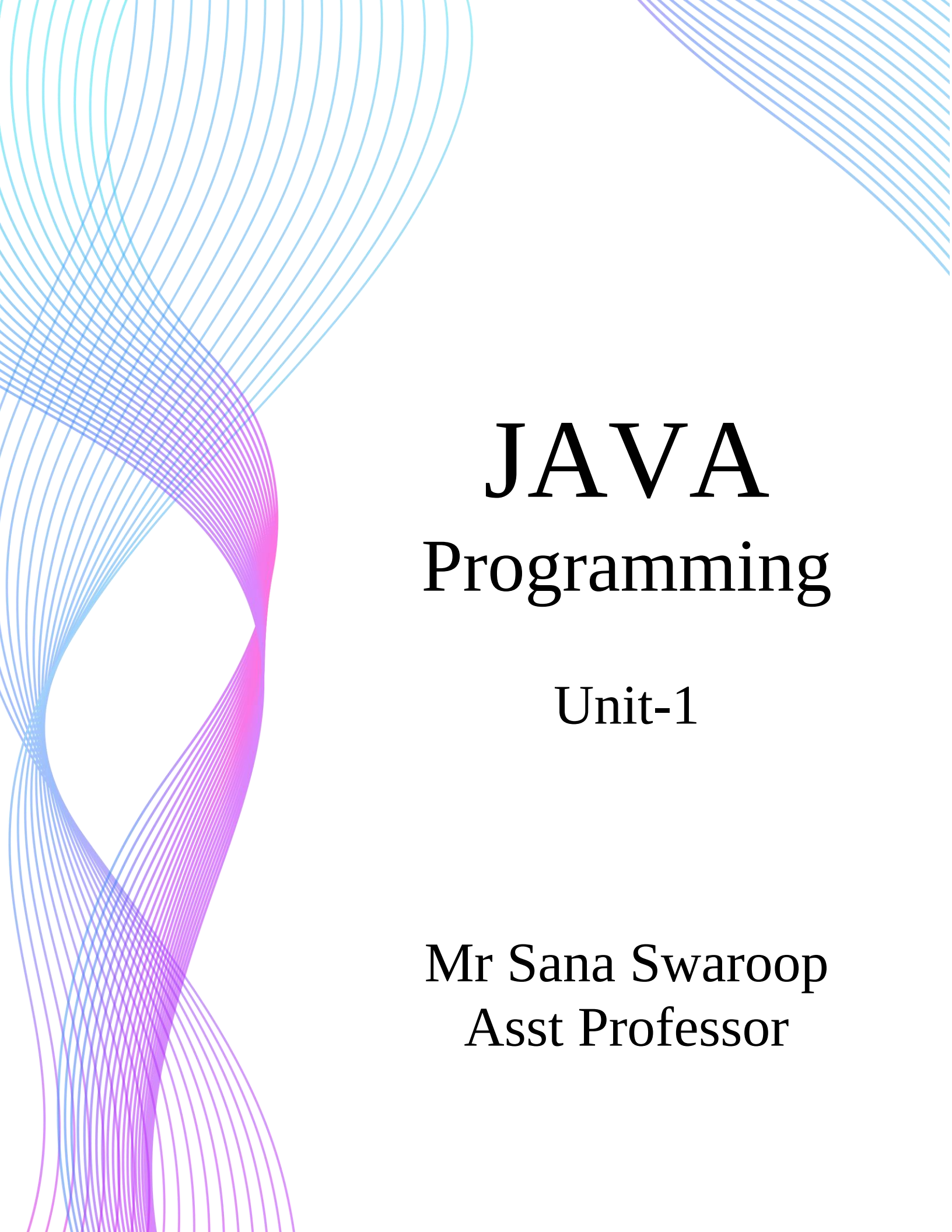

JAVA
Programming

Unit-1

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1.0 Introduction to Object Oriented Programming

The 1960s gave birth to structured programming. This is the method of programming championed by languages such as C. With the advent of languages such as c, structured programming became very popular and was the main technique of the 1980's. Structured programming was a powerful tool that enabled programmers to write moderately complex programs fairly easily. However, as the programs grew larger, even the structured approach failed to show the desired result in terms of bug-free, easy-to- maintain, and reusable programs. To solve these problems, a new way to program was invented, called *object-oriented programming* (OOP).

Object Oriented Programming (*OOP*) is an approach to program organization and development that attempts to eliminate some of the pitfalls of conventional programming methods by incorporating the best of structured programming features with several powerful new concepts. It is a new way of organizing and developing programs and has nothing to do with any particular language. However, not all languages are suitable to implement the OOP concepts easily.

1.1 PO Programming Vs OO Programming

All computer programs consist of two elements: code and data. Furthermore, a program can be conceptually organized around its code or around its data. That is, some programs are written around ― *"what is happening"* and others are written around ―*"who is being affected"*. These are the two paradigms that govern how a program is constructed. The first way is called the *process- oriented* model or *procedural* language. This approach characterizes a program as a series of linear steps (i.e. code). The process-oriented model can be thought of as code acting on data. Procedural languages such as C employ this model to considerable success.

To manage increasing complexity, the second approach, called *object-oriented* programming, was designed. Object-oriented programming organizes a program around its data (i.e. objects) and a set of well-defined interfaces to that data. An object-oriented program can be characterized as data controlling access to code.

Difference between POP and OOP

	Procedure Oriented Programming	**Object Oriented Programming**
Divided Into	Program is divided into small parts called ***functions*.**	Program is divided into parts called ***objects.***
Importance	Importance is given to functions as well as sequence of actions to be done.	Importance is given to the data rather than procedures or functions because it works as a real world.
Approach	It follows Top-down approach.	It follows Bottom-up approach.
Data Moving	Data can move freely from function to function in the system.	Objects can communicate with each other through member functions.
Expansion	To add new data and function in POP is not so easy.	It provides an easy way to add new data and function.

Data Access	Most function uses Global data for sharing that can be accessed freely from function to function in the system.	Data cannot move easily from function to function, it can be kept public or private so we can control the access of data.
Data Hiding	It does not have any proper way for hiding data so it is less secure.	It supports data hiding so provides more security.
Overloading	In POP, Overloading is not possible.	In OOP, overloading is possible in the form of Function Overloading and Operator Overloading.
Inheritance	No such concept of inheritance in POP	Inheritance is allowed in OOP
Access Specifiers	It does not have any access specifiers.	It has access specifiers named Public, Private, Protected.
Examples	C, BASIC, FORTRAN, Pascal, COBOL.	C++, JAVA, C#, Smalltalk, Action Script.

1.2 Principles of OOP

It is necessary to understand some of the concepts used extensively in object-oriented programming. These include:

- Object
- Class
- Encapsulation
- Data abstraction
- Inheritance
- Polymorphism
- Dynamic binding
- Message passing

Object

Object is the basic run time entity in an object-oriented system. It may represent a person, a place, a bank account, a table of data, vectors, time and lists. Objects have states and behaviors. Example: A dog has states - color, name, breed as well as behaviors – wagging the tail, barking, eating. An object is an instance of a class.

In OOP, A problem is analyzed in term of objects and the nature of communication between them. Objects should be chosen such that they match closely with the real-world objects. Objects take up space in the memory and have an associated address like a *structure* in *C*. When a program is executed, the objects interact by sending messages to one another.

For example, if "customer" and "account" are to object in a program, then the *customer* object may send a message to the *account* object requesting for the bank balance. Each object contain data, and code to manipulate data. Below figure shows two notations that are popularly used in object oriented analysis and design.

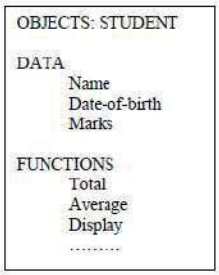


Fig. representing an object

Class

A class is a collection of similar objects that share the same properties, methods, relationships and semantics. A class can be defined as a template/blueprint that describes the behavior/state of the object.

Encapsulation

Definition: The process binding (or wrapping) code and data together into a single unit is known as Encapsulation. For example: capsule, it is wrapped with different medicines.

Capsule

- Java supports the feature of Encapsulation using *classes*.
- The data in the class is not accessed by outside world.
- The functions that are defined along with the data within the same class are allowed to access the data.
- These functions provide the interface between the object's data and the program. This insulation of the data from direct access by the program is called *data hiding or information hiding*.
- A class defines the structure and behavior (data and code) that will be shared by a set of objects. Each object of a given class contains the same structure and behavior defined by the class.
- The objects are referred to as instances of a class. Thus, a class is a logical construct; an object is physical reality.

Data abstraction

Definition: It a process of providing essential features without providing the background or implementation details. For example: It is not important for the user how TV is working internally, and different components are interconnected. The essential features required to the user are how to start, how to control volume, and change channels.

