



# INSTITUTE OF AERONAUTICAL ENGINEERING (Autonomus)

DUNDIGAL, HYDERABAD – 500 043

## Electronics and Communication Engineering

Course Title	JAVA PROGRAMMING	
Course Code	ACS552	
Programme	B.Tech	
Semester	VI	ECE
Course Type	Elective	
Regulation	IARE - R16	
Chief Coordinator	Mr. G Chandra Sekhar, Assistant Professor	
Course Faculty	Mr. G Chandra Sekhar, Assistant Professor	
Lecture Numbers	1-60	
Topic Covered	All	

### I. COURSE OBJECTIVES:

The course should enable the students to:	
I	Understand fundamentals of object-oriented terminology and programming concepts in java.
II	Acquire basics of how to translate solution problem into object oriented form.
III	Develop programs in java for solving simple applications.
IV	Design and implement simple program that use exceptions and multithreads.

### II. COURSE OUTCOMES (COs):

The course should enable the students to:	
I	Learn the concept of object oriented programming that helps to organize complex programs
II	Understand the appropriate roles of subtyping and inheritance, and use them effectively.
III	Demonstrate an ability to design high speed, fault tolerant applications using multi-threading and exception handling concepts.
IV	Design and develop the java applications by using concepts of interfaces and packages.
V	Experiment with the usage of files and database connectivity, to familiarize the advanced java programming skills and develop java based web applications.

### III. SYLLABUS:

<b>UNIT-I</b>	<b>OOPS CONCEPTS AND JAVA PROGRAMMING</b>
OOP concepts: Classes and objects, data abstraction, encapsulation, inheritance, benefits of inheritance, polymorphism, constructors, methods, data types, variables, constants, scope and life time of variables, operators, operator hierarchy, expressions, type conversion and casting, enumerated types, control flow statements, arrays, parameter passing.	
<b>UNIT-II</b>	<b>INHERITANCE</b>
Inheritance: Inheritance hierarchies, super and subclasses, member access rules, Polymorphism: Dynamic binding, method overriding, abstract classes and methods	
<b>UNIT-III</b>	<b>EXCEPTION HANDLING AND MULTITHREADING</b>
Exception Handling: Benefits of exception handling, the classification of exceptions, usage of try, catch, throw, throws and finally.	
Multithreading: Differences between multiple processes and multiple threads, thread states, creating threads, interrupting threads.	
<b>UNIT-IV</b>	<b>INTERFACES AND PACKAGES</b>
Interface: Interfaces vs Abstract classes, defining an interface, implement interfaces, Packages: Defining, creating and accessing a package, importing packages.	
<b>UNIT-V</b>	<b>FILES AND CONNECTING TO DATABASE</b>
Files: streams – byte streams, character stream, text input/output, binary input/output, file management; Connecting to Database: Connecting to a database, querying a database and processing the results, updating data with JDBC.	
<b>Text Books:</b>	
<ol style="list-style-type: none"><li>1. Herbert Schildt and Dale Skrien, “Java Fundamentals – A comprehensive Introduction”, McGraw Hill, 1<sup>st</sup> Edition, 2013.</li><li>2. Herbert Schildt, “Java the Complete Reference”, McGraw Hill, Osborne, 7<sup>th</sup> Edition, 2011.</li><li>3. T.Budd, “Understanding Object- Oriented Programming with Java”, Pearson Education, Updated Edition (New Java 2 Coverage), 1999.</li></ol>	
<b>Reference Books:</b>	
<ol style="list-style-type: none"><li>1. P.J.Dietel and H.M.Dietel , “Java How to program”, Prentice Hall, 6<sup>th</sup> Edition, 2005.</li><li>2. P.Radha Krishna , “Object Oriented Programming through Java”, CRC Press, 1<sup>st</sup> Edition, 2007.</li><li>3. S.Malhotra and S. Choudhary, “ Programming in Java”, Oxford University Press, 2<sup>nd</sup> Edition, 2014.</li></ol>	

## UNIT- I

### INTRODUCTION

**UNIT – I: OOP concepts: Classes and objects, data abstraction, encapsulation, inheritance, benefits of inheritance, polymorphism, constructors, methods, data types, variables, constants, scope and life time of variables, operators, operator hierarchy, expressions, type conversion and casting, enumerated types, control flow statements, arrays, parameter passing.**

Everywhere you look in the real world you see objects—people, animals, plants, cars, planes, buildings, computers and so on. Humans think in terms of objects. Telephones, houses, traffic lights, microwave ovens and water coolers are just a few more objects. Computer programs, such as the Java programs you’ll read in this book and the ones you’ll write, are composed of lots of interacting software objects.

We sometimes divide objects into two categories: animate and inanimate. Animate objects are “alive” in some sense—they move around and do things. Inanimate objects, on the other hand, do not move on their own. Objects of both types, however, have some things in common. They all have attributes (e.g., size, shape, color and weight), and they all exhibit behaviors (e.g., a ball rolls, bounces, inflates and deflates; a baby cries, sleep crawls, walks and blinks; a car accelerates, brakes and turns; a towel absorbs water). We will study the kinds of attributes and behaviors that software objects have. Humans learn about existing objects by studying their attributes and observing their behaviors. Different objects can have similar attributes and can exhibit similar behaviors. Comparisons can be made, for example, between babies and adults and between humans and chimpanzees. Object-oriented design provides a natural and intuitive way to view the software design process—namely, modeling objects by their attributes and behaviors just as we describe real-world objects. OOD also models communication between objects. Just as people send messages to one another (e.g., a sergeant commands a soldier to stand at attention), objects also communicate via messages. A bank account object may receive a message to decrease its balance by a certain amount because the customer has withdrawn that amount of money.

#### **Object-Oriented:**

Although influenced by its predecessors, Java was not designed to be source-code compatible with any other language. This allowed the Java team the freedom to design with a blank slate. One outcome of this was a clean, usable, pragmatic approach to objects. Borrowing liberally from many seminal object-software environments of the last few decades, Java manages to strike a balance between the purist’s “everything is an object” paradigm and the pragmatist’s “stay out of my way” model. The object model in Java is simple and easy to extend, while simple types, such as integers, are kept as high-performance nonobjects.

OOD encapsulates (i.e., wraps) attributes and operations (behaviors) into objects, an object’s attributes and operations are intimately tied together. Objects have the property of information hiding. This means that objects may know how to communicate with one another across well-defined interfaces, but normally they are not allowed to know how other objects are implemented, implementation details are hidden within the objects themselves. We can

drive a car effectively, for instance, without knowing the details of how engines, transmissions, brakes and exhaust systems work internally—as long as we know how to use the accelerator pedal, the brake pedal, the wheel and so on. Information hiding, as we will see, is crucial to good software engineering.

Languages like Java are object oriented. Programming in such a language is called object-oriented programming (OOP), and it allows computer programmers to implement an object-oriented design as a working system. Languages like C, on the other hand, are procedural, so programming tends to be action oriented. In C, the unit of programming is the function. Groups of actions that perform some common task are formed into functions, and functions are grouped to form programs. In Java, the unit of programming is the class from which objects are eventually instantiated (created). Java classes contain methods (which implement operations and are similar to functions in C) as well as fields (which implement attributes).

Java programmers concentrate on creating classes. Each class contains fields, and the set of methods that manipulate the fields and provide services to clients (i.e., other classes that use the class). The programmer uses existing classes as the building blocks for constructing new classes. Classes are to objects as blueprints are to houses. Just as we can build many houses from one blueprint, we can instantiate (create) many objects from one class.

Classes can have relationships with other classes. For example, in an object-oriented design of a bank, the “bank teller” class needs to relate to the “customer” class, the “cash drawer” class, the “safe” class, and so on. These relationships are called associations.

Packaging software as classes makes it possible for future software systems to reuse the classes. Groups of related classes are often packaged as reusable components. Just as realtors often say that the three most important factors affecting the price of real estate are “location, location and location,” people in the software community often say that the three most important factors affecting the future of software development are “reuse, reuse and reuse.” Reuse of existing classes when building new classes and programs saves time and effort. Reuse also helps programmers build more reliable and effective systems, because existing classes and components often have gone through extensive testing, debugging and performance tuning.

Indeed, with object technology, you can build much of the software you will need by combining classes, just as automobile manufacturers combine interchangeable parts. Each new class you create will have the potential to become a valuable software asset that you and other programmers can use to speed and enhance the quality of future software development efforts.

## **NEED FOR OOP PARADIGM:**

### **Object-Oriented Programming:**

Object-oriented programming is at the core of Java. In fact, all Java programs are object-oriented—this isn’t an option the way that it is in C++, for example. OOP is so integral to Java. Therefore, this chapter begins with a discussion of the theoretical aspects of OOP.

## Two Paradigms of Programming:

As you know, all computer programs consist of two elements: code and data. Furthermore, a program can be conceptually organized around its code or around its data. That is, some programs are written around “what is happening” and others are written around “who is being affected.” These are the two paradigms that govern how a program is constructed.

The first way is called the process-oriented model. This approach characterizes a program as a series of linear steps (that is, code). The process-oriented model can be thought of as code acting on data. Procedural languages such as C employ this model to considerable success. Problems with this approach appear as programs grow larger and more complex. To manage increasing complexity, the second approach, called object-oriented programming, was conceived.

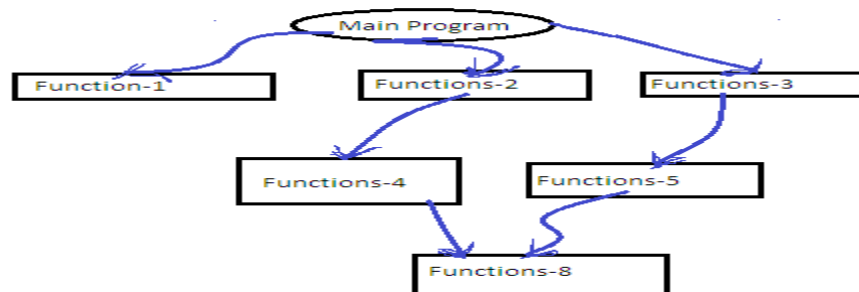
Object-oriented programming organizes a program around its data (that is, objects) and a set of well-defined interfaces to that data. An object-oriented program can be characterized as data controlling access to code. As you will see, by switching the controlling entity to data, you can achieve several organizational benefits.

## Procedure oriented Programming:

In this approach, the problem is always considered as a sequence of tasks to be done. A number of functions are written to accomplish these tasks. Here primary focus on “Functions” and little attention on data.

There are many high level languages like COBOL, FORTRAN, PASCAL, C used for conventional programming commonly known as POP.

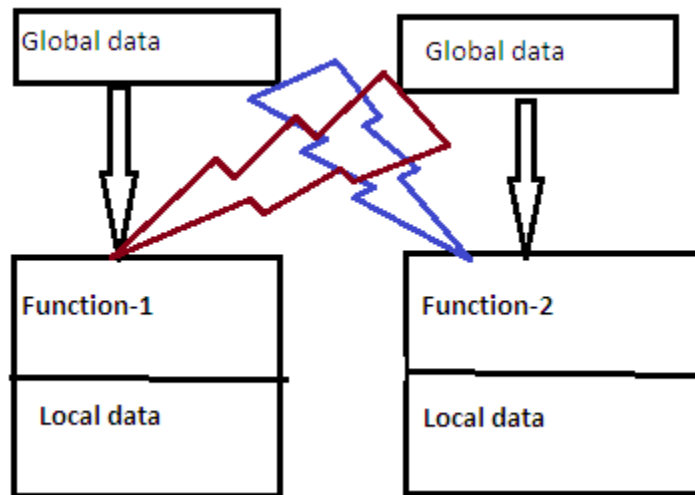
POP basically consists of writing a list of instructions for the computer to follow, and organizing these instructions into groups known as functions.



Normally a flowchart is used to organize these actions and represent the flow of control logically sequential flow from one to another. In a multi-function program, many important data items are placed as global so that they may be accessed by all the functions. Each function may have its own local data. Global data are more vulnerable to an in advert change by a function. In a large program it is very difficult to identify what data is used by which function. In case we need to

revise an external data structure, we should also revise all the functions that access the data. This provides an opportunity for bugs to creep in.

Drawback: It does not model real world problems very well, because functions are action oriented and do not really corresponding to the elements of the problem.



### Characteristics of POP:

- Emphasis is on doing actions.
- Large programs are divided into smaller programs known as functions.
- Most of the functions shared global data.
- Data move openly around the program from function to function.
- Functions transform data from one form to another.
- Employs top-down approach in program design.

### OOP:

OOP allows us to decompose a problem into a number of entities called objects and then builds data and methods around these entities.

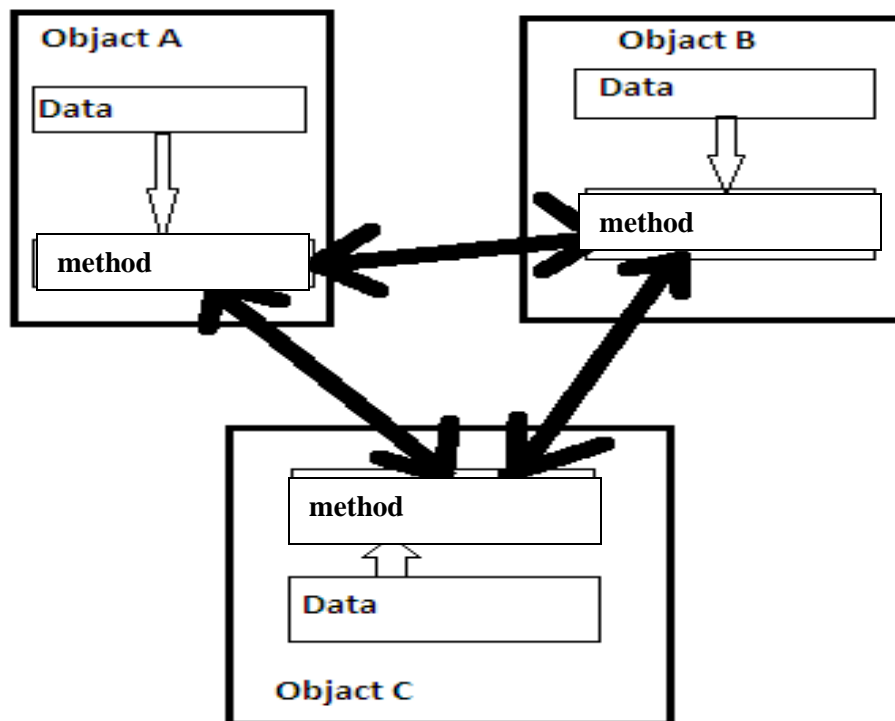
DEF: OOP is an approach that provides a way of modularizing programs by creating portioned memory area for both data and methods that can used as templates for creating copies of such modules on demand.

That is, an object a considered to be a partitioned area of computer memory that stores data and set of operations that can access that data. Since the memory partitions are independent, the objects can be used in a variety of different programs without modifications.

### OOP Chars:

- Emphasis on data.
- Programs are divided into what are known as methods.
- Data structures are designed such that they characterize the objects.
- Methods that operate on the data of an object are tied together.
- Data is hidden.
- Objects can communicate with each other through methods.
- Reusability.
- Follows bottom-up approach in program design.

### Organization of OOP:



**Evolution of Computing and Programming:** Computer use is increasing in almost every field of endeavor. Computing costs have been decreasing dramatically due to rapid developments in both hardware and software technologies. Computers that might have filled large rooms and cost millions of dollars decades ago can now be inscribed on silicon chips smaller than a fingernail, costing perhaps a few dollars each. Fortunately, silicon is one of the most abundant materials on earth it is an ingredient in common sand. Silicon chip technology has made computing so economical that about a billion general-purpose computers are in use worldwide, helping people

in business, industry and government, and in their personal lives. The number could easily double in the next few years. Over the years, many programmers learned the programming methodology called structured programming.

You will learn structured programming and an exciting newer methodology, object-oriented programming. Why do we teach both? Object orientation is the key programming methodology used by programmers today. You will create and work with many software objects in this text. But you will discover that their internal structure is often built using structured-programming techniques. Also, the logic of manipulating objects is occasionally expressed with structured programming.

**Language of Choice for Networked Applications:** Java has become the language of choice for implementing Internet-based applications and software for devices that communicate over a network. Stereos and other devices in homes are now being networked together by Java technology. At the May 2006 JavaOne conference, Sun announced that there were one billion java-enabled mobile phones and hand held devices! Java has evolved rapidly into the large-scale applications arena. It's the preferred language for meeting many organizations' enterprise-wide programming needs. Java has evolved so rapidly that this seventh edition of Java How to Program was published just 10 years after the first edition was published. Java has grown so large that it has two other editions. The Java Enterprise Edition (Java EE) is geared toward developing large-scale, distributed networking applications and web-based applications. The Java Micro Edition (Java ME) is geared toward developing applications for small, memory constrained devices, such as cell phones, pagers and PDAs.

## **Data Abstraction**

An essential element of object-oriented programming is abstraction. Humans manage complexity through abstraction. For example, people do not think of a car as a set of thousands of individual parts. They think of it as a well-defined object with its own unique behavior. This abstraction allows people to use a car to drive to the grocery store without being overwhelmed by the complexity of the parts that form the car. They can ignore the details of how the engine, transmission, and braking systems work. Instead they are free to utilize the object as a whole.

A powerful way to manage abstraction is through the use of hierarchical classifications. This allows you to layer the semantics of complex systems, breaking them into more manageable pieces. From the outside, the car is a single object. Once inside, you see that the car consists of several subsystems: steering, brakes, sound system, seat belts, heating, cellular phone, and so on. In turn, each of these subsystems is made up of more specialized units. For instance, the sound system consists of a radio, a CD player, and/or a tape player. The point is that you manage the complexity of the car (or any other complex system) through the use of hierarchical abstractions.

