

Lesson Objectives

After completing this lesson, participants will be able to:

- Define classes and objects
- Create Packages
- Work with Access Specifiers
- Define Constructors
- understand **this** reference
- Understand memory management in java
- use **static** keyword
- Declaring and using Enum
- Best Practices



Lesson Objectives:

This lesson introduces to the fundamentals of the Java Programming Language.

Lesson 4: Classes and Objects

4.1: Classes and Objects

4.2: Packages

4.3: Access Specifiers

4.4: Constructors

4.5: this reference

4.6: Memory Management

4.7: using static keyword

4.8: Enums

4.9: Best Practices

4.1 : Classes and Objects

Classes and Objects



Class:

- A template for multiple objects with similar features
- A blueprint or the definition of objects

Object:

- Instance of a class
- Concrete representation of class

```
class < class_name>
{
    type var1; ...
    Type method_name(arguments )
    {
        body
    } ...
} //class ends
```

Classes describe objects that share characteristics, methods, relationships, and semantics. Each class has a name, attributes (its values determine state of an object), and operations (which provides the behavior for the object).

What is the relationship between objects and classes? What exists in real world is objects. When we classify these objects on the basis of commonality of structure and behavior, the result that we get are the classes.

Classes are “logical”. They don’t really exist in real world. When writing software programs, it is the classes that get defined first. These classes serve as a blueprint from which objects are created.

Reference: Refer to OOP material for a detailed discussion on Object-Oriented Programming Concept.

Note: Java does not have functions defined outside classes (as C++ does).

4.1 : Classes and Objects

Introduction to Classes



A class may consist the following elements:

- Fields
- Methods
- Constructors
- Initializers

A Java class may consist of the components as listed in the above slide. Fields and methods are primary components of any class and are termed as members of class. A class can have zero or more class members.

A class methods are categorized as business method or getters/setters. A business method of a class usually contains the business logic for the given problem/requirement.

A getter/setter usually written to access the private properties/attributes of a class. For example, consider the property given below:

```
private String name;  
//getter  
public String getName() { return name;}  
//setter  
public void setName(String name) {this.name=name;}
```

For the boolean properties, the getter format isXXX()

Constructors are special methods (having same name as the class name and with no value return) which are used to create object of class. A class must have at least one constructor.

Initializers are special blocks in class, used to initialize members of class. A class can have zero or more initializers.

4.1 : Classes and Objects

Introduction to Classes



```
class Box{
    double dblWidth;
    double dblHeight;
    double dblDepth;
    double calcVolume(){
        return dblWidth * dblHeight * dblDepth;
    } //method calcVolume ends.
} //class Box ends.
```

```
class BoxDemo{
    public static void main(String a[])
    {
        Box box;                                //declare a reference to object
        box = new Box();                        //allocate a memory for box object.
        box.calcVolume();                       // call a method on that object.
    } }
```

The above slide shows an example of Box class with 3 fields and 1 method.

The new operator followed by the call to constructor of the class is used to create object. The above slide shows how to create an object of Box class.

new <<call to constructor>>;

Even though the Box class doesn't add constructor, Java compiler internally does. This constructor is called as default constructor and added by Java compiler only when class don't have any constructor declared.

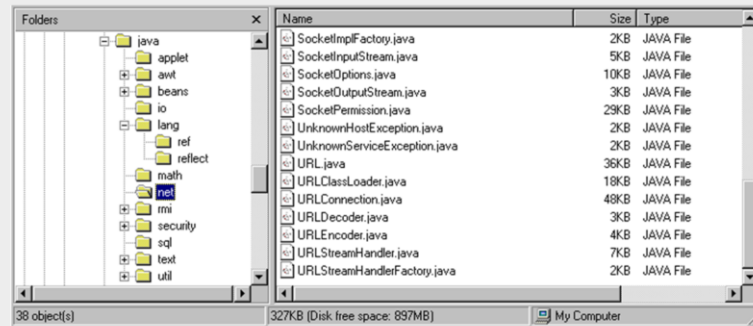
```
Box() { }
```

Once object created, we can access class members using dot operator. The contents of main() method shows how objects are instantiated and how methods are invoked.

