History of Java

- Java was initially developed in 1991 named as “oak” but was renamed “Java” in 1995.
- Originally designed for small, embedded systems in electronic appliances like set-top boxes.
- The primary motivation was the need for a platform-independent language that could be used to create software to be embedded in various consumer electronic devices.
- Java programming language was originally developed by **Sun Microsystems** which was initiated by **James Gosling** and released in 1995 as core component of Sun Microsystems' Java platform (Java 1.0 [J2SE]).
- It promised **Write Once, Run Anywhere** (WORA), providing no-cost run-times on popular platforms.
- Java 2, new versions had multiple configurations built for different types of platforms. J2EE included technologies and APIs for enterprise applications typically run in server environments, while J2ME featured APIs optimized for mobile applications.
- The desktop version was renamed J2SE. In **2006**, for marketing purposes, Sun renamed new J2 versions as Java EE, Java ME, and Java SE, respectively.
- On 13 November **2006**, Sun released much of Java as **free and open-source software** (FOSS), under the terms of the GNU **General Public License** (GPL).
- On 8 May **2007**, Sun finished the process, making all of Java's core code free and open-source, aside from a small portion of code to which Sun did not hold the copyright.

Write and explain Features of JAVA. OR Explain advantages of JAVA.

- Java promised “Write Once, Run Anywhere”, providing no-cost run-time on popular platform. Fairly secure and featuring configurable security, it allowed network and file access restriction.

1) Simple

- ✓ It’s simple because it contains many features of other languages like C and C++ and java **removes complexities** because it doesn’t use **pointers, Storage classes and Go To statement** and it also does not support **multiple Inheritance**.

2) Secure

- ✓ When we transfer the code from one machine to another machine, it will first check the code it is affected by the virus or not, it checks the safety of the code, if it contains virus then it will never execute that code.

3) Object-Oriented

- ✓ We know that all pure object oriented language, in them all of the code is in the form of classes and objects.
- ✓ This feature of java is most important and it also supports code reusability and maintainability etc.

4) Robust

- ✓ Two main reasons for program failures are:
  1. **Memory management mistake**

2. Mishandled exception or Run time errors

- ✓ Java does not support direct pointer manipulation. This resolves the java program to overwrite memory.
- ✓ Java manages the memory allocation and de-allocation itself. De-allocation is completely automatic, because Java provides garbage collection for unused objects.
- ✓ Java provides object-oriented exception handling. In a well written Java program all run-time errors can be managed by the program.

5) Multithreaded

- ✓ A thread is like a separate program executing concurrently.
- ✓ We can write java programs that deal with many tasks at once by defining multiple threads.
- ✓ The main advantage of multithreading is that it shares the same memory.
- ✓ Threads are important for multi-media, web application etc.

6) Distributed

- ✓ Java is designed for the distributed environment of the Internet, because it **handles TCP / IP** protocols.
- ✓ The widely used protocol like HTTP and FTP are developed in Java.
- ✓ Internet programmers can call functions on these protocols and can get access the files from any remote machine on the internet rather than writing code on their local system.

7) Architecture-Neutral

- ✓ It means that the programs written in one platform can run on any other platform without rewrite or recompile them. In other words it follows "**write once, run anywhere, any time, forever**" approach.
- ✓ Java program are compiled into bytecode format which does not depend on any machine architecture but can be easily translated into a specific machine by a **JVM** for that machine.
- ✓ This will be very helpful when applets or applications are developed which are download by any machine & run anywhere in any system.

8) Platform Independent

- ✓ It means when we compile a program in java, it will create a byte code of that program and that byte code will be executed when we run the program.
- ✓ It's not compulsory in java, that in which operating system we create java program, in the same operating system we have to execute the program.

9) Interpreted

- ✓ Most of the programming languages either compiled or interpreted, java is both compiled and interpreted.
- ✓ Java **compiler** translates a **java source file to byte code** and the java **interpreter** executes the **translated byte codes** directly on the system that implements the JVM.

10) High Performance

- ✓ Java programs are complied in to intermediate representation called **bytecode**, rather than to native machine level instructions and JVM executes Java bytecode on any machine on which JVM is installed.
- ✓ Java bytecode then translate directly into native machine code for very high performance by using a Just-In-Time compiler.
- ✓ So, Java programs are faster than program or scripts written in purely interpreted languages but slower than C and C++ programs that compiled to native machine languages.

11) Dynamic

- ✓ At the run time, java environment can extend itself by linking in classes that may be located on remote server on a network.
- ✓ At the run time, java interpreter performs name resolution while linking in the necessary classes.
- ✓ The java interpreter is responsible for determining the placement of object in the memory.

JDK (Java Development Kit)

- Java Developer Kit contains tools needed to develop the Java programs, and JRE to run the programs.
- The tools include compiler (javac.exe), Java application launcher (java.exe), Appletviewer, etc… Compiler converts java code into byte code.
- **Java application launcher** opens a **JRE**, loads the class, and invokes its main method.
- For running java programs, JRE is sufficient. JRE is targeted for execution of Java files i.e. **JRE = JVM + Java Packages Classes(like util, math, lang, awt,swing etc)+runtime libraries**.

JRE (Java Runtime Environment)

- Java Runtime Environment contains **JVM, class libraries, and other supporting files**.
- It does not contain any development tools such as compiler, debugger, etc.
- Actually, **JVM** runs the program, and it uses the class libraries, and other supporting files provided in JRE.

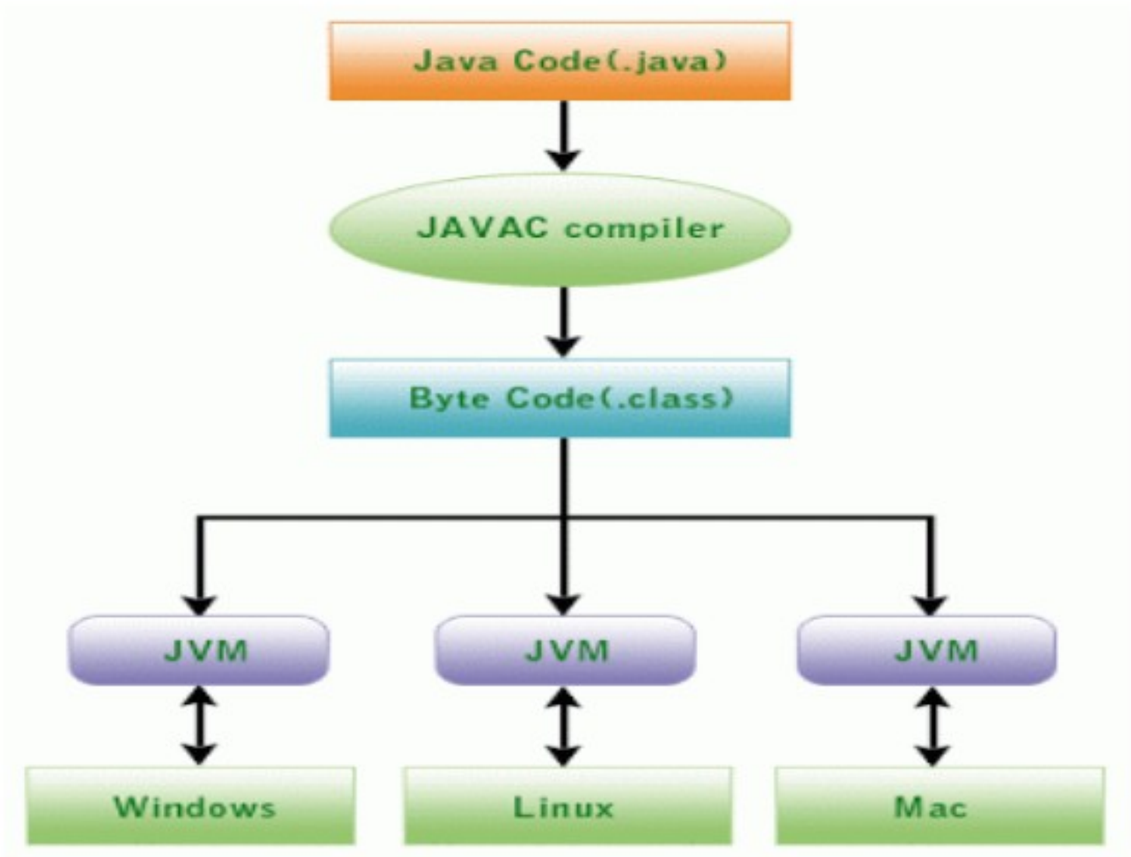
JVM (Java Virtual Machine)

- The JVM is called **virtual** because it provides a machine interface that does not depend on the operating system and machine hardware architecture.
- This independence from hardware and operating system is a cornerstone of the **write-once, run-anywhere** java programs.
- When we compile a Java file, output is not an **'.exe'** but it is a **'.class'** file.
- '.**class'** file consists of Java byte codes which are understandable by **JVM**.
- Java Virtual Machine **interprets** the byte code into the machine code depending upon the operating system and hardware combination.
- It is responsible for all the things like garbage collection, array bounds checking, etc…
- **JVM** itself is platform **dependent**.

- As of 2014 most JVMs use **JIT** (**Just in Time**) compiling, not interpreting, to achieve greater speed.

BYTE CODE

- **Bytecode** is nothing but the intermediate representation of Java source code which is produced by the Java compiler by compiling that source code.
- This byte code is a machine independent code. It is not completely a compiled code but it is an intermediate code somewhere in the middle which is **later interpreted and executed** by **JVM**.
- Bytecode is a machine code for JVM. But the machine code is platform specific whereas bytecode is platform independent that is the main difference between them.
- It is stored in .**class** file which is created after compiling the source code.



JAVA Environment Setup

- Setting up the path for windows: Assuming you have installed Java in **c:\Program Files\java\jdk** directory
- Right-click on **'My Computer'** and select **'Properties'**.
- Click on the **'Environment variables'** button under the **'Advanced'** tab.
- Now, Under **'System variables'** alter the **'Path'** variable so that it also contains the path to the Java executable.
- **Example**, if the path is currently set to 'C:\WINDOWS\SYSTEM32', then change your path to read 'C:\WINDOWS\SYSTEM32;c:\Program Files\java\jdk\bin'.

Describe the sample structure of JAVA program

- A Java Program may contain many **classes** of which only one class defines a **main** method.
- **Classes** contain **data members** and **methods** that operate on the data members of the class.
- **Methods** may contain data type declarations and executable statements.
- A Java Program may contain one or more sections as shown.

Documentation Section	Suggested
Package Statement	Optional
Import Statements	Optional

Interface Statement	Optional
Class Definitions	Optional

Main Method class
{
Main Method Definition
}
	Essential

Documentation Section

- The documentation section comprises a set of comment lines giving the name of the program, the author and other details, which the programmers would like to refer to at a later stage.
- Java also uses a comment such as /* …. */ know as documentation comment.
- This form is used for documentation automatically.

Package Statement

- The first statement allowed in Java file is a **package** statement.
- This statement declares a package name and informs the compiler that the classes defined here belong to this package.
  Example: Package Student;

Import Statements

- The next thing after a package statement may be a number of import statements. This is similar to the **#include** statement in C.
  Example: Import student.test;

Interface Statement

- An interface is like a **class** but includes a group of method declarations.
- This is also an optional section and is used only when we wish to implement the multiple inheritance features in the program.

Class Definition

- A **Java** Program may contain multiple class definitions.
- **Classes** are primary and essential elements of Java program.
- These classes are used to map the objects of real-world programs.

Main Method Class

- Since, every Java stand-alone program requires a **main** method as its starting point this is the essential part of Java program.
- A simple Java program may contain only this part.
- The main method creates objects of various classes and establishes communication between them.

Procedure-Oriented vs. Object-Oriented Programming

Procedure Oriented Programming (POP)	Object Oriented Programming (OOP)
• Importance is not given to **data** but to functions as well as **sequence** of actions to be done.	• Importance is given to the data rather than procedures or functions.

Procedure Oriented Programming (POP)	Object Oriented Programming (OOP)
• **Top Down** approach in program design.	• **Bottom Up** approach in program design.
• Large programs are divided into smaller programs known as **functions.**	• Large programs are divided into **classes and objects**.
• POP does not have any access specifier.	• OOP has access specifier named **Public, Private, Protected**, etc..
• 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.
• Adding of data and function is difficult.	• Adding of data and function is easy.
• Concepts like inheritance, polymorphism, data encapsulation, abstraction, access specifier are missing.	• Concepts like inheritance, polymorphism, data encapsulation, abstraction, access specifier are available and can be used easily.
• **Examples**: C, Fortran, Pascal, etc…	• **Examples**: C++, Java, C#, etc…

Basic Concepts of OOP

- Various concepts present in OOP to make it more **powerful, secure, reliable and easy**.

Object

- An **object** is an **instance of a class**.
- An **object** means anything from real world like as person, computer etc...
- Every object has at least one unique identity.
- An **object** is a component of a program that knows how to **interact** with other pieces of the program.
- An **object** is the **variable** of the type class.

Class

- A **class** is a template that specifies the attributes and behavior of objects.
- A class is a blueprint or prototype from which objects are created.
- Simply **class** is collection of objects.
- A class is the implementation of an **abstract data type** (ADT). It defines attributes and methods which implement the data structure and operations of the ADT, respectively.

Data Abstraction

- Just represent **essential** features without including the **background** details.
- Implemented in class to provide data security.
- We use **abstract** class and **interface** to achieve abstraction.

Encapsulation

- Wrapping up (Binding) of a data and functions into single unit is known as **encapsulation**.
- The data is not accessible to the outside world, only those functions can access it which is wrapped together within single unit.

Inheritance

- Inheritance is the process, by which class can acquire the properties and methods of another class.
- The mechanism of deriving a **new class** from an **old class** is called inheritance.
- The **new class** is called **derived** class and **old class** is called **base** class.
- The **derived** class may have all the features of the **base** class and the programmer can add new features to the derived class.

Polymorphism

- Polymorphism means the **ability to take more than one form**.
- It allows a single name to be used for more than one related purpose.
- It means ability of operators and functions to act differently in different situations.
- We use method overloading and method overriding to achieve polymorphism.