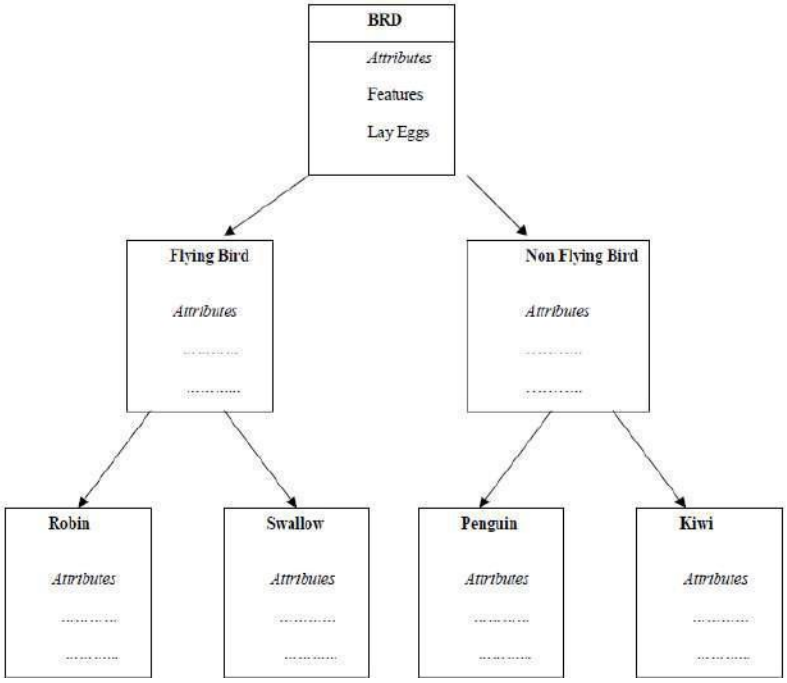
In java, we use *abstract class* and *interface* to achieve abstraction.

Inheritance

It a process by which an object of one class acquires the properties and methods of another class. It supports the concept of *hierarchical classification*. For example, the bird, 'robin' is a part of class 'flying bird' which is again a part of the class 'bird'. The principal behind this sort of division is that each derived class shares common characteristics with the class from which it is derived as illustrated in below figure.

In OOP, the concept of inheritance provides the idea of *reusability*. This means that we can add additional features to an existing class without modifying it. This is possible by deriving a new class from the existing one. The new class will have the combined feature of both the classes. The Class from which the properties are acquired is called *super class*, and the class that

acquires the properties is called *subclass*. This is mainly used for *Method Overloading* and *Code reusability*.



Polymorphism

Polymorphism is another important OOP concept. Polymorphism, a Greek term, means the ability to take more than one form. An operation may exhibit different behavior is different instances. The behavior depends upon the types of data used in the operation.
In Java, we use *method overloading* and *method overriding* to achieve polymorphism.

For example can be to speak something e.g. cat speaks meow, dog barks woof , duck speaks quack, etc.

Advantages of OOP

OOP offers several benefits to both the program designer and the user. Object-Orientation contributes to the solution of many problems associated with the development and quality of

software products. The new technology promises greater programmer productivity, better quality of software and lesser maintenance cost. The principal advantages are:

- It presents a simple, clear and easy to maintain structure.
- Software complexity can be easily managed.
- It enhances program modularity since each object exists independently.
- New features can be easily added without disturbing the existing one.
- Objects can be reused in other program.
- It allows designing and developing safe programs using the data hiding.
- Through inheritance, we can eliminate redundant code extend the use of existing classes.
- It is easy to partition the work in a project based on objects.
- Object-oriented system can be easily upgraded from small to large system.
- Message passing techniques for communication between objects makes to interface descriptions with external systems much simpler.

Applications of OOP

Applications of OOP are beginning to gain importance in many areas. The most popular application of object-oriented programming, up to now, has been in the area of user interface design such as window. Hundreds of windowing systems have been developed, using the OOP techniques. The promising areas of application of OOP include:

- Real-time systems
- Simulation and modeling
- Object-oriented data bases
- Hypertext, Hypermedia, and Expertext
- AI and expert systems
- Neural networks and Parallel programming
- Decision support and Office automation systems
- CAM/CAD Systems

1.3 What is Java?

Java is a **programming language** and a **platform**. Java is a high level, robust, secured and object-oriented programming language.

Platform: Any hardware or software environment in which a program runs, is known as a platform. Since Java has its own runtime environment (JRE) and API, it is called platform.

Where it is used (Applications)?

According to Sun, 3 billion devices run java. There are many devices where Java is currently used. Some of them are as follows:

1. Desktop GUI Applications such as acrobat reader, media player, antivirus etc.
2. Web Applications such as irctc.co.in, javabay.com etc.
3. Enterprise Applications such as banking applications.

4. Mobile Applications
5. Embedded Systems
6. Smart Cards
7. Robotics
8. Games etc.

Types of Java Applications

There are mainly 4 types of applications that can be created using java programming:

1. **Standalone Application**
   It is also known as desktop application or window-based application. An application that we need to install on every machine such as media player, antivirus etc. AWT and Swing are used in java for creating standalone applications.
2. **Web Application**
   An application that runs on the server side and creates dynamic page, is called web application. Currently, *servlet, jsp, struts, jsf* etc. technologies are used for creating web applications in java.
3. **Enterprise Application**
   An application that is distributed in nature such as banking applications etc. It has the advantage of high level security, load balancing and clustering. In java, EJB is used for creating enterprise applications.
4. **Mobile Application**
   An application that is created for mobile devices. Currently Android and Java ME are used for creating mobile applications.

Java Platforms / Editions

There are 4 platforms or editions of Java:

1. **Java SE (Java Standard Edition)**
   It is a java programming platform. It includes Java programming APIs such as java.lang, java.io, java.net, java.util, java.sql, java.math etc. It includes core topics like OOPs, String, Regex, Exception, Inner classes, Multithreading, I/O Stream, Networking, AWT, Swing, Reflection, Collection etc.
2. **Java EE (Java Enterprise Edition)**
   It is an enterprise platform which is mainly used to develop web and enterprise applications. It is built on the top of Java SE platform. It includes topics like Servlet, JSP, Web Services, EJB, JPA etc.
3. **Java ME (Java Micro Edition)**
   It is a micro platform which is mainly used to develop mobile applications.
4. **JavaFx**
   It is used to develop rich internet applications. It uses light-weight user interface API.

History of Java

The history of java starts from Green Team. Java team members (also known as **Green Team**), initiated a revolutionary task to develop a language for digital devices such as set-top boxes, televisions etc.

For the green team members, it was an advance concept at that time. But, it was suited for internet programming. Later, Java technology as incorporated by Netscape.

James Gosling

Currently, Java is used in internet programming, mobile devices, games, e-business solutions etc. There are given the major points that describe the history of java.

1. **James Gosling**, **Mike Sheridan**, and **Patrick Naughton** initiated the Java language project in June 1991 at *Sun Microsystems*. The small team of sun engineers called **Green Team**.
2. Originally designed for small, embedded systems in electronic appliances like set-top boxes.
3. Firstly, it was called ***"Greentalk"*** by James Gosling and file extension was ***".gt"***.
4. After that, it was called ***Oak*** and was developed as a part of the Green project.
5. **Why Oak?** Oak is a symbol of strength and chosen as a national tree of many countries like U.S.A., France, Germany, Romania etc.
6. In 1995, Oak was renamed as **"Java"** because it was already a trademark by Oak Technologies.

Why "Java" name

7. Why had they chosen *Java* name for java language? The team gathered to choose a new name. The suggested words were "dynamic", "revolutionary", "Silk", "jolt", "DNA" etc. They wanted something that reflected the essence of the technology: revolutionary, dynamic, lively, cool, unique, and easy to spell and fun to say.

   According to James Gosling "Java was one of the top choices along with Silk". Since java was so unique, most of the team members preferred *Java*.
8. *Java* is an *island* of *Indonesia* where first coffee was produced (called java coffee).
9. Notice that Java is just a name not an acronym.
10. Originally developed by James Gosling at Sun Microsystems (which is now a subsidiary of Oracle Corporation) and released in 1995.
11. In 1995, Time magazine called Java one of the Ten Best Products of 1995.
12. JDK 1.0 released in(January 23, 1996).

Java Version History

There are many java versions that have been released. Current stable release of Java is Java SE 8.

1. JDK Alpha and Beta (1995)
2. Initial Java Versions 1.0 and 1.1 were released in the year 1996 for Linux, Solaris, Mac and Windows.

3. J2SE 1.2 (Commonly called as Java 2) was released in the year 1998.
4. J2SE 1.3 codename Kestrel was released in the year 2000.
5. J2SE 1.4 codename Merlin was released in the year 2002.
6. J2SE 5.0 codename 'Tiger' was released in the year 2004.
7. Java SE 6 codename 'Mustang' was released in the year 2006.
8. Java SE 7 codename 'Dolphin' was released in the year 2011.
9. Java SE 8 is the current stable release which was released this year 2014.

Five Goals which were taken into consideration while developing Java

1. Keep it simple, familiar and object oriented.
2. Keep it Robust and Secure.
3. Keep it architecture-neural and portable.
4. Executable with High Performance.
5. Interpreted, threaded and dynamic.

Why we call it Java 2, Java 5, Java 6, Java 7 and Java 8, not their actual version numbers which 1.2, 1.5, 1.6, 1.7 and 1.8?

Java 1.0 and 1.1 were Java. When Java 1.2 was released it had a lots of changes and marketers / developers wanted a new name so they called it Java 2 (***J2SE***), remove the numeric before decimal. This was not the condition when Java 1.3 and Java 1.4 were released hence they were never called Java 3 and Java 4, but they were still Java 2.