4.2: Packages Packages



In Java, by the use of packages, you can group a number of related classes and/or interfaces together into a single unit.



Packages:

When you work on some small projects you intend to put all java files into one single directory. It is quick, easy and harmless. However, if your project gets bigger, and the number of files increase, putting all these files into the same directory would be tedious for you. In java, you can avoid this sort of problem by using packages.

Basically, files in one directory (or package) have different functionality from those of another directory. For example, files in java.io package carry out functions related to I/O, but files in java.net package provide you the way to deal with the Network.

4.2: Packages

Benefits of Packages



These are the benefits of organising classes into packages:

- It prevents name-space collision.
- It indicates that the classes and interfaces in the package are related.
- You know where to find the classes you want if they're in a specific package.
- It is convenient for organizing your work and separating your work from code libraries provided by others.

Benefits of Packages:

Prevents name-space collision: One of the many concerns that programmers face today is, how to ensure that their source code does not conflict with the source code of other programmers. A typical example is the case in which two programmers define two distinct classes that have the same name. Suppose, you decide to write a List class that keeps a sorted list of objects. This would inherently conflict with the List class in the Java API that is used for displaying a list of items in a Graphical User Interface. To this problem, Java has a simple solution, which is known as namespace management. In namespace management, each programmer defines their own namespace and places their code within that namespace, thus two classes that have the exactly same name are now distinguishable since they occur in different namespaces. Namespaces are called packages in Java.

Provides greater control over source codes: Another important reason for using packages is that it provides programmers with greater control over their source code. It is typical to have a few thousand source files in medium to large scale applications. Trying to maintain them would be difficult, if not impossible. However, separating these source files into packages makes it much easier to manage the source code. Usually, related classes are grouped into a single package, for example, all the user interface classes of an application are grouped into a package.

Makes it easy to find a class: If you are looking for a specific class and you know about the functionality it provides, you will naturally be able to find it in the right package. For example, if you are looking for an `InputStreamReader`, you will find it in the input and output package, that is, `java.io`.

4.2: Packages

Creating Your Own Package

```
package com.igate.trg.demo;
public class Balance {
    String name;
    public Balance(String n) {
        name = n;
    }
    public void show() {
        .....
        if( bal < 0)
            System.out.println(name + ": $" + bal);
    }
}
```



Package should be the first statement

Creating Your Own Package:

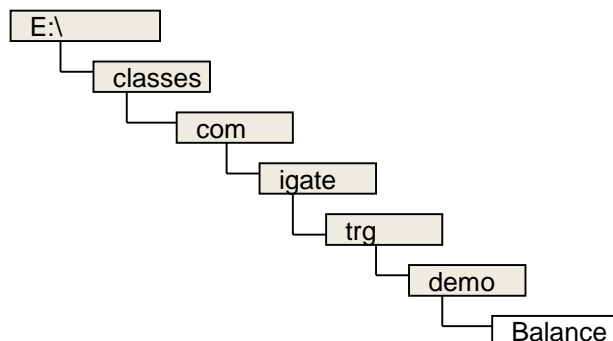
A package is a directory structure mapped on the operating system, hence compilation of Balance.java file results in the creation of directory structure com\igate\trg\demo and under that directory, Balance.class file is created. A package can contain more than one class and interface.

Compiling into a Package:

While compiling the file, we need to specify the URL where directory, com is to be created. For example, if you give the following command at command prompt.

```
E:\yourdirectory> javac -d E:\classes Balance.java
```

It is expected that you have a directory called classes under E:\. the result of this command is this directory structure. Here, all the grayed boxes are directories.