Message Passing

- A program contains set of object that communicates with each other.
- **Basic steps to communicate**
  1. Creating classes that define objects and their behavior.
  2. Creating objects from class definition
  3. Establishing communication among objects.

Dynamic and Static Binding

Static Binding	Dynamic Binding
• Type of the object is determined at **compiled** time (by the compiler), it is known as static binding.	• Type of the object is determined at **run-time**, it is known as dynamic binding.
• Static binding uses **Type** information for binding.	• Dynamic binding uses **Object** to resolve binding.
• **Static, private, final** methods and variables are resolved using static binding.	• **Virtual** methods are resolves during runtime based upon runtime object.
• **Overloaded** methods are resolve using static binding.	• **Overridden** methods are resolve using dynamic binding at runtime.

Write a Program to print "My First Program In Java" in java.

```
/* Write a Program to print "My First Program In Java" in java.*/
import  java.util.*;
class MyFirstProgram
{
        public static void main(String[] args)
        {
                // This statement will print the message.
                System.out.println("My First Program In Java");
        }
}
```

Primitive Data Types

- Primitive data types can be classified in four groups:

1) Integers :

- This group includes **byte**, **short**, **int**, and **long**.
- All of these are signed, **positive** and **negative** values.

DataType	Size	Example
byte	8-bit	byte b, c;
short	16-bit	short b,c;
int	32-bit	int b,c;
long	64-bit	long b,c;

2) Floating-point :

- This group includes **float** and **double**, which represent numbers with fractional precision.

DataType	Size	Example
float	32 bits	float a,b;
double	64 bits	double pi;

3) Characters :

- This group includes **char**, which represents symbols in a character set, like letters and numbers.
- Java **char** is a 16-bit type. The range of a **char** is 0 to 65,536. There are no negative **char**s.

  For example : char name = 'x';

4) Boolean :

- This group includes **boolean**, which is a special type for representing true/false values.
- It can have only one of two possible values, **true** or **false**.

  For example : boolean b = true;

Example:

```
class datatypeDemo
{
        public static void main(String args[])
        {
                int r=10;
                float pi=3.14f,a;                //You can also use here double data type
                char ch1=97,ch2='A' ;
                boolean x=true;
                a = pi*r*r;
                System.out.println("Areat of Circle is :: "+a);
                System.out.println("Ch1 and Ch2 are :: "+ch1+" "+ch2);
                System.out.println("Value of X is :: "+x);
        }
```

```
}
```

Output:

```
Area of Circle is :: 314.0
Ch1 and Ch2 are :: a A
Value of X is :: true
```

User Defined Data Type

Class

- A **class** is a template that specifies the attributes and behavior of things or objects.
- A **class** is a blueprint or prototype from which creates as many desired objects as required.

Example:

```
class Box
{
        double width=1;
        double height=2;
        double depth=3;
        void volume()
        {
                System.out.print("Volume is ");
                System.out.println(width * height * depth);
        }
}
class demo
{
        public static void main(String args[])
        {
                Box  b1 = new Box();
                b1.volume();
        }
}
```

Interface

- An **interface** is a collection of abstract methods.
- A **class** implements an interface, thereby inheriting the abstract methods of the interface.
- An **interface** is not a class. A class describes the attributes and behaviors of an object. An interface contains behaviors that a class implements.
- Unless the class that implements the interface is abstract, all the methods of the interface need to be defined in the class.

Example:

```
interface  Animal
{
     public void eat();
     public void travel();
}
```

Identifiers and Literals

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 characters and dollar-sign characters.**
- There are some rules to define identifiers as given below:
  1) Identifiers must start with a **letter or underscore** (_).
  2) Identifiers cannot start with a **number**.
  3) **White space(blank, tab, newline)** are not allowed.
  4) You can't use a **Java keyword** as an identifier.
  5) Identifiers in Java are **case-sensitive**; **foo** and **Foo** are two different identifiers.

Examples :

Valid Identifiers	Not Valid Identifiers
AvgNumber	2number
A1	int
$hello	-hello
First_Name	First-Name

Literals (Constants)

- A constant value in a program is denoted by a **literal**. Literals represent numerical (integer or floating-point), character, boolean or string values.

Integer	Floating-point	Character	Boolean	String
33, 0, -19	0.3, 3.14	(' 'R' 'r' '{'	(predefined values) true, false	“language”,”0.2” ,“r”

Variables

- A variable is defined by the combination of an **identifier**, a **type**, and an optional **initializer**.
- All variables have a scope, which is defines their visibility and lifetime.

Declaring of variable

- All variables must be declared before they can be used.

  Syntax:

  type identifier [= value][, identifier [= value] ...];
  - The **type** is one of Java’s **atomic types, or the name of a class or interface**.
  - The **identifier** is the name of the **variable**.
  - You can **initialize** the variable by specifying an **equal sign and a value**.
  - To declare **more than one variable** of the specified type, use a comma separated list.

  Example: int a, b, c = 10;

Dynamic Initialization

- Java allows variables to be initialized dynamically by using any valid expression at the time the **variable is declared**.

  Example:

```
int  a=2, b=3;        // Constants as initializer
int  c = a+b;         // Dynamic initialization
```

Scope of Variables

- Java allows variables to be declared within any **block**.
- A **block** is begun with an opening curly brace and ended by a closing curly brace.
- A block defines a scope. Thus, each time you start a new block, you are creating a new scope.
- A **scope** determines which **objects** are visible to other parts of your program.
- Java defines two general categories of scopes: **global** and **local**.
- Variables declared inside a scope is not **visible** to code that is defined outside that scope.
- Thus, when you declare a variable within a scope, then you can access it within that scope only and protecting it from **unauthorized access**.
- Scopes can be **nested**. So, outer scope encloses the inner scope. This means that objects declared in the **outer** scope will be **visible** to code within the **inner** scope.
- However, the reverse is not true. **Objects** declared within **inner** scope will not be **visible outside** it.

  Example:

```
class  scopeDemo
{
        public static void main(String args[])
        {
                int  x;             // visible to all code within main
                x = 10;
                if(x == 10) // start new scope
                {
                        int  y = 20;      // Visible only to this block
                                // x and y both are visible here.
                        System.out.println("x and y: " + x + " " + y);
                        x = y * 2;
                }
                // y = 100;                     // Error! y not visible here
                // x is still visible here.
                System.out.println("x is " + x);
        }

}
```

Default values of variables declared

- If you are not assigning value, then Java runtime assigns default value to variable and when you try to access the variable you get the default value of that variable.
- Following table shows variables types and their default values:

Data type	Default value
boolean	FALSE
char	\u0000
int,short,byte / long	0 / 0L
float /double	0.0f / 0.0d
any reference type	null

- Here, char primitive default value is \u0000, which means blank/space character.
- When you declare any local/block variable, they didn't get the default values.

Type Conversion and Casting

- It assigns a value of one type variable to a variable of another type. If the two types are **compatible**, then Java will perform the conversion automatically (Implicit conversion).
- **For example**, it is always possible to assign an **int** value to a **long** variable. However, not all types are compatible, and thus, not all type conversions are implicitly allowed.
- There is no automatic conversion defined from **double** to **byte**. Fortunately, it is possible conversion between **incompatible** types. For that you must perform type casting operation, which performs an **explicit conversion** between incompatible types.

Implicit Type Conversion (Widening Conversion)

- When one type of data is assigned to another type of variable, an automatic type conversion will take place if the following two conditions are met:
    1. **Two types are compatible.**
    2. **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, so no explicit cast statement is required.
- **Following table shows compatibility of numeric data type:**

Status	Integer	Floating-Point	Char	Boolean
Compatible	✓	✓		
Incompatible			✓	✓

- Also, **Boolean** and **char** are not compatible with each other.

Explicit Type Conversion (Narrowing Conversion)

- Although the automatic type conversions are helpful, they will not fulfill all needs. **For example**, if we want to assign an **int** value to a **byte** variable then conversion will not be performed automatically, because a **byte** is smaller than an **int**.
- This kind of conversion is sometimes called a **narrowing** conversion.
- For, this type of conversion we need to make the value narrower explicitly. so that, it will fit into the target data type.
- To create a conversion between **two incompatible** types, you must use a **cast**.
- A cast is simply an explicit type conversion.

  Synatax: **(target-type) value**
- Here, **target-type** specifies the desired type to convert the specified value to.
- **For example**, the following casts an **int** to a **byte**.

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

- A different type of conversion will occur when a floating-point value is assigned to an integer type: **truncation**.
- As we know, integers do not have fractional components. Thus, 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.

  Example:

```
class  conversionDemo
{
        public static void main(String args[])
        {
                byte b;
int i = 257;
double d = 323.142;

System.out.println("\nConversion of int to byte.");
b = (byte) i;
System.out.println("i and b " + i + " " + b);

System.out.println("\nConversion of double to int.");
i = (int) d;
System.out.println("d and i " + d + " " + i);

System.out.println("\nConversion of double to byte.");
b = (byte) d;
```

```
                System.out.println("d and b " + d + " " + b);
            }
        }
```

Output:

```
Conversion of int to byte.
i and b 257   1
Conversion of double to int.
d and i 323.142   323
Conversion of double to byte.
d and b 323.142   67
```

- When the value 257 is cast into a **byte** variable, the result is the remainder of the division of 257 by 256 (the range of a **byte**), which is 1 in this case.
- When the **d** is converted to an **int**, its fractional component is lost.
- When **d** is converted to a **byte**, its fractional component is lost, and the value is reduced modulo 256, which in this case is 67.

Wrapper Class

- **Wrapper** class wraps (encloses) around a data type and gives it an **object** appearance.
- Wrapper classes are used to convert any data type into an **object**.
- The primitive data types are not objects and they do not belong to any class.
- So, sometimes it is required to convert data types into objects in java.
- Wrapper classes include methods to unwrap the object and give back the data type.

  Example:

```
int  k = 100;
Integer  it1 = new Integer(k);
```

  - The **int** data type **k** is converted into an object, **it1** using **Integer** class.
  - The **it1** object can be used wherever **k** is required an object.
  - To unwrap (getting back int from Integer object) the object **it1**.

  Example:

```
int  m = it1.intValue();
System.out.println(m*m);       // prints 10000
```

  - **intValue()** is a method of **Integer** class that returns an **int** data type.
- Eight wrapper classes exist in **java.lang** package that represent 8 data types:

Primitive Data Type	Wrapper Class	Unwrap Methods
byte	Byte	byteValue()
short	Short	shortValue()
int	Integer	intValue()
long	Long	longValue()
float	Float	floatValue()
double	Double	doubleValue()

char	Character	charValue()
boolean	Boolean	booleanValue()

- There are mainly two uses with wrapper classes.
  1) To convert **simple data types** into **objects**.
  2) To convert **strings** into **data types** (known as parsing operations), here methods of type **parseX()** are used. (Ex. parseInt())
- The **wrapper classes** also provide methods which can be used to convert a **String** to any of the **primitive data types**, except **character**.
- These methods have the format **parsex()** where **x** refers to any of **the primitive data types** except **char**.
- To convert any of the primitive data type value to **a String**, we use the **valueOf()** methods of the String class.

  Example:

```
int x =  Integer.parseInt("34");          // x=34
double y = Double.parseDouble("34.7");       // y =34.7
String s1= String.valueOf('a');             // s1="a"
String s2=String.valueOf(true);          // s2="true"
```

Comment Syntax

- Comments are the statements which are never execute. (i.e. non-executable statements).
- Comments are often used to add notes between source code. So that it becomes easy to understand & explain the function or operation of the corresponding part of source code.
- Java Compiler doesn't read comments. **Comments are simply ignored during compilation**.
- There are three types of comments available in Java as follows;
  1. Single Line Comment
  2. Multi Line Comment
  3. Documentation Comment

Single Line Comment

- This comment is used whenever we need to write anything in single line.

  Syntax : //<write comment here>

  Example: //This is Single Line Comment.

Multi Line Comment

- These types of comments are used whenever we want to write detailed notes (i.e. more than one line or in multiple lines) related to source code.

  Syntax :

```
/*
   <Write comment here>
*/
```

Example :

```
/*
        This Is
        Multi line comment.
*/
```

Documentation Comment

- The documentation comment is used commonly to produce an HTML file that documents our program.
- This comment begins with /** and end with a */.
- Documentation comments allow us to embed information about our program into the program itself.
- Then, by using the **javadoc** utility program to extract the information and put it into an HTML file.
- In the documentation comment, we can add different notations such as author of the project or program, version, parameters required, information on results in return if any, etc.
- To add these notations, we have '@' operator. We just need to write the required notation along with the '@' operator.
- **Some javadoc tags are given below:**
    - @author – To describe the author of the project.
    - @version – To describe the version of the project.
    - @param – To explain the parameters required to perform respective operation.
    - @return – To explain the return type of the project.

Syntax :

```
/**
*<write comment/description here>
*@author <write author name>
*@version <write version here>
*/
```

Example:

```
/**
* This is Documentation Comment.
* @author Vishal Makwana
* @version 1.0.0
*/
```

Garbage Collection

- Since objects are dynamically allocated by using the **new** operator, you might be wondering how such objects are destroyed and their memory released for later reallocation.
- In some languages, such as C++, dynamically allocated objects must be manually released by use of a **delete** operator.

- Java takes a different approach; it handles **deallocation** for you **automatically**. The technique that accomplishes this is called **garbage collection**.
- When no references to an object exist, that object is assumed to be no longer needed, and the memory occupied by the object can be recovered.
- **Garbage collection** only occurs occasionally during the execution of your program.
- Different Java run-time implementations will take varying approaches to garbage collection.

Array

- An array is a group of like-typed variables that are referred to by a common name.
- A specific element in an array is accessed by its index.
- Array index start at zero.
- Arrays of any type can be created and may have one or more dimensions.

One Dimensional Array

- **Steps To create a one dimensional array:**
  - You must declare a variable of the desired array type.
  - You must allocate the memory that will hold the array, using **new** operator and assign it to the array variable.
- In java, all arrays are dynamically allocated.

