermost set of curly braces that contains their declaration.

**Parameters** Sometimes called **arguments**. Parameters are declared in a method's signature. The values for parameters are passed to the method from its caller. A parameter may be referenced anywhere inside the method where it is defined, and its value only extends to the end of the specific method call.

### Type of a variable

- Every variable needs to be **declared** before it can be used. This declaration specifies the type and scope of the variable.
- This **type** can be a built-in datatype like `int` or `char`, or it can be a class or interface.
- When assigning a value to a variable, the type of the value must match the type of the variable.

A quick summary:

Variable	Scope	Lifetime	Type Declaration	Initialization
Instance	each object	as long as object is around	top of class file	constructor
Static	any object of the class	always there	top of class file	declaration
Local	innermost { . . }	only within the { .. }	method body	declaration
Parameter	method	duration of method call	method signature	method call

**Practice** Imagine a `Student` class. Which type of variable is best to use for each of the following pieces of information?

1. The variable holding the maximum allowed length for student last names.
2. The variable holding a student's current age
3. In a method called `isOlderThan`, which compares a student's current age to a provided target age, the variable that holds the provided age with which to compare the student's current age.
4. In the method `isOlderThan`, the boolean variable that holds the result of comparing the two ages.

## Syntax elements

### Java program files

Java files use the extension `.java`. They consist of the following:

- *package* statement indicating which package the file belongs to
- *import* statements that load public elements from other packages
- class or interface definition

**Import statements** are used to avoid having to refer to classes by their fully qualified names.

Classes can be used without being imported by **fully qualifying** the class name. For example, `graphics.Rectangle` is how the `Rectangle` class would need to be referred to if the class was not imported.

Using import statements in your file allows you to use shorter forms to reference classes. Below are three possible import statements that could be used to import the `Rectangle` class.

```
import graphics.Rectangle;  
import graphics.*;  
import graphics.Rectangle.*;
```

- The first import line above allows us to refer to the `Rectangle` class directly in our code, e.g., `new Rectangle`.
- The second import line does the same for *all* classes within the `graphics` package.
- The third import line will make every *static* inner class and *static* method within the `Rectangle` class available directly.

As an example, if `Rectangle` had a static `draw` method, then with the first two imports we can refer to this method as `Rectangle.draw(...)`, while with the last import we can do `draw(...)` instead.

### Class definitions

Class definitions have the keyword `class`, possibly preceded by an *access modifier* and followed by the class name. In Java, it is conventional to *capitalize* class names. *Top-level classes must be contained in a file that has the same name as the class.*

The class name may be followed by `extends ...` and/or `implements ...` clauses, if the class is a subclass of another class or if it implements a certain interface. For example,

```
public class Circle extends AbstractShape implements Drawable {  
    ...  
}
```

The interior of a class definition may contain any of the following, in any order:

- field declarations
- zero or more constructor definitions
- method definitions
- inner class definitions

**Interface** definitions are similar to class definitions with the following exceptions:

- They cannot contain an `extends` part, unless it is to extend another interface.
- They cannot contain an `implements` part.
- They cannot have constructors.
- They have **method declarations** instead of method definitions.

Method declarations have no body; instead, a method declaration ends with a semicolon.

**Abstract class** definitions are similar to regular class definitions with the following exceptions.

- They cannot have constructors.
- They use the `abstract` modifier in their definitions.
- They can contain both method definitions and method declarations.

Methods that are simply declared *must* contain the `abstract` keyword modifier.

## Field declarations

A field declaration specifies the visibility of the field, its data type, and possibly an initial value. Below are some examples:

- `private String firstName;`
  - Specifies a private field called `firstName` that is of type `String`. This field will likely be initialized in the constructor.
- `static final int MAX_CAPACITY = 40;`
  - Specifies what is effectively a *class constant*. `MAX_CAPACITY` is visible within the package (hence no access modifier in front). It is of type `int` and has been declared **final**, meaning its value cannot be changed.
- `public static String hostname;`
  - Specifies a field called `hostname` that is visible everywhere. Using the `static` keyword modifier indicates that `hostname` is a *class variable*, with one copy of the variable being shared by all class objects.