4.2: Packages

Packages and Name Space Collision

Namespace collision can be avoided by accessing classes with the same name in multiple packages by their fully qualified name.

package pack1;

class Teacher

class Student

package pack2;

class Student

class Courses

```
import pack1.*;  
import pack2.*;  
pack1.Student stud1;  
pack2.Student stud2;  
Teacher teacher1;  
Courses course1;
```

4.2: Packages

Using Packages



Use fully qualified name.

```
java.util.Date = new java.util.Date();
```

You can use import to instruct Java where to look for things defined outside your program.

```
import java.util.Scanner;  
Scanner sc = new Scanner (System.in);
```

You can use
multiple
import
statements

You can use * to import all classes in package:

```
import java.util.*;  
Scanner sc = new Scanner (System.in);
```

Use *
carefully; you
may
overwrite
definitions

java.lang package is automatically imported by every Java program.

4.2: Packages

Static Import

Static import enables programmers to import static members. Class name and a dot (.) are not required to use an imported static member.

```
import static java.lang.Math.*;
public class StaticImportTest
{
    public static void main( String args[] )
    {
        System.out.printf( "sqrt( 900.0 ) = %.1f\n", sqrt( 900.0 ) );
    } // end main
}
```

Note: It's
not
Math.sqrt

Static Import:

A static import declaration has two forms:

1. The form that imports a particular static member (which is known as single static import):

The following syntax imports only the sqrt method of the Math class:

```
import static java.lang.Math.sqrt;
```

2. The form that imports all static members of a class:

The following syntax imports all static members of the Math class:

```
import static java.lang.Math.*
```

4.2: Packages

Some Java Packages



Package Name	Description
java.lang	Classes that apply to the language itself, which includes the Object class, the String class, and the System class. It also contains the Wrapper classes. <u>"Classes belonging to java.lang package need not be explicitly imported"</u> .
java.util	Utility classes, such as Date, as well as collection classes, such as Vector and Hashtable
java.io	Input & output classes for writing to & reading from streams (such as standard input and output) & for handling files
java.net	Classes for networking support, including Socket and URL (a class to represent references to documents on the WWW)
java.applet	Classes to implement Java applets, including the Applet class itself, as well as the AudioClip interface

Refer to the java documentation for more details on other important packages.

4.2: Packages

Demo : Package

Execute the following programs:

- Balance.java
- AccountBalance.java
- StaticImportDemo.java
- StaticImportNotUsed.java



```
package com.igate.lesson4.demo;
public class Balance {
    String name;
    double bal;
    public Balance(String n, double b) {
        name = n;
        bal = b;
    }
    public void show() {
        if(bal<0)
            System.out.println(name + ": $" + bal);
    }
}
```

```
package com.igate.lesson4;
import com.igate.lesson4.demo.Balance;
class AccountBalance {
    public static void main(String args[]) {
        Balance object= new Balance("K. J. Fielding", 123.23);
        object.show();
    }
}
```

4.3: Access Modifiers

Types of Access Modifiers

Default
Private
Public
Protected

Location/Access Modifier	Private	Default	Protected	Public
Same class	Yes	Yes	Yes	Yes
Same package subclass	No	Yes	Yes	Yes
Same package non-subclass	No	Yes	Yes	Yes
Different package subclass	No	No	Yes	Yes
Different package non-subclass	No	No	No	Yes

public access modifier

Fields, methods and constructors declared public (least restrictive) within a public class are visible to any class in the Java program, whether these classes are in the same package or in another package.

private access modifier

Fields, methods or constructors declared private (most restrictive) cannot be accessed outside an enclosing class. This modifier cannot be used for classes. It also cannot be used for fields and methods within an interface. A standard design strategy is to make all fields private and provide public getter methods for them.

protected access modifier

Fields, methods and constructors declared protected in a superclass can be accessed only by subclasses in other packages. Classes in the same package can also access protected fields, methods and constructors, even if they are not a subclass of the protected member's class. This modifier cannot be used for classes. It also cannot be used for fields and methods within an interface.

default access modifier

Default specifier is used when "no access modifier is present". Any class, field, method or constructor that has no declared access modifier is accessible only by classes in the same package. The default modifier is not used for fields and methods within an interface.