  Syntax:

```
data_type  array_var[];
array_var  =  new  data_type[size];
                OR
data_type  array_var []  =  new  data_type[size];
```

  Example:

```
int  a[]  = new  int[10];
```

- Here, **datatype** specifies the type of data being allocated, **size** specifies the number of elements in the array, and **array_var** is the array variable that is linked to the array.
- **new** is a special operator that allocates memory.
- The elements in the array allocated by **new** will automatically be initialized to **zero.**

  Example:

```
class  demo_array
{
        public static void main (String args[])
        {
                int a[] = new int[3];                // int a[] = {1,2,3};
                a[0] = 1;
                a[1] = 2;
                a[2] = 3;
                System.out.println("Your array elements are :: "+ a[0]+" "+a[1]+" "+a[2]);
        }
}
```

Output:

Your array elements are :: 1 2 3

Multidimensional Array

- Multidimensional arrays are actually **arrays of arrays**.
- To declare a multidimensional array variable, specify each additional index using another set of square brackets.

  Syntax:

  data_type array_var [][] = new data_type[size][size];

  Example:

  int a[][] = new int[3][5];
- This allocates a 3 by 5 array and assigns it to **a**. Internally, this matrix is implemented as an array of arrays of **int**.

  Example:

```
class demo_Tarray
{
        public static void main (String args[])
        {
                int a[][] = new int[2][2];              // int a[][] = {{1,2},{3,4}};
                a[0][0] = 1;
                a[0][1] = 2;
                a[1][0] = 3;
                a[1][1] = 4;
                System.out.println("Your array elements are :: "+ a[0][0]+" "+a[0][1]+"
                                "+a[1][0]+" "+a[1][1]);
        }
}
```

Output:

Your array elements are :: 1 2 3 4

String

- Strings are widely used in JAVA Programming, are not only a sequence of characters but it defines object.
- **String** Class is defined in **java.lang** package.
- The **String** type is used to declare string variables. Also we can declare array of strings.
- A variable of type **String** can be assign to another variable of type **String**.

  Example:

  String s1 = “Welcome To Java String”;

  System.out.println(s1);

  - Here , **s1** is an object of type **String**.
- **String** objects have many special features and attributes that makes them powerful.

String class has following features:

- It is **Final** class
- Due to Final, String class cannot be inherited.
- It is immutable.

Method	Description
charAt(int index)	Returns the char value at the specified index.
compareTo(String anotherString)	Compares two strings lexicographically.
compareToIgnoreCase(String str)	Compares two strings, ignoring case differences.
concat(String str)	Concatenates the specified string to the end of this string.
contentEquals(StringBuffer sb)	Compares this string to the specified StringBuffer.
equals(Object anObject)	Compares this string to the specified object.
isEmpty()	Returns true if, and only if, length() is 0.
length()	Returns the length of this string.
split(String regex)	Splits this string around matches of the given regular expression.
toLowerCase()	Converts all of the characters in this String to lower case.
toString()	This object (which is already a string!) is itself returned.
toUpperCase()	Converts all of the characters in this String to upper case.
trim()	Returns a copy of the string, with leading and trailing whitespace omitted.

Example:

```
import java.io.*;
class  stringDemo
{
        public static void main(String args[])
        {
                String str = "Darshan Institute of Engineering & Technology";
System.out.println(str.length());
if(str.equals("DIET"))
{
        System.out.println("Same");
}
else
{
        System.out.println("Not Same");
}
if ( str.compareTo("Darshan") > 0)
{
        System.out.println("Darshan is greater than Darshan Institute of
        Engineering & Technology ");
}
```

```
                    else
                    {
                            System.out.println("Darshan Institute of Engineering &
                            Technology is greater than Darshan");
                    }
                    System.out.println( str.substring(1,3));
            }
    }
```

StringBuffer Class

- Java **StringBuffer** class is a thread-safe, mutable sequence of characters.
- Every string buffer has a capacity.
- It contains some particular sequence of characters, but the length and content of the sequence can be changed through certain method calls.

StringBuffer class Constructor

Constructor	Description
StringBuffer()	This constructs a string buffer with no characters in it and an initial capacity of **16** characters.
StringBuffer(CharSequence seq)	This constructs a string buffer that contains the same characters as the specified **CharSequence**.
StringBuffer(int capacity)	This constructs a string buffer with no characters in it and the specified initial **capacity**.
StringBuffer(String str)	This constructs a string buffer initialized to the contents of the specified **string**.

StringBuffer Methods

Method	Description
capacity()	Returns the current capacity of the String buffer.
charAt(int index)	This method returns the char value in this sequence at the specified index.
toString()	This method returns a string representing the data in this sequence.
insert(int offset, char c)	Inserts the string representation of the char argument into this character sequence.
append(String str)	Appends the string to this character sequence.
reverse()	The character sequence contained in this string buffer is replaced by the reverse of the sequence.

Example:

```
import java.io.*;
class  stringBufferDemo
{
    public static void main(String args[])
    {
            StringBuffer strBuf1 = new StringBuffer("DIET");
            StringBuffer strBuf2 = new StringBuffer(100);
```

```
                System.out.println("strBuf1 : " + strBuf1);
                System.out.println("strBuf1 capacity : " + strBuf1.capacity());
                System.out.println("strBuf2 capacity : " + strBuf2.capacity());
                System.out.println("strBuf1 reverse : " + strBuf1.reverse());
                System.out.println("strBuf1 charAt 2 : " +strBuf1.charAt(2));
                System.out.println("strBuf1 toString() is : " + strBuf1.toString());
                strBuf1.append("Darshan Institute of Engineering & Tech.");
                System.out.println("strBuf3 when appended with a String : "+ strBuf1);
        }
    }
```

Output:

```
strBuf1 : DIET
strBuf1 capacity : 20
strBuf2 capacity : 100
strBuf1 reverse : TEID
strBuf1 charAt 2 : I
strBuf1 toString() is : TEID
strBuf3 when appended with a String : TEIDDarshan Institute of Engineering & Tech.
```

Difference Between String and StringBuffer

String	StringBuffer
It is **immutable** means you cannot modify.	It is **mutable** means you can modify.
String class is **slower** than the StringBuffer.	StringBuffer class is **faster** than the String.
String is **not safe** for use by multiple **threads**.	String buffers are **safe** for use by multiple **threads**.
String Class not provides **insert()** Operation.	StringBuffer Class provides **insert()** Operation.
String Class provides **split()** Operation.	StringBuffer Class not provides **split()** Operation.
String class overrides the **equals()** method of Object class. So you can compare the contents of two strings by equals() method.	StringBuffer class doesn't override the **equals()** method of Object class.

Operator

Arithmetic Operator

- Arithmetic operators are used in **mathematical** expressions.
- The following table lists the arithmetic operators: Assume integer variable **A** holds **10** and variable **B** holds **20**, then

Operator	Description	Example
+	Addition - Adds values on either side of the operator	A + B will give 30
-	Subtraction - Subtracts right hand operand from left hand operand	A - B will give -10
*	Multiplication - Multiplies values on either side of the operator	A * B will give 200

/	Division - Divides left hand operand by right hand operand	B / A will give 2
%	Modulus - Divides left hand operand by right hand operand and returns remainder	B % A will give 0
++	Increment - Increases the value of operand by 1	B++ gives 21
--	Decrement - Decreases the value of operand by 1	B-- gives 19

Relational Operator

- There are following relational operators supported by Java language. Assume variable **A** holds **10** and variable **B** holds **20**, then:

Operator	Description	Example
==	Checks if the values of two operands are equal or not, if yes then condition becomes true.	(A == B) is not true.
!=	Checks if the values of two operands are equal or not, if values are not equal then condition becomes true.	(A != B) is true.
>	Checks if the value of left operand is greater than the value of right operand, if yes then condition becomes true.	(A > B) is not true.
<	Checks if the value of left operand is less than the value of right operand, if yes then condition becomes true.	(A < B) is true.
>=	Checks if the value of left operand is greater than or equal to the value of right operand, if yes then condition becomes true.	(A >= B) is not true.
<=	Checks if the value of left operand is less than or equal to the value of right operand, if yes then condition becomes true.	(A <= B) is true.

Bitwise Operator

- Bitwise operator works on bits and performs bit-by-bit operation.
- Assume if **a = 60** and **b = 13**, now in binary format they will be as follows:

```
    a = 0011 1100
    b = 0000 1101
    ----------------
a&b= 0000 1100
 a|b= 0011 1101
a^b = 0011 0001
 ~a  = 1100 0011
```

Operator	Description	Example
&	Binary **AND** Operator copies a bit to the result if it exists in both operands.	(A & B) will give 12 which is 0000 1100
|	Binary **OR** Operator copies a bit if it exists in either operand.	(A | B) will give 61 which is 0011 1101

^	Binary **XOR** Operator copies the bit if it is set in one operand but not both.	(A ^ B) will give 49 which is 0011 0001
~	Binary **ones Complement** Operator is **unary** and has the effect of 'flipping' bits.	(~A) will give -61 which is 1100 0011
<<	Binary **Left Shift** Operator. The left operands value is moved left by the number of bits specified by the right operand.	A << 2 will give 240 which is 1111 0000
>>	Binary **Right Shift** Operator. The left operands value is moved right by the number of bits specified by the right operand.	A >> 2 will give 15 which is 0000 1111

Logical Operator

- The following table lists the logical operators: Assume Boolean variables **A** holds **true** and variable **B** holds **false**, then:

Operator	Description	Example
&&	Called Logical **AND** operator. If both the operands are non-zero, then the condition becomes true.	(A && B) is false.
||	Called Logical **OR** Operator. If any of the two operands are non-zero, then the condition becomes true.	(A || B) is true.
!	Called Logical **NOT** Operator. Use to reverses the logical state of its operand. If a condition is true then Logical NOT operator will make false.	!(A && B) is true.

Assignment Operator

- There are following assignment operators supported by Java:

Operator	Description	Example
=	Simple assignment operator, Assigns values from right side operands to left side operand.	C = A + B will assign value of A + B into C
+=	Add and assignment operator, It adds right operand to the left operand and assign the result to left operand.	C += A is equivalent to C = C + A
-=	Subtract and assignment operator, It subtracts right operand from the left operand and assign the result to left operand.	C -= A is equivalent to C = C - A
*=	Multiply and assignment operator, It multiplies right operand with the left operand and assign the result to left operand.	C *= A is equivalent to C = C * A
/=	Divide and assignment operator, It divides left operand with the right operand and assign the result to left operand.	C /= A is equivalent to C = C / A

Conditional (Ternary) Operator

- **Conditional** operator is also known as the **ternary** operator.
- This operator consists of three operands and is used to evaluate **boolean** expressions.
- The goal of the operator is to decide which value should be assigned to the variable.

Syntax:

variable x = (expression) ? value if true : value if false

Example:

```
class conditionalDemo
{
        public static void main(String args[])
        {
            int a , b;
            a = 10;
            b = (a == 1) ? 20: 30;
            System.out.println( "Value of b is : " +  b );
            b = (a == 10) ? 20: 30;
            System.out.println( "Value of b is : " + b );
        }
}
```

Output:

```
Value of b is : 30
Value of b is : 20
```

Increment and Decrement Operator

- There are 2 Increment or decrement operators :: **++ (Increment value by 1) and -- (Decrement value by 1)**
- Both operators can be written before the operand called prefix increment/decrement, or after, called postfix increment/decrement.

Example: Assume, **x = 1**

```
y = ++x;
System.out.println(y);
z = x++;
System.out.println(z);
```

Output:

```
2
1
```

Mathematical Function

- Built-in mathematical function are available in **java.lang.math** package.
- There are so many mathematical function supported by Java. But few of them are as given below:

Function	Description
abs()	Returns the absolute value of the input **integer** argument.
round()	It returns the closest **integer** to the **float** argument.
ceil()	It returns the smallest integer greater than or equal to the number.
floor()	It returns the largest integer less than or equal to the number
min()	It returns the smaller of the two arguments.

max()	It returns the larger of two arguments.
sqrt()	It returns the square root of argument.
cos()	It returns the trigonometric cosine of argument(angle). Same for sine.
pow()	It returns the first argument raised to the power of second argument.

- **All argument to the function should be double.**

Example:

```
import java.lang.*;
class mathLibraryExample
{
        public static void main(String[] args)
        {
                int j = -9;
                double x = 72.3;

                System.out.println("|" + j + "| is " + Math.abs(j));
                System.out.println("|" + x + "| is " + Math.abs(x));
               System.out.println(x + " is approximately " + Math.round(x));
                System.out.println("The ceiling of " + x + " is " + Math.ceil(x));
               System.out.println("The floor of " + x + " is " + Math.floor(x));

               System.out.println("min(" + j + "," + x + ") is " + Math.min(j,x));
               System.out.println("max(" + j + "," + x + ") is " + Math.max(j,x));
               System.out.println("pow(2.0, 2.0) is "  + Math.pow(2.0,2.0));
               System.out.println("The square root of 9 is " + Math.sqrt(9));
        }
}
```

Output:

```
|-9| is  9
|72.3| is  72.3
72.3 is approximately   72
The ceiling of 72.3 is   73.0
The floor of 72.3 is   72.0
min(-9,72.3) is   -9.0
max(-9,72.3) is   72.3
pow(2.0, 2.0) is  4.0
The square root of 9 is 3.0
```

Selection Statement

- Java supports two **selection** statements: **if** and **switch**.
- These statements allow you to control the flow of your program's execution based upon conditions known only during run time.

If statement

- if statement consists of a condition followed by one or more statements.

  Syntax:

```
if (condition)
{
  //Statements will execute if the Boolean expression is true
}
```

- If the condition is true then the block of code inside **if** statement will be executed.

  Example:

```
class ifDemo
{
        public static void main(String[] args)
        {
            int marks = 76;
            String grade = null;
            if (marks >= 40)
            {
                    grade = "Pass";
            }
            if (marks < 40)
            {
                    grade = "Fail";
            }
            System.out.println("Grade = " + grade);
        }
}
```

Output:

```
Grade = Pass
```

If … else Statement

- The **if …else** statement is Java's conditional branch statement.
- Here is the general form of the **if..else** statement:

  Syntax:

```
if (condition)
        statement1;
else
        statement2;
```

- Here, each statement may be a **single statement** or a **compound statement** enclosed in curly braces (that is, a block).
- The condition is any expression that returns a **boolean** value. The **else** clause is optional.