## Method definitions

Method definitions begin with *modifiers* followed by the method's *return type*, the method name, and a parenthesized list of parameter declarations. The body of the method then follows, enclosed in curly braces. Below are some examples:

```
public void setFirstName(String newFirstName) {  
    ...  
}  
  
public String getFirstName() {  
    ...  
}  
  
private static boolean isValidName(String firstName, String lastName) {  
    ...  
}
```

Note that if your program has a **main method**, this method has a specific required signature. For example:

```
public static void main(String[] args) {  
    System.out.println("Hello_world!");  
}
```

## Constructors

Constructors are similar to method definitions. The name of a class also functions as the name for the class constructor. *Constructors cannot be static*. They also do not explicitly return a value from within their body. Instead, the newly created object is automatically returned.

A class can have multiple constructors as long as the constructors have differences in their parameter lists. When a class has multiple constructors, it is customary for all constructors to eventually call the same constructor, the one with the most complete set of arguments.

A class implemented without a constructor will be given the following *default constructor*:  
`public void ClassName() {}`.

Example:

```
public Person(String firstName, String lastName, int age) {  
    this.firstName = firstName;  
    this.lastName = lastName;  
    this.age = age;  
}  
  
// This constructor simply calls the longer constructor.  
public Person(String firstName, String lastName) {  
    this(firstName, lastName, 0);  
}
```

Constructors are called when the keyword `new` is used to create a class instance. For example, `Person p = new Person("Peter", "Doe", 26);` will automatically call the `Person` class constructor.

It also common practice to create static methods for classes that might have multiple constructors. These methods then provide a name for *how* you are constructing the object.

## Control structures

Java contains many of the standard control elements you may have seen in other languages to control the flow of execution:

- conditionals
- while loops
- for loops
- switch statements

**Conditionals** Java conditionals follow a standard if–then–else pattern:

```
if (thisIsTrue) {
    ... true case code
}

if (thisIsTrue) {
    ... true case code
} else {
    ... false case code
}

if (thisIsTrue) {
    ... true case code
} else if (thatIsTrue) {
    ... case where thatIsTrue is true but thisIsTrue is false
} else {
    ... both false
}
```

There is also the **ternary operator**, which *returns a value*. For example,

```
int x = (y > 5) ? 5 : y;
```

This can be translated as “if y is greater than 5 then return 5; otherwise, return the value of y”.

**While loops** Java implements the familiar while loop that executes a block of code as long as a specific condition is true. For example,

```
while (account.hasMoney()) {
    account.withdraw();
}
```

This loop will continue executing the `account.withdraw()` method as long as `account.hasMoney()` is true.

**For loops** Java provides two kinds of for loops. The standard *counter loop* and a *foreach loop* for iterating over a collection.

```
for (int i = 0; i < allNames.length; i++) {  
    System.out.println(allNames[i]);  
}  
  
for (String name : names) {  
    System.out.println(name);  
}
```

The second for loop will iterate over all the items in names using the variable name as its loop variable. This kind of for loop is preferred if you simply need to loop over the elements of a collection and you have no need for the loop index i. And as an extra benefit, it works for all sorts of *iterables* and not just for arrays. Any object whose class implements the Iterable interface<sup>2</sup> can be used in this so-called **for-each loop**.

**Switch statements** A switch statement compares a value against a series of constant values presented in case expressions, and executes the corresponding statements. It will fall through to the next case unless you remember to use break.

```
switch (person.getType()) {  
    case "faculty":  
        doSomething();  
        break;  
    case "student":  
        doSomethingElse();  
        break;  
    default:  
        // We don't do anything otherwise  
}
```

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<sup>2</sup><https://docs.oracle.com/en/java/javase/11/docs/api/java.base/java/lang/Iterable.html>