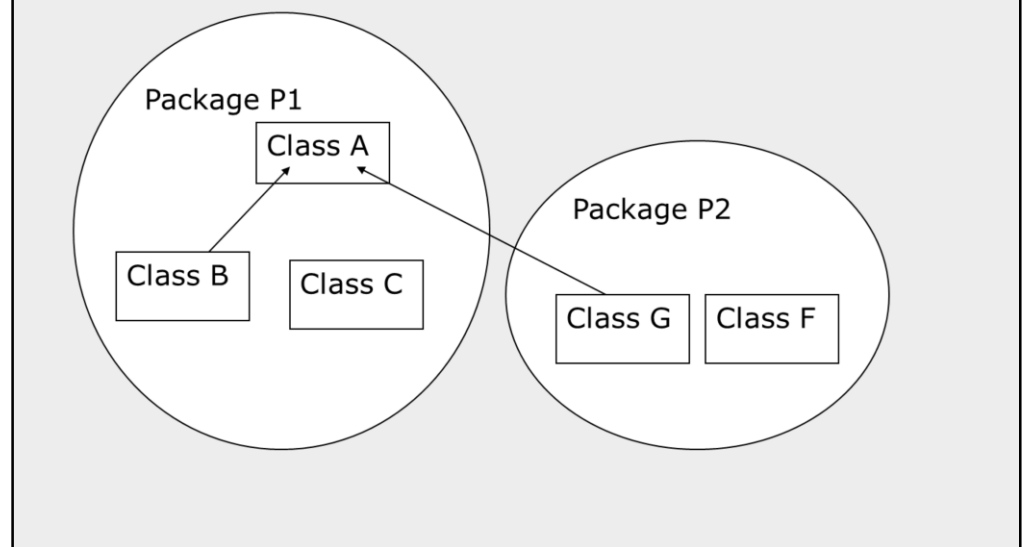
The table shown above is applicable only to members of classes. A class has only two possible access levels: default and public.

When a class is declared as public, it is accessible by any other code.

If a class has default access, then it can only be accessed by other code within its same package

4.3: Access Specifiers and Modifiers

What is access protection?



Access Protection:

Classes and packages are both means of encapsulating and containing the name space and scope of variables and methods. Packages act as containers for classes. Classes act as containers for data and code. Accessibility in java is specified with respect to packages. Because of the interplay between classes and packages, Java addresses five categories of visibility for class members.

Same Class

Subclass in the same package

Non-subclasses in the same package

Subclasses in different package

Classes that are neither in the same package nor in subclasses.

See the diagram given in the slide, to understand the five categories.

There are two packages P1 and P2. Package P1 contains Class A, B and C. B inherits from A. Package P2 contains Class G and F. G inherits from A. Which class comes under which category with respect to class A, is described below:

Same Class (Class A)

Subclass in the same package (Class B)

Non-subclasses in the same package (Class C)

Subclasses in different package (Class G)

Classes that are in neither the same package nor subclasses. (Class F)

4.4: Constructors

Default Constructors

All Java classes have *constructors*

- Constructors initialize a new object of that type

Default no-argument constructor is provided if program has no constructors

Constructors:

- Same name as the class
- No return type, not even void

```
class Box {  
    double  
    dblWidth;  
    double  
    dblHeight;  
    double  
    dblDepth;  
}
```

Compiler

```
class Box {  
    double  
    dblWidth;  
    double  
    dblHeight;  
    double  
    dblDepth;  
    Box() { }  
}
```

Class basically holds blueprint of Objects. In order to create and instantiate objects of class and also to provide initial values for the object, constructors are used. The structure of a constructor looks similar to a method. Constructors are used to create objects of a class. A Java class must have at least one constructor.

A class can have many constructors in order to facilitate the object creation in different ways.


Default Constructor: If class doesn't declare any constructor, compiler adds a constructor to the class. This constructor is called as default constructor. The default constructor accepts no arguments. Above slide shows an example of default constructor.

4.4: Constructors

Demo

Execute the BoxDemo.java program.

- This uses the Box.java



This demo example contains default (no-arg) constructor as well as a constructor that takes 3 parameters. Three box objects are created with initialization done using constructors and setter methods.