When Java 5 was released, once again it was having a lots of changes for the developer / marketers and need a new name. The next number in sequence was 3, but calling Java 1.5 as Java 3 was confusing hence a decision was made to keep the naming as per version number and till now the legacy continues.

1.4 Java Features / Buzz words

There is given many features of java. They are also known as java buzzwords. The Java Features given below are simple and easy to understand.

1. Simple
2. Secure
3. Portable
4. Object-oriented
5. Robust
6. Multithreaded
7. Architecture-neutral
8. Interpreted
9. High performance
10. Distributed
11. Dynamic

Simple

Java inherits all the best features from the programming languages like C, C++ and thus makes it really easy for any developer to learn with little programming experience. Removed many confusing and/or rarely-used features e.g., explicit pointers, operator overloading etc. No need to remove unreferenced objects because there is Automatic Garbage Collection in java.

Secure

When Java programs are executed they don't instruct commands to the machine directly. Instead Java Virtual machine reads the program (***Byte code***) and convert it into the machine instructions. This way any program tries to get illegal access to the system will not be allowed by the JVM. Allowing Java programs to be executed by the JVM makes Java program fully secured under the control of the JVM.

Portable

Java programs are portable because of its ability to run the program on any platform and no dependency on the underlying hardware / operating system.

Object Oriented

Everything in Java is an Object. The object model in Java is simple and easy to extend, while primitive types, such as integers, are kept as high-performance non-objects.

Robust

The multi-platformed environment of the Web places extraordinary demands on a program, because the program must execute reliably in a variety of systems. Thus, the ability to create robust programs was given a high priority in the design of Java. Following features of Java make it Robust.

- Platform Independent
- Object Oriented Programming Language

- Memory management
- Exception Handling

Multithreaded

Java was designed to meet the real-world requirement of creating interactive, networked programs. To accomplish this, Java supports multithreaded programming, which allows you to write programs that do many things simultaneously.

Architecture-neutral

The Java designers made several hard decisions in the Java language and the Java Virtual Machine in an attempt to alter this situation. Their goal was ― *write once; run anywhere, anytime, forever*. To a great extent, this goal was accomplished.

Interpreted and High Performance

Java enables the creation of cross-platform programs by compiling into an intermediate representation called Java byte code. This code can be executed on any system that implements the Java Virtual Machine. Most previous attempts at cross-platform solutions have done so at the expense of performance. As explained earlier, the Java byte code was carefully designed so that it would be easy to translate directly into native machine code for very high performance by using a just-in-time compiler.

Distributed

Java is designed for the distributed environment of the Internet because it handles TCP/IP protocols. In fact, accessing a resource using a URL is not much different from accessing a file. Java also supports Remote Method Invocation (RMI). This feature enables a program to invoke methods across a network.

Dynamic

Java programs carry with them substantial amounts of run-time type information that is used to verify and resolve accesses to objects at run time. This makes it possible to dynamically link code in a safe and expedient manner.

1.5 Java Virtual Machine (JVM)

The key that allows Java to solve both the security and the portability problems is the byte code. The output of *Java Compiler* is not directly executable file. Rather, it contains highly optimized set of instructions. This set of instructions is called, "***byte code***". This byte code is designed to be executed by *Java Virtual Machine (JVM)*. The JVM also called as the *interpreter* for byte code.

JVM also helps to solve many problems associated with web-based programs. Translating a Java program into byte code makes it much easier to run a program in a wide variety of environments because only the JVM needs to be implemented for each platform. Once the run-time package exists for a given Figure 2 JVM system, any Java program can run on it. Remember, although the details of the JVM will differ from platform to

platform, all understand the same Java byte code. Thus, the execution of byte code by the JVM is the easiest way to create truly portable programs.

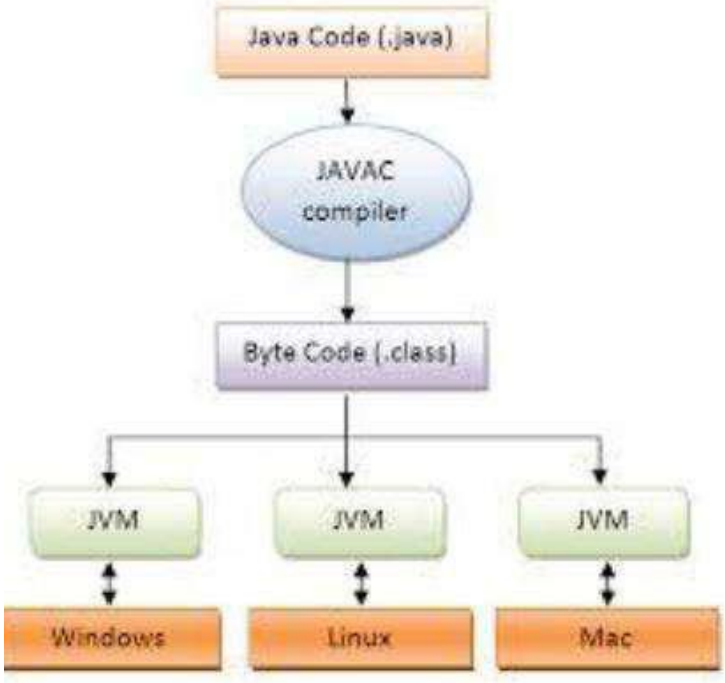


Figure 2 JVM

Internal Architecture of JVM

JVM (Java Virtual Machine) is an abstract machine. It is a specification that provides runtime environment in which java bytecode can be executed.

- JVMs are available for many hardware and software platforms (i.e. JVM is platform dependent).
- It is a specification where working of Java Virtual Machine is specified. But implementation provider is independent to choose the algorithm. Its implementation has been provided by Sun and other companies.
- Its implementation is known as JRE (Java Runtime Environment).
- Whenever you write java command on the command prompt to run the java class, an instance of JVM is created.

What it does

The JVM performs following operations:

- Loads code
- Verifies code
- Executes code
- Provides runtime environment

JVM provides definitions for the:

- Memory area
- Class file format
- Register set
- Garbage-collected heap
- Fatal error reporting etc.

Let's understand the internal architecture of JVM. It contains class loader, memory area, execution engine etc.

1. **Classloader**
   Classloader is a subsystem of JVM that is used to load class files.

2. **Class(Method) Area**
   Class (Method) Area stores per-class structures such as the runtime constant pool, field and method data, the code for methods.

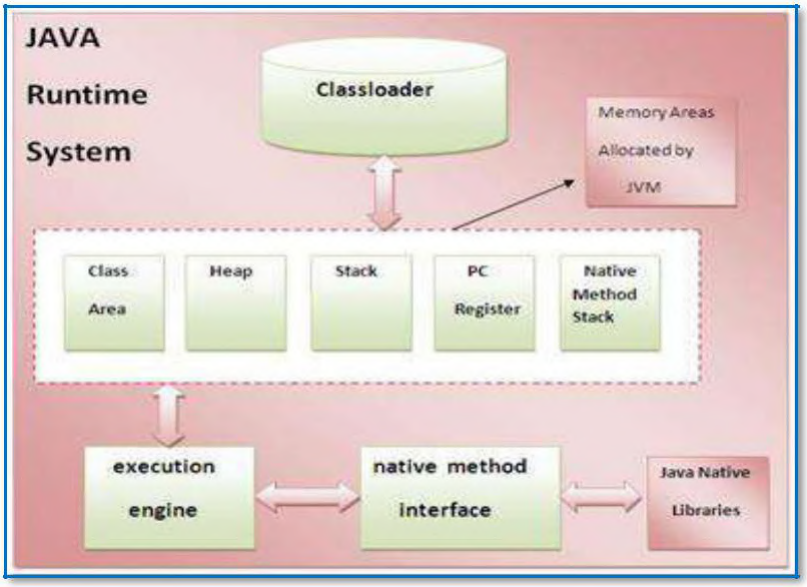


Fig. Internal architecture of JVM

3. **Heap**
   It is the runtime data area in which objects are allocated.

4. **Stack**
   Java Stack stores frames. It holds local variables and partial results, and plays a part in method invocation and return. Each thread has a private JVM stack, created at the same time as thread. A new frame is created each time a method is invoked. A frame is destroyed when its method invocation completes.

5. **Program Counter (PC) Register**
   PC (program counter) register. It contains the address of the Java virtual machine instruction currently being executed.

6. **Native Method Stack**
   It contains all the native methods used in the application. A **native method** is a **Java method** (either an instance **method** or a class **method**) whose implementation is written in another programming language such as C.

7. **Execution Engine**
   It contains:
   a. *A virtual processor*

b. *Interpreter:* Read bytecode stream then execute the instructions.
c. *Just-In-Time(JIT) compiler*: It is used to improve the performance. JIT compiles parts of the byte code that have similar functionality at the same time, and hence reduces the amount of time needed for compilation.