- The **if..else** works as follow: If the condition is **true**, then **statement1** is executed. Otherwise, **statement2** (if it exists) is executed.
  Example:

```
class ifelseDemo
{
        public static void main(String[] args)
        {
            int marks = 76;
            String grade;
            if (marks >= 40)
            {
                    grade = "Pass";
            }
            else
            {
                    grade = "Fail";
            }
            System.out.println("Grade = " + grade);
        }
}
```

Output:

```
Grade = Pass
```

Switch Statement

- The **switch** statement is Java's multiway branch statement. It provides an easy way to execute different parts of your code based on the value of an **expression**.
- Here is the general form of a **switch** statement:
  Syntax:

```
switch (expression)
{
        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** or **char**.
- 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 as follow: 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 literal matches the value of the **expression**, then the **default** statement is executed. However, the **default** statement is optional.
- The **break** statement is used inside the **switch** to terminate a statement sequence.

Example:

```
class switchDemo
{
        public static void main(String[] args)
        {
            int day = 8;
            switch (day)
            {
               case 1:  System.out.println("Monday"); break;
               case 2:  System.out.println("Tuesday"); break;
               case 3:  System.out.println("Wednesday"); break;
               case 4:  System.out.println("Thursday"); break;
               case 5:  System.out.println("Friday"); break;
               case 6:  System.out.println("Saturday"); break;
               case 7:  System.out.println("Sunday"); break;
               default: System.out.println("Invalid Day");break;
            }
        }
}
```

Output:

```
Thursday
```

Iteration Statement

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

while

- It repeats a statement or block until its **controlling expression** is true.

Syntax:

```
while(condition)
{
        // body of loop
}
```

- The condition can be any **boolean** expression. The body of the loop will be executed as long as the conditional expression is **true**.
- When condition becomes **false**, control passes to the next line of code immediately following the loop.

Example:

```
class whileDemo
{
```

```
        public static void main(String args[])
        {
            int x = 1;
            while( x < 5 )
            {
                System.out.print(x+" " );
                x++;
            }
        }
    }
```

Output:

```
1 2 3 4
```

do-while

- Sometimes it is desirable to execute the body of a loop at least **once**, even if the conditional expression is **false**.
- The **do-while** loop always executes its body at least once, because its conditional expression is at the bottom of the loop.

Syntax:

```
do
{
        // body of loop
} while (condition);
```

- Each iteration of the **do-while** loop first executes the body of the loop and then evaluates the conditional expression. If this expression is **true**, the loop will **repeat**. Otherwise, the loop terminates. Condition must be a **boolean** expression.

Example:

```
class dowhileDemo
{
        public static void main(String args[])
        {
            int x = 1;
            do
            {
                System.out.print(x+" “);
                x++;
            }while( x < 5);
        }
    }
```

Output:

```
1 2 3 4
```

for

Syntax:

```
for(initialization; condition; iteration)
{
```

```
        // body
    }
```

- When the loop first starts, the **initialization** portion of the loop is executed. Generally, this is an expression that sets the value of the loop control variable, which acts as a counter that controls the loop. The **initialization** expression is only executed **once**.
- Next, **condition** is evaluated. This must be a **boolean** expression. It usually tests the loop control variable against a target value. If this expression is **true**, then the body of the loop is executed. If it is **false**, the loop **terminates**.
- Next, the **iteration portion** of the loop is executed. This is usually an expression that **increments** or **decrements** the loop control variable.
- The loop then iterates, **first** evaluating the **conditional expression**, then executing the body of the loop, and then executing the iteration expression with each pass. This process repeats until the **controlling expression is false**.

Example:

```
class forDemo
{
        public static void main(String args[])
        {
                for(int x = 1; x < 5; x++ )
                {
                    System.out.print(x+" ");
                }
        }
}
```

Output:

```
1 2 3 4
```

Jump Statement

- These statements transfer control to another part of your program.

break

- The **break** keyword is used to **stop** the entire loop. The **break** keyword must be used inside any **loop or a switch** statement.
- The **break** keyword will stop the execution of the **innermost** loop and start executing the next line of code after the block.

Example:

```
class breakDemo
{
        public static void main(String args[])
        {
                int [] numbers = {10, 20, 30, 40, 50};
                for(int x=0;x<5;x++ )
                {
                        if( numbers[x] == 30 )
                        {
```

```
                        break;
                    }
                    System.out.print( numbers[x] +"  ");
                }
            }
        }
```

Output:

```
10  20
```

Continue

- **Continue** statement is used when we want to **skip** the rest of the statement in the body of the loop and **continue** with the **next** iteration of the loop.

  Example:

```
class  continueDemo
{
        public static void main(String args[])
        {
            int [] numbers = {10, 20, 30, 40, 50};
            for(int x=0;x<5;x++ )
            {
                if( numbers[x] == 30 )
                {
                    continue;
                }
                System.out.print( numbers[x] +"  ");
            }
        }
    }
```

Output:

```
10  20  40  50
```

return

- The **return** statement is used to **explicitly return** from a **method**. It transfers control of program **back to the caller** of the method.
- The **return** statement immediately **terminates the method** in which it is executed.

  Example:

```
class Test
{
        public static void main(String args[])
        {
            int a=10, b=20, c;
            c=add(a,b);
            System.out.println("Addition="+c);
        }
        public static int add(int x, int y)
        {
            return x+y;
```

```
                }
        }
```

Output:

Addition=30

Class

- A class is a **template** that specifies the **attributes** and **behavior** of things or objects.
- A class is a **blueprint** or **prototype** from which objects are created.
- A class is the implementation of an **abstract data type** (ADT). It defines attributes and methods which implement the data structure and operations of the ADT, respectively.

  Syntax:

```
class classname
{
        Datatype variable1;
        Datatype variable2;
        // ...
        Datatype variableN;

        return_type   methodname1(parameter-list)
        {
                // body of method
        }

        return_type   methodname2(parameter-list)
        {
                // body of method
        }

        return_type   methodnameN(parameter-list)
        {
                // body of method
        }
}
```

  - A class is declared by use of the **class** keyword.
  - The **data**, or **variables**, defined within a class are called **instance** variables because each instance of the class (that is, each object of the class) contains its **own copy** of these variables. Thus, the data of one object is **separate** and **unique** from the data of another.
  - The actual code contained within **methods**.
  - The **methods** and **variables** defined within a class are called members of the class.

Methods

Syntax:

```
return_type   method_name(parameter-list)
{
    // body of method
}
```

- Here, **return_type** specifies the type of data **returned** by the method. This can be any **valid** type. If the method does not **return** a value, its return type must be **void**.

- The name of the method is specified by **method_name**. This can be any legal **identifier** other than those already used by other member within the **current scope**. The **parameter-list** is a sequence of **type and identifier** pairs separated by **commas**.
- Parameters are essentially variables that **receive** the value of the **arguments** passed to the method when it is called. If the method has no parameters, then the parameter list will be **empty.**

Return value

- Method that have a **return type** other than **void** return a value to the calling **method** using the following form of the return statement:

  Syntax:

  return value;

  - Here, **value** is the value returned.

  Example:

```
class  Box
{
        double width = 1;
        double height = 2;
        double depth = 3;

        double volume()
        {
                return  (width * height * depth);
        }
}
```

Method Call

Syntax:

var_name = **object_name.**method_name(parameter-list);

Example:

vol = b1.volume();

- In above example, **b1** is an object and when **volume( )** is called, it is put on the right side of an **assignment** statement. On the left is a **variable,** in this case **vol**, that will receive the value returned by **volume( )**.

Declaring Object

- To obtain an **object** of class, **first** you must declare a **variable** of the **class type**. This variable does not define an object. Instead, it is simply a variable that can **refer** to an **object**.
- **Second**, you must obtain an **actual** copy of the object and **assign** it to that variable. You can do this using the **new** operator.
- The **new** operator dynamically allocates (that is, allocates at run time) memory for an object and returns a **reference** to it. This **reference** is an **address** in memory of the object allocated by **new**.

Syntax:

Step - 1 : class_name class_var;
Step - 2: class_var = new class_name( );

- Here, **class_var** is a variable of the class type being created. The **class_name** is the name of the class that is being instantiated.

Assigning Object Reference Variables

- **Object reference** variables acts differently than you might expect when an assignment takes place.

Example:

```
Box  b1 = new Box();
Box  b2 = b1;
```

- Here, **b1** and **b2** will both refer to the **same** object. The assignment of **b1** to **b2** did not allocate any memory of the original object.
- It simply makes **b2** refer to the same object as **b1** does. Thus, any changes made to the object through **b2** will affect the object to which **b1** is referring, since they are the same **object.**

Example:

```
class Box
{
        double width = 1.0;
        double height = 2.0;
        double depth = 3.0;

        void volume()
        {
                System.out.print("Volume is ");
                System.out.println(width * height * depth);
        }
}
class BoxDemo
{
        public static void main(String args[])
        {
                Box b1 ;                    // declare reference to object
                b1 = new Box()              // allocate a Box object
                //Box b1 = new Box();       We can also combine above two statement.
                b1.volume();
        }
}
```

Output:

```
Volume is 6.0
```

Visibility Controls of JAVA

- Java provides a number of **access modifiers** to set access levels for **classes**, **variables**, **methods** and **constructors**. The four access levels are:
  1) **Package/friendly (default) -**Visible to the **package**. **No modifiers are needed**.
  2) **Private** - Visible to the **class** only.
  3) **Public**- Visible to the **class** as well as **outside the class**.
  4) **Protected**- Visible to the **package** and all **subClasses**.

Default Access Modifier – No Keyword

- **Default** access modifier means no need to declare an access modifier for a **class**, **field**, **method** etc.
- A variable or method declared without any access control modifier is **available to any other class in the same package**. The **default** modifier cannot be used for methods in an **interface** because the methods in an interface are by default **public**.

Example:

```
String  str = "Hi";
void a()
{
        System.out.println(str);
}
```

Private Access Modifier – private

- Methods, Variables and Constructors that are declared **private** can only be accessed within the **declared class itself**.
- Private access modifier is the most **restrictive access level**. **Class** and **interfaces** cannot be **private**.
- Variables that are declared private can be accessed outside the class if **public getter** methods are present in the **class**.
- Using the private modifier, an object **encapsulates** itself and **hides** data from the outside world.

Example:

```
class  A
{
        private String s1 = "Hello";
        public String getName()
        {
                return  this.s1;
        }
}
```

- Here, **s1** variable of **A** class is private, so there's no way for other classes to retrieve. So, to make this variable available to the outside world, we defined public methods: **getName()**, which returns the value of **s1**.

Public Access Modifier - public

- The **public** keyword is an access specifier, which allows the programmer to control the visibility of class members.
- When a class member is preceded by **public**, then that member may be accessed by code **outside the class**.
- A class, method, constructor, interface etc declared public can be accessed from any other class.
- Therefore, methods or blocks declared inside a public class can be accessed from any class belonging to the Java world.
- However, if the public class we are trying to access is in a different package, and then the public class still need to be **imported**. Because of class inheritance, all public methods and variables of a class are inherited by its **subClasses**.

  Example:

```
public static void main(String[] args)
{
    // ...
}
```

- The **main( )** method of an application needs to be **public**. Otherwise, it could not be called by a **Java interpreter** (such as java) to run the class.

Protected Access Modifier – Protected

- Variables, methods and constructors which are declared **protected** in a super class can be accessed only by the **subClasses** in other package or any class within the package of the protected members' class.
- The protected access modifier cannot be applied to **class** and **interfaces**. **Methods** can be declared **protected**, however **methods** in a **interface** cannot be declared **protected**.
- Protected access gives chance to the subClass to use the helper method or variable, while prevents a non-related class from trying to use it.

Example:

```
package p1;
class A
{
    float f1;
    protected int i1;
}

// note that class B belongs to the same package as class A
package p1;
class B
{
    public void getData()
    {
        // create an instance of class A
```

```
                A  a1 = new A();
                a1.f1 = 19;
                a1.i1 = 12;
        }
    }
```

- In above example, class **A** and **B** are in same package **p1**. Class **A** has **i1** variable which is declared as protected. So, it can be accessed through entire package and all its subclasses. Thus, in **getData()** method of class **B** we can access variable **f1** as well as **i1.**

this Keyword

- Sometimes a method will need to refer to the object that invoked it.
- To allow this, Java defines the **this** keyword. Keyword **this** can be used inside any method or constructor of class to refer to the current object.
- It means, **this** is always a reference to the object on which the method was invoked.
- **this** keyword can be very useful in case of Variable Hiding.
- You can use **this** anywhere a reference to an object of the current class' type is permitted.
- We cannot create two **Instance/Local** variables with same name. But it is legal to create one instance variable & one local variable or method parameter with same name.
- **Local Variable** will hide the instance variable which is called Variable Hiding.

Example:

```
class A
{
        int v = 5;
        public static void main(String args[])
        {
                A a1 = new A();
                a1.method(20);
                a1.method();
        }
        void method(int variable)
        {
                int  v = 10;
                System.out.println("Value of Instance variable :" + this.v);
                System.out.println("Value of Local variable :" + v);
        }
        void method()
        {
                int v = 40;
                System.out.println("Value of Instance variable :" + this.v);
                System.out.println("Value of Local variable :" + v);
        }
}
```

Output:

```
Value of Instance variable :5
Value of Local variable :10
```

Value of Instance variable :5
Value of Local variable :40

static Keyword

- When a member is declared **static**, it can be accessed before any objects of its class are created, and without reference to any object.
- You can declare both methods and variables to be **static**. The most common example of a **static** member is **main( )**.
- **main( )** is declared as **static** because it must be called before any objects exist.
- When objects of its class are declared, no copy of a **static** variable is made. Instead, all instances of the class share the same **static** variable.
- **Methods** declared as **static** have several restrictions:
  1) They can only call other **static** methods.
  2) They must only access **static** data.
  3) They cannot refer to **this** or **super** in any way.

Example:

```
class staticDemo
{
        static int count=0;      //will get memory only once and retain its value

        staticDemo()
        {
                count++;
                System.out.println(count);
        }
        static
        {
                System.out.println("Static block initialized...");
        }
        static void display()
        {
                System.out.println("Static method call…");
        }
        public static void main(String args[])
        {
                staticDemo s1=new staticDemo();
                staticDemo s2=new staticDemo();
                staticDemo s3=new staticDemo();
                display();
        }
}
```

Output:

```
Static block initialized...
1
```

2
3
Static method call…

- If you wish to call a **static** method from outside its class, you can do so using the following general form:

  classname.method( );

- Here, **classname** is the name of the class in which the **static** method is declared. No need to call static method through object of that class.

final Keyword

- A **variable** can be declared as **final**. You cannot change the value of final variable. It means, final variable act as **constant** and value of that variable can never be changed.
- If you declared any **method** as **final** then you cannot **override** it.
- If you declared any **class** as **final** then you cannot **inherit** it.

Example:

```
class finalDemo
{
        final int b = 100;
        void  m1()
        {
                b = 200;   /* Error generate because we cannot change the value of
                              final variable*/
        }
        public static void main(String args[])
        {
                finalDemo f1 = new finalDemo();
                f1.m1();
        }
}
```

Output:

Compile Time Error

Method Overloading

- If class have multiple methods with **same name** but **different parameters** is known as **Method Overloading**.
- Method overloading is also known as **compile time (static) polymorphism**.
- The same method name will be used with **different number of parameters and parameters of different type**.
- Overloading of methods with **different return types is not allowed**.
- Compiler identifies which method should be called among all the methods have same name using the **type** and **number of arguments**.
- However, the two functions with the same name must differ in at least one of the following,

1) The number of parameters
2) The data type of parameters
3) The order of parameter

Example:

```
class overloadingDemo
{
        void  sum(int a,int b)
        {
                System.out.println("Sum of (a+b) is:: "+(a+b));
        }
        void  sum(int a,int b,int c)
        {
                System.out.println("Sum of (a+b+c) is:: "+(a+b+c));
        }
        void  sum(double a,double b)
        {
                System.out.println("Sum of double (a+b) is:: "+(a+b));
        }
        public static void main(String args[])
        {
                overloadingDemo o1 = new overloadingDemo();
                o1.sum(10,10);          // call method1
                o1.sum(10,10,10);       // call method2
                o1.sum(10.5,10.5);      // call method3
        }
}
```

Output:

```
Sum of (a+b) is:: 20
Sum of (a+b+c) is:: 30
Sum of double (a+b) is:: 21.0
```

Constructor

- Constructor is special type of method that is used to initialize the object.
- It is invoked at the time of object creation.
- **There are two rules to define constructor as given below:**
  1) Constructor name must be same as its class name.
  2) Constructor must not have return type.
- Return type of class constructor is the **class type itself**.
- **There are two type of constructor :**
  1) Default Constructor
  2) Parameterized constructor

Default Constructor

- A constructor that has **no parameter** is known as **default constructor**.
- If we don't explicitly declare a constructor for any class, the compiler creates a default constructor for that class.

Example:

```
class A
{
        A()                 //Default constructor
        {
                System.out.println("Default constructor called..");
        }
        public static void main(String args[])
        {
                A a = new A();
        }
}
```

Output:

```
Default constructor called..
```

Parameterized Constructor

- A constructor that has parameters is known as **parameterized constructor**.
- It is used to provide different values to the distinct objects.
- It is required to pass parameters on creation of objects.
- If we define only parameterized constructors, then we cannot create an object with **default constructor**. This is because compiler will not create default constructor. You need to create default constructor explicitly.

Example:

```
class A
{
        int a;
        String s1;
        A(int b,String s2)        //Parameterized constructor
        {
                b = a;
                s2 = s1;
        }
        void display()
        {
                System.out.println("Value of parameterized constructor is :: "+a+" and
"+b);
        }
        public static void main(String args[])
        {
                A a = new A(10,"Hello");
```

```
                a.display();
            }
        }
```

Output:

Value of parameterized constructor is :: 10 and Hello

Copy Constructor

- A copy constructor is a constructor that takes only **one parameter** which is the same type as the class in which the copy constructor is defined.
- A copy constructor is used to create another **object** that is a copy of the object that it takes as a parameter. But, the newly created copy is totally **independent** of the original object.
- It is **independent** in the sense that the copy is located at different address in memory than the original.

Overloading Constructor

- Constructor overloading in java allows to **more than one constructor** inside one Class.
- It is not much different than **method overloading**. In Constructor overloading you have multiple constructors with **different signature** with only difference that constructor doesn't have **return type**.
- These types of constructor known as **overloaded constructor**.

Passing object as a parameter

- If you want to construct a new object, thatis initially the same as some existing object. To do this, you must define a constructor that takes an object of its class as a parameter.

Example:

```
class Box
{
        double width;
        double height;
        double depth;
        // It takes an object of type Box. Copy constructor
        Box(Box ob)
        {
                // pass object to constructor
                width = ob.width;
                height = ob.height;
                depth = ob.depth;
        }
        // Parameterized constructor
        Box(double w, double h, double d)
        {
                width = w;
                height = h;
                depth = d;
```

```
}
// Default constructor
Box()
{
        width = -1; // use -1 to indicate
        height = -1; // an uninitialized
        depth = -1; // box
}
// constructor used when cube is created
Box(double len)
{
        width = height = depth = len;
}
// compute and return volume
        double volume()
        {
                return width * height * depth;
        }
}
class DemoAllCons
{
        public static void main(String args[])
        {
                Box mybox1 = new Box(10, 20, 15);
                Box mybox2 = new Box();
                Box mycube = new Box(7);
                Box myclone = new Box(mybox1); // create copy of mybox1
                double vol;
                // get volume of first box
                vol = mybox1.volume();
                System.out.println("Volume of mybox1 is " + vol);
                // get volume of second box
                vol = mybox2.volume();
                System.out.println("Volume of mybox2 is " + vol);
                // get volume of cube
                vol = mycube.volume();
                System.out.println("Volume of cube is " + vol);
                // get volume of clone
                vol = myclone.volume();
                System.out.println("Volume of clone is " + vol);
        }
}
```

Output:

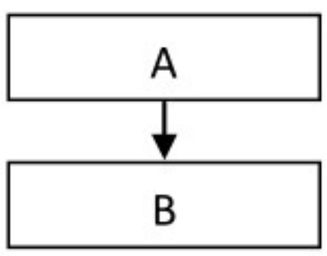
```
Volume of mybox1 is 3000.0
Volume of mybox2 is -1.0
Volume of cube is 343.0
Volume of clone is 3000.0
```

Inheritance

- **Inheritance** is the process, by which class can acquire the properties and methods of its parent class.
- The mechanism of deriving a **new child class** from **an old parent class** is called **inheritance**.
- The new class is called **derived** class and old class is called **base** class.
- When you inherit from an existing class, you can **reuse** methods and **fields** of **parent** class, and you can add new methods and fields also.
- All the properties of **superclass** except private properties can be inherit in its **subclass** using **extends** keyword.

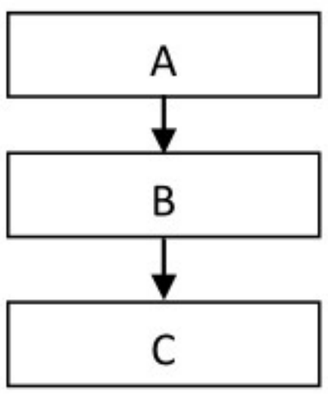
Types of Inheritance

Single Inheritance



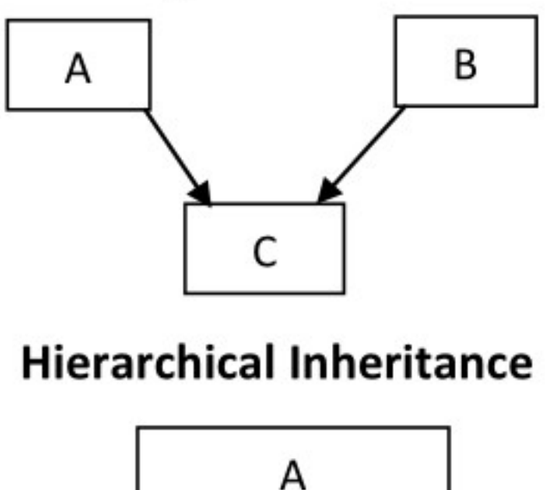
- If a class is derived from a single class then it is called **single** inheritance.
- Class **B** is derived from class **A.**

Multilevel Inheritance



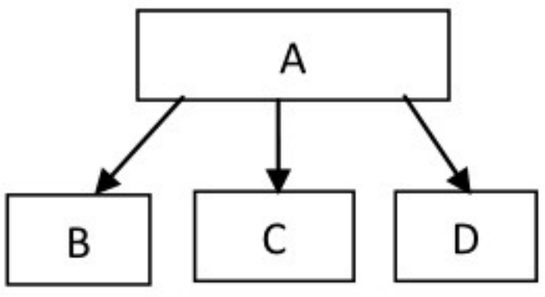
- A class is derived from a class which is derived from another class then it is called **multilevel** inheritance
- Here, class **C** is derived from class **B** and class **B** is derived from class **A**, so it is called multilevel inheritance.

Multiple Inheritance



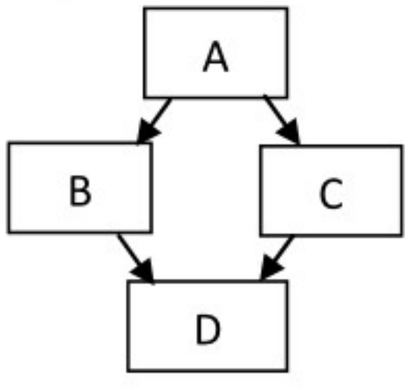
- If one class is derived from more than one class then it is called multiple inheritance.
- It is **not supported** in java through class.

Hierarchical Inheritance



- If one or more classes are derived from one class then it is called **hierarchical** inheritance.
- Here, class **B**, class **C** and class **D** are derived from class **A**.

Hybrid Inheritance



- Hybrid inheritance is combination of **single** and **multiple** inheritance.
- But java doesn't support multiple inheritance, so the hybrid inheritance is also **not possible**.

Example

```
class A
{
    public  void displayA()
    {
            System.out.println("class A method");
    }
}
class B extends A                    //Single Inheritance - class B is derived from class A
{
    public  void displayB()
    {
            System.out.println("class B method");
    }
}
class C extends B   // Multilevel Inheritance - class C is derived from class B
{
    public  void displayC()
    {
            System.out.println("class C method");
    }
}
class D extends A  //Hierarchical Inheritance - Class B and Class D are derived from Class A
{
    public  void displayD()
    {
            System.out.println("class D method");
    }
}
class  Trial
{
    public  static  void  main(String []args)
    {
            B b=new B();
            C c=new C();
            D d=new D();
            b.displayB();
            c.displayC();
            d.displayD();
    }
}
```

- Class **B** and class **D** are derived from class **A** so it is example of **Hierarchal Inheritance**.

Method Overriding

- When a method in a **subclass** has the **same name and type signature** as method in its **superclass**, then the method in the **subclass** is said to **override the method** of the super class.
- **The benefit of overriding is:** Ability to define a behavior that's specific to the **subclass** type. Which means a subclass can implement a superclass method based on its requirement.
- Method overriding is used for **runtime** polymorphism.
- In object oriented terms, overriding means to **override the functionality** of any existing method.

Example:

```
class A
{
    public void display()
    {
        System.out.println("Class A");
    }
}
class B extends A
{
    public void display()
    {
        System.out.println("Class B");
    }
}
class Trial
{
    public static void main(String args[])
    {
        A a = new A();          // A reference and object
        A b = new B();          // A reference but B object
        a.display();            // Runs the method in A class
        b.display();            // Runs the method in B class
    }
}
```

Output:

```
Class A
Class B
```

- In the above example, you can see that even though **b** is a type of **A** it runs the **display()** method of the **B** class.
- Because, at **compile** time reference type of object is checked. However, at the **runtime** JVM determine the object type and execute the method that belongs to that particular **object**.

Rules for method overriding

- The **argument list** should be exactly the **same** as that of the overridden method.

- The **return type** should be the **same** as the return type declared in the original overridden method in the superclass.
- **Instance methods** can be overridden only if they are **inherited** by the **subclass**.
- A method declared **final** cannot be overridden.
- A method declared **static** cannot be overridden but can be re-declared.
- If a method cannot be **inherited** then it cannot be **overridden**.
- A subclass within the same package as the instance's superclass can override any superclass method that is not declared private or final.
- A subclass in a different package can only override the non-final methods declared public or protected.
- **Constructors** cannot be overridden.

super keyword

- The **super** keyword in java is a reference variable that is used to refer **immediate parent** class object.

super To Access super-class Members

- If your method overrides one of its super-class methods, you can invoke the **overridden** method through the use of the keyword **super**.

Example:

```
class A
{
    String name = "Class A";
    public  void  display()
    {
            System.out.println("Class A display method called..");
    }
}
class B extends A
{
    String name = "Class B";
    public  void  display()
    {
            System.out.println("Class B display method called..");
    }
    void  printName()
    {
            //this will print value of name from subclass(B)
            System.out.println("Name from subclass : " + name);

            // this will print value of name from superclass(A)
            System.out.println("Name from Superclass: " + super.name);
```

```
                //invoke display() method of Class B method
                display();

                // invoke display() method of class A(superclass) using super
                super.display();
        }
}
class SuperDemo
{
        public static void main(String args[])
        {
                B b1 = new B();
                b1.printName();
        }
}
```

Output:

```
Name from subclass : Class B
Name from Superclass: Class A
Class B display method called..
Class A display method called..
```

- Here, **display()** method of **subclass** overrides the **display()** method of its **super-class**.
- So, to call **superclass(A)** members within **subclass(B) super** keyword is used.

super To Call super-class Constructor

- Every time a parameterized or non-parameterized constructor of a **subclass** is created, by default a default constructor of **superclass** is called **implicitly**.
- The syntax for calling a **superclass** constructor is:

```
super();
```

OR

```
super(parameter list);
```

- The following example shows how to use the **super** keyword to invoke a superclass's constructor.

Example:

```
class A
{
        A()
        {
                System.out.println("Super class default constructor called..");
        }
        A(String s1)
        {
                System.out.println("Super class parameterized constructor called: "+s1);
        }
}
class B extends A
{
```