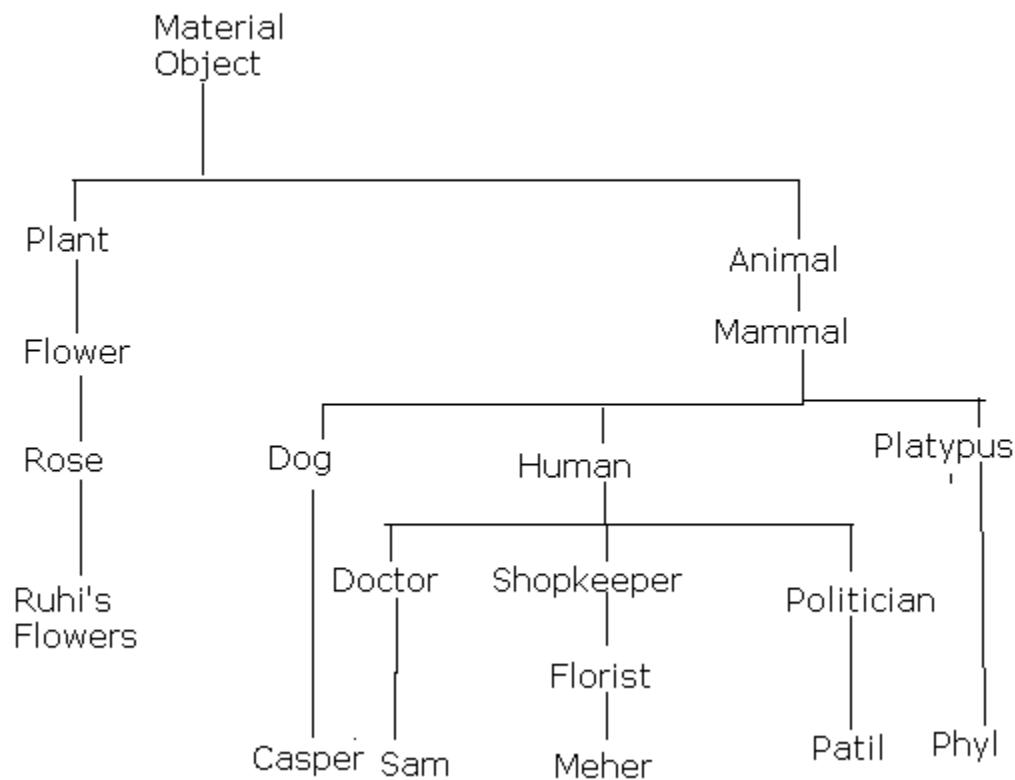


## Encapsulation

An object encapsulates the methods and data that are contained inside it .the rest of the system interacts with an object only through a well defined set of services that it provides.

## Inheritance

- I have more information about Flora – not necessarily because she is a florist but because she is a shopkeeper.
- One way to think about how I have organized my knowledge of Flora is in terms of a hierarchy of categories:



**Fig:** A Class Hierarchy for Different kinds of Material objects

## CLASSES AND OBJECTS

### Concepts of classes and objects:

#### Class Fundamentals

Classes have been used since the beginning of this book. However, until now, only the most rudimentary form of a class has been used. The classes created in the preceding chapters primarily exist simply to encapsulate the main() method, which has been used to demonstrate the basics of the Java syntax.

Thus, a class is a template for an object, and an object is an instance of a class. Because an object is an instance of a class, you will often see the two words object and instance used interchangeably.

## **The General Form of a Class**

When you define a class, you declare its exact form and nature. You do this by specifying the data that it contains and the code that operates on that data.

A class is declared by use of the **class** keyword. The classes that have been used up to this point are actually very limited examples of its complete form. Classes can (and usually do) get much more complex. The general form of a **class** definition is shown here:

```
class classname {
type instance-variable1;
type instance-variable2;
// ...
type instance-variableN;
type methodname1(parameter-list) {
// body of method
}
type methodname2(parameter-list) {
// body of method
}
// ...
type methodnameN(parameter-list) {
// body of method
}
}
```

The data, or variables, defined within a **class** are called instance variables. The code is contained within methods. Collectively, the methods and variables defined within a class are called members of the class. In most classes, the instance variables are acted upon and accessed by the methods defined for that class. Thus, it is the methods that determine how a class' data can be used.

## **Declaring Objects**

As just explained, when you create a class, you are creating a new data type. You can use this type to declare objects of that type. However, obtaining objects of a class is a two-step process. 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 acquire an actual, physical 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, more or less, the address in memory of the object allocated by **new**.

Ex: `Box mybox = new Box();`

This statement combines the two steps just described. It can be rewritten like this to show each step more clearly:

```
Box mybox; // declare reference to object
mybox = new Box(); // allocate a Box object
```

### A Closer Look at new

As just explained, the **new** operator dynamically allocates memory for an object. It has this general form:

```
class-var = new classname( );
```

Here, class-var is a variable of the class type being created. The classname is the name of the class that is being instantiated. The class name followed by parentheses specifies the constructor for the class. A constructor defines what occurs when an object of a class is created. Constructors are an important part of all classes and have many significant attributes. Most real-world classes explicitly define their own constructors within their class definition. However, if no explicit constructor is specified, then Java will automatically supply a default constructor. This is the case with **Box**.

Procedural	OO programming
<ul style="list-style-type: none"><li>• Code is placed into totally distinct functions or procedures</li><li>• Data placed in separate structures and is manipulated by these functions or procedures</li><li>• Code maintenance and reuse is difficult</li><li>• Data is uncontrolled and unpredictable (i.e. multiple functions may have access to the global data)</li><li>• You have no control over who has access to the data</li><li>• Testing and debugging are much more difficult</li><li>• Not easy to upgrade</li><li>• Not easy to partition the work in a project</li></ul>	<ul style="list-style-type: none"><li>• Everything treated as an Object</li><li>• Every object consist of attributes(data) and behaviors (methods)</li><li>• Code maintenance and reuse is easy</li><li>• The data of an object can be accessed only by the methods associated with the object</li><li>• Good control over data access</li><li>• Testing and debugging are much easy</li><li>• Easy to upgrade</li><li>• Easy to partition the work in a project</li></ul>

## POLYMORPHISM

Polymorphism is the ability of an object to take on many forms. The most common use of polymorphism in OOP occurs when a parent class reference is used to refer to a child class object.

Any Java object that can pass more than one IS-A test is considered to be polymorphic. In Java, all Java objects are polymorphic since any object will pass the IS-A test for their own type and for the class Object.

It is important to know that the only possible way to access an object is through a reference variable. A reference variable can be of only one type. Once declared, the type of a reference variable cannot be changed.

The reference variable can be reassigned to other objects provided that it is not declared final. The type of the reference variable would determine the methods that it can invoke on the object.

A reference variable can refer to any object of its declared type or any subtype of its declared type. A reference variable can be declared as a class or interface type.

Now, the Deer class is considered to be polymorphic since this has multiple inheritance. Following are true for the above examples –

- A Deer IS-A Animal
- A Deer IS-A Vegetarian
- A Deer IS-A Deer
- A Deer IS-A Object

When we apply the reference variable facts to a Deer object reference, the following declarations are legal –

## CONSTRUCTORS:

A constructor initializes an object when it is created. It has the same name as its class and is syntactically similar to a method. However, constructors have no explicit return type.

Typically, you will use a constructor to give initial values to the instance variables defined by the class, or to perform any other start-up procedures required to create a fully formed object.

All classes have constructors, whether you define one or not, because Java automatically provides a default constructor that initializes all member variables to zero. However, once you define your own constructor, the default constructor is no longer used.

Syntax

Following is the syntax of a constructor –

```
class ClassName {  
    ClassName() {
```

```
}  
}
```

Java allows two types of constructors namely –

- No argument Constructors
- Parameterized Constructors

### No argument Constructors

As the name specifies the no argument constructors of Java does not accept any parameters instead, using these constructors the instance variables of a method will be initialized with fixed values for all objects.

Example

```
Public class MyClass {  
    Int num;  
    MyClass() {  
        num = 100;  
    }  
}
```

### Parameterized Constructors

Most often, you will need a constructor that accepts one or more parameters. Parameters are added to a constructor in the same way that they are added to a method, just declare them inside the parentheses after the constructor's name.

Example

Here is a simple example that uses a constructor –

```
// A simple constructor.  
class MyClass {  
    int x;  
  
    // Following is the constructor  
    MyClass(int i ) {  
        x = i;  
    }  
}
```

## **HISTORY OF JAVA**

Java was conceived by James Gosling, Patrick Naughton, Chris Warth, Ed Frank, and Mike Sheridan at Sun Microsystems, Inc. in 1991. It took 18 months to develop the first Working version. This language was initially called “Oak” but was renamed “Java” in 1995. Between the initial implementation of Oak in the fall of 1992 and the public Announcement of Java in the spring of 1995, many more people contributed to the design and evolution of the language. Bill Joy, Arthur van Hoff, Jonathan Payne, Frank Yellin, and Tim Lindholm were key contributors to the maturing of the original prototype.

The trouble with C and C++ (and most other languages) is that they are designed to be compiled for a specific target. Although it is possible to compile a C++ program for just about any type of CPU, to do so requires a full C++ compiler targeted for that CPU. The problem is that compilers are expensive and time-consuming to create. An easier—and more cost-efficient—solution was needed. In an attempt to find such a solution, Gosling and others began work on a portable, platform-independent language that could be used to produce code that would run on a variety of CPUs under differing environments. This effort ultimately led to the creation of Java.

As mentioned earlier, Java derives much of its character from C and C++. This is by intent. The Java designers knew that using the familiar syntax of C and echoing the object-oriented features of C++ would make their language appealing to the legions of experienced C/C++ programmers. In addition to the surface similarities, Java shares some of the other attributes that helped make C and C++ successful. First, Java was designed, tested, and refined by real, working programmers.

### **The Java Buzzwords:**

No discussion of the genesis of Java is complete without a look at the Java buzzwords. Although the fundamental forces that necessitated the invention of Java are portability and security, other factors also played an important role in molding the final form of the language. The key considerations were summed up by the Java team in the following list of buzzwords:

- Simple
- Secure
- Portable
- Object-oriented
- Robust
- Multithreaded
- Architecture-neutral
- Interpreted
- High performance
- Distributed
- Dynamic

**Simple:**

Java was designed to be easy for the professional programmer to learn and use effectively. Assuming that you have some programming experience, you will not find Java hard to master. If you already understand the basic concepts of object-oriented programming, learning Java will be even easier. Best of all, if you are an experienced C++ programmer, moving to Java will require very little effort. Because Java inherits the C/C++ syntax and many of the object-oriented features of C++, most programmers have little trouble learning Java..

**Object-Oriented:**

Although influenced by its predecessors, Java was not designed to be source-code compatible with any other language. Borrowing liberally from many seminal object-software environments of the last few decades, Java manages to strike a balance between the purist's "everything is an object" paradigm and the pragmatist's "stay out of my way" model.

**Robust**

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

To better understand how Java is robust, consider two of the main reasons for program failure: memory management mistakes and mishandled exceptional conditions (that is, run-time errors). Memory management can be a difficult, tedious task in traditional programming environments. For example, in C/C++, the programmer must manually allocate and free all dynamic memory. This sometimes leads to problems, because programmers will either forget to free memory that has been previously allocated or, worse, try to free some memory that another part of their code is still using. Java virtually eliminates these problems by managing memory allocation and deallocation for you.

**Multithreaded**

Java was designed to meet the real-world requirement of creating interactive, networked programs. To accomplish this, Java supports multithreaded programming, which allows you to write programs that do many things simultaneously. The Java run-time system comes with an elegant yet sophisticated solution for multiprocess synchronization that enables you to construct smoothly running interactive systems.

**Architecture-Neutral:**

A central issue for the Java designers was that of code longevity and portability. One of the main problems facing programmers is that no guarantee exists that if you write a program today, it will run tomorrow—even on the same machine. Operating system upgrades, processor upgrades, and changes in core system resources can all combine to make a program malfunction. The Java designers made several hard decisions in the Java language and the Java Virtual Machine in an attempt to alter this situation. Their goal was "write once; run anywhere, any time, forever." To a great extent, this goal was accomplished.

**Interpreted and High Performance**

As described earlier, Java enables the creation of cross-platform programs by compiling into an intermediate representation called Java bytecode. This code can be interpreted on any system that provides a Java Virtual Machine. Most previous attempts at cross platform solutions have done so at the expense of performance. Other interpreted systems, such as BASIC, Tcl, and PERL, suffer from almost insurmountable performance deficits. Java, however, was designed to perform well on very low-power CPUs.

### **Distributed:**

Java is designed for the distributed environment of the Internet, because it handles TCP/IP protocols. In fact, accessing a resource using a URL is not much different from accessing a file. The original version of Java (Oak) included features for intra address-space messaging. This allowed objects on two different computers to execute procedures remotely. Java revived these interfaces in a package called Remote MethodInvocation (RMI). This feature brings an unparalleled level of abstraction to client/server programming.

### **Dynamic**

Java programs carry with them substantial amounts of run-time type information that is used to verify and resolve accesses to objects at run time. This makes it possible to dynamically link code in a safe and expedient manner. This is crucial to the robustness of the applet environment, in which small fragments of bytecode may be dynamically updated on a running system.

### **DATA TYPES**

Java defines eight simple (or elemental) types of data: **byte**, **short**, **int**, **long**, **char**, **float**, **double**, and **boolean**. These can be put in four groups:

- **Integers:** This group includes **byte**, **short**, **int**, and **long**, which are for whole valued signed numbers.
- **Floating-point numbers:** This group includes **float** and **double**, which represent numbers with fractional precision.
- **Characters:** This group includes **char**, which represents symbols in a character set, like letters and numbers.
- **Boolean:** This group includes **boolean**, which is a special type for representing true/false values.

### **Integers**

Java defines four integer types: **byte**, **short**, **int**, and **long**. All of these are signed, positive and negative values. Java does not support unsigned, positive-only integers. Many other Computer languages, including C/C++, support both signed and unsigned integers.



Name	Width	Range
long	64	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
int	32	-2,147,483,648 to 2,147,483,647
short	16	-32,768 to 32,767
byte <b>byte</b>	8	-128 to 127

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

Syntax: `byte b, c;`

### **short**

**short** is a signed 16-bit type. It has a range from -32,768 to 32,767. It is probably the least-used Java type, since it is defined as having its high byte first (called big-endian format). This type is mostly applicable to 16-bit computers, which are becoming increasingly scarce. Here are some examples of **short** variable declarations:

```
short s;
short t;
int
```

The most commonly used integer type is **int**. It is a signed 32-bit type that has a range from -2,147,483,648 to 2,147,483,647. In addition to other uses, variables of type **int** are commonly employed to control loops and to index arrays. Any time you have an integer expression involving **bytes**, **shorts**, **ints**, and literal numbers, the entire expression is promoted to **int** before the calculation is done.

### **long**

**long** is a signed 64-bit type and is useful for those occasions where an **int** type is not large enough to hold the desired value. The range of a **long** is quite large. This makes it useful when big, whole numbers are needed. For example, here is a program that computes the number of miles that light will travel in a specified number of days.

#### Floating-Point Types

Floating-point numbers, also known as real numbers, are used when evaluating expressions that require fractional precision. For example, calculations such as square root, or transcendentals such as sine and cosine, result in a value whose precision requires a floating-point type.

Their width and ranges are shown here:

Name	Width	Bits Approximate Range
<b>double</b>	64	4.9e-324 to 1.8e+308
<b>float</b>	32	1.4e-045 to 3.4e+038
float		

The type **float** specifies a single-precision value that uses 32 bits of storage. Single precision is faster on some processors and takes half as much space as double precision, but will become imprecise when the values are either very large or very small. Variables of type **float** are useful when you need a fractional component, but don't require a large degree of precision. For example, **float** can be useful when representing dollars and cents.

Here are some example **float** variable declarations:

```
float hightemp, lowtemp;
```

```
double
```

Double precision, as denoted by the **double** keyword, uses 64 bits to store a value. Double precision is actually faster than single precision on some modern processors that have been optimized for high-speed mathematical calculations.

Here is a short program that uses **double** variables to compute the area of a circle:

```
// Compute the area of a circle.
class Area {
public static void main(String args[]) {
double pi, r, a;
r = 10.8; // radius of circle
pi = 3.1416; // pi, approximately
a = pi * r * r; // compute area
System.out.println("Area of circle is " + a);
}
}
```

## Characters

In Java, the data type used to store characters is **char**. However, C/C++ programmers beware: **char** in Java is not the same as **char** in C or C++. In C/C++, **char** is an integer type that is 8 bits wide. This is not the case in Java. Instead, Java uses Unicode to represent characters. There are no negative **chars**. The standard set of characters known as ASCII still ranges from 0 to 127 as always, and the extended 8-bit character set, ISO-Latin-1, ranges from 0 to 255.

## Booleans

Java has a simple type, called **boolean**, for logical values. It can have only one of two possible values, **true** or **false**. This is the type returned by all relational operators, such as **a < b**. **boolean** is also the type required by the conditional expressions that govern the control statements such as **if** and **for**.

Here is a program that demonstrates the **boolean** type:

There are three interesting things to notice about this program. First, as you can see, when a **boolean** value is output by **println()**, "true" or "false" is displayed.

Second, the value of a **boolean** variable is sufficient, by itself, to control the **if** statement. There is no need to write an **if** statement like this:

```
if(b == true) ...
```

Third, the outcome of a relational operator, such as **<**, is a **boolean** value. This is why the expression **10 > 9** displays the value “true.” Further, the extra set of parentheses around **10 > 9** is necessary because the **+** operator has a higher precedence than the **>**.

### Variables

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

#### Declaring a Variable

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

```
type identifier [ = value][, identifier [= value] ...] ;
```

The type is one of Java’s atomic types, or the name of a class or interface. (Class and interface types are discussed later in Part I of this book.) The identifier is the name of the variable.

Here are several examples of variable declarations of various types. Note that some include an initialization.

```
int a, b, c;           // declares three ints, a, b, and c.
int d = 3, e, f = 5;  // declares three more ints, initializing
                    // d and f.
byte z = 22;         // initializes z.
double pi = 3.14159; // declares an approximation of pi.
char x = 'x';        // the variable x has the value 'x'.
```

### The Scope and Lifetime of Variables

So far, all of the variables used have been declared at the start of the **main( )** method. However, Java allows variables to be declared within any block. As explained in Chapter 2, 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. As you probably know from your previous programming experience, a scope determines what objects are visible to other parts of your program. It also determines the lifetime of those objects.

Most other computer languages define two general categories of scopes: global and local. However, these traditional scopes do not fit well with Java’s strict, object oriented model. The scope defined by a method begins with its opening curly brace.

To understand the effect of nested scopes, consider the following program:

```
// Demonstrate block scope.
```

## Arrays

An array is a group of like-typed variables that are referred to by a common name. Arrays of any type can be created and may have one or more dimensions. A specific element in an array is accessed by its index. Arrays offer a convenient means of grouping related information.