1.6 Basic Structure of Java Program

Basically, a Java program involves the following sections:

- Documentation Section
- Package Statement
- Import Statements
- Interface Statement
- Class Definition
- Main Method Class
- Main Method Definition

Section	Description
Documentation Section	It comprises of a comment line which gives the names program, the programmer's name and some other brief details. Java provides 3 styles of comments 1. Single line (//) 2. Multi-line(/* */) 3. Documentation comment (/**….*/)
Package statement	The first statement allowed in Java file is the Package statement which is used to declare a package name and it informs the compiler that the classes defined within the program belong to this package. It is declared as: *package package_name;*
Import statements	The next is the number of import statements, which is equivalent to the #include statement in C++. Example: *import java.util.Scanner;*
Interface statement	Interfaces are like a class that includes a group of method declarations. This is an optional section and can be used only when programmers want to implement multiple inheritances within a program.
Class Definition	A Java program may contain multiple class definitions. Classes are the main and important elements of any Java program. These classes are used to plot the objects of the real world problem.
Main Method Class	Since every Java stand-alone program requires the main method as the starting point of the program. This class is essentially a part of Java program. A simple Java program contains only this part of the program.

To create a simple java program, you need to create a class that contains main method. Let's understand the requirement first.

Requirement for Welcome Java Example

For executing any java program, you need to

- Install the JDK if you don't have installed it, download the JDK and install it.
- Set path of the *jdk/bin* directory.
- Create the java program
- Compile and Run the java program

Sample Code of "Welcome" Java program

Example: **Welcome.java**

```
class Welcome
{
    public static void main(String[] args)
    {
        System.out.println("Welcome to Java");
    }
}
```

Output:

Welcome to Java

Entering the Program

- We can use any text editor such as "notepad' or "dos text editor".
- The source code is typed and is saved with ".java" as extension.
- The source code contains one or more class definitions. The program name will be same as class name in which main function is written. This in not compulsory, but by convention this is used.
- The source file is officially called as compilation unit.
- We can even uses our choice of interest name for the program. If we use a different name than the class name, then compilation is done with program name, and running is done with class file name. To avoid this confusion and organize the programs well, it is suggested to put the same name for the program and class name, but not compulsory.

Compiling the Program

To compile the program, specifying the name of the source file on the command line, as shown below:

C:/>javac Welcome.java

The *javac* compiler creates the file called *"Welcome.class" that* contains the byte code version of the source code. This byte code is the intermediate representation of the source code that contains the instructions that the Java Virtual Machine (JVM) will execute. Thus the output of the *javac* is not the directly executable code.

Running the Program

To run the program, we must use Java interpreter, called "*java*". This is interpreter the "*Welcome.class*" file given as input.

C:/>java Welcome

When the program is run with java interpreter, the following output is produced: *Welcome to Java*

Description of the program

The *first line* contains the keyword *class* and class name, which actually the basic unit for encapsulation and is used to declare a class in java, in which data and methods are declared.
Second line contains "{" which indicates the beginning of the class.

Third line contains the *public static void main(String args[])*

where

- *public* keyword is an access modifier which represents visibility, it means it is visible to all.
- *static* is a keyword, if we declare any method as static, it is known as static method. The core advantage of static method is that there is no need to create object to invoke the static method. The main method is executed by the JVM, so it doesn't require to create object to invoke the main method. So it saves memory.
- *void* is the return type of the method, it means it doesn't return any value.
- *main* represents startup of the program where execution starts.
- *String[] args* is used to read command line argument.

Fourth line contains the "{", which is the beginning of the main function.
Fifth line contains the statement

System.out.println("Hello World");

Here "*System*" is the predefined class, that provides access to the system, and *out* is the output stream that is used to connect to the console. The *println()*, is used to display string passed to it. This can even display other information to.

1.7 Lexical issues

Java programs are a collection of whitespace, identifiers, literals, comments, operators, separators, and keywords.

Whitespace

Java is a free-form language. This means that you do not need to follow any special indentation rules. For example, the Java program could be written all on one line or in any other strange way you felt like typing it, as long as there was at least one whitespace character between each token that was not already delineated by an operator or separator. In Java, whitespace is a space, tab, or newline.

Identifiers

Identifiers are used to name things, such as classes, variables, and methods. An identifier may be any descriptive sequence of uppercase and lowercase letters, numbers, or the underscore and dollar-sign characters. They must not begin with a number. Java is case-sensitive, so **VALUE** is a different identifier than **Value**. Some examples of valid identifiers are

AvgTemp	count	a4	$test	this_is_ok

Invalid identifier names include these:

High-temp	2count	4a	Not/ok

Literals

A constant value in Java is created by using a *literal* representation of it. For example, here are some literals:

100	98.6	'C'	"This is a test"

Left to right, the first literal specifies an integer, the next is a floating-point value, the third is a character constant, and the last is a string.
A literal can be used anywhere a value of its type is allowed.

Comments

As mentioned, there are three types of comments defined by Java. You have already seen two: single-line and multiline. The third type is called a *documentation comment*. This type of comment is used to produce an HTML file that documents your program. The documentation comment begins with a /** and ends with a */.

Separators

In Java, there are a few characters that are used as separators. The separators are shown in the following table:

Symbol	Name	Purpose
( )	Parentheses	Used to contain lists of parameters in method definition and invocation. Also used for defining precedence in expressions, expressions in control statements, and surrounding cast types.
{ }	Braces	Used to contain the values of automatically initialized arrays. Used to define a block of code, for classes, methods, and local scopes
[ ]	Brackets	Used to declare array types and to dereferencing array values.
;	Semicolon	Terminates statements.
,	Comma	Separates consecutive identifiers in a variable declaration.
.	Period	Used to separate package names from sub-packages and classes and used to separate a variable or method from a reference variable.

The Java Keywords

- There are 50 keywords currently defined in the Java language (see below Table).
- These keywords, combined with the syntax of the operators and separators, form the foundation of the Java language.
- These keywords cannot be used as identifiers. Thus, they cannot be used as names for a variable, class, or method.
- The keywords *const* and *goto* are reserved but not used.
- In addition to the keywords, Java reserves the following: **true**, **false**, and **null**. These are values defined by Java.

abstract	continue	for	new	switch
assert	default	goto	package	synchronized
boolean	do	if	private	this
break	double	implements	protected	throw
byte	else	import	public	throws
case	enum	instanceof	return	transient
catch	extends	int	short	try
char	final	interface	static	void
class	finally	long	strictfp	volatile
const	float	native	super	while

Table: Java Keywords

Operators

An operator performs an operation on one or more operands. Java provides a rich set of operators. An operator that performs an operation on one operand is called unary operator. An operator that performs an operation on two operands is called binary operator.

1.8 Variables

The variable is the basic unit of storage in a Java program. A variable is defined by the combination of an identifier, a type, and an optional initializer. In addition, all variables have a scope, which defines their visibility, and a lifetime.

Declaring a Variable

In Java, all variables must be declared before they can be used. The basic form of a variable declaration is shown here:

type identifier [= value/literal][, identifier [= value/literal] ...] ;

Here the *type* is any primitive data type, or class name. The *identifier* is the name of the variable. We can initialize the variable by specifying the equal sign and value.

Example

```
int a, b, c;            // declares three ints, a, b, and c.
int d = 3, e, f = 5;    // declares three more ints, initializing d and f.
byte z = 22;            // initializes z with 22.
double pi = 3.1415;     // declares an approximation of pi.
char c = 'x';           //  variable c has the value 'x'
```

Dynamic Initialization of the variable

We can also assign a value to the variable dynamically as follow:

```
int x = 12, y=13;
float z = Math.sqrt (x+y);
```

The Scope and Lifetime of Variables

- A *scope* determines what objects are visible to parts of your program. It also determines the life time of the objects.
- Java allows, declaring a variable within any block.

- A block begins with opening curly brace({) and ended with end curly brace (}).
- Thus, each time we start new block, we create new scope.
- Many programming languages define two scopes: Local and Global
- As a general rule a variable defined within one scope, is not visible to code defined outside of the scope.
- Scopes can be also nested. The variable defined in outer scope are visible to the inner scopes, but reverse is not possible.

Example code

```
void method1( )
{                           //outer block
        int a =10;
        if(a==10)
        {                   // inner block and here a,b,c are visible to the inner scope
                int b=a*20;
                int c=a+30;
        }                   //end of inner block
        b=20*2;             // b is not known here, which declared in inner scope
}                           //end of the outer block
```

1.9 Identifiers

Identifiers are used for class names, method names, and variable names. An identifier may be any descriptive sequence of uppercase and lowercase letters, numbers, or the underscore and dollar-sign characters. They must not begin with a number, lets they be confused with a numeric literal. Java is case-sensitive, so VALUE is a different identifier than Value. Some examples of valid identifiers are:

Rules for Naming Identifier:

1. The first character of an identifier must be a letter, or dollar($) sign.
2. The subsequent characters can be letters, an underscore, dollar sign or digit.
3. White spaces are not allowed within identifiers.
4. Identifiers are case sensitive so *VALUE* is a different identifier than *Value*

Valid Identifiers are as follows:

Average Temperature A1 Total_Score

Invalid Identifiers are as follows:

2a Area-circle Not/ok

Naming Convention for Identifiers

- *Class or Interface* - These begin with a capital letter. The first alphabet of every internal word is capitalized. Ex: class Myclass
- *Variable or Method* – These start with lower case letters. The first alphabet of every internal word is capitalized. Ex: int totalPay;

- *Constants* - These are in upper case. Underscore is used to separate the internal word. Ex:-final double PI=3.14;
- *Package* – These consist of all lower-case letters. Ex: import java.util.*;

1.10 Data Types

Java is strongly typed language

Java is strongly typed language. The safety and robustness of the Java language is in fact provided by its strict typing. There are two reasons for this: First, every variable and expression must be defined using any one of the type. Second, the parameters to the method also should have some type and also verified for type compatibility.