4.5: this reference this reference



The **this** keyword is used to refer to the current object from any method or constructor.

There are mainly two uses of this keyword:

- Refer the class level fields
- Chaining constructors

```
// Field reference using this
class Point {
    int xCord; // instance variable
    int yCord;

    Point(int xCord, int yCord) {
        this.xCord = xCord;
        this.yCord = yCord;
    }
}
```

this keyword:

this keyword is used to refer the current object. As shown in the above example, the constructor parameters are shadowing the instance variables. Therefore we can use this keyword to make difference between the local variables/parameters and instance variables.

The other use of this keyword is to invoke constructor of same class.

```
class Point {
    int xCord;
    int yCord;
    Point() {
        this(0, 0);    //chaining constructors using this
    }
    Point(int xCord, int yCord) {
        this.xCord = xCord;
        this.yCord = yCord;
    }
}
```

Note: this keyword cannot be used to refer static variables.

4.6: Memory Management

Memory Management



Dynamic and Automatic

No *Delete* operator

Java Virtual Machine (JVM) de-allocates memory allocated to unreferenced objects during the garbage collection process

4.6: Memory Management

Enhancement in Garbage Collector

**Garbage Collector:**

- Lowest Priority Daemon Thread
- Runs in the background when JVM starts
- Collects all the unreferenced objects
- Frees the space occupied by these objects
- Call *System.gc()* method to "hint" the JVM to invoke the garbage collector
 - There is no guarantee that it would be invoked. It is implementation dependent

There is a common misconception that `system.gc()` invokes the garbage collector, however that is not true. It just gives a request or hint to JVM to start garbage collector, but JVM may not start it immediately or even till end of the program execution. It is JVM implementation dependent issue, as to when it would start. It can even do some optimization by starting garbage collection, only when certain amount of memory is consumed etc.

An object is eligible for garbage collection when there are no more references to that object. References that are held in a variable are naturally dropped when the variable goes out of scope. So, you can explicitly drop an object reference by setting the value of a variable whose data type is a reference type to null.

```
StringBuffer sb = new StringBuffer("hello");
System.out.println(sb);
// The StringBuffer object is not eligible for collection
sb = null;
// Now the StringBuffer object is eligible for collection
```

4.6: Memory Management

Finalize() Method



Memory is automatically de-allocated in Java

Invoke *finalize()* to perform some housekeeping tasks before an object is garbage collected

Invoked just before the garbage collector runs:

- protected void finalize()

Note :

'protected' prevents access to finalize() by code defined outside its class.

This method only approximates the working of C++'s destructor. There is no way to determine when the finalize() method will run. There is no concept of destructors in Java as is there in C++.

To add a finalizer to a class, you simply have to override the finalize() method from the object class and can write the code for finalization inside the finalize() method

Syntax

```
class A {  
    protected void finalize() {  
        super.finalize();  
        //Write the code for finalization over here.  
        . ....  
    }  
}
```

4.7: using static keyword

Static modifier



Static modifier can be used in conjunction with:

- A variable
- A method

Static members can be accessed before an object of a class is created, by using the class name

Static variable :

- Is shared by all the class members
- Used independently of objects of that class
- Example: `static int intMinBalance = 500;`

Variables and methods marked with static modifier belong to the class rather than any particular instance. I.e, you do not have to instantiate the class to invoke a static method or access a static variable.

4.7: using static keyword Static modifier



Static methods:

- Can only call other static methods
- Must only access other static data
- Cannot refer to this or super in any way
- Cannot access non-static variables and methods

Static constructor:

- used to initialize static variables

Method `main()` is a static method. It is called by JVM.



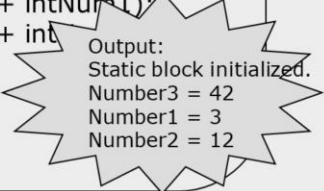
`main()` is called by JVM. Making this method static means the JVM does not have to create an instance of your class to start running code.

Static constructor is also known as static initialization block. This is a normal block of code enclosed in braces `{ }` and preceded by the static keyword. This can appear anywhere in the class body. It is normally used to initialize static variables.