### One-Dimensional Arrays

A one-dimensional array is, essentially, a list of like-typed variables. To create an array, you first must create an array variable of the desired type. The general form of a one dimensional array declaration is

```
type var-name[ ];
```

Here, type declares the base type of the array. The base type determines the data type of each element that comprises the array.

```
// Demonstrate a one-dimensional array.
```

```
class Array {
```

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

```
int month_days[];
```

```
month_days = new int[12];
```

```
month_days[0] = 31;
```

```
month_days[1] = 28;
```

```
month_days[2] = 31;
```

```
month_days[3] = 30;
```

```
month_days[4] = 31;
```

```
month_days[5] = 30;
```

```
month_days[6] = 31;
```

```
month_days[7] = 31;
```

```
month_days[8] = 30;
```

```
month_days[9] = 31;
```

```
month_days[10] = 30;
```

```
month_days[11] = 31;
```

```
System.out.println("April has " + month_days[3] + " days.");
```

```
}
```

```
}
```

### **Multidimensional Arrays**

In Java, multidimensional arrays are actually arrays of arrays. These, as you might expect, look and act like regular multidimensional arrays. However, as you will see there are a couple of subtle differences. To declare a multidimensional array variable, specify each additional index using another set of square brackets. For example, the following declares a two-dimensional array variable called **twoD**.

```
int twoD[][] = new int[4][5];
```

This allocates a 4 by 5 array and assigns it to **twoD**. Internally this matrix is implemented as an array of arrays of **int**.

```
// Demonstrate a two-dimensional array.
```

```
class TwoDArray {
public static void main(String args[]) {
int twoD[][]= new int[4][5];
int i, j, k = 0;
for(i=0; i<4; i++)
for(j=0; j<5; j++) {
twoD[i][j] = k;
k++;
}
for(i=0; i<4; i++) {
for(j=0; j<5; j++)
System.out.print(twoD[i][j] + " ");
System.out.println();
}
}
}
```

This program generates the following output:

```
0 1 2 3 4
5 6 7 8 9
10 11 12 13 14
15 16 17 18 19
```

As stated earlier, since multidimensional arrays are actually arrays of arrays, the length of each array is under your control. For example, the following program creates a two dimensional array in which the sizes of the second dimension are unequal.

## OPERATORS

Arithmetic operators are used in mathematical expressions in the same way that they are used in algebra. The following table lists the arithmetic operators:

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

%=	Modulus assignment
--	Decrement

The operands of the arithmetic operators must be of a numeric type. You cannot use them on **boolean** types, but you can use them on **char** types, since the **char** type in Java is, essentially, a subset of **int**.

#### The Bitwise Operators

Java defines several bitwise operators which can be applied to the integer types, **long**, **int**, **short**, **char**, and **byte**. These operators act upon the individual bits of their operands.

They are summarized in the following table:

Operator	Result
~	Bitwise unary NOT
&	Bitwise AND
	Bitwise OR
^	Bitwise exclusive OR
>>	Shift right
>>>	Shift right zero fill
<<	Shift left
&=	Bitwise AND assignment
=	Bitwise OR assignment
^=	Bitwise exclusive OR assignment
>>=	Shift right assignment
>>>=	Shift right zero fill assignment
<<=	Shift left assignment

#### Relational Operators

The relational operators determine the relationship that one operand has to the other. Specifically, they determine equality and ordering. The relational operators are shown here:

Operator	Result
==	Equal to
!=	Not equal to
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to

The outcome of these operations is a **boolean** value. The relational operators are most frequently used in the expressions that control the **if** statement and the various loop statements.

## The Assignment Operator

You have been using the assignment operator since Chapter 2. Now it is time to take a formal look at it. The assignment operator is the single equal sign, =. The assignment operator works in Java much as it does in any other computer language. It has this general form:

```
var = expression;
```

Here, the type of var must be compatible with the type of expression.

The assignment operator does have one interesting attribute that you may not be familiar with: it allows you to create a chain of assignments. For example, consider this fragment:

```
int x, y, z;  
x = y = z = 100; // set x, y, and z to 100
```

This fragment sets the variables **x**, **y**, and **z** to 100 using a single statement. This works because the = is an operator that yields the value of the right-hand expression. Thus, the value of **z = 100** is 100, which is then assigned to **y**, which in turn is assigned to **x**. Using a “chain of assignment” is an easy way to set a group of variables to a common value.

## The ? Operator

Java includes a special ternary (three-way) operator that can replace certain types of if-then-else statements. This operator is the **?**, and it works in Java much like it does in C, C++, and C#. It can seem somewhat confusing at first, but the **?** can be used very effectively once mastered. The **?** has this general form:

```
expression1 ? expression2 : expression3
```

Here, expression1 can be any expression that evaluates to a **boolean** value. If expression1 is **true**, then expression2 is evaluated; otherwise, expression3 is evaluated. The result of the **?** operation is that of the expression evaluated. Both expression2 and expression3 are required to return the same type, which can't be **void**.

## CONTROL STATEMENTS

### if

The **if** statement was introduced in Chapter 2. It is examined in detail here. The **if** statement is Java's conditional branch statement. It can be used to route program execution through two different paths. Here is the general form of the **if** statement:

```
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.

```
int a, b;  
// ...  
if(a < b) a = 0;  
else b = 0;
```

## The if-else-if Ladder

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

```
if(condition)
statement;
else if(condition)
statement;
else if(condition)
statement;
...
else
statement;
```

## switch

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

Here is the general form of a **switch** statement:

```
switch (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 of the values specified in the **case** statements must be of a type compatible with the expression. Each **case** value must be a unique literal (that is, it must be a constant, not a variable). Duplicate **case** values are not allowed

## Iteration Statements

Java's iteration statements are **for**, **while**, and **do-while**. These statements create what we commonly call loops. As you probably know, a loop repeatedly executes the same set of instructions until a termination condition is met. As you will see, Java has a loop to fit any programming need.



## While

The **while** loop is Java's most fundamental looping statement. It repeats a statement or block while its controlling expression is true. Here is its general form:

```
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. The curly braces are unnecessary if only a single statement is being repeated.

## do-while

As you just saw, if the conditional expression controlling a **while** loop is initially false, then the body of the loop will not be executed at all. However, sometimes it is desirable to execute the body of a **while** loop at least once, even if the conditional expression is false to begin with.

System:

```
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.

```
// Demonstrate the do-while loop.
```

```
class DoWhile {  
public static void main(String args[]) {  
int n = 10;  
do {  
System.out.println("tick " + n);  
n--;  
} while(n > 0);  
}  
}
```

## For

You were introduced to a simple form of the **for** loop in Chapter 2. As you will see, it is a powerful and versatile construct. Here is the general form of the **for** statement:

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

If only one statement is being repeated, there is no need for the curly braces.

The **for** loop operates as follows. When the loop first starts, the initialization portion of the loop is executed. Generally, this is an expression that sets the value of the loopcontrol variable, which acts as a counter that controls the loop. 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.

```
// Demonstrate the for loop.
class ForTick {
public static void main(String args[]) {
int n;
for(n=10; n>0; n--)
System.out.println("tick " + n);
}
}
```

## Using break

In Java, the **break** statement has three uses. First, as you have seen, it terminates a statement sequence in a **switch** statement. Second, it can be used to exit a loop. Third, it can be used as a “civilized” form of goto. The last two uses are explained here.

### Return

The last control statement is **return**. The **return** statement is used to explicitly return from a method. That is, it causes program control to transfer back to the caller of the method. As such, it is categorized as a jump statement. Although a full discussion of **return** must wait until methods are discussed in Chapter 7, a brief look at **return** is presented here.

As you can see, the final **println()** statement is not executed. As soon as **return** is executed, control passes back to the caller.

## Type Conversion and Casting

### Type Conversion and Casting

If you have previous programming experience, then you already know that it is fairly common to assign a value of one type to a variable of another type. If the two types are compatible, then Java will perform the conversion automatically. 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.

### Java’s Automatic Conversions

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:

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

When these two conditions are met, a widening conversion takes place. For example, the **int** type is always large enough to hold all valid **byte** values, so no explicit cast statement is required.

It has this general form:

### **(target-type) value**

Here, target-type specifies the desired type to convert the specified value to. For example, the following fragment casts an **int** to a **byte**. If the integer's value is larger than the range of a **byte**, it will be reduced modulo (the remainder of an integer division by the) **byte**'s range.

```
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 you 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. Of course, if the size of the whole number component is too large to fit into the target integer type, then that value will be reduced modulo the target type's range.

The following program demonstrates some type conversions that require casts:

### **// Demonstrate casts.**

```
class Conversion {  
    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);  
    }  
}
```

This program generates the following 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

### SIMPLE JAVA PROGRAM

```
/*  
This is a simple Java program.  
Call this file "Example.java".  
*/  
class Example {  
// Your program begins with a call to main().  
public static void main(String args[]) {  
System.out.println("This is a simple Java program.");  

```

### Access Control

As you know, encapsulation links data with the code that manipulates it. However, encapsulation provides another important attribute: access control.

How a member can be accessed is determined by the access specifier that modifies its declaration. Java supplies a rich set of access specifiers. Some aspects of access control are related mostly to inheritance or packages. (A package is, essentially, a grouping of classes.) These parts of Java's access control mechanism will be discussed later. Here, let's begin by examining access control as it applies to a single class. Once you understand the fundamentals of access control, the rest will be easy. Java's access specifiers are **public**, **private**, and **protected**. Java also defines a default access level. **protected** applies only when inheritance is involved. The other access specifiers are described next.

Let's begin by defining **public** and **private**. When a member of a class is modified by the **public** specifier, then that member can be accessed by any other code. When a member of a class is specified as **private**, then that member can only be accessed by other members of its class. Now you can understand why **main( )** has always been preceded by the **public** specifier. It is called by code that is outside the program—that is, by the Java run-time system. When no access specifier is used, then by default the member of a class is public within its own package, but cannot be accessed outside of its package.

### this Keyword

Sometimes a method will need to refer to the object that invoked it. To allow this, Java defines the **this** keyword. **this** can be used inside any method to refer to the current object. That is, **this** is always a reference to the object on which the method was invoked. You can use **this**

anywhere a reference to an object of the current class' type is permitted. To better understand what **this** refers to, consider the following version of **Box()**:

```
// A redundant use of this.  
Box(double w, double h, double d) {  
    this.width = w;  
    this.height = h;  
    this.depth = d;  
}
```

This version of **Box()** operates exactly like the earlier version. The use of **this** is redundant, but perfectly correct. Inside **Box()**, **this** will always refer to the invoking object. While it is redundant in this case, **this** is useful in other contexts, one of which is explained in the next section.

### **Instance Variable Hiding**

As you know, it is illegal in Java to declare two local variables with the same name inside the same or enclosing scopes. Interestingly, you can have local variables, including formal parameters to methods, which overlap with the names of the class' instance variables. However, when a local variable has the same name as an instance variable, the local variable hides the instance variable.

```
// Use this to resolve name-space collisions.  
Box(double width, double height, double depth) {  
    this.width = width;  
    this.height = height;  
    this.depth = depth;  
}
```

A word of caution: The use of **this** in such a context can sometimes be confusing, and some programmers are careful not to use local variables and formal parameter names that hide instance variables.

### **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. It works like this: 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 reclaimed. Furthermore, different Java run-time implementations will take varying approaches to garbage collection, but for the most part, you should not have to think about it while writing your programs.

## Overloading methods and constructors

### Overloading Methods

In Java it is possible to define two or more methods within the same class that share the same name, as long as their parameter declarations are different. When this is the case, the methods are said to be overloaded, and the process is referred to as method overloading. Method overloading is one of the ways that Java implements polymorphism.

```
// Demonstrate method overloading.
class OverloadDemo {
    void test() {
        System.out.println("No parameters");
    }
    // Overload test for one integer parameter.
    void test(int a) {
        System.out.println("a: " + a);
    }
    // Overload test for two integer parameters.
    void test(int a, int b) {
        System.out.println("a and b: " + a + " " + b);
    }
    // overload test for a double parameter
    double test(double a) {
        System.out.println("double a: " + a);
        return a*a;
    }
}
class Overload {
    public static void main(String args[]) {
        OverloadDemo ob = new OverloadDemo();
        double result;
        // call all versions of test()
        ob.test();
        ob.test(10);
        ob.test(10, 20);
        result = ob.test(123.25);
        System.out.println("Result of ob.test(123.25): " + result);
    }
}
```

This program generates the following output:

```
No parameters
a: 10
a and b: 10 20
double a: 123.25
```

Result of ob.test(123.25): 15190.5625  
As you can see, **test()** is overloaded four times.

### **Overloading Constructor**

In addition to overloading normal methods, you can also overload constructor methods. In fact, for most real-world classes that you create, overloaded constructors will be the norm, not the exception. To understand why, let's return to the **Box** class developed in the preceding chapter. Following is the latest version of **Box**:

```
class Box {
double width;
double height;
double depth;
// This is the constructor for Box.
Box(double w, double h, double d) {
width = w;
height = h;
depth = d;
}
// compute and return volume
double volume() {
return width * height * depth;
}
}
```

### **Argument/Parameter passing**

In general, there are two ways that a computer language can pass an argument to a subroutine. The first way is call-by-value. This method copies the value of an argument into the formal parameter of the subroutine. Therefore, changes made to the parameter of the subroutine have no effect on the argument. The second way an argument can be passed is call-by-reference. In this method, a reference to an argument (not the value of the argument) is passed to the parameter. Inside the subroutine, this reference is used to access the actual argument specified in the call. This means that changes made to the parameter will affect the argument used to call the subroutine. As you will see, Java uses both approaches, depending upon what is passed.

For example, consider the following program:

```
// Simple types are passed by value.
class Test {
void meth(int i, int j) {
i *= 2;
j /= 2;
}
}
```

```

class CallByValue {

public static void main(String args[]) {
Test ob = new Test();
int a = 15, b = 20;
System.out.println("a and b before call: " +
a + " " + b);
ob.meth(a, b);
System.out.println("a and b after call: " +
a + " " + b);
}
}

```

The output from this program is shown here:

```

a and b before call: 15 20
a and b after call: 15 20

```

### **Recursion**

Java supports recursion. Recursion is the process of defining something in terms of itself. As it relates to Java programming, recursion is the attribute that allows a method to call itself. A method that calls itself is said to be recursive. The classic example of recursion is the computation of the factorial of a number. The factorial of a number N is the product of all the whole numbers between 1 and N.

// A simple example of recursion(factorial).

```

class Factorial {
// this is a recursive function
int fact(int n) {
int result;
if(n==1) return 1;
result = fact(n-1) * n;
return result;
}
}

class Recursion {
public static void main(String args[]) {
Factorial f = new Factorial();
System.out.println("Factorial of 3 is " + f.fact(3));
System.out.println("Factorial of 4 is " + f.fact(4));
System.out.println("Factorial of 5 is " + f.fact(5));
}
}

```



The output from this program is shown here:

Factorial of 3 is 6

Factorial of 4 is 24

Factorial of 5 is 120

## UNIT-II INHERITANCE

**Inheritance:** Inheritance hierarchies, super and subclasses, member access rules

**Polymorphism:** Dynamic binding, method overriding, abstract classes and methods.

### Hierarchical abstractions & Concept of Inheritance:

- In OOP another important feature is Reusability which is very use full in two major issues of development :
  - Saving Time
  - Saving Memory
- In C++/Java the mechanism implements this reusability is Inheritance.

General form of a class declaration is:

```
Class subclass-name extends super class-name
{
    // body of super class
}
```

// A simple example of inheritance.

// Create a superclass.

```
class A {
int i, j;
void showij() {
System.out.println("i and j: " + i + " " + j);
}
}
```

// Create a subclass by extending class A.

```
class B extends A {
int k;
void showk() {
System.out.println("k: " + k);
}
void sum() {
System.out.println("i+j+k: " + (i+j+k));
}
}
```

```
class SimpleInheritance {
public static void main(String args[]) {
A superOb = new A();
B subOb = new B();
// The superclass may be used by itself.
superOb.i = 10;
superOb.j = 20;
System.out.println("Contents of superOb: ");
}
```

```
superOb.showij();
System.out.println();
/* The subclass has access to all public members of
its superclass. */
subOb.i = 7;
subOb.j = 8;
subOb.k = 9;
System.out.println("Contents of subOb: ");
subOb.showij();
subOb.showk();
System.out.println();
System.out.println("Sum of i, j and k in subOb:");
subOb.sum();
}
}
```

Output:

Contents of superOb:

i and j: 10 20

Contents of subOb:

i and j: 7 8

k: 9

Sum of i, j and k in subOb:

i+j+k: 24

**Forms of Inheretence:**

- Single Inheretence
- Hierarichal Inherintence
- Multiple Inherintence
- Multilevel Inherintence
- Hybrid Inherintence

**Single Inherintence:**

Derivation a subclass from only one super class is called Single Inherintence.

**Hierarchical Inherintence:**

Derivation of several classes from a single super class is called Hierarchical Inherintence:

**Multilevel Inheritance:**

Derivation of a classes from another derived classes called Multilevel Inheritance.

## Multiple Inheritance:

Derivation of one class from two or more super classes is called Multiple Inheritance. But Java does not support Multiple Inheritance directly. It can be implemented by using interface concept.

## Hybrid Inheritance:

Derivation of a class involving more than one form of Inheritance is called Hybrid Inheritance.

## Defining a Subclass:

A subclass is defined as

Syntax: class subclass-name extends superclass-name

```
{  
  
    Variable declaration;  
    Method declaration;  
  
}
```

The keyword `extends` signifies that the properties of the super class name are extended to the subclass name. The subclass will now contain its own variables and methods as well as those of the super class. But it is not vice-versa.

## Member access rules

- Even though a subclass includes all of the members of its super class, it cannot access those members who are declared as **Private** in super class.
- We can assign a reference of super class to the object of sub class. In that situation we can access only super class members but not sub class members. This concept is called as “Super class Reference, Sub class Object”.

/\* In a class hierarchy, private members remain private to their class.

This program contains an error and will not compile.

\*/

// Create a superclass.

```
class A {  
    int i; // public by default  
    private int j; // private to A  
    void setij(int x, int y) {  
        i = x;  
        j = y;  
    }  
}
```

```

// A's j is not accessible here.
class B extends A {
int total;
void sum() {
total = i + j; // ERROR, j is not accessible here
}
}
class Access {
public static void main(String args[]) {
B subOb = new B();
subOb.setij(10, 12);
subOb.sum();
System.out.println("Total is " + subOb.total);
}
}

```

Super class variables can refer sub-class object

- To a reference variable of a super class can be assigned a reference to any subclass derived from that super class.
- When a reference to a subclass object is assigned to a super class reference variable, we will have to access only to those parts of the object defined by the super class
- It is bcz the super class has no knowledge about what a sub class adds to it.

### **Program**

```

class RefDemo
{
public static void main(String args[])
{
BoxWeight weightbox = new BoxWeight(3, 5, 7, 8.37);
Box plainbox = new Box();
double vol;
vol = weightbox.volume();
System.out.println("Volume of weightbox is " + vol);
System.out.println("Weight of weightbox is " +
weightbox.weight);
System.out.println();
// assign BoxWeight reference to Box reference
plainbox = weightbox;
vol = plainbox.volume(); // OK, volume() defined in Box
System.out.println("Volume of plainbox is " + vol);
/* The following statement is invalid because plainbox
does not define a weight member. */
// System.out.println("Weight of plainbox is " + plainbox.weight);
}
}

```

```
}  
}
```

### Using super keyword

- When ever a sub class needs to refer to its immediate super class, it can do so by use of the key word **super**.
- Super has two general forms:
  - Calling super class constructor
  - Used to access a member of the super class that has been hidden by a member of a sub class

### Using super to call super class constructor

- A sub class can call a constructor defined by its super class by use of the following form of super:
  - super (parameter-list);
  - Parameter list specifies parameters needed by the constructor in the super class.

Note: Super ( ) must always by the first statement executed inside a sub-class constructor.