```
    /* Implicitly default constructor of superclass(A) will be called. Whether you define super or not in subclass(B) constructor */
    B()
    {
            System.out.println("Sub class default constructor called..");
    }
    /* To call a parameterized constructor of superclass(A) you must write super() with same number of arguments*/
    B(String s1)
    {
            super("Class A");
            System.out.println("Sub class parameterized constructor called: " + s1);
     }
}
class SuperConDemo
{
    public static void main(String args[])
    {
            B b1 = new B();
            B b2 = new B("Class B");
    }
}
```

Output:

```
Super class default constructor called..
Sub class default constructor called..
Super class parameterized constructor called: Class A
Sub class parameterized constructor called: Class B
```

- Here, implicitly a default constructor of **superclass** is called not a parameterized one. To call a **parameterized** constructor of a **superclass** we must use **'super(parameters..)'** with matching parameters.

Dynamic Method Dispatch

- Dynamic method dispatch is the mechanism by which a call to an overridden method is resolved at run time, rather than compile time.
- It is also known as **run-time polymorphism**.
- A **superclass** reference variable can refer to a **subclass object**. It is known as **Upcasting**.
- When an overridden method is called through a **superclass reference**, the determination of the method to be called is based on **the object being referred** to by the reference variable.
- This determination is made at **run time**.

Example:

```
class   A
{
    void callme()
    {
```

```
                System.out.println("Inside A's callme method");
        }
}
class B extends A
{
        void callme()
        {
                System.out.println("Inside B's callme method");
        }
}
class C extends A
{
        void callme()
        {
                System.out.println("Inside C's callme method");
        }
}
class DispatchDemo
{
        public static void main(String args[])
        {
                A a = new A();          // object of type A
                B b = new B();          // object of type B
                C c = new C();          // object of type C
                A r;                    // obtain r a reference of type A
                r = a;                  // r refers to an A object
                r.callme();             // calls A's version of callme()
                r = b;                  // r refers to a B object
                r.callme();             // calls B's version of callme()
                r = c;                  // r refers to a C object
                r.callme();             // calls C's version of callme()
        }
}
```

Output:

```
Inside A's callme method
Inside B's callme method
Inside C's callme method
```

Object Class

- The **Object class** is the **parent** class (java.lang.Object) of all the classes **in java bydefault**.
- The Object class provides some common behaviors to all the objects must have, such as object can be compared, object can be converted to a string, object can be notified etc..
- **Some Java object class methods are given below:**

Method	Description
equals()	To compare two objects for equality.

getClass()	Returns **a runtime representation of the class** of this object. By using this class object we can get information about class such as its name, its superclass etc.
toString()	Returns a **string representation** of the object.
notify()	Wakes up **single thread**, waiting on this object's monitor.
notifyAll()	Wakes up **all the threads**, waiting on this object's monitor.
wait()	Causes the **current thread to wait**, until another thread notifies.

Example:

```
class parent
{
    inti = 10;
    Integer i1 = new Integer(i);
    void PrintClassName(Object obj)      // Pass object of class as an argument
    {
        System.out.println("The Object's class name is ::" + obj.getClass().getName());
    }
}
class ObjectClassDemo
{
    public static void main(String args[])
    {
        parent a1 = new parent();
        a1.PrintClassName(a1);
        System.out.println("String representation of object i1 is:: "+a1.i1.toString());

    }
}
```

Output:

```
The Object's class name is :: parent
String representation of object i1 is:: 10
```

Packages

- A **java package** is a group of similar types of **classes, interfaces and sub-packages**.
- Packages are used to **prevent naming conflicts** and provides **access protection**.
- It is also used to **categorize the classes and interfaces.** so that, they can be easily **maintained**.
- We can also **categorize the package** further by using concept of **subpackage**. Package inside the package is called the **subpackage**.
- Package can be categorized in two form: **built-in package** and **user-defined package**.
  - **built-in packages :**Existing Java package such as **java.lang, java.util, java.io, java.net, java.awt.**
  - **User-defined-package :** Java package created by **user** to categorized **classes** and **interface.**
- Programmers can define their own packages to bundle group of **classes, interfaces** etc.

Creating a package

- To create a package, **package** statement followed by **the name of the package**.

- The **package** statement should be the first line in the source file. There can be only **one package statement** in each source file.
- If a package statement is **not used** then the class, interfaces etc. will be put into an unnamed package.

Example:

```
package mypack;
class Book
{
    String bookname;
    String author;
    Book()
    {
        bookname = "Complete Reference";
        author = "Herbert";
    }
    void show()
    {
        System.out.println("Book name is :: "+bookname+"\nand author name is :: "+
author);
    }
}
class DemoPackage
{
    public static void main(String[] args)
    {
        Book b1 = new Book();
        b1.show();
    }
}
```

Compile: javac -d . DemoPackage.java

To run the program : java mypack.DemoPackage

Output:

```
Book name is :: Complete Reference
and author name is :: Herbert
```

- The **-d** is a switch that tells the compiler where to put the class file. **Like**, /home (Linux), d:/abc (windows) etc.
- The . (dot) represents the **current folder**.

Import Package

- **import** keyword is used to import **built-in and user-defined** packages into your java source file.
- If a **class** wants to use **another class** in the **same package**, no need to import the package.
- But, if a **class** wants to use **another class** that is **not exist in same package** then **import** keyword is used to import that package into your java source file.
- A class file can contain **any number of import** statements.
- **There are three ways to access the package from outside the package:**

1) import package.*;
2) import package.classname;
3) fully qualified name

1) Using packagename.* :

- If you use **packagename.*** then all the **classes and interfaces** of this package will be accessible but **not subpackages**.
  Syntax: import packagename.*;

2) Using packagename.classname :

- If you use **packagename.classname** then only declared **class** of this package will be accessible.
  Syntax: import packagename.**classname**;

3) Using fully qualified name :

- If you use **fully qualified name** then only **declared class** of this package will be accessible. So, no need to import the package.
- But, you need to use **fully qualified name every time** when you are accessing the class or interface.
- It is generally used when two packages have **same class name** e.g. java.util and java.sql packages contain **Date** class.

Example:

File 1: **A.java**

```
package  pack;
public  class A
{
        public void display()
        {
                System.out.println("Welcome to package pack...");
        }
}
```

File 2: **Q.java**

```
package  pack;
public  class Q
{
        public void Q_display()
        {
                System.out.println("Welcome to package pack through qualified
name...");
        }
}
```

File 3: **B.java**

```
package  mypack;
import  pack.*;              // Here, you can also use    import pack.A ;
class  B
{
        public static void main(String args[])
        {
```

```
                A a1 = new A();
                pack.Q  q1= new  pack.Q();
        /*Here Q  is class in package A. If you want to access Q_display() method of class Q
        using fully qualified name then no need to import package named pack */
                a1.display();
                q1.Q_display();
            }
        }
```

Output: **java mypack.B**

Welcome to package pack...
Welcome to package pack through qualified name...

- In above example, **class A, class Q and all its methods** must be declared as **public** otherwise they can be access in **class B**.

Visibility and Access Rights

class \ have access to	Private	Default	Protected	Public
own class	yes	yes	yes	yes
subclass - same package	no	yes	yes	yes
subclass - another package	no	no	yes	yes
class - another package	no	no	no	yes

Interfaces

- An **interface** is a collection of **abstract methods**. An interface is not a **class**.
- When you **create** an interface it defines what a class can do without saying anything about how the class will do it.
- Interface contains only **static constants** and **abstract methods** only.
- The interface in java is **a mechanism to achieve fully abstraction**. There can be only abstract methods in the java interface not method body.
- By default (Implicitly), an interface is **abstract**, interface **fields**(data members) are **public, static and final** and **methods** are **public and abstract.**
- It is **used** to achieve fully **abstraction** and **multiple inheritance** in Java.
- **Similarity between class and interface are given below:**
  - An interface can contain any **number of methods**.
  - An interface is written in a file with a **.java** extension, with the name of the interface matching the name of the file.
  - The **bytecode** of an interface appears in a .**class** file.
- **Difference between class and interface are given below:**

Class	Interface
• You can **instantiate** class.	• You cannot **instantiate** an interface.
• It contains default as well as **parameterize constructors**.	• It does **not** contain any **constructors**.

• All the methods should have **definition** otherwise declare method as abstract explicitly.	• All the methods in an interface are **abstract** by default.
• All the **variables** are **instance by default**.	• All the **variables** are **static final by default**, and a value needs to be assigned at the time of definition.
• A class can **inherit** only **one Class** and can implement **many interfaces**.	• An interface cannot **inherit** any **class** while it can **extend many interfaces.**

Declaring Interfaces

- The **interface** keyword is used to **declare** an interface.

Syntax: NameOfInterface.java

```
import java.lang.*;
public interface NameOfInterface
{
        //Any number of final, static fields
        //Any number of abstract method declarations
}
```

Example: DemoInterface.java

```
interface DemoInterface
{
        int i = 10;
        void  demo();
}
```

  - In above example, name of interface is **DemoInterface** and it contains a variable **i** of integer type and an abstract method named **demo()**.

Implementing Interfaces

- A **class** uses the **implements** keyword to implement an **interface**.
- A **class** implements **an interface** means, you can think of the class as signing a contract, agreeing to perform the **specific behaviors** of the interface.
- If a class **does not perform all the behaviors** of the interface, the class must declare itself as **abstract**.

Example: DemoInterfaceImp.java

```
public class DemoInterfaceImp implements DemoInterface
{
    public void demo()
    {
            System.out.println("Value of i is :: "+i);
    }
    public static void main(String args[])
    {
            DemoInterfaceImp  d = new DemoInterfaceImp();
            d.demo();
```

```
        }
    }
```

Output:

Value of i is :: 10

Inheritance on Interfaces

- We all knows a class can extend another class. Same way an **interface can extend another interface.**
- The **extends** keyword is used to extend an interface, and the **child interface** inherits the methods of the **parent interface**.

Example:

```
public interface  A
{
    void getdata(String name);
}
public  interface  B  extends  A
{
    void setdata();
}
class  InheritInterface  implements  B
{
    String display;
    public void getdata(String name)
    {
            display = name;
    }
    public void setdata()
    {
            System.out.println(display);
    }
    public static void main(String args[])
    {
            InheritInterface obj = new InheritInterface();
            obj.getdata("Welcome TO Heaven");
            obj.setdata();
    }
}
```

Output:

Welcome TO Heaven

- The interface **B** has one method, but it **inherits** one from interface **A**; thus, a class **InheritInterface** that implements **B** needs to implement **two methods**.

Multiple Inheritance using Interface

- If a **class** implements **multiple interfaces**, or an **interface** extends **multiple interfaces** known as **multiple inheritance**.

- A java **class** can only extend **one parent class**. Multiple inheritances are not allowed. However, an **interface** can extend **more than one parent interface**.
- The **extends** keyword is used once, and the **parent interfaces** are declared in a **comma-separated list.**

Example:

```
public interface  A
{
    void  getdata(String name);
}
public  interface  B    /* Here we can also extends multiple interface like  interface B extends A,C*/
{
    void  setdata();
}
class  InheritInterface  implements A, B
{
    String  display;
    public  void getdata(String  name)
    {
            display = name;
    }
    public  void setdata()
    {
            System.out.println(display);
    }
    public  static  void  main(String args[])
    {
            InheritInterface obj = new  InheritInterface();
            obj.getdata("Welcome TO Heaven");
            obj.setdata();
        }
    }
```

Output:

Welcome TO Heaven

Abstract Class

- A **class** that is declared with **abstract** keyword, is known as an **abstract class** in java. It can have **abstract** and **non-abstract methods** (method with body).
- It needs to be **extended** and its method implemented. It cannot be instantiated means we can't create object of it.
- Any class that extends an **abstract** class must implement all the **abstract methods** declared by the super class.

Syntax:

```
abstract classclass_name
{
```

```
        //Number of abstract as well as non-abstract methods.
    }
```

- A **method** that is declared as **abstract** and does not have implementation is known as **abstract method.**
- The method body will be defined by its **subclass**. Abstract method can never be **final** and **static**.

Syntax:

```
abstract return_typefunction_name ();        // No definition
```

Example:

```
abstract class A
{
    abstract void abs_method();
    public void display()
    {
        System.out.println("This is concrete method..");
    }
}
class DemoAbstract extends A
{
    void abs_method()
    {
        System.out.println("This is an abstract method..");
    }
    public static void main(String[] args)
    {
        DemoAbstract abs = new DemoAbstract();
        abs.abs_method();
        abs.display();
    }
}
```

Output:

```
This is an abstract method..
This is concrete method..
```

Final Keyword

- The **final keyword** in java is used to restrict the user. The java final keyword can be used with:
    1) variable
    2) method
    3) class
- **Final Variable:** If you make any variable as **final**, you cannot change the value of that final variable (It will be constant).
    - A variable that is declared as **final** and **not initialized** is called a **blank final** variable. A blank final variable forces the **constructors to initialize it**.
- **Final Method:** Methods declared as **final** cannot be **overridden**.
- **Final Class:** Java classes declared as final cannot be extended means cannot **inherit**.
- If you declare any parameter as **final**, you cannot change the value of it.

Example:

```
class  DemoBase
{
    final  inti = 1;              //final variable must be initialize.
    final  void  display()
    {
            System.out.println("Value of i is :: "+ i);
    }
}
class  DemoFinal  extends  DemoBase
{
    /*void display()        // Compilation error final method cannot override.
    {
            System.out.println("Value of i is :: "+ i);
    }*/
    public  static  void  main(String args[])
    {
            DemoFinal  obj = new  DemoFinal();
            obj.display();
    }
}
```

Output:

Value of iis :: 1

Difference between Method Overloading and overriding

Overriding	Overloading
• The **argument list** must exactly match that of the overridden method.	• Overloaded methods MUST change the **argument list**.
• The **return type** must be the same as overridden method in the super class.	• Overloaded methods CAN change the **return type**.
• **Private** and **final** methods cannot be overridden.	• **Private** and **final** methods can be overloaded.
• Method overriding occurs in two classes that have inheritance.	• Method overloading is performed within class.
• **Dynamic binding**is being used for overridden methods.	• **Static binding** is being used for overloaded methods.
• Method overriding is the example of **run time polymorphism**.	• Method overloading is the example of **compile time polymorphism**.

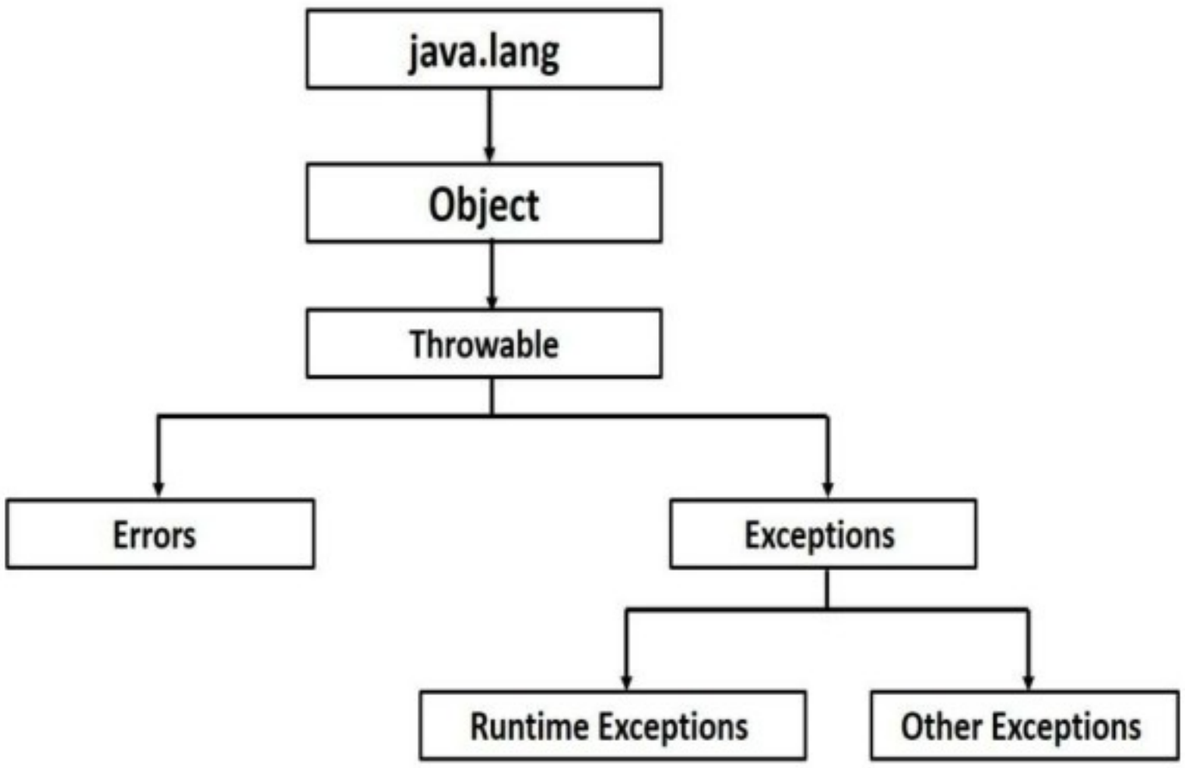
Difference between Interface and Abstract class

Interface	Abstract class
• Interface can have **only abstract** methods.	• Abstract class can **have abstract and non-abstract** methods.
• Interface **supports multiple inheritance**.	• Abstract class **doesn't support multiple inheritance**.

• Interface **can't have static methods, main method or constructor**.	• Abstract class **can have static methods, main method and constructor**.
• In interface all method should be define in a class in which we implement them.	• This is not applicable for abstract classes.
• Interface **can't provide the implementation of abstract class**.	• Abstract class **can provide the implementation of interface**.

Exceptions Handling

- An exception (or exceptional event) is a problem that arises during the **execution** of a program. When an Exception occurs the normal flow of the program is **disrupted** and the program/Application terminates abnormally, therefore these exceptions are needs to be handled.
- A **Java Exception** is an **object** that describes the exception that occurs in a program. When an **exceptional event** occurs in java, an **exception** is said to be **thrown**.
- An exception can occur for many different reasons, some of them are as given below:
  - A user has entered **invalid** data.
  - A **file** that needs to be **opened** cannot be found.
  - A **network connection** has been lost in the middle of communications, or the **JVM** has run out of memory.
- Exceptions are caused by users, programmers or when some physical resources get failed.
- The **Exception Handling** in java is one of the powerful mechanisms to handle the exception (runtime errors), so that **normal flow** of the application can be maintained.
- In Java there are **three categories** of Exceptions:
  1) **Checked exceptions:** A checked exception is an exception that occurs at **the compile time**, these are also called as **compile time exceptions**. Example, **IOException, SQLException** etc.
  2) **Runtime exceptions:** An Unchecked exception is an exception that occurs during the execution, these are also called as **Runtime Exceptions**. These include programming bugs, such as **logic errors or improper use of an API**.
     - Runtime exceptions are **ignored** at the time of compilation.
     - **Example :** ArithmeticException, NullPointerException, Array Index out of Bound exception.
  3) **Errors:** These are not exceptions at all, but problems that arise beyond the control of **the user or the programmer**. **Example:** OutOfMemoryError, VirtualMachineErrorException.
- All exception classes are subtypes of the **java.lang.Exception** class. The exception class is a subclass of the **Throwable** class. Other than the exception class there is another subclass called **Error** which is derived from the **Throwable** class.



- **Errors** are not normally trapped form the Java programs. These conditions normally happen in case of **severe** failures, which are not handled by the java programs. Errors are generated to indicate errors generated by **the runtime environment**. **Example**: **JVM** is out of Memory. Normally programs cannot recover from errors.
- The Exception class has two main subclasses: **IOException** class and **RuntimeException** class.

Exception Handling Mechanism

- Exception handling is done using five keywords:
  1) try
  2) catch
  3) finally
  4) throw
  5) throws

Using try and catch

1) try block :

- Java try block is used to enclose the code that **might throw an exception**. It must be used within the **method**.
- Java try block must be followed by **either catch or finally block**.

2) catch block:

- Java catch block is used to **handle** the Exception. It must be used **after the try block only**.
- The catch block that follows the **try is checked**, if the type of exception that occurred is listed in the **catch block** then the exception is handed over to the catch block that handles it.
- You can use **multiple catch block with a single try**.

Syntax:

```
try
{
        //Protected code
}
catch(ExceptionName1  e1)
{
        //Catch block 1
}
catch(ExceptionName2  e2)
{
        //Catch block 2
}
```

- In above syntax, there are two catch blocks. In try block, we write code that might generate exception. If the exception generated by protected code then exception thrown to the **first catch block**.
- If the data type of the exception thrown matches **ExceptionName1**, it gets caught there and **execute** the catch block.
- If not, the exception passes down to the **second catch block**.
- This continues **until** the exception either **is caught or falls through all catches**, in that case the current method stops execution.

Example:

```
class  demoTry
{
        public static void main(String[]  args)
        {
                try
                {
                        int arr[]={1,2,3};
                        arr[3]=3/0;
                }
                catch(ArithmeticException  ae)
                {
                        System.out.println("Divide by zero  :: " + ae);
                }
                catch(ArrayIndexOutOfBoundsException  e)
                {
                        System.out.println("Array index out of bound exception  :: "+e);
                }
        }
}
```

Output:

divide by zero :: java.lang.ArithmeticException: / by zero

Nested Try-Catch Blocks

- In java, the **try block** within a **try block** is known as **nested try block**.
- Nested try block is used when a **part of a block** may cause **one error** while **entire block** may cause **another error**.
- In that case, if **inner try block** does not have a **catch** handler for a particular **exception** then the **outer try** is checked for **match**.
- This continues until one of the catch statements succeeds, or until the entire nested try statements are done in. If no one catch statements match, then the Java run-time system will handle the exception.

Syntax:

```
try
{
        Statement 1;
        try
        {
                //Protected code
        }
        catch(ExceptionName  e1)
        {
                //Catch block1
        }
}
catch(ExceptionName1  e2)
```

```
{
        //Catch block 2
}
```

Example:

```
class demoTry1
{
        public static void main(String[]  args)
        {
                try
                {
                        int  arr[]={5,0,1,2};
                        try
                        {
                                arr[4] = arr[3]/arr[1];
                        }
                        catch(ArithmeticException e)
                        {
                                System.out.println("divide by zero :: "+e);
                        }
                }
                catch(ArrayIndexOutOfBoundsException e)
                {
                        System.out.println("array index out of bound exception :: "+e);
                }
                catch(Exception e)
                {
                        System.out.println("Generic exception :: "+e);
                }
                System.out.println("Out of try..catch block");
        }
}
```

Output:

```
divide by zero :: java.lang.ArithmeticException: / by zero
Out of try..catch block
```

3) finally:

- A **finally** keyword is used to create a block of code that **follows a try or catch** block.
- A **finally block** of code always executes **whether or not exception has occurred**.
- A **finally** block appears at the **end of catch** block.

Syntax:

```
try
{
        //Protected code
}
catch(ExceptionType1  e1)
{
        //Catch block 1
```

```
}
catch(ExceptionType2 e2)
{
        //Catch block 2
}
finally
{
        //The finally block always executes.
}
```

Example:

```
class  demoFinally
{
        public static void main(String args[])
        {
                int  a[] = new int[2];
                try
                {
                        System.out.println("Access element three :" + a[3]);
                }
                catch(ArrayIndexOutOfBoundsException e)
                {
                        System.out.println("Exception thrown  :" + e);
                }
                finally
                {
                        a[0] = 10;
                        System.out.println("First element value: " +a[0]);
                        System.out.println("The finally block is always executed");
                }
                System.out.println("Out of try...catch...finally... ");
}
```

Output:

```
Exception thrown  :java.lang.ArrayIndexOutOfBoundsException: 3
First element value: 10
The finally block is always executed
Out of try...catch...finally...
```

Key points to keep in mind:

- A **catch** clause cannot exist **without a try** statement.
- It is not compulsory to have **finally** clause for every try/catch.
- The **try** block cannot be present without either **catch** clause or **finally** clause.
- **Any code** cannot be present in between the **try, catch, finally blocks**.

4) **throw :**
   - The **throw** keyword is used to **explicitly** throw an exception.
   - We can throw either **checked** or **uncheked** exception using **throw** keyword.
   - Only object of **Throwable** class or its **sub classes** can be **thrown**.
   - Program **execution stops** on encountering throw statement, and the **closest catch** statement is checked for matching type of **exception**.

Syntax:

throw **ThrowableInstance;**

Example:

```
class demoThrow
{
        static void demo()
        {
                try
                {
                        throw new ArithmeticException("demo");
                }
                catch(ArithmeticException  e)
                {
                        System.out.println("Exception caught");
                }
        }
        public static void main(String args[])
        {
                demo();
        }
}
```

Output:

Exception caught

5) **throws:**
   - The throws keyword is used to **declare an exception**.
   - If a method does not handle a **checked** exception, the method must declare it using the **throws** keyword. The **throws** keyword appears **at the end of a method's signature**.
   - You can declare **multiple exceptions**.

Syntax:

```
return_type  method_name() throws exception_class_name_list
{
        //method code
}
```

Example:

```
class  demoThrows
{
        static void display() throws ArithmeticException
        {
                System.out.println("Inside check function");
```

```
                throw new ArithmeticException("Demo");
        }
        public static void main(String args[])
        {
                try
                {
                        display();
                }
                catch(ArithmeticException e)
                {
                        System.out.println("caught :: " + e);
                }
        }
}
```

Output:

```
Inside check function
caught :: java.lang.ArithmeticException: Demo
```

User Defined Exception

- In java, we can create our own exception that is known as **custom exception or user-defined exception**.
- We can have our own exception and message.

Key points to keep in mind:

- All exceptions must be a child of **Throwable**.
- If you want to write a **checked** exception that is automatically enforced by the Declare Rule, you need to extend the **Exception** class.
- If you want to write a **runtime exception**, you need to extend the **RuntimeException** class.

Example:

```
class demoUserException extends Exception
{
        private int ex;
        demoUserException(int a)
        {
                ex=a;
        }
        public String toString()
        {
                return "MyException[" + ex +"] is less than zero";
        }
}
class demoException
{
        static void sum(int a,int b) throws demoUserException
        {
                if(a<0)
```