Java language has 8 primitive data types: They are: *char, byte, short, int, long, float, double, boolean*. These are again categorized into 4 groups.

1. Integer Group: The integer group contains *byte, short, int, long.* These data types will need different sizes of the memory. These are assigned positive and negative values. The width and ranges of these values are as follow:

byte

- The smallest integer type is *byte*.
- This is a signed 8-bit type that has a range from –128 to 127.
- Variables of type byte are especially useful when you're working with a stream of data from a network or file and working with raw binary data that may not be directly compatible with Java's other built-in types.
- Byte variables are declared by use of the *byte* keyword.

For example, the following declares two byte variables called b and c:

```
byte b, c;        // where b and c are identifiers
```

short

- short is a signed 16-bit type.
- It has a range from –32,768 to 32,767.
- It is probably the least-used Java type.

Here are some examples of short variable declarations:

```
short s, t;
```

int

- The most commonly used integer type is *int*.
- It is a signed 32-bit type that has a range from – 2,147,483,648 to 2,147,483,647.
- In addition to other uses, variables of type *int* are commonly employed to control loops and to index arrays.
- We can store byte and short values in an int.

Example: int x=12;

long

- *long* is a signed 64-bit type and is useful for those occasions where an int type is not large enough to hold the desired value.
- The range of a long is -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807.

- This makes it useful when big, whole numbers are needed.

Example: long x=123456;

2. Floating-Point Group

Floating-point numbers, also known as real numbers, are used when evaluating expressions that require fractional precision. These are used with operations such as square root, cosine, and sine etc. There are two types of Floating-Point numbers:

1. float
2. double.

The float type represents *single precision* and double represents *double precision*. **float**

- The type float specifies a single-precision value that uses 32 bits of storage.
- The range of a float is 1.4e–045 to 3.4e+038
- Single precision is faster on some processors and takes half as much space as double precision.
- Variables of type float are useful when you need a fractional component, but don't require a large degree of precision.

Example

float height, price;

double

- Double precision, as denoted by the double keyword, uses 64 bits to store a value.
- The range of a *double* is 4.9e–324 to 1.8e+308
- Double precision is actually faster than single precision on some modern processors that have been optimized for high-speed mathematical calculations.
- All the math functions, such as sin( ), cos( ), and sqrt( ), return double values.

Example:

double area, pi;

Example program to calculate the area of a circle

```
import java.io.*;
class Circle {
    public static void main(String args[ ] ) {
        double r, area, pi;
        r=2.5;
        pi=3.14;
        area=pi*r*r;
        System.out.println("The Area of the Circle is:"+area);
    }
}
```

Output

The Area of the Circle is: 19.625

3. Characters Group

In Java, the data type used to store characters is *char*. Java uses Unicode to represent characters. Unicode defines a fully international character set that can represent all of the characters found in all human languages.

Java char is a 16-bit type. The range of a char is 0 to 65,536. The standard set of characters known as ASCII still ranges from 0 to 127 as always, and the extended 8-bit character set, ISO-Latin-1, ranges from 0 to 255.

Here is a program that demonstrates char variables:

```
class CharDemo  {
        public static void main(String args[ ]) {
                char ch1, ch2;
                ch1 = 88;                   // code for X
                ch2 = 'Y';
                System.out.print("ch1 and ch2: ");
                System.out.println(ch1 + " " + ch2);
        }
}
```

Output

ch1 and ch2: X Y

4. Booleans Group

Java has a primitive type, called *boolean*, for logical values. It can have only one of two possible values, *true* and/or *false*.

Here is a program that demonstrates the boolean type:

```
class BoolTest {
        public static void main(String args[])
        {
                boolean b;
                b = false;
                System.out.println("b is " + b);
                b = true;
                System.out.println("b is " + b);
                // a boolean value can control the if
                statement if(b)
                        System.out.println("This is executed.");
                else
                        System.out.println("This is not executed.");
                // outcome of a relational operator is a boolean value
                System.out.println("10 > 9 is " + (10 > 9));
        }
}
```

Output

b is false
b is true
This is executed.
10>9 is true

1.11 Literals/Constants

A *literal* is a value that can be passed to a variable or constant in a program. Literals can be numeric, boolean, character, string or null.

Integer Literals

- Integers are the most commonly used type in the typical program.
- Any whole number value is an integer literal.
- Examples are 1, 2, 3, and 42. These are all decimal values, meaning they are describing a base 10 number.
- Octal values are denoted in Java by a leading zero.
- Octal numbers are ranging from 0 to 7 range. A more common base for numbers used by programmers is hexadecimal,

which matches cleanly with modulo 8 word sizes, such as 8, 16, 32, and 64 bits. You signify a hexadecimal constant with a leading zero-x, (0x or 0X). The range of a hexadecimal digit is 0 to 15, so *A* through *F* (or *a* through *f*) are substituted for 10 through 15.

Integer literals create an int value, which in Java is a 32-bit integer value. Since Java is strongly typed, you might be wondering how it is possible to assign an integer literal to one of Java's other integer types, such as byte or long, without causing a type mismatch error. Fortunately, such situations are easily handled. When a literal value is assigned to a byte or short variable, no error is generated if the literal value is within the range of the target type. An integer literal can always be assigned to a long variable. However, to specify a long literal, you will need to explicitly tell the compiler that the literal value is of type long. You do this by appending an upper- or lowercase L to the literal. For example, 0x7fffffffffffffL or 9223372036854775807L is the largest long. An integer can also be assigned to a char as long as it is within range.

1.12 Operators

An operator is defined as a symbol that operates on operands and does something. The something may be mathematical, relational or logical operation. Java supports a lot of operators to be used in expressions. These operators can be categorized into the following groups:

1. Arithmetic operators
2. Bitwise operators
3. Relational operators and
4. Logical operators
5. Miscellaneous operators

Arithmetic Operators

- These are used to perform mathematical operations.
- Most of them are binary operators since they operate on two operands at a time except unary minus and plus.
- They can be applied to any integers, floating-point number or characters. •

Java supports 5 arithmetic operators. They are +, -, *, /, %.

- The modulo (%) operator can only be applied to integer operands as well as double operands.

The following table lists the arithmetic operators:

Operator	Result
+	Addition (also unary plus)
-	Subtraction (also unary minus)
*	Multiplication
/	Quotient division
%	Modulo Division
++	Increment
--	Decrement
+=	Addition assignment
-=	Subtraction assignment
*=	Multiplication assignment
/=	Division assignment
%=	Modulus assignment

Example program to perform all the arithmetic operations (Arith.java)

```
import java.io.*;
class Arith
{
	public static void main(String args[])
	{
		int a,b;
		a=5;
		b=6;
		int c=a+b;		//arithmetic addition
		int d=a-b;		//aritmetic subtraction
		int e=a/b;		//arithmetic division
		int f=a*b;		//arithmetic multiplication
		System.out.println("The Sum is :"+c);
		System.out.println("The Subtraction is :"+d);
		System.out.println("The Division is :"+e);
		System.out.println("The Multiplication is :"+f);
	}
}
```

Output

```
The Sum is : -1
The Subtraction is : -1
The Division is : 0
The Multiplication is : 30
```

The Modulus Operator (%)

The modulus operator returns the remainder of a division operation. It can be applied to integer types as well as floating-point types. The following program demonstrates the % operator.

```
// Demonstrate the % operator.
(Modulus.java) class Modulus
{
        public static void main(String args[])
        {
                int x = 42;
                double y = 6.25;
                System.out.println("x mod 10 = " + x % 10);
                System.out.println("y mod 2.5 = " + y % 2.5);
        }
}
```

Output

x mod 10 = 2
y mod 2.5 = 1.25

Arithmetic Compound Assignment Operators

Java provides special operators that can be used to combine an arithmetic operation with an assignment. As you probably know, statements like the following are quite common in programming:

a = a + 4;

In Java, you can rewrite this statement as shown here: a += 4;

This version uses the += compound assignment operator. Both statements perform the same action: they increase the value of a by 4.

Here is another example, a = a % 2; which can be expressed as a %= 2;

Increment and Decrement Operators

- The ++ and the – – are Java's increment and decrement operators.
- The increment operator is unary operator that increases value of its operand by 1. Similarly, the decrement operator decreases value of its operand by 1.
- These operators are unique in that they work only on variables not on constants.
- These are used in loops like while, do-while and for statements.