4.7: using static keyword Static modifier




```
// Demonstrate static variables, methods, and blocks.
public class UseStatic {
    static int intNum1 = 3;           // static variable
    static int intNum2;
    static {                          //static constructor
        System.out.println("Static block initialized.");
        intNum2 = intNum1 * 4;
    }
    static void myMethod(int intNum3) { // static method
        System.out.println("Number3 = " + intNum3);
        System.out.println("Number1 = " + intNum1);
        System.out.println("Number2 = " + intNum2);
    }
    public static void main(String args[]) {
        myMethod(42);
    }
}
```




Output:
Static block initialized.
Number3 = 42
Number1 = 3
Number2 = 12

4.8: Enums
Enums



ENUM representation
pre-J2SE 5.0



```
public static final int SEASON_WINTER = 0;
public static final int SEASON_SUMMER = 1;
public static final int SEASON_SUMMER = 2;
```

Problem?

- Not type safe (any integer will pass)
- No namespace (SEASON_*)
- Brittleness (how do add value in-between?)
- Printed values uninformative (prints just int values)

Solution: New type of class declaration

- enum type has public, self-typed members for each enum constant

In pre Java 5, the standard way to represent an enumerated type was the int Enum pattern. An example shown in the box above.

But this pattern suffers from problems such as:

Not typesafe – A season is just an int you can pass in any other int value where a season is required, or add two seasons together (makes no sense)!

No namespace - Constants of an int enum must be prefixed with a string (eg SEASON_) to avoid collisions with other int enum types.

Brittleness - Since int enums are compile-time constants, they are compiled into clients that use them. If a new constant is added between two existing constants or the order is changed, clients must be recompiled.

Printed values are uninformative - Since they are just ints, printing one out will get you a number, which tells you nothing about what it represents, or what type it is.

In J2SE5 the enumerations have become separate classes. Thus, they are type-safe, flexible to use. For example the above enum is now represented as :

```
enum Season { WINTER, SPRING, SUMMER, FALL }
```

4.8: Enums

Declaring Type Safe Enums



Permits variable to have only a few pre-defined values from a given list
Helps reduce bugs in the code

▪ Example:

cs can have values *BIG*, *HUGE* and *OVERWHELMING* only

```
enum CoffeeSize { BIG, HUGE, OVERWHELMING };  
CoffeeSize cs = CoffeeSize.BIG;
```

Enum lets you restrict a variable to having one of only a few pre-defined values—in other words, one value from an enumerated list. This can help reduce the bugs in your code. For instance, in your coffee shop application you might want to restrict your size selections to BIG, HUGE, and OVERWHELMING. If you let an order for a LARGE or a GRANDE slip in, it might cause an error. See the declaration above. With this, you can guarantee that the compiler will stop you from assigning anything to a CoffeeSize except BIG, HUGE, or OVERWHELMING.

Then, the only way to get a CoffeeSize is with a statement like the following:

```
CoffeeSize cs = CoffeeSize.BIG;
```

It is not required that enum constants be in all upper case, but borrowing from the Sun code convention that constants are named in upper case, it is a good idea.

Important point to ponder about enums:

- enum can be declared with only a public or default modifier.

- enums are not strings or integer type.

- Enums can be declared as their own class, or enclosed in another class, and that the syntax for accessing an enum's members depends on where the enum was declared.

- enum cannot be declared in functions.

- A semicolon after an enum is optional

4.8: Enums

Enums with Constructors, Methods and Variables



Add constructors, instance variables, methods, and a constant specific class body

▪ Example:

```
enum CoffeeSize {  
    BIG(8), HUGE(10), OVERWHELMING(16);  
    // the arguments after the enum value are "passed"  
    // as values to the constructor  
    CoffeeSize(int ounces) {  
        this.ounces = ounces;  
        // assign the value to an instance variable  
    }  
}
```

Because an enum really is a special kind of class, you can do more than just list the enumerated constant values. You can add constructors, instance variables, methods, and something really strange known as a constant specific class body. To understand why you might need more in your enum, think about this scenario: imagine you want to know the actual size, in ounces, that map to each of the three `CoffeeSize` constants.