```
// A complete implementation of BoxWeight.  
class Box {  
private double width;  
private double height;  
private double depth;  
// construct clone of an object  
Box(Box ob) { // pass object to constructor  
width = ob.width;  
height = ob.height;  
depth = ob.depth;  
}  
// constructor used when all dimensions specified  
Box(double w, double h, double d) {  
width = w;  
height = h;  
depth = d;  
}  
// constructor used when no dimensions specified  
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;
}
}
// BoxWeight now fully implements all constructors.
class BoxWeight extends Box {
double weight; // weight of box
// construct clone of an object
BoxWeight(BoxWeight ob) { // pass object to constructor
super(ob);
weight = ob.weight;
}
// constructor when all parameters are specified
BoxWeight(double w, double h, double d, double m) {
super(w, h, d); // call superclass constructor
weight = m;
}
// default constructor
BoxWeight() {
super();
weight = -1;
}
// constructor used when cube is created
BoxWeight(double len, double m) {
super(len);
weight = m;
}
}
class DemoSuper {
public static void main(String args[]) {
BoxWeight mybox1 = new BoxWeight(10, 20, 15, 34.3);
BoxWeight mybox2 = new BoxWeight(2, 3, 4, 0.076);
BoxWeight mybox3 = new BoxWeight(); // default
BoxWeight mycube = new BoxWeight(3, 2);
BoxWeight myclone = new BoxWeight(mybox1);
double vol;
vol = mybox1.volume();
System.out.println("Volume of mybox1 is " + vol);
System.out.println("Weight of mybox1 is " + mybox1.weight);
System.out.println();
vol = mybox2.volume();
System.out.println("Volume of mybox2 is " + vol);
}
}

```

```

System.out.println("Weight of mybox2 is " + mybox2.weight);
System.out.println();
vol = mybox3.volume();
System.out.println("Volume of mybox3 is " + vol);
System.out.println("Weight of mybox3 is " + mybox3.weight);
System.out.println();
vol = myclone.volume();
System.out.println("Volume of myclone is " + vol);
System.out.println("Weight of myclone is " + myclone.weight);
System.out.println();
vol = mycube.volume();
System.out.println("Volume of mycube is " + vol);
System.out.println("Weight of mycube is " + mycube.weight);
System.out.println();
}
}

```

#### Output:

```

Volume of mybox1 is 3000.0
Weight of mybox1 is 34.3
Volume of mybox2 is 24.0
Weight of mybox2 is 0.076
Volume of mybox3 is -1.0
Weight of mybox3 is -1.0
Volume of myclone is 3000.0
Weight of myclone is 34.3
Volume of mycube is 27.0
Weight of mycube is 2.0

```

#### Calling members of super class using super

- The second form of super acts somewhat like **this** keyword, except that it always refers to the super class of the sub class in which it is used.
- The syntax is:
  - **Super.member ;**
  - Member can either be method or an instance variable

#### Program

```

// Using super to overcome name hiding.
class A {
int i;
}
// Create a subclass by extending class A.
class B extends A {
int i; // this i hides the i in A
B(int a, int b) {
super.i = a; // i in A

```



```

i = b; // i in B
}
void show() {
System.out.println("i in superclass: " + super.i);
System.out.println("i in subclass: " + i);
}
}
class UseSuper {
public static void main(String args[]) {
B subOb = new B(1, 2);
subOb.show();
}
}

```

Output:

```

i in superclass: 1
i in subclass: 2

```

**When the constructor called:**

Always the super class constructor will be executed first and sub class constructor will be executed last.

```

// Demonstrate when constructors are called.
// Create a super class.
class A {
A() {
System.out.println("Inside A's constructor.");
}
}
// Create a subclass by extending class A.
class B extends A {
B() {
System.out.println("Inside B's constructor.");
}
}
// Create another subclass by extending B.
class C extends B {
C() {
System.out.println("Inside C's constructor.");
}
}
class CallingCons {
public static void main(String args[]) {
C c = new C();
}
}

```

### Output:

Inside A's constructor

Inside B's constructor

Inside C's constructor

### Using Final keyword:

- We can use final key word in **three** ways:
  - Used to create equivalent of a named constant
    - Final datatype identifier = .....
  - Used to prevent inheritance
    - Final class .....
  - Used to avoid overloading
    - Final return type .....

### Using final to Prevent Overriding:

While method overriding is one of Java's most powerful features, there will be times when you will want to prevent it from occurring. To disallow a method from being overridden, specify **final** as a modifier at the start of its declaration. Methods declared as **final** cannot be overridden. The following fragment illustrates **final**:

```
class A {  
    final void meth() {  
        System.out.println("This is a final method.");  
    }  
}
```

```
class B extends A {  
    void meth() { // ERROR! Can't override.  
        System.out.println("Illegal!");  
    }  
}
```

### Using final to Prevent Inheritance:

Sometimes you will want to prevent a class from being inherited. To do this, precede the class declaration with **final**. Declaring a class as **final** implicitly declares all of its methods as **final**, too. As you might expect, it is illegal to declare a class as both **abstract** and **final** since an abstract class is incomplete by itself and relies upon its subclasses to provide complete implementations.

Here is an example of a **final** class:

```
final class A {  
    // ...  
}  
// The following class is illegal.  
class B extends A { // ERROR! Can't subclass A  
    // ...  
}
```

As the comments imply, it is illegal for **B** to inherit **A** since **A** is declared as **final**.

### **Polymorphism Method overriding:**

- In a class hierarchy, when a method in a sub class has the same name and type signature as a method in its super class, then the method in the sub class is said to be override the method in the sub class.
- When an overridden method is called from within a sub class, it will always refers to the version of that method defined by the sub class.
- The version of the method defined in the super class is hidden.
- In this situation, first it checks the method is existed in super class are not. If it is existed then it executes the version of sub class otherwise it gives no such method found exception.

Note: Methods with different signatures overloading but not overriding.

```
// Method overriding.  
class A {  
    int i, j;  
    A(int a, int b) {  
        i = a;  
        j = b;  
    }  
    // display i and j  
    void show() {  
        System.out.println("i and j: " + i + " " + j);  
    }  
}  
class B extends A {  
    int k;  
    B(int a, int b, int c) {  
        super(a, b);  
        k = c;  
    }  
    // display k – this overrides show() in A  
    void show() {  
        System.out.println("k: " + k);  
    }  
}
```

```

}
class Override {
public static void main(String args[]) {
B subOb = new B(1, 2, 3);
subOb.show(); // this calls show() in B
}
}

```

Output:

k: 3

### **Dynamic method dispatch**

- It is a mechanism by which a call to an overridden method is resolved at run time rather than compile time.
- It is important because this is how java implements runtime polymorphism.
- Before going to that we must know about super class reference sub class object.

```

// Dynamic Method Dispatch
class A {
void callme() {
System.out.println("Inside A's callme method");
}
}
class B extends A {
// override callme()
void callme() {
System.out.println("Inside B's callme method");
}
}
class C extends A {
// override callme()
void callme() {
System.out.println("Inside C's callme method");
}
}

```

```

class Dispatch {
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 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

**Abstract class:**

- An abstract method is a method that is declared with only its signatures with out implementations.
- An abstract class is class that has at least one abstract method.

**The syntax is:**

```
Abstract class class-name
{
Variables
Abstract methods;
Concrete methods;

}
```

- We can't declare any abstract constructor.
- Abstract class should not include any abstract static method.
- Abstract class can't be directly instantiated with the new operator.
- Any sub class of abstract class must be either implements all the abstract methods in the super class or declared it self as abstract.
- Abstract modifier referred as "subclass responsibilities" . because of no implementation of methods. Thus, a sub class must overridden them.

// A Simple demonstration of abstract.

```
abstract class A {
abstract void callme();
// concrete methods are still allowed in abstract classes
void callmetoo() {
System.out.println("This is a concrete method.");
}
}
class B extends A {
void callme() {
System.out.println("B's implementation of callme.");
}
}
```

```

}
class AbstractDemo {
public static void main(String args[]) {
B b = new B();
b.callme();
b.callmetoo();
}
}

// Using abstract methods and classes.
abstract class Figure {
double dim1;
double dim2;
Figure(double a, double b) {
dim1 = a;
dim2 = b;
}
// area is now an abstract method
abstract double area();
}
class Rectangle extends Figure {
Rectangle(double a, double b) {
super(a, b);
}
// override area for rectangle
double area() {
System.out.println("Inside Area for Rectangle.");
return dim1 * dim2;
}
}
class Triangle extends Figure {
Triangle(double a, double b) {
super(a, b);
}
// override area for right triangle
double area() {
System.out.println("Inside Area for Triangle.");
return dim1 * dim2 / 2;
}
}

class AbstractAreas
{
public static void main(String args[])
{

```

```
// Figure f = new Figure(10, 10); // illegal now
Rectangle r = new Rectangle(9, 5);
Triangle t = new Triangle(10, 8);
Figure figref; // this is OK, no object is created
figref = r;
System.out.println("Area is " + figref.area());
figref = t;
System.out.println("Area is " + figref.area());
}
}
```

## UNIT-III

**Exception Handling: Benefits of exception handling, the classification of exceptions, usage of try, catch, throw, throws and finally.**

**Multithreading: Differences between multiple processes and multiple threads, thread states, creating threads, interrupting threads.**

### Introduction

- An exception is an event that occurs during the execution of a program that disrupts the normal flow of instruction.
- Or
- An abnormal condition that disrupts Normal program flow.
- There are many cases where abnormal conditions happen during program execution, such as
  - Trying to access an out - of – bounds array elements.
  - The file you try to open may not exist.
  - The file we want to load may be missing or in the wrong format.
  - The other end of your network connection may be non – existence.
- If these cases are not prevented or at least handled properly, either the program will be aborted abruptly, or the incorrect results or status will be produced.
- When an error occurs with in the java method, the method creates an exception object and hands it off to the runtime system.
- The exception object contains information about the exception including its type and the state of the program when the error occurred. The runtime system is then responsible for finding some code to handle the error.
- In java creating an exception object and handling it to the runtime system is called throwing an exception.
- Exception is an object that is describes an exceptional ( i.e. error) condition that has occurred in a piece of code at run time.
- When a exceptional condition arises, an object representing that exception is created and thrown in the method that caused the error. That method may choose to handle the exception itself, or pass it on. Either way, at some point, the exception is caught and processed.
- Exceptions can be generated by the Java run-time system, or they can be manually generated by your code.
- System generated exceptions are automatically thrown by the Java runtime system

General form of Exception Handling block

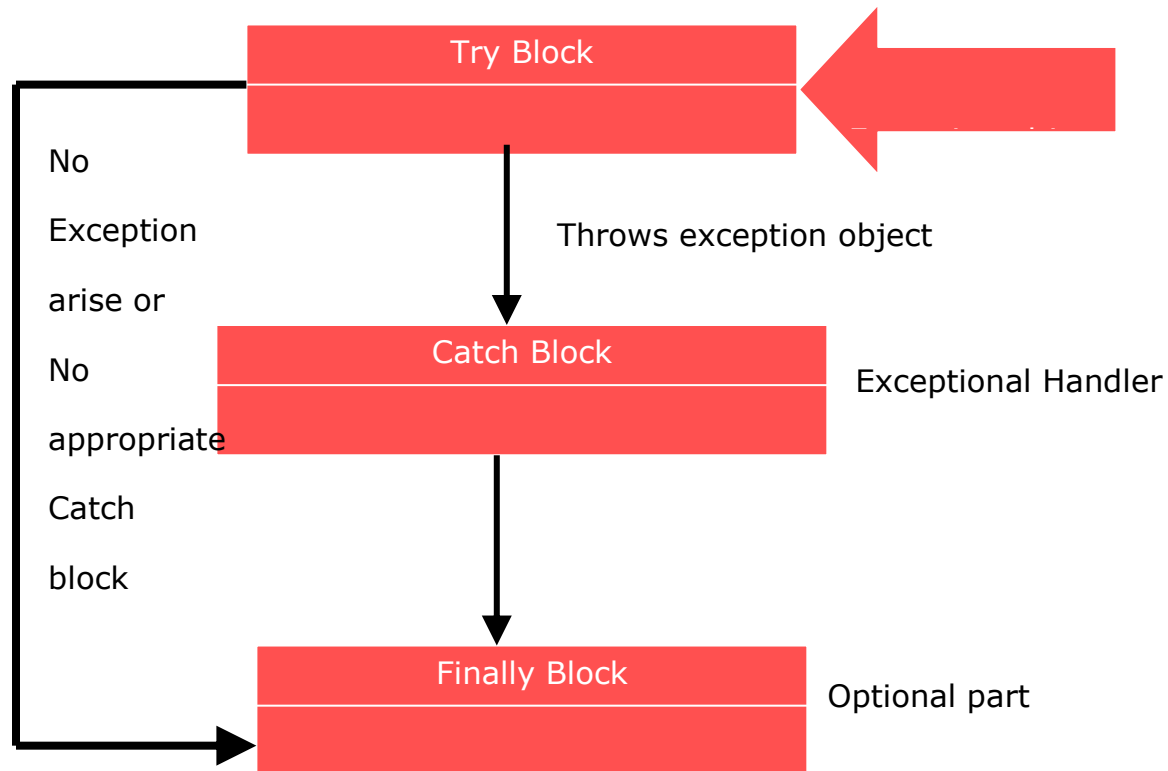
```
try {  
// block of code to monitor for errors  
}  
catch (ExceptionType1 exOb) {  
// exception handler for ExceptionType1  
}
```



```

catch (ExceptionType2 exOb) {
// exception handler for ExceptionType2
}
// ...
finally {
// block of code to be executed before try block ends
}

```



- ✦ By using exception to managing errors, Java programs have have the following advantage over traditional error management techniques:
  - Separating Error handling code from regular code.
  - Propagating error up the call stack.
  - Grouping error types and error differentiation.

For Example:

```

class Exc0 {
public static void main(String args[]) {
int d = 0;
int a = 42 / d;
}
}

```

When the Java run-time system detects the attempt to divide by zero, it constructs a new exception object and then throws this exception. This causes the execution of **Exc0** to stop, because once an exception has been thrown, it must be caught by an exception handler and dealt

with immediately. In this example, we haven't supplied any exception handlers of our own, so the exception is caught by the default handler provided by the Java run-time system. Any exception that is not caught by your program will ultimately be processed by the default handler. The default handler displays a string describing the exception, prints a stack trace from the point at which the exception occurred, and terminates the program. Here is the output generated when this example is executed.

```
java.lang.ArithmeticException: / by zero
at Exc0.main(Exc0.java:4)
```

Notice how the class name, **Exc0**; the method name, **main**; the filename, **Exc0.java**; and the line number, **4**

### Try and Catch Blocks

- ✦ If we don't want to prevent the program to terminate by the exception we have to trap the exception using the try block. So we can place the statements that may causes an exception in the try block.

```
Try
{
}
```

- ✦ If an exception occurs with in the try block, the appropriate exception handler that is associated with the try block handles the exception immediately following the try block, include a catch clause specifies the exception type we wish to catch. A try block must have at least one catch block or finally that allows it immediately.

Catch block

- ✦ The catch block is used to process the exception raised. A try block can be one or more catch blocks can handle a try block.
- ✦ Catch handles are placed immediately after the try block.

Catch(exceptiontype e)

```
{
    //Error handle routine is placed here for handling exception
}
```

Program 1

Class trycatch

```
{
Public static void main(String args[])
{
Int[] no={1,2,3};
Try
{
System.out.println(no[3]);
}
Catch(ArrayIndexOutOfBoundsException e)
```

```
{
System.out.println("Out of bonds");
}
System.out.println("Quit");
}
}
```

### **Output**

Out of the Range  
Quit

```
Program 2
Class ArithExce
{
Public static void main(String args[])
{
Int a=10;
Int b=0;
Try
{
a=a/b;
System.out.println("Won't Print");
}
Catch(ArithmeticException e)
{
System.out.println("Division by Zero error");
System.out.println("Change the b value");

}
System.out.println("Quit");
}
}
```

### **Output**

Division By zero error  
Please change the B value  
Quit

Note:

- A try and its catch statement form a unit.
- We cannot use try block alone.
- The compiler does not allow any statement between try block and its associated catch block

Displaying description of an Exception

- ✦ Throwable overrides the toString() method (defined by Object) so that it returns a string containing a description of the exception.
- ✦ We can display this description in a println statement by simply passing the exception as an argument.

```
catch (ArithmeticException e) {
System.out.println("Exception: " + e);
a = 0; // set a to zero and continue
}
```

- ✦ When this version is substituted in the program, and the program is run, each divide-by-zero error displays the following message:
  - Exception: java.lang.ArithmeticException: / by zero

### Multiple Catch Blocks

In some cases, more than one exception could be raised by a single piece of code. To handle this type of situation, you can specify two or more **catch** clauses, each catching a different type of exception. When an exception is thrown, each **catch** statement is inspected in order, and the first one whose type matches that of the exception is executed. After one **catch** statement executes, the others are bypassed, and execution continues after the **try/catch** block. The following example traps two different exception types:

```
// Demonstrate multiple catch statements.
class MultiCatch {
public static void main(String args[]) {
try {
int a = args.length;
System.out.println("a = " + a);
int b = 42 / a;
int c[] = { 1 };
c[42] = 99;
} catch(ArithmeticException e) {
System.out.println("Divide by 0: " + e);
} catch(ArrayIndexOutOfBoundsException e) {
System.out.println("Array index oob: " + e);
}
System.out.println("After try/catch blocks.");
}
}
```

This program will cause a division-by-zero exception if it is started with no commandline parameters, since **a** will equal zero. It will survive the division if you provide a command-line argument, setting **a** to something larger than zero. But it will cause an **ArrayIndexOutOfBoundsException**, since the **int** array **c** has a length of 1, yet the program attempts to assign a value to **c[42]**.