There are *two* ways to use increment or decrement operators in expressions. If you put the operator in front of the operand *(prefix)*, it returns the new value of the operand (incremented or decremented). If you put the operator after the operand *(postfix)*, it returns the original value of the operand (before the increment or decrement)

For example, this statement:

x = x + 1;

can be rewritten like this by use of the increment operator: x++;

Operator	Name	Value returned	Effect on variable
x++	Post-increment	x	Incremented
++x	Pre-increment	x+1	Incremented
x--	Post-decrement	x	Decremented
--x	Pre-decrement	x+1	Decremented

The following program demonstrates the increment and decrement operator. (IncDec.java)

```
class IncDec
{
        public static void main(String args[])
        {
                int x=5;
                System.out.println("x="+(x++));       // post increment
                System.out.println("x="+(++x));       // pre increment
                System.out.println("x="+(x--));       // post decrement
                System.out.println("x="+(--x));       // pre decrement
        }
}
```

Output

```
x  = 5
x  = 7
x  = 7
x  = 5
```

The Bitwise Operators

Java defines several *bitwise operators* that can be applied to the integer types, *long, int, short, char, and byte*. These operators act upon the individual bits of their operands. They are summarized in the following table:

Operator	Result
~	Bitwise unary NOT (Complement)
&	Bitwise AND
|	Bitwise OR
^	Bitwise exclusive OR
>>	Shift right
>>>	Shift right zero fill
<<	Shift left
&=	Bitwise AND assignment
|=	Bitwise OR assignment
^=	Bitwise exclsive OR assignment
>>=	Shift right assigment
>>>=	Shift right zero fill assigment
<<=	Shift left assigment

These operators are again classified into two categories: Logical operators, and Shift operators.

The Bitwise Logical Operators

The bitwise logical operators are &, |, ^, and ~. The following table shows the outcome of each operation. The bitwise operators are applied to each individual bit within each operand.

A	B	A | B	A & B	A ^ B	~A
0	0	0	0	0	1
1	0	1	0	1	0
0	1	1	0	1	1
1	1	1	1	0	0

The Bitwise NOT (~)

One's complement operator (Bitwise NOT) is used to convert each 1 to 0 and 0 to 1, in the given binary pattern. It is a unary operator i.e. it takes only one operand. For example, the number 56, which has the following bit pattern:

```
  ~ 00111000  → 56
  ------------  →
    11000111    -57
```

The Bitwise AND (&)

The Bitwise AND operator produces a 1 bit if both operands are also 1. A zero is produced in all other cases. Here is an example:

```
    00111000  → 56
  & 00010100  → 20
  ------------  →
    00010000    16
```

The Bitwise OR(|)

The Bitwise OR operator combines bits such that if either of the bits in the operands is a 1, then the resultant bit is a 1, as shown here:

```
    00111000  → 56
  | 00010100  → 20
  ------------  →
    00111100    60
```

The Bitwise XOR (^)

The bitwise XOR operator combines bits such that if both operands are different then the result is 1. Otherwise, the result is zero. The following example shows the effect of the ^.

```
    00111000  → 56
  ^ 00010100  → 20
  ------------  →
    00101100    44
```

The following program demonstrates the bitwise logical operators:

Example: (BitwiseOp.java)

```
class BitwiseOp
{
        public static void main(String args[])
        {
                int x = 56,y=20,z;
                int a = x&y;
                int b = x|y;
                int c = x^y;
```

```
                int d = ~x;
                System.out.println("x = " +Integer.toBinaryString(x));
                System.out.println("y = "+Integer.toBinaryString(y));
                System.out.println("x&y = "+Integer.toBinaryString(a));
                System.out.println("x|y = "+Integer.toBinaryString(b));
                System.out.println("x^y = "+Integer.toBinaryString(c));
                System.out.println("~x = "+Integer.toBinaryString(d));
        }
}
```

Output

x = 00111000
y = 00010100
x&y = 00010000
x|y = 00111100
x^y = 00101100
~x = 11000111

Bitwise Shift Operators

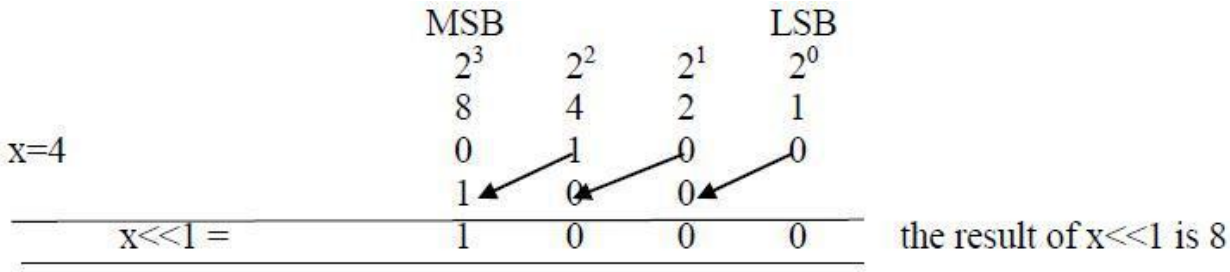
Java supports three bitwise shift operators. They are shift-left (<<) and shift-right (>>) and unsigned shift-right(>>>). These operations are simple and are responsible for shifting bits either to left or to the right. The syntax for shift operation can be given as:

operand operator num

where the bits in *operand* are shifted left or right depending on the *operator* (<<, >>) by the number of places denoted by *num*.

The Left Shift (<<)

When we apply left-shift, every bit in *x* is shifted to left by one place. So, the MSB (Most Significant Bit) of *x* is lost, the LSB (Least Significant Bit) of *x* is set to 0.
Let us consider int x=4;



Left-shift is equals to multiplication by 2.

The Right Shift(>>)

When we apply right-shift, every bit in *x* is shifted to right by one place. So, the LSB (Least Significant Bit) of *x* is lost, the MSB (Most Significant Bit) of x is set to previous value. This preserves the sign of the value.

Let us consider int x=4; Now shifting the bits towards right for 1 time, will give the following result.

	2^3	2^2	2^1	2^0	
	8	4	2	1	
x=4	0	1	0	0	
		0	1	0	
x>>1 =	0	0	1	0	the result of x>>1 is 2

Right-shift is equals to division by 2.

The following program demonstrates the bitwise logical operators:

Example: (ShiftOp.java)

```
class ShiftOp
{
        public static void main(String args[])
        {
                int x = 4;
                System.out.println("x<<1 = " +x);
                System.out.println("x<<1 = " +(x<<1));
                System.out.println("x>>1 = "+(x>>1));
                x=-4;
                System.out.println("x>>>1 = "+(x>>>1));
        }
}
```

Output

```
x = 4
x<<1 = 8
x>>1 = 2
x>>>1 = 2147483646
```

Relational Operators

A relational operator, also known as a comparison operator, is an operator that compares two operands. The operands can be variables, constants or expressions. Relational operators always return either true or false depending on whether the conditional relationship between the two operands holds or not.

The outcome of these operators is a *Boolean* value. The relational operators are most frequently used in the expressions to control *if* and *loop* statements.

Java has six relational operators. The following table shows these operators along with their meanings

Operator	**Meaning**	**Example**
<	Less than	4<5 return *true*
>	Greater than	4>5 return *false*
<=	Less than or equal to	100<=100 return *true*
>=	Greater than or equal to	50>=100 return *false*
= =+	Equal to	4==5 return *false*
!=	Not equal to	4!=5 return *true*

The following program demonstrates the Relational operators:

Example: (RelOp.java)

```
class RelOp
{
        public static void main(String args[])
        {
                int x = 4,y=5;
                System.out.println(x + "<" + y +" = " + (x<y));
                System.out.println(x + ">" + y +" = " + (x>y));
                System.out.println(x + "<=" + y +" = " + (x<=y));
                System.out.println(x + ">=" + y +" = " + (x>=y));
                System.out.println(x + "==" + y +" = " + (x==y));
                System.out.println(x + "!=" + y +" = " + (x!=y));
        }
}
```

Output

```
4<5 = true
4>5 = false
4<=5 = true
4>=5 = false
4==5 = false
4!=5 = true
```

Logical Operators (|| and &&)

Operators which are used to combine two or more relational expressions are known as logical operators. Java supports three logical operators – logical AND(&&), logical OR(||), logical NOT(!). These are also known as *short-circuit* logical operators.

- Logical && and logical || are binary operators whereas logical ! is an unary operator.
- All of these operators when applied to expressions yield either true or false.
- When we use || operator if left hand side expression is true, then the result will be true, no matter what is the result of right hand side expression.
- In the case of && if the left hand side expression results false, then the result will be false, no matter what is the result of right hand side expression.

Example 1: (expr1 || expr2) Example2: (expr1 && expr2)

Miscellaneous Operators

The Assignment Operator

The assignment operator is the single equal sign, =. The assignment operator works in Java much as it does in any other computer language. It has this general form:

```
var = expression;
```

Here, the type of *var* must be *compatible* with the type of *expression*. The assignment operator allows you to create a chain of assignments. For example, consider this fragment:

```
int x, y, z;
x = y = z = 52; // set x, y, and z to 52
```

The ? Operator

Java includes a special ternary (three-way) operator that can replace certain types of if-then-else statements. The ? has this general form:

```
var = expr1 ? expr2 : expr3
```

Here, *expr1* can be any expression that evaluates to a *boolean* value. If *expr1* is true, then *expr2* is evaluated; otherwise, *expr3* is evaluated and its value is assigned to *var*.