```
        {
                throw new demoUserException (a);
        }
        else
        {
                System.out.println(a+b);
        }
}
public static void main(String[] args)
{
        try
        {
                sum(-10, 10);
        }
        catch(demoUserException e)
        {
                System.out.println(e);
        }
    }
}
```

Output:

MyException[-10] is less than zero

List of Java Exception (Built-In Exception)

- Java defines several built-in exception classes inside the standard package **java.lang.**

Checked Exception:

Exception	Description
ClassNotFoundException	This Exception occurs when Java run-time system fail to find the specified class mentioned in the program.
IllegalAccessException	This Exception occurs when you create an object of an abstract class and interface.
NotSuchMethodException	This Exception occurs when the method you call does not exist in class.
NoSuchFieldException	A requested field does not exist.

Unchecked Exception:

Exception	Description
ArithmeticException	This Exception occurs, when you divide a number by zero causes an Arithmetic Exception.
ArrayIndexOutOfBounds Exception	This Exception occurs, when you assign an array which is not compatible with the data type of that array.
NumberFormatException	This Exception occurs, when you try to convert a string variable in an incorrect format to integer (numeric format) that is not

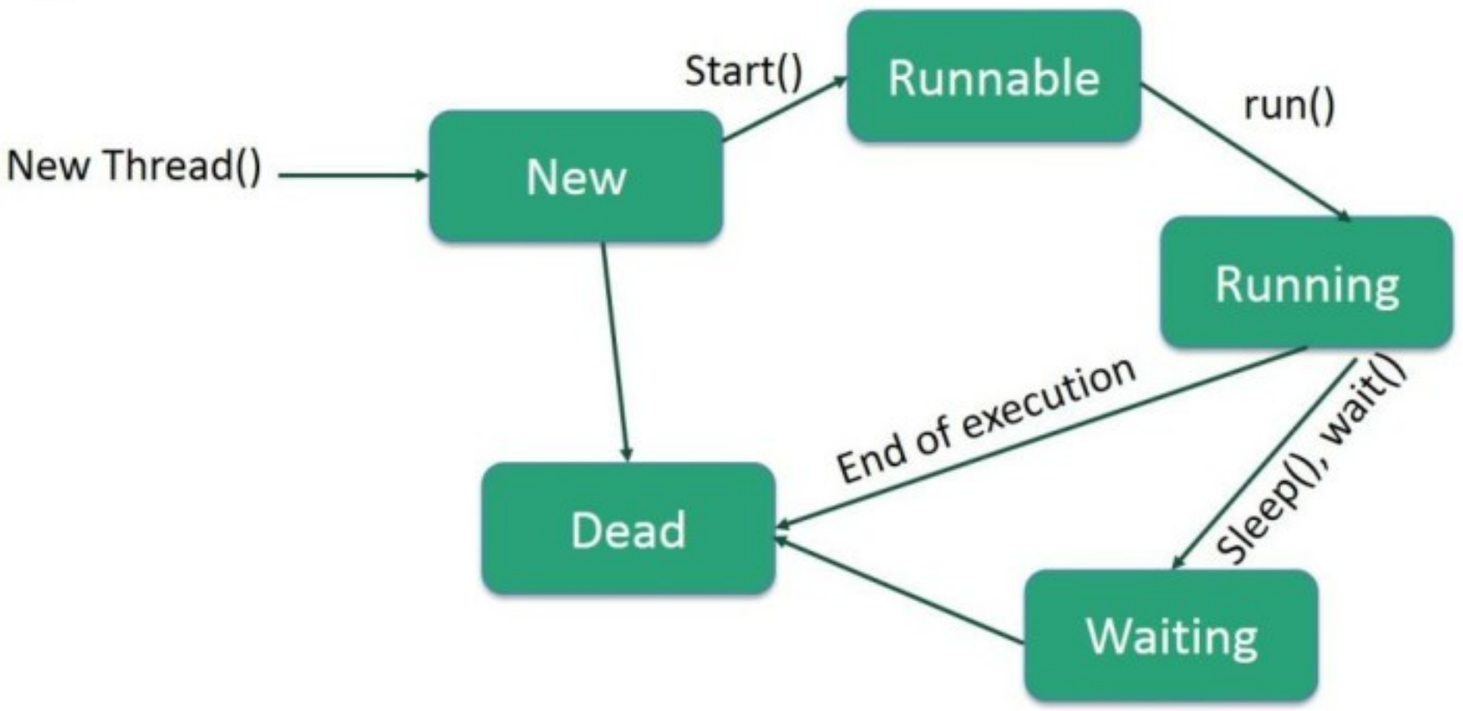
	compatible with each other.
ClassCastException	Invalid cast.
NullPointerException	Invalid use of a null reference.

Multithreading

- Java is a **multithreaded** programming language which means we can develop multi threaded program using Java.
- **Multithreaded** programs contain **two or more threads** that can run concurrently. This means that a single program can perform two or more tasks simultaneously.
- Thread is basically a **lightweight sub-process**, a smallest unit of processing.
- Multiprocessing and multithreading, both are used to **achieve multitasking**.
- But we use **multithreading** than **multiprocessing** because threads share a **common memory area**. They don't allocate separate memory area which saves memory, and context-switching between the threads **takes less time than process**.
- Threads are **independent.** So, it doesn't affect other threads if **exception occurs** in a single thread.
- Java Multithreading is mostly used in games, animation etc.
- For example, **one thread** is writing content on a file at the same time **another thread** is performing spelling check.
- In **Multiprocessing**, Each process has its own address in memory. So, each process allocates separate memory area.
- Switching from one process to another require some time for saving and loading registers, memory maps, updating lists etc. So that cost of communication between **the processes is high**.
- **Disadvantage:** If you create too many threads, you can actually **degrade the performance** of your program rather than **enhance** it.
- Remember, some overhead is associated with **context switching**. If you create too many threads, more **CPU time** will be spent changing contexts than executing your program.

Life Cycle of Thread

- A thread goes through various stages in its life cycle. **For example**, a thread is **born**, **started**, **runs**, and then **dies**.
- **Diagram:**



- **New:**
  - A new thread begins its life cycle in the **New** state. It remains in this state until the program **starts the thread** by invoking **Start()** method. It is also referred to as a **born** thread.
- **Runnable:**
  - The thread is in **runnable** state after invocation of **start()** method, but the thread **scheduler** has not selected it to be **the running thread**.
  - The thread is in **running** state if the **thread scheduler** has selected it.
- **Waiting:**
  - Sometimes a **thread transitions** to the waiting state while the thread waits for another thread to perform a task. A thread transitions back to the runnable state only when another thread **signals** the waiting thread to continue executing.
- **Timed waiting:**
  - A runnable thread can enter the **timed waiting** state for a **specified interval of time**. A thread in this state transition back to the runnable state when that **time interval expires** or when the event it is waiting for occurs.
- **Terminated:**
  - A **runnable** thread enters the **terminated** state when it (**run() method exits**) completes its task.

Thread Priorities

- Every Java thread has a **priority** that helps the operating system determine the **order in which threads are scheduled**.
- Java priorities are in the range between **MIN_PRIORITY** (a constant of 1) and **MAX_PRIORITY** (a constant of 10).
- By default, every thread is given priority **NORM_PRIORITY** (a constant of 5).
- Threads with **higher** priority are more important to a program and should be allocated **processor time** before **lower**-priority threads.
- The thread scheduler mainly uses **preemptive** or **time slicing** scheduling to schedule the threads.

Creating a Thread

- **Thread class** provide **constructors** and **methods** to create and perform operations on a thread.

1) Constructor of Thread class:

- Thread ()
- Thread (String name)
- Thread (Runnable r)
- Thread (Runnable r, String name)

2) Methods of Thread Class:

Method	Description
public void **run**()	Entry point for a thread
public void **start**()	Start a thread by calling run() method.
public String **getName**()	Return thread's name.
public void **setName**(String **name**)	To give thread a name.

public int **getPriority**()	Return thread's priority.
public int **setPriority**(int **priority**)	Sets the priority of this Thread object. The possible values are between 1 and 10.
public final boolean **isAlive**()	Checks whether thread is still running or not.
public static void **sleep**(long **millisec**)	Suspend thread for a specified time.
public final void **join**(long **millisec**)	Wait for a thread to end.

- Java defines two ways by which a thread can be created.
  - By implementing the **Runnable** interface.
  - By extending the **Thread** class.

1) By implementing the Runnable interface:

- The easiest way to create a thread is to create a **class that implements the runnable interface**.
- After implementing runnable interface, the class needs to implement the **run()** method, which has following form:

public void run( )

- This method provides **entry point** for the thread and you will put you complete **business logic** inside this method.
- After that, you will instantiate a **Thread object** using the following constructor:

Thread (Runnable threadObj**, String** threadName**) ;**

- Where, **threadObj** is an instance of a class that implements the **Runnable** interface and **threadName** is the **name** given to the **new thread**.
- Once **Thread object** is created, you can start it by calling **start( )** method, which executes a call to **run( )** method.

void start ( );

Example:

```
class demoThread3 implements Runnable
{
        public void run()
        {
                System.out.println("Thread is running...");
        }
        public static void main(String args[])
        {
                demoThread3 d1=new demoThread3 ();
                Thread t1 =new Thread(d1);
                t1.start();
        }
}
```

Output:

```
Thread is running...
```

Example:

```
class RunnableDemo implements Runnable
{
        Thread t;
        String threadName;
        RunnableDemo( String name)
        {
                threadName = name;
                System.out.println("Creating " +  threadName );
        }
        public void run()
        {
                System.out.println("Running " +  threadName );
                try
                {
                        for(int i = 2; i >= 0; i--)
                        {
                                System.out.println("Thread: " + threadName + ", " + i);
                                // Let the thread sleep for a while.
                                Thread.sleep(1000);
                        }
                }
                catch (InterruptedException e)
                {
                        System.out.println("Thread " +  threadName + " interrupted.");
                }
                System.out.println("Thread " +  threadName + " exiting.");
        }
        public void start ()
        {
                System.out.println("Starting " +  threadName );
                if (t == null)
                {
                        t = new Thread (this, threadName);
                        t.start ();
                }
        }

}
public class ThreadDemo
{
        public static void main(String args[])
        {
                RunnableDemo R1 = new RunnableDemo( "Thread-1");
                R1.start();
        }
}
```

Output:

```
Creating Thread-1
Starting Thread-1
Running Thread-1
Thread: Thread-1, 2
Thread: Thread-1, 1
Thread: Thread-1, 0
Thread Thread-1 exiting.
```

2) By extending the Thread class.

- Second way to create a thread is to **create a new class** that extends **Thread** class and then create an instance of that class.
- The extending class must override the **run( )** method, which is the entry point for the new thread.
- Once **Thread object** is created, you can start it by calling **start( )** method, which executes a call to **run( )** method.

Example:

```
class demoThread2 extends Thread
{
        public void run()
        {
                System.out.println("Thread is running...");
        }
        public static void main(String args[])
        {
                demoThread2  t1 = new demoThread2();
                t1.start();
        }
}
```

Output:

```
Thread is running...
```

Example:

```
class ThreadDemo extends Thread
{
        Thread t;
        String threadName;
        ThreadDemo( String name)
        {
                threadName = name;
                System.out.println("Creating " +  threadName );
        }
        public void run()
```

```
{
        System.out.println("Running " +  threadName );
        try
        {
                for(int i = 2; i >= 0; i--)
                {
                        System.out.println("Thread: " + threadName + ", " + i);
                        // Let the thread sleep for a while.
                        Thread.sleep(1000);
                }
        }
        catch (InterruptedException e)
        {
                System.out.println("Thread " +  threadName + " interrupted.");
                }
                System.out.println("Thread " +  threadName + " exiting.");
        }
        public void start ()
        {
                System.out.println("Starting " +  threadName );
                if (t == null)
                {
                        t = new Thread (this, threadName);
                        t.start ();
                }
        }
}
public class ThreadDemo2
{
        public static void main(String args[])
        {
                ThreadDemo T1 = new ThreadDemo( "Thread-1");
                T1.start();
        }
}
```

Output:

```
Creating Thread-1
Starting Thread-1
Running Thread-1
Thread: Thread-1, 2
Thread: Thread-1, 1
```

Thread: Thread-1, 0
Thread Thread-1 exiting.

Thread Synchronization

- When two or more threads need access to a **shared** resource, they need some way to ensure that the resource will be used by **only one thread at a time**.
- The process by which this synchronization achieved is called **thread synchronization**.
- The **synchronized** keyword in Java creates a block of code referred to as **a critical section**.
- Every Java object with a critical section of code gets a **lock associated with the object**.
- To enter **a critical section**, a thread needs to obtain the corresponding object's lock.

Syntax:

```
synchronized(object)
{
        // statements to be synchronized
}
```

  - Here, **object** is a reference to the object being **synchronized**.
  - A synchronized block ensures that a call to a method that is a member of **object** occurs only after the current thread has successfully entered object's critical section.

Example:

```
class PrintDemo
{
        public void printCount()
        {
                try
                {
                        for(int i = 3; i > 0; i--)
                        {
                                System.out.println("Counter   ---   "  + i );
                        }
                }
                catch (Exception e)
                {
                        System.out.println("Thread  interrupted.");
                }
        }
}
class ThreadDemo extends Thread
{
        Thread t;
        String threadName;
        PrintDemo  PD;

        ThreadDemo( String name,  PrintDemo pd)
        {
                threadName = name;
```

```
            PD = pd;
    }
    public void run()
    {
            synchronized(PD)
            {
                    PD.printCount();
            }
            System.out.println("Thread " +  threadName + " exiting.");
    }
    public void start ()
    {
            System.out.println("Starting " +  threadName );
            if (t == null)
            {
                    t = new Thread (this, threadName);
                    t.start ();
                }
        }
}
public class ThreadSchro
{
        public static void main(String args[])
        {
                PrintDemo PD = new PrintDemo();
                ThreadDemo T1 = new ThreadDemo( "Thread - 1 ", PD );
                ThreadDemo T2 = new ThreadDemo( "Thread - 2 ", PD );

                T1.start();
                T2.start();
        }
}
```

Output:

```
Starting Thread - 1
Starting Thread - 2
Counter   ---   3
Counter   ---   2
Counter   ---   1
Thread Thread - 1  exiting.
Counter   ---   3
Counter   ---   2
Counter   ---   1
Thread Thread - 2  exiting.
```

Inter-thread Communication

- **Inter-thread communication or Co-operation** is all about allowing **synchronized threads** to communicate with each other.
- Inter-thread communication is a mechanism in which a **thread is paused running in its critical section** and another thread is allowed to enter (or lock) in the same critical section to be executed.
- To avoid **polling**(It is usually implemented by loop), **Inter-thread communication** is implemented by following methods of **Object class**:
  - **wait( ):** This method tells the calling thread to give up the **critical section** and go to **sleep** until some other thread enters the same **critical section** and calls notify( ).
  - **notify( ):** This method **wakes up** the first thread that called **wait**( ) on the **same object**.
  - **notifyAll( ):** This method **wakes up** all the threads that called **wait**( ) on the **same object**. The highest priority thread will run first.
- Above all methods are implemented as **final** in Object class.
- All three methods can be called only from **within a synchronized context**.

Example:

```
class Customer
{
        int amount=10000;
        synchronized void withdraw(int amount)
        {
                System.out.println("going to withdraw...");

                if(this.amount<amount)
                {
                        System.out.println("Less balance; waiting for deposit...");
                        try
                        {
                                wait();
                        }
                        catch(Exception e){}
                }
                this.amount-=amount;
                System.out.println("withdraw completed...");
        }
        synchronized void deposit(int amount)
        {
                System.out.println("going to deposit...");
                this.amount+=amount;
                System.out.println("deposit completed... ");
                notify();
        }
}
class InterThreadDemo
{
        public static void main(String args[])
```

```
        {
                final Customer c = new Customer();
                new Thread()
                {
                        public void run(){c.withdraw(15000); }
                }.start();
                new Thread()
                {
                        public void run(){c.deposit(10000);}
                }.start();
        }
    }
```

Output:

```
going to withdraw...
Less balance; waiting for deposit...
going to deposit...
deposit completed...
withdraw completed...
```