Here is the output generated by running it both ways:

```
C:\>java MultiCatch
```

```
a = 0
```

```
Divide by 0: java.lang.ArithmeticException: / by zero
```

```
After try/catch blocks.
```

```
C:\>java MultiCatch TestArg
```

```
a = 1
```

```
Array index oob: java.lang.ArrayIndexOutOfBoundsException
```

```
After try/catch blocks.
```

## Throw Keyword

- So far, we have only been catching exceptions that are thrown by the Java Run – Time systems. However, it is possible for our program to throw an exception explicitly, using the throw statement.
  - Throw ThrowableInstance
- Here, ThrowableInstance must be an object of type **Throwable** or a subclass of **Throwable**. Simple types, such as **int** or **char**, as well as non-**Throwable** classes, such as **String** and **Object**, cannot be used as exceptions
- There are two ways you can obtain a **Throwable** object:
  - using a parameter into a **catch** clause
  - creating one with the **new** operator.
- The flow of execution stops immediately after the **throw** statement; any subsequent statements are not executed. The nearest enclosing **try** block is inspected to see if it has a **catch** statement that matches the type of the exception. If it does find a match, control is transferred to that statement. If not, then the next enclosing **try** statement is inspected, and so on. If no matching **catch** is found, then the default exception handler halts the program and prints the stack trace

```
// Demonstrate throw.
class ThrowDemo {
static void demoproc() {
try {
throw new NullPointerException("demo");
} catch(NullPointerException e) {
System.out.println("Caught inside demoproc.");
throw e; // rethrow the exception
}
}
public static void main(String args[]) {
try {
demoproc();
} catch(NullPointerException e) {
System.out.println("Recaught: " + e);
}
}}
```

- This program gets two chances to deal with the same error. First, **main( )** sets up an exception context and then calls **demoproc( )**. The **demoproc( )** method then sets up another exception-handling context and immediately throws a new instance of **NullPointerException**, which is caught on the next line. The exception is then rethrown. Here is the resulting output:
- Caught inside demoproc.
- Recaught: java.lang.NullPointerException: demo
- The program also illustrates how to create one of Java's standard exception objects. Pay close attention to this line:
- `throw new NullPointerException("demo");`
- Here, **new** is used to construct an instance of **NullPointerException**. All of Java's built-in run-time exceptions have at least two constructors: one with no parameter and one that takes a string parameter. When the second form is used, the argument specifies a string that describes the exception. This string is displayed when the object
- is used as an argument to **print( )** or **println( )**. It can also be obtained by a call to **getMessage( )**, which is defined by **Throwable**.

### Throws Keyword

- If a method is capable of causing an exception that it does not handle, it must specify this behavior so that callers of the method can guard themselves against that exception. You do this by including a **throws** clause in the method's declaration. A **throws** clause lists the types of exceptions that a method might throw. This is necessary for all exceptions, except those of type **Error** or **RuntimeException**, or any of their subclasses. All other exceptions that a method can throw must be declared in the **throws** clause. If they are not, a compile-time error will result. This is the general form of a method declaration that includes a **throws** clause:

```
type method-name(parameter-list) throws exception-list
{
// body of method
}
```

- Here, exception-list is a comma-separated list of the exceptions that a method can throw

### Program:

```
class ThrowsDemo {
static void throwOne() throws IllegalAccessException {
System.out.println("Inside throwOne.");
}
```

```

throw new IllegalAccessException("demo");
}
public static void main(String args[]) {
try {
throwOne();
} catch (IllegalAccessException e) {
System.out.println("Caught " + e);
}
}
}

```

➤ Here is the output generated by running this example program:

- inside throwOne
- caught java.lang.IllegalAccessException

### **S.No. throw**

### **throws**

- |   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1) Java throw keyword is used to explicitly throw an exception.</li> <li>2) Checked exception cannot be propagated using throw only.</li> <li>3) Throw is followed by an instance.</li> <li>4) Throw is used within the method.</li> <li>5) You cannot throw multiple exceptions.</li> </ol> | <p>Java throws keyword is used to declare an exception.</p> <p>Checked exception can be propagated with throws.</p> <p>Throws is followed by class.</p> <p>Throws is used with the method signature.</p> <p>You can declare multiple exceptions e.g. public void method()throws IOException,SQLException.</p> |
|---|---|

### **Finally block**

- When exceptions are thrown, execution in a method takes a rather abrupt, nonlinear path that alters the normal flow through the method. Depending upon how the method is coded, it is even possible for an exception to cause the method to return prematurely. This could be a problem in some methods. For example, if a method
- opens a file upon entry and closes it upon exit, then you will not want the code that closes the file to be bypassed by the exception-handling mechanism. The **finally** keyword is designed to address this contingency.
- **finally** creates a block of code that will be executed after a **try/catch** block has completed and before the code following the **try/catch** block. The **finally** block will execute whether or not an exception is thrown. If an exception is thrown, the **finally** block will execute even if no **catch** statement matches the exception. Any time a method is about to return to the caller from inside a **try/catch** block, via an uncaught exception or an explicit return statement, the **finally** clause is also executed just before the method returns. This can be useful for closing file handles and freeing up any other resources that might have been allocated at the beginning of a method with the intent of disposing of them before returning. The **finally** clause is optional. However, each **try** statement requires at least one **catch** or a **finally** clause.

```

// Demonstrate finally.
class FinallyDemo {

```

```

// Through an exception out of the method.
static void procA() {
try {
System.out.println("inside procA");
throw new RuntimeException("demo");
} finally {
System.out.println("procA's finally");
}
}
// Return from within a try block.
static void procB() {
try {
System.out.println("inside procB");
return;
} finally {
System.out.println("procB's finally");
}
}
// Execute a try block normally.
static void procC() {
try {
System.out.println("inside procC");
} finally {
System.out.println("procC's finally");
}
}
public static void main(String args[]) {
try {
procA();
} catch (Exception e) {
System.out.println("Exception caught");
}
procB();
procC();
}
}

```

- ✦ In this example, **procA( )** prematurely breaks out of the **try** by throwing an exception. The **finally** clause is executed on the way out. **procB( )**'s **try** statement is exited via a **return** statement. The **finally** clause is executed before **procB( )** returns. In **procC( )**, the **try** statement executes normally, without error. However, the **finally** block is still executed. If a **finally** block is associated with a **try**, the **finally** block will be executed upon conclusion of the **try**.

- ✦ Here is the output generated by the preceding program:  
inside procA  
procA's finally



Exception caught  
inside procB  
procB's finally  
inside procC  
procC's finally

### Difference between final, finally and finalize:

There are many differences between final, finally and finalize. A list of differences between final, finally and finalize are given below:

No.	final	finally	finalize
1)	Final is used to apply restrictions on class, method and variable. Final class can't be inherited, final method can't be overridden and final variable value can't be changed.	Finally is used to place important code, it will be executed whether exception is handled or not.	Finalize is used to perform clean up processing just before object is garbage collected.
2)	Final is a keyword.	Finally is a block.	Finalize is a method.

### Java final example

```

1. class FinalExample{
2. public static void main(String[] args){
3. final int x=100;
4. x=200;//Compile Time Error
5. }}

```

### Java finally example

```

6. class FinallyExample{
7. public static void main(String[] args){
8. try{
9. int x=300;
10. }catch(Exception e){System.out.println(e);}
11. finally{System.out.println("finally block is executed");}
12. }}

```

### Java finalize example

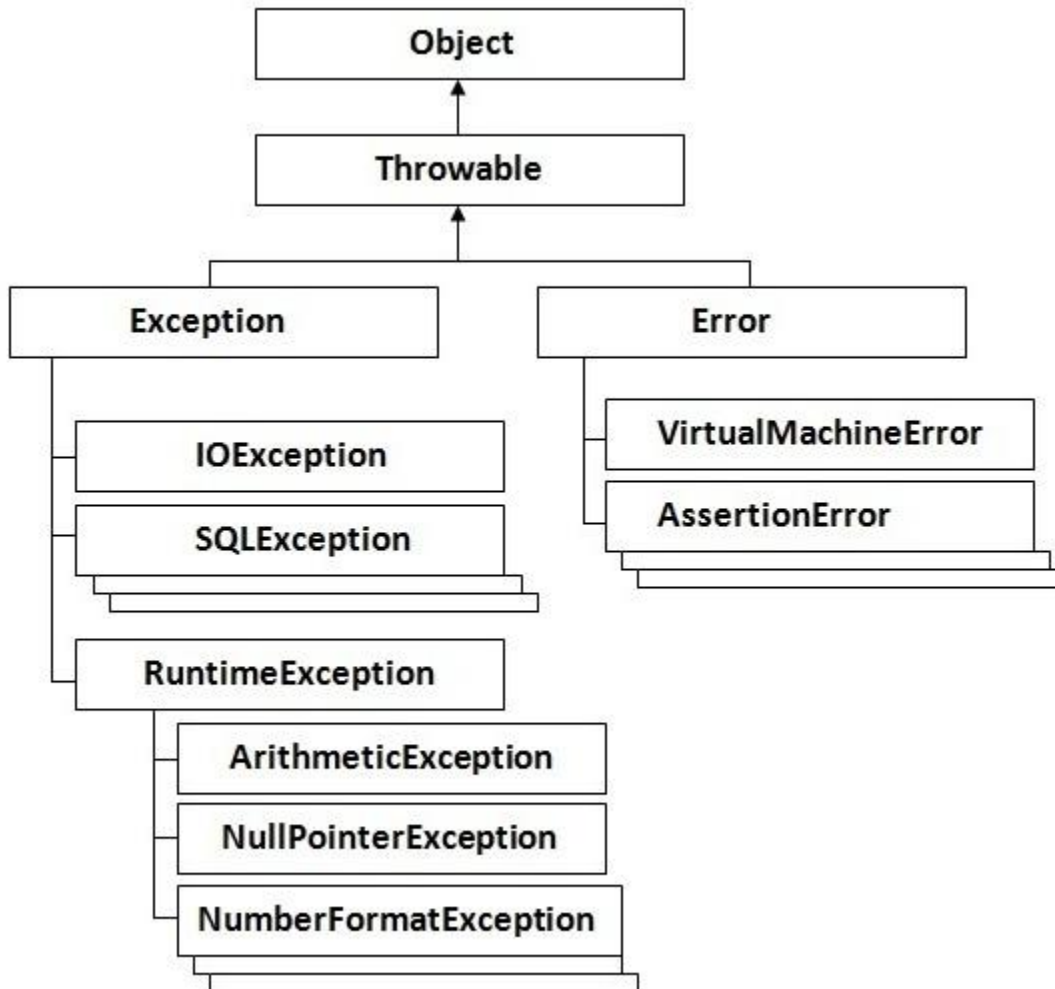
```

1. class FinalizeExample{
2. public void finalize(){System.out.println("finalize called");}
3. public static void main(String[] args){

```

4. FinalizeExample f1=new FinalizeExample();
5. FinalizeExample f2=new FinalizeExample();
6. f1=null;
7. f2=null;
8. System.gc();
9. }}

### Hierarchy of Java Exception classes



### Java Built – In Exceptions

Inside the standard package **java.lang**, Java defines several exception classes. A few have been used by the preceding examples. The most general of these exceptions are subclasses of the standard type **RuntimeException**. Since **java.lang** is implicitly imported into all Java programs,

most exceptions derived from **RuntimeException** are automatically available. Furthermore, they need not be included in any method's **throws** list. In the language of Java, these are called unchecked exceptions because the compiler does not check to see if a method handles or throws these exceptions. The unchecked exceptions defined in **java.lang** are listed in Table 10-1. Table 10-2 lists those exceptions defined by **java.lang** that must be included in a method's **throws** list if that method can generate one of these exceptions and does not handle it itself. These are called checked exceptions. Java defines several other types of exceptions that relate to its various class libraries

### List of Unchecked exceptions

<b>Exception</b>	<b>Meaning</b>
ArithmeticException	Arithmetic error, such as divide-by-zero.
ArrayIndexOutOfBoundsException	Array index is out-of-bounds.
ArrayStoreException	Assignment to an array element of an incompatible type.
ClassCastException	Invalid cast.
IllegalArgumentException	Illegal argument used to invoke a method.
IllegalMonitorStateException	Illegal monitor operation, such as waiting on an unlocked thread.
IllegalStateException	Environment or application is in incorrect state.
IllegalThreadStateException	Requested operation not compatible with current thread state.
IndexOutOfBoundsException	Some type of index is out-of-bounds.
NegativeArraySizeException	Array created with a negative size.

<b>Exception</b>	<b>Meaning</b>
NullPointerException	Invalid use of a null reference.
NumberFormatException	Invalid conversion of a string to a numeric format.
SecurityException	Attempt to violate security.
StringIndexOutOfBoundsException	Attempt to index outside the bounds of a string.
UnsupportedOperationException	An unsupported operation was encountered.

### List of Checked exceptions

## **Exception**

`ClassNotFoundException`  
`CloneNotSupportedException`  
`IllegalAccessException`  
`InstantiationException`  
`InterruptedException`  
`NoSuchFieldException`  
`NoSuchMethodException`

## **Meaning**

Class not found.  
Attempt to clone an object that does not implement the `Cloneable` interface.  
Access to a class is denied.  
Attempt to create an object of an abstract class or interface.  
One thread has been interrupted by another thread.  
A requested field does not exist.  
A requested method does not exist.

## **User defined exceptions**

- We can create our own exception by extending exception class.
- The `throw` and `throws` keywords are used while implementing user defined exceptions

Class `ownException` extends `Exception`

```
{  
ownException(String msg)  
{  
Super(msg);  
}  
}
```

Class `test`

```
{  
Public static void main(String args[])  
Int mark=101;  
Try  
{  
if(mark>100)  
{  
Throw new ownException("Marks>100");  
}  
}  
Catch(ownException e)  
{  
System.out.println ("Exception caught");  
System.out.println("e.getMessage());  
}  
Finally  
{  
System.out.println("End of prg");  
}
```

```
}  
}  
}
```

Output:

Exception caught  
Marks is > 100  
End of program

## **Multi Threaded Programming**

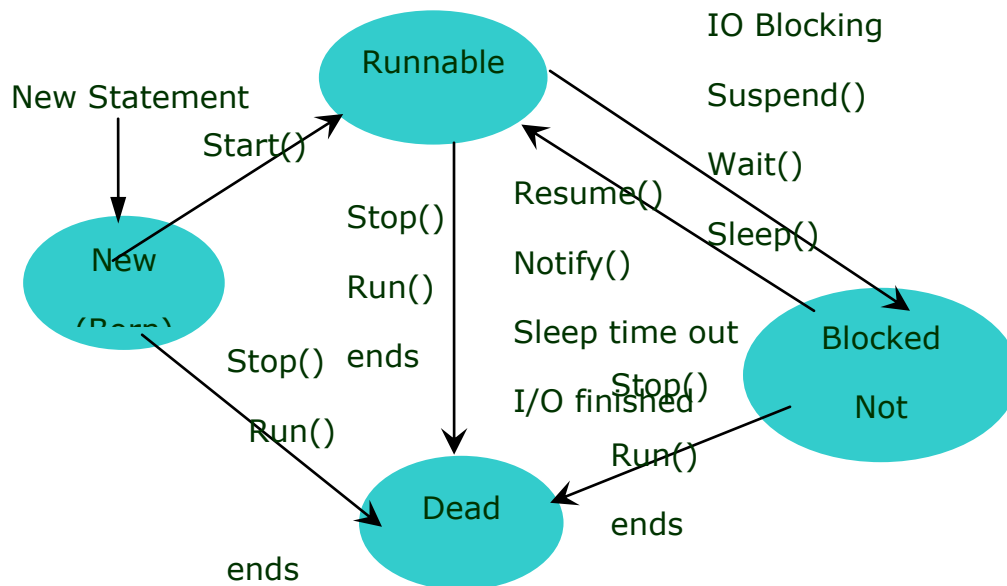
### **Introduction:**

- Java provides a built – in support for multithreaded programming.
- A multithreaded program contains two or more parts that can run concurrently.
- Each part of such a program called thread.
- Each thread defines a separate path of execution.
- Thus multi thread is a specialized form of multi tasking.
- Multi tasking is supported by OS
- There are two distinct types of multi tasking
- Process based multi tasking
- Process is a program that is executing.
- In process based multi tasking, a program is the smallest unit of code that can be dispatched by the scheduler
- Process based multi tasking is a feature that allows computer to run two or more programs concurrently
- For example :
- This tasking enables us to run the Java compiler and text editor at the same time
- Thread based multi tasking
- Thread is a smallest unit of dispatchable code
- The single program can perform two or more tasks simultaneously.
- For example:
- A text editor can format text at the same time that is printing as long as these two actions are performed by two separate threads.
- Multitasking threads require less overhead than multitasking processes.

### **Thread Model**

- One thread can pause without stopping other parts of your program.
  - For example, the idle time created when a thread reads data from a network or waits for user input can be utilized elsewhere.
  - Multithreading allows animation loops to sleep for a second between each frame without causing the whole system to pause.

- When a thread blocks in a Java program, only the single thread that is blocked pauses. All other threads continue to run.
- Thread States
  - Threads exist in several states.
    - A thread can be running. It can be ready to run as soon as it gets CPU time.
    - A running thread can be suspended, which temporarily suspends its activity.
    - A suspended thread can then be resumed, allowing it to pick up where it left off.
    - A thread can be blocked when waiting for a resource.
    - At any time, a thread can be terminated, which halts its execution immediately.
    - Once terminated, a thread cannot be resumed
- Every thread after creation and before destruction can have any one of four states:
  - Newly created
  - Runnable state
  - Blocked
  - Dead



## THREAD LIFE CYCLE

### New State

- A thread enters the newly created by using a new operator.
- It is new state or born state immediately after creation. i.e. when a constructor is called the Thread is created but is not yet to `run()` method will not begin until it `start()` method is called.

- After the start() method is called, the thread will go to the next state, Runnable state.
- Note : in the above cycle stop(), resume() and suspend are deprecated methods. Java 2 strongly discourage their usage in the program
- **Runnable state**
  - Once we invoke the start() method, the thread is runnable.
  - It is divided into two states:
    - The running state
      - When the thread is running state, it assigned by CPU cycles and is actually running.
    - The Queued state.
      - When the thread is in Queued state, it is waiting in the Queue and competing for its turn to spend CPU cycles
      - It is controlled by Virtual Machine Controller.
      - When we use yield() method it makes sure other threads of the same priority have chance to run.
      - This method cause voluntary move itself to the queued state from the running state.

### **Blocked state**

- The blocked state is entered when one of the following events occurs:
  - The thread itself or another thread calls the suspend() method (it is deprecated)
  - The thread calls an object's wait() method
  - The thread itself calls the sleep() method.
  - The thread is waiting for some I/O operations to complete.
  - The thread will join() another thread.