For example, you want to know that `BIG` is 8 ounces, `HUGE` is 10 ounces, and `OVERWHELMING` is a whopping 16 ounces. You could make some kind of a lookup table, using some other data structure, but that would be a poor design and hard to maintain. The simplest way is to treat your enum values (`BIG`, `HUGE`, and `OVERWHELMING`), as objects that can each have their own instance variables. Then you can assign those values at the time the enums are initialized, by passing a value to the enum constructor.

4.8: Enums Demo



Demo: EnumMonths.java

You can do much more than the plain representation you saw in the previous example. You can define a full-fledged class (dubbed an enum type). It not only solves all the problems mentioned previously, it also allows you to add arbitrary methods and fields to an enum type, to implement arbitrary interfaces, and more. Enum types provide high-quality implementations of all the Object methods. For more information on Enum please refer the appendix.

4.9: Best Practices Constructor



Initializing fields to default values is redundant
Constructors should not call *overridables*
Beware of mistaken field *redeclares*

```
public final class Quark {  
    //private String fName;  
    //private double fMass;  
    public Quark(String aName, double aMass){  
        fName = aName;  
        fMass = aMass;  
    }  
    //WITH redundant initialization to default values  
    private String fName = null;  
    private double fMass = 0;  
}
```

```
>javap -c -classpath . Quark
```

Initializing fields to default values is redundant.

In the declaration of a field, setting it explicitly to its default initial value is always redundant, and may even cause the same operation to be performed twice (depending on your compiler). Declaring and initializing object fields as null, for instance, is simply not necessary in Java.

(It is worth recalling here that Java defines default initial values only for fields, and not for local variables).

Constructors should not call overridables.

That is, they should only call methods that are private, static, or final.

Beware of mistaken field re-declares.

Beware of this simple mistake, which can be hard to track down : if a field is mistakenly redeclared within the body of a method, then the field is not being referenced, but rather a temporary local variable with the same name. A common symptom of this problem is that a stack trace indicates that a field is null, but a cursory examination of the code makes it seem as if the field has been correctly initialized.

4.9: Best Practices

Static and Constants



Declare constants as static and final
Static, final and private methods are faster
If possible, use constants in *if* conditions

Declare constants as static and final.

Use static, if variable is not going to change. This reduces the memory space for the object. A single copy is shared among all the objects.

Static, final and private methods are faster.

Static, final and private functions are treated as inline functions. These types of methods are resolved faster than other types because resolutions are done only within the class. So, if the method is not to be overridden by the sub class then define it as final, static and private.

If possible, use constants in if conditions.

Conditional Compilation may be useful. Conditional compilation gets rid of the run time resolution of variables and their values.

```
class A {  
    public static final constA = 1;  
}  
class B {  
    public static void main(String arg[]) {  
        if (A.constA == 1) System.out.println("inside if ");  
    }  
}
```

In the above example, during the compilation of Class B the if condition is checked. Since the condition involves the final (constant), the time required for resolving the if condition and variables are not done at runtime, which can save some time. But if the value of const "constA" is changed ensure that both classes are compiled.

Lab



Lab 2: Language Fundamentals , Classes and Objects



Summary



In this lesson you have learnt:

- Classes and Objects
- Packages
- Access Specifiers
- Constructors - Default and Parameterized
- this reference
- Memory management
- Using static keyword
- Enums
- Best Practices



Add the notes here.

Review Questions



Question 1: Which of the following are the benefits of using Package?

- **Option1:** prevents name-space collision.
- **Option2:** To implement security of contained classes.
- **Option3:** Better code library management.
- **Option4:** To increase performance of your class.



Question 2: Which of the following is true regarding enum?

- **Option1:** enum cannot be used inside methods.
- **Option2:** enum need not have a semicolon at the end.
- **Option3:** enum can be only declared with public or default access specifier.
- **Option4:** All the above are true.