The following program demonstrates the Relational operators: **(Ternary.java)**

```
class Ternary
{
	public static void main(String args[])
	{
		int x=4,y=6;
		int res= (x>y)?x:y;
		System.out.println("The result is :"+res);
	}
}
```

Output

The result is : 6

1.13 Expressions

In Java programming, an expression is any legal combination of operators and operands that evaluated to produce a value. Every expression consists of at least one operand and can have one or more operators. Operands are either variables or values, whereas operators are symbols that represent particular actions.

In the expression x + 5; x and 5 are operands, and + is an operator.

In Java programming, there are mainly two types of expressions are available. They are as follows:

1. Simple expression
2. Complex expression

Simple expression: It contains one operator and two operands or constants.

Example: x+y; 3+5; a*b; x-y etc.

Complex expression: It contains two or more operators and operands or constants.

Example: x+y-z; a+b-c*d; 2+5-3*4; x=6-4+5*2 etc.

Operators provided mainly two types of properties. They are as follows:

1. Precedence
2. Associativity

Operator Precedence

It defines the order in which operators in an expression are evaluated depends on their relative precedence. Example: Let us see x=2+2*2

1st pass -- 2+**2*2**
2nd pass -- **2+4**
3rd pass -- 6 that is x=6.

Associativity defines the order in which operators with the same order of precedence are evaluated. Let us see x=2 / 2 * 2

1st pass -- **2 / 2** * 2
2nd pass -- **1*2**
3rd pass -- 2 that is x=2

Below Table shows the order of precedence for Java operators, from highest to lowest. Operators in the same row are equal in precedence. In binary operations, the order of evaluation is *left to right* (except for *assignment*, which evaluates *right to left*). The [ ], ( ), and **.** would have the highest precedence.

Highest(↓)							**Associativity**
++(postfix)	**--(postfix)**						**L to R**
++(prefix)	**--(prefix)**	**~**	**!**	**+ (unary)**	**(-) unary**	**(type cast)**	**L to R**
*****	/	**%**					**L to R**
+	**-**						**L to R**
>>	**>>>**	**<<**					**L to R**
>	**>=**	**<**	**<=**	**instanceof**			**L to R**
==	**!=**						**L to R**
&							**L to R**
^							**L to R**
|							**L to R**
&&							**L to R**
||							**L to R**
?:							**L to R**
=	**op=**						**R to L**
Lowest							**L to R**

Using Parentheses

Parentheses raise the precedence of the operations that are inside them. This is often necessary to obtain the result you desire. For example, consider the following expression:

a >> b + 3

This expression first adds 3 to b and then shifts a right by that result. That is, this expression can be rewritten using redundant parentheses like this:

a >> (b + 3)

However, if you want to first shift a right by b positions and then add 3 to that result, you will need to parenthesize the expression like this:

(a >> b) + 3

In addition to altering the normal precedence of an operator, parentheses can sometimes be used to help clarify the meaning of an expression.

1.14 Type Conversion and casting

Type casting is a way to convert a variable from one data type to another data type. It can be of two types: They are

1. Implicit Conversion
2. Explicit Conversion.

Implicit Conversion

When the type conversion is performed automatically by the compiler without programmer's intervention, such type of conversion is known as *implicit type* conversion or *automatic type promotion*. In this, all the lower data types are converted to its next higher data type.

In the case of Java, An automatic type conversion will take place if the following two conditions are met:

- The two types are compatible.
- The destination type is larger than the source type.

When these two conditions are met, a widening conversion takes place. For example, the *int* type is always large enough to hold all valid *byte* values,

For widening conversions, the numeric types, including integer and floating-point types, are compatible with each other. However, there are no automatic conversions from the numeric types to char or boolean. Also, char and boolean are not compatible with each other.

The Type Promotion Rules

Java defines several type promotion rules that apply to expressions. They are as follows:

- First, all byte, short, and char values are promoted to int, as just described.
- Then, if one operand is a long, the whole expression is promoted to long.
- If one operand is a float, the entire expression is promoted to float.
- If any of the operands is double, the result is double.

Example (TypePromo.java)

```
class TypePromo
{
        public static void main(String args[])
        {
                int num=10;
                float sum,f =10;
                char ch='A';
                sum=num+ch+f;
                System.out.println("The value of sum = "+sum);
        }
}
```

Output

```
The value of sum = 85.0
```

Explicit Conversion (Type casting)

It is intentionally performed by the programmer for his requirement in a Java program. The explicit type conversion is also known as *type casting*. This kind of conversion is sometimes called a *narrowing conversion*, since you are explicitly making the value narrower so that it will fit into the target type.

To create a conversion between two incompatible types, you must use a cast. A cast is simply an explicit type conversion. It has this general form:

```
(target - type ) value;
```

Here the target type specifies the destination type to which the value has to be converted. Example

```
int a=1234;
byte b=(byte) a;
```

The above code converts the *int* to *byte*. If the integer's value is larger than the range of a byte, it will be reduced modulo (the remainder of an integer division by the) byte's range.

A different type of conversion will occur when a floating-point value is assigned to an integer type: *truncation*. When a floating-point value is assigned to an integer type, the fractional component is lost. For example, if the value 1.23 is assigned to an integer, the resulting value will simply be 1.The 0.23 will have been truncated.

1.15 Flow of Control (Control Statements)

Control statements are used to control the flow of execution to advance and branch based on changes to the state of a program. Java control statements can be put into the three categories:

1. Selection
2. Iteration
3. Jump

Iteration statements enable program execution to repeat one or more statements (that is, iteration statements form loops). Jump statements allow your program to execute in a nonlinear fashion

1.15.1 Selection statements

They allow your program to choose different paths of execution based upon the outcome of an
expression or the state of a variable. They are also called as *Conditional or Decision Making Statements.* These include *if* and *switch*.

if..else statement

This is the Java's conditional branch statement. This is used to route the execution through two different paths. The general form of *if* statement will be as follow:

```
if (conditional expression) {
        statement1;
 }
else {
        statement2;
}
```

Here the statements inside the block can be *single* statement or *composite* statements. The *conditional* expression is any expression that returns the *Boolean* value. The *else* clause is optional. The *if* works as follows: if the conditional expression is true, then *statement1* will be executed. Otherwise *statement2* will be executed. Example:

Write a java program to find whether the given number is even or odd? (**EvenOdd.java**)

```
import java.io.*;
class EvenOdd {
        public static void main(String args[]) throws IOException {
                DataInputStream dis =new DataInputStream(System.in);
                System.out.print("Enter the value of n:");
                int n=Integer.parseInt(dis.readLine());
                if(n%2==0)
                        System.out.println(n+" is Even Number");
                else
                        System.out.println(n+"is ODD Number");
        }
}
```

Output

Enter the value of n: 5
5 is ODD Number

Nested if

The nested if statement is *if* statement, that contains another if and else inside it. When we nest *if*s, the else always associated with the nearest if. The general form of the nested if will be as follow:

```
if(conditional expr1) {
        if(conditional expr2) {
                statement1;
        }
else {          statement2;     }
        }
}
else { statement3; }
```

Example

Write a java Program to test whether a given number is positive or negative. **(Positive.java)**

```
import java.io.*;
class Positive
{
        public static void main(String args[]) throws IOException
        {
                DataInputStream dis=new DataInputStream(System.in);
                System.out.print("Enter a number to test:"); int
                n=Integer.parseInt(dis.readLine());
                if(n>-1) {
                        if(n>0)
                                System.out.println(n+ " is Positive");
```

```
                }
                else
                        System.out.println(n+ " is Negative");
        }
}
```

Output

Enter a number to test: -1
-1 is Negative

The if-else-if Ladder

A common programming construct that is based upon a sequence of nested ifs is the if-else-if ladder. It looks like this:

```
if(condition1)
        statement1;
else if(condition2)
        statement2;
                .
                .
else if(conditionN)
        statementN;
else
        statement;
```

The *if* statements are executed in a sequential manner. As soon as one of the *condition* is true, the statement associated with that *if* is executed, and the rest of the ladder is bypassed. If none of the *conditions* is true, then the *final else* statement will be executed.

Example Program:

Write a Java Program to test whether a given character is Vowel or Consonant? **(Vowel.java)**

```
import java.io.*;
class Vowel {
        public static void main(String args[]) throws IOException
        {
                System.out.print("Enter character to test:");
                char ch=(char)System.in.read();
                if(ch=='a')
                        System.out.println("Vowel");
                else if(ch=='e')
                        System.out.println("Vowel");
                else if(ch=='i')
                        System.out.println("Vowel");
                else if(ch=='o')
                        System.out.println("Vowel");
                else if(ch=='u')
```

```
                System.out.println("Vowel");
            else
                System.out.println("Consonant");
        }
}
```

Output

```
Enter character to test:a
Vowel
Enter character to test:r
Consonant
```

The Switch statement

The switch statement is Java's multi-way branch statement. It provides an easy way to dispatch execution to different parts of your code based on the value of an expression. As such, it often provides a better alternative than a large series of if-else-if statements. Here is the general form of a switch statement:

```
switch(expr)
{

    case value1:
        // statement sequence
        break;
    case value2:
        // statement sequence
        break;
    case valueN:
        // statement sequence
        break;
    default:
        // default statement sequence
}
```

- The expression must be of type *byte, short, int, char or string;*
- Each of the values specified in the case statements must be of a type compatible with the expression.
- Each case value must be a unique literal (that is, it must be a constant, not a variable).
- Duplicate case values are not allowed.