### **Dead state**

- A thread is dead for any one of the following reasons:
  - It dies a natural death because the un method exists normally.
  - It dies abruptly because an uncaught exception terminates the run method.
  - In particular stop() is used to kill the thread. This is deprecated.
  - To find whether thread is alive i.e. currently running or blocked
    - Use isAlive() method
      - If it returns true the thread is alive

### **Thread priorities**

- Java assigns to each thread a priority that determines how that thread should be treated with respect to the others. Thread priorities are integers that specify the relative priority of one thread to another. As an absolute value, a priority is meaningless; a higher-priority thread doesn't run any faster than a lower-priority thread if it is the only thread running. Instead, a thread's priority is used to decide when to switch from one running thread to

the next. This is called a context switch. The rules that determine when a context switch takes place are simple:

- A thread can voluntarily relinquish control. This is done by explicitly yielding, sleeping, or blocking on pending I/O. In this scenario, all other threads are examined, and the highest-priority thread that is ready to run is given the CPU.
  - A thread can be preempted by a higher-priority thread. In this case, a lower-priority thread that does not yield the processor is simply preempted—no matter what it is doing—by a higher-priority thread. Basically, as soon as a higher-priority thread wants to run, it does. This is called preemptive multitasking.
- In cases where two threads with the same priority are competing for CPU cycles, the situation is a bit complicated. For operating systems such as Windows 98, threads of equal priority are time-sliced automatically in round-robin fashion. For other types of operating systems, threads of equal priority must voluntarily yield control to their peers. If they don't, the other threads will not run.

### **Synchronization**

- Because multithreading introduces an asynchronous behavior to your programs, there must be a way for you to enforce synchronicity when you need it. For example, if you want two threads to communicate and share a complicated data structure, such as a linked list, you need some way to ensure that they don't conflict with each other. That is, you must prevent one thread from writing data while another thread is in the middle of reading it. For this purpose, Java implements an elegant twist on an age-old model of interprocess synchronization: the monitor. The monitor is a control mechanism first defined by C.A.R. Hoare. You can think of a monitor as a very small box that can hold only one thread. Once a thread enters a monitor, all other threads must wait until that thread exits the monitor. In this way, a monitor can be used to protect a shared asset from being manipulated by more than one thread at a time.

### **Messaging**

- After you divide your program into separate threads, you need to define how they will communicate with each other. When programming with most other languages, you must depend on the operating system to establish communication between threads. This, of course, adds overhead. By contrast, Java provides a clean, low-cost way for two or more threads to talk to each other, via calls to predefined methods that all objects have. Java's messaging system allows a thread to enter a synchronized method on an object, and then wait there until some other thread explicitly notifies it to come out.

### **Thread class and Runnable interface**

The Thread Class and the Runnable InterfaceJava's multithreading system is built upon the **Thread** class, its methods, and its companion interface, **Runnable**. **Thread** encapsulates a thread of execution. Since you can't directly refer to the ethereal state of a running thread, you will deal with it through its proxy, the **Thread** instance that spawned it. To create a new thread, your program will either extend **Thread** or implement the **Runnable** interface.



- The **Thread** class defines several methods that help manage threads.

Method	Meaning
<code>getName</code>	Obtain a thread's name.
<code>getPriority</code>	Obtain a thread's priority.
<code>isAlive</code>	Determine if a thread is still running.
<code>join</code>	Wait for a thread to terminate.
<code>run</code>	Entry point for the thread.
<code>sleep</code>	Suspend a thread for a period of time.
<code>start</code>	Start a thread by calling its <code>run</code> method.

### Main method

- When a Java program starts up, one thread begins running immediately. This is usually called the main thread of your program, because it is the one that is executed when your program begins. The main thread is important for two reasons:
  - It is the thread from which other “child” threads will be spawned .
  - Often it must be the last thread to finish execution because it performs various shutdown actions.
- Although the main thread is created automatically when your program is started, it can be controlled through a **Thread** object. To do so, you must obtain a reference to it by calling the method `currentThread()`, which is a **public static** member of **Thread**. Its general form is
  - `static Thread currentThread()`
- This method returns a reference to the thread in which it is called. Once you have a reference to the main thread, you can control it just like any other thread.

// Controlling the main Thread.

```
class CurrentThreadDemo {
public static void main(String args[]) {
Thread t = Thread.currentThread();
System.out.println("Current thread: " + t);
// change the name of the thread
t.setName("My Thread");
System.out.println("After name change: " + t);
try {
for(int n = 5; n > 0; n--) {
System.out.println(n);
Thread.sleep(1000);
}
} catch (InterruptedException e) {
System.out.println("Main thread interrupted");
}
}
}
```

Current thread: Thread[main,5,main]  
After name change: Thread[My Thread,5,main]  
5  
4  
3  
2  
1

### How to create a thread

- In the most general sense, you create a thread by instantiating an object of type **Thread**.
- Java defines two ways in which this can be accomplished:
  - You can implement the **Runnable** interface.
  - You can extend the **Thread** class, itself.

### Implementing thread class

- The easiest way to create a thread is to create a class that implements the **Runnable** interface. **Runnable** abstracts a unit of executable code. You can construct a thread on any object that implements **Runnable**. To implement **Runnable**, a class need only implement a single method called **run()**, which is declared like this:
  - `public void run()`
- Inside **run()**, you will define the code that constitutes the new thread. It is important to understand that **run()** can call other methods, use other classes, and declare variables, just like the main thread can. The only difference is that **run()** establishes the entry point for another, concurrent thread of execution within your program. This thread will end when **run()** returns.
- After you create a class that implements **Runnable**, you will instantiate an object of type **Thread** from within that class. **Thread** defines several constructors. The one that we will use is shown here:
  - `Thread(Runnable threadOb, String threadName)`
- In this constructor, `threadOb` is an instance of a class that implements the **Runnable** interface. This defines where execution of the thread will begin. The name of the new thread is specified by `threadName`.
- After the new thread is created, it will not start running until you call its **start()** method, which is declared within **Thread**. In essence, **start()** executes a call to **run()**.
- The **start()** method is shown here:
  - `void start()`

### Extending thread class

The second way to create a thread is to create a new class that extends **Thread**, and then to create an instance of that class. The extending class must override the **run()** method, which is the entry point for the new thread. It must also call **start()** to begin execution of the new thread. Here is the preceding program rewritten to extend **Thread**

```
// Create a second thread by extending Thread
```

```

class NewThread extends Thread {
NewThread() {
// Create a new, second thread
super("Demo Thread");
System.out.println("Child thread: " + this);
start(); // Start the thread
}
// This is the entry point for the second thread.
public void run() {
try {
for(int i = 5; i > 0; i--) {
System.out.println("Child Thread: " + i);
Thread.sleep(500);
}
} catch (InterruptedException e) {
System.out.println("Child interrupted.");
}
System.out.println("Exiting child thread.");
}
}
class ExtendThread {
public static void main(String args[]) {
new NewThread(); // create a new thread
try {
for(int i = 5; i > 0; i--) {
System.out.println("Main Thread: " + i);
Thread.sleep(1000);
}
} catch (InterruptedException e) {
System.out.println("Main thread interrupted.");
}
System.out.println("Main thread exiting.");
}
}

```

### **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 is achieved is called synchronization. As you will see, Java provides unique, language-level support for it. Key to synchronization is the concept of the monitor (also called a semaphore).

A monitor is an object that is used as a mutually exclusive lock, or mutex. Only one thread can own a monitor at a given time. When a thread acquires a lock, it is said to have entered the monitor. All other threads attempting to enter the locked monitor will be suspended until the first thread exits the monitor. These other threads are said to be waiting for the monitor. A thread that owns a monitor can reenter the same monitor if it so desires.

You can synchronize your code in either of two ways. Both involve the use of the **synchronized** keyword, and both are examined here.

### Using Synchronized Methods

Synchronization is easy in Java, because all objects have their own implicit monitor associated with them. To enter an object's monitor, just call a method that has been modified with the **synchronized** keyword. While a thread is inside a synchronized method, all other threads that try to call it (or any other synchronized method) on the same instance have to wait. To exit the monitor and relinquish control of the object to the next waiting thread, the owner of the monitor simply returns from the synchronized method.

While creating **synchronized** methods within classes that you create is an easy and effective means of achieving synchronization, it will not work in all cases. To understand why, consider the following. Imagine that you want to synchronize access to objects of a class that was not designed for multithreaded access. That is, the class does not use **synchronized** methods. Further, this class was not created by you, but by a third party, and you do not have access to the source code. Thus, you can't add **synchronized** to the appropriate methods within the class. How can access to an object of this class be synchronized? Fortunately, the solution to this problem is quite easy: You simply put calls to the methods defined by this class inside a **synchronized** block.

This is the general form of the **synchronized** statement:

```
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 monitor.

Here is an alternative version of the preceding example, using a synchronized block within the **run()** method:

```
// This program uses a synchronized block.
```

```
class Callme {  
    void call(String msg) {  
        System.out.print("[ " + msg);  
        try {  
            Thread.sleep(1000);  
        } catch (InterruptedException e) {  
            System.out.println("Interrupted");  
        }  
        System.out.println("]");  
    }  
}  
  
class Caller implements Runnable {  
    String msg;  
    Callme target;  
    Thread t;
```

```

public Caller(Callme targ, String s) {
target = targ;
msg = s;
t = new Thread(this);
t.start();
}
// synchronize calls to call()
public void run() {
synchronized(target) { // synchronized block
target.call(msg);
}
}
}

class Synch1 {
public static void main(String args[]) {
Callme target = new Callme();
Caller ob1 = new Caller(target, "Hello");
Caller ob2 = new Caller(target, "Synchronized");
Caller ob3 = new Caller(target, "World");
// wait for threads to end
try {
ob1.t.join();
ob2.t.join();
ob3.t.join();
} catch (InterruptedException e) {
System.out.println("Interrupted");
}
}
}

```

Here, the `call()` method is not modified by **synchronized**. Instead, the **synchronized** statement is used inside **Caller's run() method. This causes the same correct output as the preceding example, because each thread waits for the prior one to finish before proceeding.**

### **Daemon Threads**

A “daemon” thread is one that is supposed to provide a general service in the background as long as the program is running, but is not part of the essence of the program. Thus when all of the non-daemon threads complete, the program is terminated. you can find out if a thread is a daemon by calling `isDaemon()`, and you can turn the “daemonhood” of a thread on and off with `setDaemon()`.if a thread is a daemon, then any threads it creates will automatically be daemons.

## INTER-THREAD COMMUNICATION IN JAVA

**Inter-thread communication** or **Co-operation** is all about allowing synchronized threads to communicate with each other.

Cooperation (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. It is implemented by following methods of **Object class**:

- wait()
- notify()
- notifyAll()

### 1) wait() method

Causes current thread to release the lock and wait until either another thread invokes the notify() method or the notifyAll() method for this object, or a specified amount of time has elapsed.

The current thread must own this object's monitor, so it must be called from the synchronized method only otherwise it will throw exception.

Method	Description
public final void wait()throws InterruptedException	waits until object is notified.
public final void wait(long timeout)throws InterruptedException	waits for the specified amount of time.

### 2) notify() method

Wakes up a single thread that is waiting on this object's monitor. If any threads are waiting on this object, one of them is chosen to be awakened. The choice is arbitrary and occurs at the discretion of the implementation. Syntax:

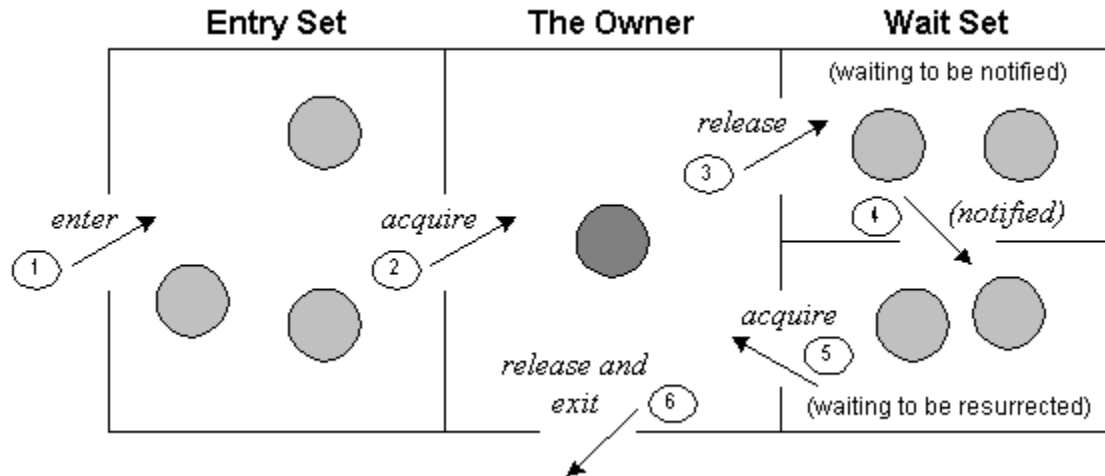
```
public final void notify()
```

### 3) notifyAll() method

Wakes up all threads that are waiting on this object's monitor. Syntax:

```
public final void notifyAll()
```

## Understanding the process of inter-thread communication



The point to point explanation of the above diagram is as follows:

1. Threads enter to acquire lock.
2. Lock is acquired by on thread.
3. Now thread goes to waiting state if you call wait() method on the object. Otherwise it releases the lock and exits.
4. If you call notify() or notifyAll() method, thread moves to the notified state (runnable state).
5. Now thread is available to acquire lock.
6. After completion of the task, thread releases the lock and exits the monitor state of the object.

### Why wait(), notify() and notifyAll() methods are defined in Object class not Thread class?

It is because they are related to lock and object has a lock.

### Difference between wait and sleep?

Let's see the important differences between wait and sleep methods.

<b>wait()</b>	<b>sleep()</b>
wait() method releases the lock	sleep() method doesn't release the lock.
is the method of Object class	is the method of Thread class
is the non-static method	is the static method
is the non-static method	is the static method
should be notified by notify() or notifyAll() methods	after the specified amount of time, sleep is completed.

## Example of inter thread communication in java

Let's see the simple example of inter thread communication.

```
1. class Customer{
2. int amount=10000;
3.
4. synchronized void withdraw(int amount){
5. System.out.println("going to withdraw...");
6.
7. if(this.amount<amount){
8. System.out.println("Less balance; waiting for deposit...");
9. try{ wait();}catch(Exception e){ }
10. }
11. this.amount-=amount;
12. System.out.println("withdraw completed...");
13. }
14.
15. synchronized void deposit(int amount){
16. System.out.println("going to deposit...");
17. this.amount+=amount;
18. System.out.println("deposit completed... ");
19. notify();
20. }
21. }
22.
23. class Test{
24. public static void main(String args[]){
25. final Customer c=new Customer();
26. new Thread(){
27. public void run(){c.withdraw(15000);}
28. }.start();
29. new Thread(){
30. public void run(){c.deposit(10000);}
31. }.start();
32.
33. }}
```

Output: going to withdraw...  
Less balance; waiting for deposit...  
going to deposit...  
deposit completed...  
withdraw completed



## INTERRUPTING A THREAD:

If any thread is in sleeping or waiting state (i.e. `sleep()` or `wait()` is invoked), calling the `interrupt()` method on the thread, breaks out the sleeping or waiting state throwing `InterruptedException`. If the thread is not in the sleeping or waiting state, calling the `interrupt()` method performs normal behaviour and doesn't interrupt the thread but sets the interrupt flag to true. Let's first see the methods provided by the `Thread` class for thread interruption.

### The 3 Methods Provided By The Thread Class For Interrupting A Thread

1. `public void interrupt()`
2. `public static boolean interrupted()`
3. `public boolean isInterrupted()`

### Example of interrupting a thread that stops working

In this example, after interrupting the thread, we are propagating it, so it will stop working. If we don't want to stop the thread, we can handle it where `sleep()` or `wait()` method is invoked. Let's first see the example where we are propagating the exception.

```
class TestInterruptingThread1 extends Thread{
public void run(){
try{
Thread.sleep(1000);
System.out.println("task");
}catch(InterruptedException e){
throw new RuntimeException("Thread interrupted..." +e);
}

}

public static void main(String args[]){
TestInterruptingThread1 t1=new TestInterruptingThread1();
t1.start();
try{
t1.interrupt();
}catch(Exception e){System.out.println("Exception handled " +e);}

}
}
```

```
Output:Exception in thread-0
java.lang.RuntimeException: Thread interrupted...
java.lang.InterruptedException: sleep interrupted
at A.run
```

## Example of interrupting a thread that doesn't stop working

In this example, after interrupting the thread, we handle the exception, so it will break out the sleeping but will not stop working.

```
class TestInterruptingThread2 extends Thread{
    public void run(){
        try{
            Thread.sleep(1000);
            System.out.println("task");
        }catch(InterruptedException e){
            System.out.println("Exception handled "+e);
        }
        System.out.println("thread is running...");
    }

    public static void main(String args[]){
        TestInterruptingThread2 t1=new TestInterruptingThread2();
        t1.start();

        t1.interrupt();
    }
}
```

Output:Exception handled  
java.lang.InterruptedException: sleep interrupted  
thread is running...

### Example of interrupting thread that behaves normally:

If thread is not in sleeping or waiting state, calling the interrupt() method sets the interrupted flag to true that can be used to stop the thread by the java programmer later.

```
class TestInterruptingThread3 extends Thread{

    public void run(){
        for(int i=1;i<=5;i++)
            System.out.println(i);
    }

    public static void main(String args[]){
        TestInterruptingThread3 t1=new TestInterruptingThread3();
        t1.start();

        t1.interrupt();

    }
}
```

Output: 1

2  
3  
4  
5

### **What About Isinterrupted And Interrupted Method:**

The `isInterrupted()` method returns the interrupted flag either true or false. The static `interrupted()` method returns the interrupted flag after that it sets the flag to false if it is true.