The switch statement works like this: The value of the *expression* is compared with each of the literal values in the case statements. If a match is found, the code sequence following that case statement is executed. If none of the constants matches the value of the expression, then the *default* statement is executed. However, the default statement is optional. If no case matches and no default is present, then no further action is taken.

The break statement is used inside the switch to terminate a statement sequence. When a break statement is encountered, execution branches to the first line of code that follows the entire switch statement. This has the effect of ―*jumping out* of the switch.

Write a Java Program to test whether a given character is Vowel or Consonant using switch?

```
import java.io.*;
class SwitchTest
{
	public static void main(String args[]) throws IOException
	{
		System.out.print("Enter achatacter to test:");
		char ch=(char)System.in.read();
		switch(ch)
		{
			//test for small letters
			case 'a':
				System.out.println("vowel");
				break;
			case 'e':
				System.out.println("vowel");
				break;
			case 'i':
				System.out.println("vowel");
				break;
			case 'o':
				System.out.println("vowel");
				break;
			case 'u':
				System.out.println("vowel");
				break;
			default:
				System.out.println("Consonant");
		}
	}
}
```

Output

```
Enter character to test: i
Vowel
Enter character to test: x
Consonant
```

There are three important features of the switch statement to note:

- The *switch* differs from the *if* in that switch can only test for equality, whereas if can evaluate any type of Boolean expression.
- No two case constants in the same switch can have identical values.

- A switch statement is usually more efficient than a set of nested ifs.

1.15. 2 Loops (Iteration Statements)

Java's iteration statements are *for*, *while*, and *do-while*. These statements create what we commonly call loops. A loop repeatedly executes the same set of instructions until a termination condition is met.

Advantages

- Reduce length of Code
- Take less memory space.
- Burden on the developer is reducing.
- Time consuming process to execute the program is reduced.

while

The *while* loop is a *pre-test* or *entry-controlled* loop. It uses *conditional expression* to control the loop. The while loop evaluates (checking) the test expression before every iteration of the loop, so it can execute *zero* times if the condition is initially false. The initialization of a loop control variable is generally done before the loop separately.

```
while (test expression)
{
        // body of loop
        inc/dec statement
}
```

How while loop works?

- Initially the while loop evaluates (checking condition) the test expression.
- If the test expression is true , statements inside the body of while loop is evaluated. Then, again the test expression is evaluated. The process goes on until the test expression is false.
- When the test expression is false, the while loop is terminated.

Example : Program to print 1 to 10 numbers using while loop.

```
class Test {
        public static void main(String[] args)
        {
                int n=1;
                while(n<=10)
                {
                        System.out.print(n+"    ");
                        n++;
                }
          }
}
```

Output:

1 2 3 4 5 6 7 8 9 10

do - while statement

do-while loop is similar to *while* loop, however there is one basic difference between them. *do-while* runs at least once even if the test condition is false at first time. Syntax of do while loop is:

```
do
{
    // body of loop
    inc/dec statement
} while (test expression);
```

How do-while loop works?

- First the code block (loop body) inside the braces ({….}) is executed once.
- Then, the test expression is evaluated (checking condition). If the test expression is true, the loop body is executed again. This process goes on until the test expression is evaluated to false (0).
- When the test expression is false, the **do...while** loop is terminated.

Example

Write a java program to add all the number from 1 to 10. (using do-while)

```
class Test
{
        public static void main(String[] args)
        {
                int n=1;
                do
                {
                        System.out.print(n+" ");
                        n++;
                 } while (n<=10);
        }
}
```

Output:

1 2 3 4 5 6 7 8 9 10

Comparison between do and while loops

S.No	While loop	Do-while loop
1	Condition is checked before entering into loop	Condition is checked after executing statements in loop
2	Top-tested /entry-controlled loop	Bottom-tested /exit-controlled loop
3	Minimum iterations are zero	Minimum iterations are one
4	Maximum iterations are N+1	Maximum iterations are N
5	General loop statement	General loop statement but well suited for menu-driven applications
6	Non-deterministic loop	Non-deterministic loop

for statement

It is the most general looping construct in Java. The *for loop* is commonly used when the number of iterations are exactly known. The syntax of a *for* loop is:

```
for ( initialization; condition; iteration)
{
                        // body of loop
}
```

- an initialization,
- a test condition, and
- incrementation(++) / decrementation(- -) /update.

Initialization: This part is executed only once when we are entering into the loop first time. This part allows us to declare and initialize any loop control variables.

Condition: if it is true, the body of the loop is executed otherwise program control goes outside the for loop.

Iteration: After completion of initialization and condition steps loop body code is executed and then increment or decrements steps is execute. This statement allows to us to update any loop control variables.

How for loop works?

- First the loop initialization statement is executed.
- Then, the test expression is evaluated. If the test expression is false, for loop is terminated. But if the test expression is true, codes inside the body of for loop is executed and the update expression is executed. This process repeats until the test expression becomes false.

Note: In for loop everything is optional but mandatory to place two semicolons (; ;)

Example program: same program using the for loop

```
class Test
{
	public static void main(String[] args)
	{
		for(int i=1;i<=10;i++)
		{
			System.out.print(i+" ");
		}
	}
}
```

Output:

```
1	2	3	4	5	6	7	8	9	10
```

For each version of the for loop:

A for loop also provides another version, which is called Enhanced Version of for loop. The general form of the for loop will be as follow:

```
for ( type itr_var : collection)
{
    // body of loop
}
```

Here, *type* is the type of the iterative variable of that receives the elements from collection, one at a time, from beginning to the end. The collection is created using the array.

Example: Write a java program to print all the elements in an array?

```
class Test
{
        public static void main(String[] args)
        {
                int a[ ] = {12,13,14,15,16};
                for(int x:a)
                {
                        System.out.print(x+" ");
                }
        }
}
```

Output

12 13 14 15 16

1.15.3 The Jump/Branching Statements

Java supports three jump statements: break, continue, and return. These statements transfer control to another part of your program.

break statement

In Java, the break statement has three uses.

1. It terminates a statement sequence in a switch statement.
2. It can be used to exit a loop.
3. It can be used as *civilized form of goto* statement.

Using break to Exit a Loop

In Java, when *break* statement is encountered inside a loop, the loop is immediately terminated, and program control is transferred to nest statement following the loop. The *break* statement is widely used with *for loop, while loop, do-while loop* and *switch* statement. Its syntax is quite simple, just type keyword break followed with a semicolon.

```
break;
```

The following example illustrates the use of break;

```
class Test  {
        public static void main(String[] args)     {
                int i=1;
                while( i <= 5)
                {
                     if (i==3)
                         break;
```

```
                    System.out.print(" "+i);
                    i = i + 1;
                }
}       }
```

Output

```
    1       2
```

Using break as a Form of Goto

For example, the *goto* can be useful when you are exiting from a deeply nested set of loops. To handle such situations, Java defines an expanded form of the break statement. By using this form of break, you can, for example, break out of one or more blocks of code. The general form of the labeled break statement is shown here:

```
break label;
```

Most often, *label* is the name of a label that identifies a block of code. This can be a stand-alone block of code but it can also be a block that is the target of another statement. When this form of break executes, control is transferred out of the named block. The labeled block must enclose the break statement, but it does not need to be the immediately enclosing block.

To name a block, put a label at the start of it. A *label* is any valid java identifier followed by a colon. Once you have labeled a block, you can then use this label as the target of a break statement.

Example code:

```
class Break {
        public static void main(String args[])  {
                boolean t = true;
                first: {
                        second: {
                                third: {
                                        System.out.println("Before the break.");
                                        if (t)
                                                break second;           // break out of second
                                        block
                                                System.out.println("This won't execute");
                                }
                                System.out.println("This won't execute");
                        }
                        System.out.println("This is after second block.");
                }
        }
}
```

Running this program generates the following output:

Before the break.

This is after second block.

continue statement

In Java, when *continue* statement is encountered inside a loop, it stops the current iteration and places the loop in next iteration. In *while* and *do-while* loops, a *continue* statement causes control to be transferred directly to the conditional expression that controls the loop. In a *for* loop, control goes first to the *iteration* portion of the for statement and then to the *conditional expression*. For all three loops, any intermediate code is bypassed. Its syntax is quite simple, just type keyword *continue* followed with a semicolon.

```
continue;
```

```
class Test {
        public static void main(String[] args) {
                int i=1;
                while( i <= 5)
                {
                i = i + 1;
                        if (i==3)
                           continue;
                        System.out.print(" "+i);
                  }
          }
}
```

Output

2 4 5 6

return statement

The last control statement is *return*. The return statement is used to explicitly return from a method. That is, it causes program control to transfer back to the caller of the method. As such, it is categorized as a jump statement.

```
return expr/value;
```

Example:

```
class Test {
        public static void main(String[] args) {                    //Caller Method
                        int a=3,b=4;
                int x= add(a,b);          //function call
                System.out.println("The sum is "+x);
        }
        static int add(int x,int y)                  // called method
        {
                return (x+y);
        }
}
```

Output

The sum is 7

After computing the result the control is transferred to the caller method, that main in this case.