```
public class TestInterruptingThread4 extends Thread{
```

```
    public void run(){  
        for(int i=1;i<=2;i++){  
            if(Thread.interrupted()){  
                System.out.println("code for interrupted thread");  
            }  
            else{  
                System.out.println("code for normal thread");  
            }  
        }  
    }  
}
```

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

```
    TestInterruptingThread4 t1=new TestInterruptingThread4();  
    TestInterruptingThread4 t2=new TestInterruptingThread4();
```

```
    t1.start();  
    t1.interrupt();
```

```
    t2.start();
```

```
    }  
}
```

Output:Code for interrupted thread  
code for normal thread  
code for normal thread  
code for normal thread

## UNIT-IV

**Interface: Interfaces vs Abstract classes, defining an interface, implement interfaces**  
**Packages: Defining, creating and accessing a package, importing packages.**

### Difference between classes and interfaces:

A class is a template for an object.

(or)

A class is a way of binding variables and methods in a single unit. With the class it is possible to create object for that object. With the one class we can extend another class.

An interface is a collection of undefined methods. Means all the methods do not contain any body. We have to provide the body for that interface. With the interface it is not possible to create object. For the declared interface we have to implement that interface.

### Defining Interfaces:

- Interface is a collection of method declarations and constants that one or more classes of objects will use.
- We can implement multiple inheritance using interface.
- Because interface consists only signatures followed by semi colon and parameter list they are implicitly abstract.
- Variables can be declared and initialized inside interface they are implicitly final and static.
- An interface method can't be final or static or private or native or protected.
- An interface can be extended from another interface.
- Declaration of interface:

```
Access interface name
{
    Return type member-name1(parameterlist);
    Return type member-name2(parameterlist);
    .
    .
    .
    Type finalvariablename=initialization;
}
```

- There will be no default implementation for methods specified in an interface.
- Each class that includes interface must implement all methods.
- All the methods and variables are implicitly public if interface itself is declared as public.

## Implementing Interfaces:

Once an **interface** has been defined, one or more classes can implement that interface. To implement an interface, include the **implements** clause in a class definition, and then create the methods defined by the interface. The general form of a class that includes the **implements** clause looks like this:

```
access class classname [extends superclass]
[implements interface [,interface...]] {
// class-body
}
```

Here, access is either **public** or not used. If a class implements more than one interface, the interfaces are separated with a comma. If a class implements two interfaces that declare the same method, then the same method will be used by clients of either interface. The methods that implement an interface must be declared **public**. Also, the type signature of the implementing method must match exactly the type signature specified in the **interface** definition.

## Applying Interfaces:

To understand the power of interfaces, let's look at a more practical example. In earlier chapters you developed a class called **Stack** that implemented a simple fixed-size stack. However, there are many ways to implement a stack. For example, the stack can be of a fixed size or it can be "growable." The stack can also be held in an array, a linked list, a binary tree, and so on. No matter how the stack is implemented, the interface to the stack remains the same. That is, the methods **push( )** and **pop( )** define the interface to the stack independently of the details of the implementation. Because the interface to a stack is separate from its implementation, it is easy to define a stack interface, leaving it to each implementation to define the specifics. Let's look at two examples.

First, here is the interface that defines an integer stack. Put this in a file called **IntStack.java**. This interface will be used by both stack implementations.

```
// Define an integer stack interface.
interface IntStack {
void push(int item); // store an item
int pop(); // retrieve an item
}
```

## Variables in Interfaces:

When you include that interface in a class (that is, when you "implement" the interface), all of those variable names will be in scope as constants. This is similar to using a header file in C/C++ to create a large number of **#defined** constants or **const** declarations. If an interface contains no methods, then any class that includes such an interface doesn't actually implement

anything. It is as if that class were importing the constant variables into the class name space as **final** variables.

```
import java.util.Random;
interface SharedConstants {
int NO = 0;
int YES = 1;
int MAYBE = 2;
int LATER = 3;
int SOON = 4;
int NEVER = 5;
}
class Question implements SharedConstants {
Random rand = new Random();
int ask() {
int prob = (int) (100 * rand.nextDouble());
if (prob < 30)
return NO; // 30%
else if (prob < 60)
return YES; // 30%
else if (prob < 75)
return LATER; // 15%
else if (prob < 98)
return SOON; // 13%
else
return NEVER; // 2%
}
}
class AskMe implements SharedConstants {
static void answer(int result) {
switch(result) {
case NO:
System.out.println("No");
break;
case YES:
System.out.println("yes");
break;
case MAYBE:
System.out.println("Maybe");
break;
case LATER:
System.out.println("Later");
break;
case SOON:
System.out.println("Soon");
break;
}
```

```

case NEVER:
System.out.println("Never");
break;
}
}
public static void main(String args[]) {
Question q = new Question();
answer(q.ask());
answer(q.ask());
answer(q.ask());
answer(q.ask());
}
}

```

### **Interfaces Can Be Extended:**

One interface can inherit another by use of the keyword **extends**. The syntax is the same as for inheriting classes. When a class implements an interface that inherits another interface, it must provide implementations for all methods defined within the interface inheritance chain. Following is an example:

```

// One interface can extend another.
interface A {
void meth1();
void meth2();
}
// B now includes meth1() and meth2() -- it adds meth3().
interface B extends A {
void meth3();
}
// This class must implement all of A and B
class MyClass implements B {
public void meth1() {
System.out.println("Implement meth1().");
}
public void meth2() {
System.out.println("Implement meth2().");
}
public void meth3() {
System.out.println("Implement meth3().");
}
}
class IFExtend {
public static void main(String arg[]) {
MyClass ob = new MyClass();
}
}

```

```
ob.meth1();
ob.meth2();
ob.meth3();
}
}
```

As an experiment you might want to try removing the implementation for **meth1()** in **MyClass**. This will cause a compile-time error. As stated earlier, any class that implements an interface must implement all methods defined by that interface, including any that are inherited from other interfaces.

### Defining Package:

- Generally, any java source file contains any (or all) of the following internal parts:
- A single package statement ( optional)
- Any number of import statements ( optional)
- A single public class declaration (required)
- Any number of classes private to the package (optional)
- Packages and Interfaces are two of the basic components of a java program.
- Packages are collection of related classes.
- Packages are containers for classes that are used to keep the class name compartmentalized.
- Packages are stored in an hierarchical manner and are explicitly imported into new class definition.
- Java packages are classified into two types:
- Java API package or pre-defined packages or built – in – packages .
- User – defined packages
- Java 2 API contains 60 java.\* packages.
- For Example:
  - java.lang
  - Java.io
  - Java.awt
  - Java.util
  - Java.net
  - Javax.swing
- To create a package
- Just give package <<packagename>> as a first statement in java program.
- Any classes declared within that file will belong to the specified package.
- If we omit package statement, the classes are stored in the default package.

Syntax: Package packagename

Syntax: Package packagename.subpackage



### Access protection:

- Classes and packages both means of encapsulating and containing the name space and scope of variables and methods.
- Packages acts as a containers for classes and other sub – ordinate packages.
- Classes act as containers for data and code.
- Java address four categories of visibility for class members:
  - Sub – classes in the same package.
  - Non – sub class in the same package.
  - Sub – classes in the different package.
  - Classes that are neither in the same package nor subclasses.
- The 3 access specifiers private, public and protected provide a variety of ways to produce the many levels of access required by these categories.

<b>Access specifier</b>	<b>Private</b>	<b>No modifier</b>	<b>Protected</b>	<b>Public</b>
<b>Access Location</b>				
Same class	Yes	Yes	Yes	Yes
Same package sub class	No	Yes	Yes	Yes
Same package non – sub class	No	Yes	Yes	Yes
Different package sub class	No	No	Yes	Yes
Different package non sub class	No	No	No	Yes

From the above table,

- Any thing declared public can be accessed from any where
- Any thing accessed private cannot be accessed from outside of its class
- In the default, it is visible to sub-class as well as to other classes in the same package
- Any thing declared as protected, this is allow an element to be seen outside your current package, but also allow to sub class in other packages access.

### UNDERSTANDING CLASSPATH:

As just explained, packages are mirrored by directories. This raises an important question: How does the Java run-time system know where to look for packages that you create? The answer has two parts. First, by default, the Java run-time system uses the current working directory as its starting point. Thus, if your package is in the current directory, or a subdirectory

of the current directory, it will be found. Second, you can specify a directory path or paths by setting the **CLASSPATH** environmental variable. For example, consider the following package specification.

### **package MyPack;**

In order for a program to find **MyPack**, one of two things must be true. Either the program is executed from a directory immediately above **MyPack**, or **CLASSPATH** must be set to include the path to **MyPack**. The first alternative is the easiest (and doesn't require a change to **CLASSPATH**), but the second alternative lets your program find **MyPack** no matter what directory the program is in. Ultimately, the choice is yours.

### **Importing Packages:**

There are no core Java classes in the unnamed default package; all of the standard classes are stored in some named package. Since classes within packages must be fully qualified with their package name or names, it could become tedious to type in the long dot-separated package path name for every class you want to use. For this reason, Java includes the **import** statement to bring certain classes, or entire packages, into visibility. Once imported, a class can be referred to directly, using only its name. The **import** statement is a convenience to the programmer and is not technically needed to write a complete Java program. If you are going to refer to a few dozen classes in your application, however, the **import** statement will save a lot of typing.

In a Java source file, **import** statements occur immediately following the **package** statement (if it exists) and before any class definitions. This is the general form of the

**import** statement:

### **import pkg1[.pkg2].(classname\*);**

Here, `pkg1` is the name of a top-level package, and `pkg2` is the name of a subordinate package inside the outer package separated by a dot (.). There is no practical limit on the depth of a package hierarchy, except that imposed by the file system. Finally,

you specify either an explicit classname or a star (\*), which indicates that the Java compiler should import the entire package. This code fragment shows both forms in use:

```
import java.util.Date;
import java.io.*;
```

The `java.io` package contains nearly every class you might ever need to perform input and output (I/O) in Java. All these streams represent an input source and an output destination. The stream in the `java.io` package supports many data such as primitives, Object, localized characters, etc.

## UNIT-V

**Files: streams – byte streams, character stream, text input/output, binary input/output, file management**

**Connecting to Database: Connecting to a database, querying a database and processing the results, updating data with JDBC.**

A stream can be defined as a sequence of data. The `InputStream` is used to read data from a source and the `OutputStream` is used for writing data to a destination.

Java provides strong but flexible support for I/O related to Files and networks but this tutorial covers very basic functionality related to streams and I/O. We would see most commonly used example one by one:

### Byte Streams

Java byte streams are used to perform input and output of 8-bit bytes. Though there are many classes related to byte streams but the most frequently used classes are , **FileInputStream** and **FileOutputStream**. Following is an example which makes use of these two classes to copy an input file into an output file:

```
import java.io.*;

public class CopyFile {
    public static void main(String args[]) throws IOException
    {
        FileInputStream in = null;
        FileOutputStream out = null;

        try {
            in = new FileInputStream("input.txt");
            out = new FileOutputStream("output.txt");

            int c;
            while ((c = in.read()) != -1) {
                out.write(c);
            }
        } finally {
            if (in != null) {
                in.close();
            }
            if (out != null) {
                out.close();
            }
        }
    }
}
```

Now let's have a file **input.txt** with the following content:

This is test for copy file.

As a next step, compile above program and execute it, which will result in creating output.txt file with the same content as we have in input.txt. So let's put above code in CopyFile.java file and do the following:

```
$javac CopyFile.java  
$java CopyFile
```

## Character Streams

Java **Byte** streams are used to perform input and output of 8-bit bytes, where as Java **Character** streams are used to perform input and output for 16-bit unicode. Though there are many classes related to character streams but the most frequently used classes are , **FileReader** and **FileWriter**.. Though internally FileReader uses FileInputStream and FileWriter uses FileOutputStream but here major difference is that FileReader reads two bytes at a time and FileWriter writes two bytes at a time.

We can re-write above example which makes use of these two classes to copy an input file (having unicode characters) into an output file:

```
import java.io.*;  
  
public class CopyFile {  
    public static void main(String args[]) throws IOException  
    {  
        FileReader in = null;  
        FileWriter out = null;  
  
        try {  
            in = new FileReader("input.txt");  
            out = new FileWriter("output.txt");  
  
            int c;  
            while ((c = in.read()) != -1) {  
                out.write(c);  
            }  
        } finally {  
            if (in != null) {  
                in.close();  
            }  
            if (out != null) {  
                out.close();  
            }  
        }  
    }  
}
```

```
    }  
  }  
}
```

Now let's have a file **input.txt** with the following content:

This is test for copy file.

As a next step, compile above program and execute it, which will result in creating output.txt file with the same content as we have in input.txt. So let's put above code in CopyFile.java file and do the following:

```
$javac CopyFile.java  
$java CopyFile
```

## Standard Streams

All the programming languages provide support for standard I/O where user's program can take input from a keyboard and then produce output on the computer screen. If you are aware of C or C++ programming languages, then you must be aware of three standard devices STDIN, STDOUT and STDERR. Similar way Java provides following three standard streams

- **Standard Input:** This is used to feed the data to user's program and usually a keyboard is used as standard input stream and represented as **System.in**.
- **Standard Output:** This is used to output the data produced by the user's program and usually a computer screen is used to standard output stream and represented as **System.out**.
- **Standard Error:** This is used to output the error data produced by the user's program and usually a computer screen is used to standard error stream and represented as **System.err**.

Following is a simple program which creates **InputStreamReader** to read standard input stream until the user types a "q":

```
import java.io.*;  
  
public class ReadConsole {  
    public static void main(String args[]) throws IOException  
    {  
        InputStreamReader cin = null;  
  
        try {  
            cin = new InputStreamReader(System.in);  
            System.out.println("Enter characters, 'q' to quit.");  
            char c;  
            do {
```

```

        c = (char) cin.read();
        System.out.print(c);
    } while(c != 'q');
}finally {
    if (cin != null) {
        cin.close();
    }
}
}
}
}

```

Let's keep above code in ReadConsole.java file and try to compile and execute it as below. This program continues reading and outputting same character until we press 'q':

```

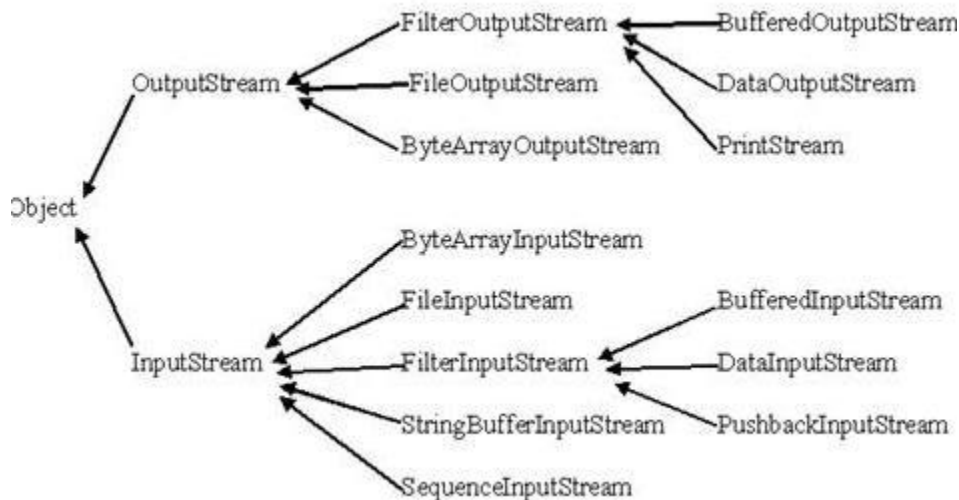
$javac ReadConsole.java
$java ReadConsole
Enter characters, 'q' to quit.
1
1
e
e
q
q

```

### Reading and Writing Files:

As described earlier, A stream can be defined as a sequence of data. The **InputStream** is used to read data from a source and the **OutputStream** is used for writing data to a destination.

Here is a hierarchy of classes to deal with Input and Output streams.



The two important streams are **FileInputStream** and **FileOutputStream**, which would be discussed in this tutorial:

### **FileInputStream:**

This stream is used for reading data from the files. Objects can be created using the keyword `new` and there are several types of constructors available.

Following constructor takes a file name as a string to create an input stream object to read the file.:

```
InputStream f = new FileInputStream("C:/java/hello");
```

Following constructor takes a file object to create an input stream object to read the file. First we create a file object using `File()` method as follows:

```
File f = new File("C:/java/hello");  
InputStream f = new FileInputStream(f);
```

Once you have `InputStream` object in hand, then there is a list of helper methods which can be used to read to stream or to do other operations on the stream.

There are other important input streams available, for more detail you can refer to the following links:

- `ByteArrayInputStream`
- `DataInputStream`

### **FileOutputStream:**

`FileOutputStream` is used to create a file and write data into it. The stream would create a file, if it doesn't already exist, before opening it for output.

Here are two constructors which can be used to create a `FileOutputStream` object.

Following constructor takes a file name as a string to create an input stream object to write the file:

```
OutputStream f = new FileOutputStream("C:/java/hello")
```

Following constructor takes a file object to create an output stream object to write the file. First, we create a file object using `File()` method as follows:

```
File f = new File("C:/java/hello");  
OutputStream f = new FileOutputStream(f);
```

Once you have OutputStream object in hand, then there is a list of helper methods, which can be used to write to stream or to do other operations on the stream.

There are other important output streams available, for more detail you can refer to the following links:

- ByteArrayOutputStream
- DataOutputStream

### **Example:**

Following is the example to demonstrate InputStream and OutputStream:

```
import java.io.*;
public class FileStreamTest{

    public static void main(String args[]){

        try{
            byte bWrite [] = {11,21,3,40,5};
            OutputStream os = new FileOutputStream("test.txt");
            for(int x=0; x < bWrite.length ; x++){
                os.write( bWrite[x] ); // writes the bytes
            }
            os.close();

            InputStream is = new FileInputStream("test.txt");
            int size = is.available();

            for(int i=0; i< size; i++){
                System.out.print((char)is.read() + " ");
            }
            is.close();
        }catch(IOException e){
            System.out.print("Exception");
        }
    }
}
```

The above code would create file test.txt and would write given numbers in binary format. Same would be output on the stdout screen.



## File Navigation and I/O:

There are several other classes that we would be going through to get to know the basics of File Navigation and I/O.

- File Class
- FileReader Class
- FileWriter Class

## Directories in Java:

A directory is a File which can contains a list of other files and directories. You use **File** object to create directories, to list down files available in a directory. For complete detail check a list of all the methods which you can call on File object and what are related to directories.

## Creating Directories:

There are two useful **File** utility methods, which can be used to create directories:

- The **mkdir( )** method creates a directory, returning true on success and false on failure. Failure indicates that the path specified in the File object already exists, or that the directory cannot be created because the entire path does not exist yet.
- The **mkdirs()** method creates both a directory and all the parents of the directory.

Following example creates "/tmp/user/java/bin" directory:

```
import java.io.File;

public class CreateDir {
    public static void main(String args[]) {
        String dirname = "/tmp/user/java/bin";
        File d = new File(dirname);
        // Create directory now.
        d.mkdirs();
    }
}
```

Compile and execute above code to create "/tmp/user/java/bin".

**Note:** Java automatically takes care of path separators on UNIX and Windows as per conventions. If you use a forward slash (/) on a Windows version of Java, the path will still resolve correctly.

## Listing Directories:

You can use `list( )` method provided by **File** object to list down all the files and directories available in a directory as follows:

```
import java.io.File;

public class ReadDir {
    public static void main(String[] args) {

        File file = null;
        String[] paths;

        try{
            // create new file object
            file = new File("/tmp");

            // array of files and directory
            paths = file.list();

            // for each name in the path array
            for(String path:paths)
            {
                // prints filename and directory name
                System.out.println(path);
            }
        }catch(Exception e){
            // if any error occurs
            e.printStackTrace();
        }
    }
}
```

This would produce following result based on the directories and files available in your **/tmp** directory:

```
test1.txt
test2.txt
ReadDir.java
ReadDir.class
```

## **JDBC – JAVA DATABASE CONNECTIVITY**

JDBC stands for **Java Database Connectivity**, which is a standard Java API for database-independent connectivity between the Java programming language and a wide range of databases.

The JDBC library includes APIs for each of the tasks commonly associated with database usage:

- Making a connection to a database
- Creating SQL or MySQL statements
- Executing that SQL or MySQL queries in the database
- Viewing & Modifying the resulting records

Fundamentally, JDBC is a specification that provides a complete set of interfaces that allows for portable access to an underlying database. Java can be used to write different types of executables, such as:

- Java Applications
- Java Applets
- Java Servlets
- Java ServerPages (JSPs)
- Enterprise JavaBeans (EJBs)

All of these different executables are able to use a JDBC driver to access a database and take advantage of the stored data.

JDBC provides the same capabilities as ODBC, allowing Java programs to contain database-independent code.

### **JDBC Architecture:**

The JDBC API supports both two-tier and three-tier processing models for database access but in general JDBC Architecture consists of two layers:

- **JDBC API:** This provides the application-to-JDBC Manager connection.
- **JDBC Driver API:** This supports the JDBC Manager-to-Driver Connection.

The JDBC API uses a driver manager and database-specific drivers to provide transparent connectivity to heterogeneous databases.

The JDBC driver manager ensures that the correct driver is used to access each data source. The driver manager is capable of supporting multiple concurrent drivers connected to multiple heterogeneous databases.

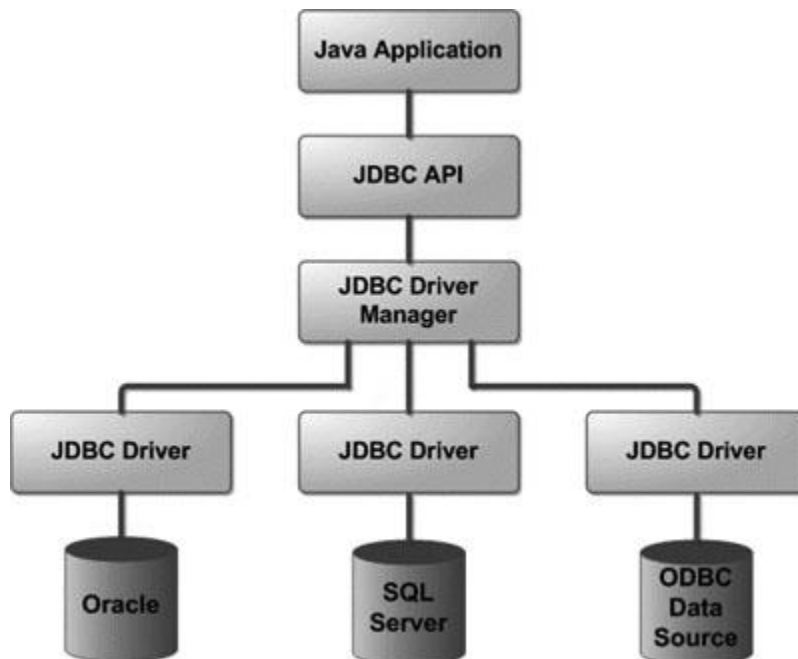
Following is the architectural diagram, which shows the location of the driver manager with respect to the JDBC drivers and the Java application:

## Why Should We Use JDBC

Before JDBC, ODBC API was the database API to connect and execute the query with the database. But, ODBC API uses ODBC driver which is written in C language (i.e. platform dependent and unsecured). That is why Java has defined its own API (JDBC API) that uses JDBC drivers (written in Java language).

We can use JDBC API to handle database using Java program and can perform the following activities:

1. Connect to the database
2. Execute queries and update statements to the database
3. Retrieve the result received from the database.



## Common JDBC Components:

The JDBC API provides the following interfaces and classes:

- **DriverManager:** This class manages a list of database drivers. Matches connection requests from the java application with the proper database driver using communication subprotocol. The first driver that recognizes a certain subprotocol under JDBC will be used to establish a database Connection.
- **Driver:** This interface handles the communications with the database server. You will interact directly with Driver objects very rarely. Instead, you use DriverManager objects, which manages objects of this type. It also abstracts the details associated with working with Driver objects

- **Connection** : This interface with all methods for contacting a database. The connection object represents communication context, i.e., all communication with database is through connection object only.
- **Statement** : You use objects created from this interface to submit the SQL statements to the database. Some derived interfaces accept parameters in addition to executing stored procedures.
- **ResultSet**: These objects hold data retrieved from a database after you execute an SQL query using Statement objects. It acts as an iterator to allow you to move through its data.
- **SQLException**: This class handles any errors that occur in a database application.

### Creating JDBC Application:

There are following six steps involved in building a JDBC application:

- **Import the packages** . Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using `import java.sql.*` will suffice.
- **Register the JDBC driver** . Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection** . Requires using the `DriverManager.getConnection()` method to create a Connection object, which represents a physical connection with the database.
- **Execute a query** . Requires using an object of type Statement for building and submitting an SQL statement to the database.
- **Extract data from result set** . Requires that you use the appropriate `ResultSet.getXXX()` method to retrieve the data from the result set.
- **Clean up the environment** . Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

### Creating JDBC Application:

There are six steps involved in building a JDBC application which I'm going to brief in this tutorial:

#### Import the packages:

This requires that you include the packages containing the JDBC classes needed for database programming. Most often, using `import java.sql.*` will suffice as follows:

```
//STEP 1. Import required packages
import java.sql.*;
```

#### Register the JDBC driver:

This requires that you initialize a driver so you can open a communications channel with the database. Following is the code snippet to achieve this:

```
//STEP 2: Register JDBC driver
Class.forName("com.mysql.jdbc.Driver");
```

### **Open a connection:**

This requires using the `DriverManager.getConnection()` method to create a `Connection` object, which represents a physical connection with the database as follows:

```
//STEP 3: Open a connection
// Database credentials
static final String USER = "username";
static final String PASS = "password";
System.out.println("Connecting to database...");
conn = DriverManager.getConnection(DB_URL,USER,PASS);
```

### **Execute a query:**

This requires using an object of type `Statement` or `PreparedStatement` for building and submitting an SQL statement to the database as follows:

```
//STEP 4: Execute a query
System.out.println("Creating statement...");
stmt = conn.createStatement();
String sql;
sql = "SELECT id, first, last, age FROM Employees";
ResultSet rs = stmt.executeQuery(sql);
```

If there is an SQL `UPDATE`, `INSERT` or `DELETE` statement required, then following code snippet would be required:

```
//STEP 4: Execute a query
System.out.println("Creating statement...");
stmt = conn.createStatement();
String sql;
sql = "DELETE FROM Employees";
ResultSet rs = stmt.executeUpdate(sql);
```

### **Extract data from result set:**

This step is required in case you are fetching data from the database. You can use the appropriate `ResultSet.getXXX()` method to retrieve the data from the result set as follows:

```
//STEP 5: Extract data from result set
while(rs.next()){
    //Retrieve by column name
    int id = rs.getInt("id");
```

```

int age = rs.getInt("age");
String first = rs.getString("first");
String last = rs.getString("last");

//Display values
System.out.print("ID: " + id);
System.out.print(", Age: " + age);
System.out.print(", First: " + first);
System.out.println(", Last: " + last);
}

```

### **Clean up the environment:**

You should explicitly close all database resources versus relying on the JVM's garbage collection as follows:

```

//STEP 6: Clean-up environment
rs.close();
stmt.close();
conn.close();

```

### **First JDBC Program:**

Based on the above steps, we can have following consolidated sample code which we can use as a template while writing our JDBC code:

This sample code has been written based on the environment and database setup done in Environment chapter.

```

//STEP 1. Import required packages
import java.sql.*;

public class FirstExample {
    // JDBC driver name and database URL
    static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
    static final String DB_URL = "jdbc:mysql://localhost/EMP";

    // Database credentials
    static final String USER = "username";
    static final String PASS = "password";
    public static void main(String[] args) {
        Connection conn = null;
        Statement stmt = null;
        try{
            //STEP 2: Register JDBC driver
            Class.forName("com.mysql.jdbc.Driver");

```

```

//STEP 3: Open a connection
System.out.println("Connecting to database...");
conn = DriverManager.getConnection(DB_URL,USER,PASS);

//STEP 4: Execute a query
System.out.println("Creating statement...");
stmt = conn.createStatement();
String sql;
sql = "SELECT id, first, last, age FROM Employees";
ResultSet rs = stmt.executeQuery(sql);

//STEP 5: Extract data from result set
while(rs.next()){
    //Retrieve by column name
    int id = rs.getInt("id");
    int age = rs.getInt("age");
    String first = rs.getString("first");
    String last = rs.getString("last");

    //Display values
    System.out.print("ID: " + id);
    System.out.print(", Age: " + age);
    System.out.print(", First: " + first);
    System.out.println(", Last: " + last);
}
//STEP 6: Clean-up environment
rs.close();
stmt.close();
conn.close();
}catch(SQLException se){
    //Handle errors for JDBC
    se.printStackTrace();
}catch(Exception e){
    //Handle errors for Class.forName
    e.printStackTrace();
}finally{
    //finally block used to close resources
    try{
        if(stmt!=null)
            stmt.close();
    }catch(SQLException se2){
    }// nothing we can do
    try{
        if(conn!=null)
            conn.close();

```



```

        }catch(SQLException se){
            se.printStackTrace();
        }//end finally try
    }//end try
    System.out.println("Goodbye!");
}//end main
} //end FirstExample

```

Now let us compile above example as follows:

```

C:\>javac FirstExample.java
C:\>

```

When you run **FirstExample**, it produces following result:

```

C:\>java FirstExample
Connecting to database...
Creating statement...
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
C:\>

```

### **SQLException Methods:**

A SQLException can occur both in the driver and the database. When such an exception occurs, an object of type SQLException will be passed to the catch clause.

The passed SQLException object has the following methods available for retrieving additional information about the exception:

By utilizing the information available from the Exception object, you can catch an exception and continue your program appropriately. Here is the general form of a try block:

```

try {
    // Your risky code goes between these curly braces!!!
}
catch(Exception ex) {
    // Your exception handling code goes between these
    // curly braces, similar to the exception clause
    // in a PL/SQL block.
}
finally {
    // Your must-always-be-executed code goes between these
    // curly braces. Like closing database connection.
}

```

```
}
```

### **JDBC - Data Types:**

The following table summarizes the default JDBC data type that the Java data type is converted to when you call the setXXX() method of the PreparedStatement or CallableStatement object or the ResultSet.updateXXX() method.

- JDBC 3.0 has enhanced support for BLOB, CLOB, ARRAY, and REF data types. The ResultSet object now has updateBLOB(), updateCLOB(), updateArray(), and updateRef() methods that enable you to directly manipulate the respective data on the server.
- The setXXX() and updateXXX() methods enable you to convert specific Java types to specific JDBC data types. The methods, setObject() and updateObject(), enable you to map almost any Java type to a JDBC data type.
- ResultSet object provides corresponding getXXX() method for each data type to retrieve column value. Each method can be used with column name or by its ordinal position.

### **Sample Code:**

This sample example can serve as a **template** when you need to create your own JDBC application in the future.

This sample code has been written based on the environment and database setup done in previous chapter.

Copy and past following example in FirstExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;

public class FirstExample {
    // JDBC driver name and database URL
    static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
    static final String DB_URL = "jdbc:mysql://localhost/EMP";

    // Database credentials
    static final String USER = "username";
    static final String PASS = "password";

    public static void main(String[] args) {
        Connection conn = null;
        Statement stmt = null;
        try{
            //STEP 2: Register JDBC driver
            Class.forName("com.mysql.jdbc.Driver");
```

```

//STEP 3: Open a connection
System.out.println("Connecting to database...");
conn = DriverManager.getConnection(DB_URL,USER,PASS);

//STEP 4: Execute a query
System.out.println("Creating statement...");
stmt = conn.createStatement();
String sql;
sql = "SELECT id, first, last, age FROM Employees";
ResultSet rs = stmt.executeQuery(sql);

//STEP 5: Extract data from result set
while(rs.next()){
    //Retrieve by column name
    int id = rs.getInt("id");
    int age = rs.getInt("age");
    String first = rs.getString("first");
    String last = rs.getString("last");

    //Display values
    System.out.print("ID: " + id);
    System.out.print(", Age: " + age);
    System.out.print(", First: " + first);
    System.out.println(", Last: " + last);
}
//STEP 6: Clean-up environment
rs.close();
stmt.close();
conn.close();
}catch(SQLException se){
    //Handle errors for JDBC
    se.printStackTrace();
}catch(Exception e){
    //Handle errors for Class.forName
    e.printStackTrace();
}finally{
    //finally block used to close resources
    try{
        if(stmt!=null)
            stmt.close();
    }catch(SQLException se2){
    }// nothing we can do
    try{
        if(conn!=null)
            conn.close();
    }catch(SQLException se){

```

```
        se.printStackTrace();
    } //end finally try
} //end try
System.out.println("Goodbye!");
} //end main
} //end FirstExample
```

Now let us compile above example as follows:

```
C:\> javac FirstExample.java
C:\>
```

When you run **FirstExample**, it produces following result:

```
C:\> java FirstExample
Connecting to database...
Creating statement...
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
C:\>
```

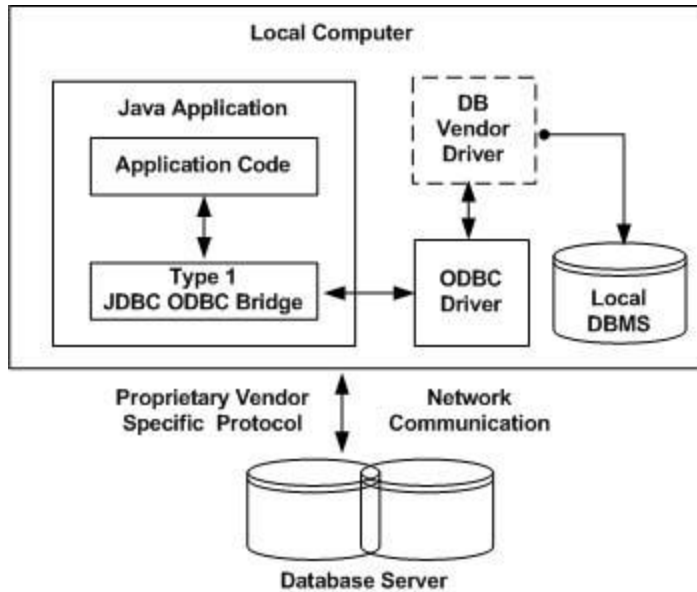
### **JDBC Drivers Types:**

JDBC driver implementations vary because of the wide variety of operating systems and hardware platforms in which Java operates. Sun has divided the implementation types into four categories, Types 1, 2, 3, and 4, which is explained below:

#### **Type 1: JDBC-ODBC Bridge Driver:**

In a Type 1 driver, a JDBC bridge is used to access ODBC drivers installed on each client machine. Using ODBC requires configuring on your system a Data Source Name (DSN) that represents the target database.

When Java first came out, this was a useful driver because most databases only supported ODBC access but now this type of driver is recommended only for experimental use or when no other alternative is available.

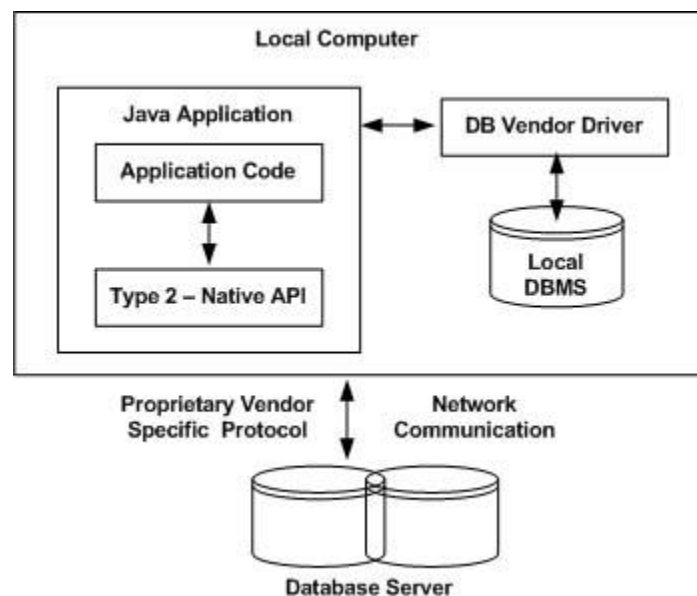


The JDBC-ODBC bridge that comes with JDK 1.2 is a good example of this kind of driver.

### Type 2: JDBC-Native API:

In a Type 2 driver, JDBC API calls are converted into native C/C++ API calls which are unique to the database. These drivers typically provided by the database vendors and used in the same manner as the JDBC-ODBC Bridge, the vendor-specific driver must be installed on each client machine.

If we change the Database we have to change the native API as it is specific to a database and they are mostly obsolete now but you may realize some speed increase with a Type 2 driver, because it eliminates ODBC's overhead.

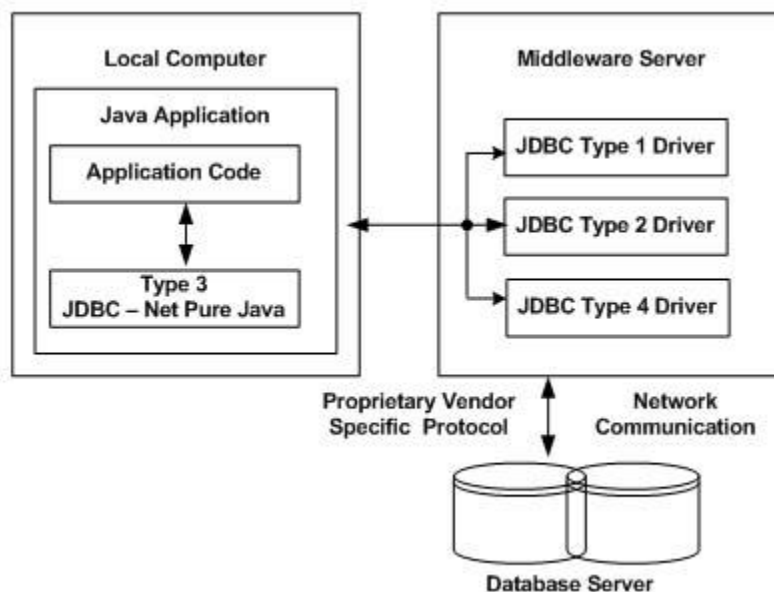


The Oracle Call Interface (OCI) driver is an example of a Type 2 driver.

### **Type 3: JDBC-Net pure Java:**

In a Type 3 driver, a three-tier approach is used to accessing databases. The JDBC clients use standard network sockets to communicate with an middleware application server. The socket information is then translated by the middleware application server into the call format required by the DBMS, and forwarded to the database server.

This kind of driver is extremely flexible, since it requires no code installed on the client and a single driver can actually provide access to multiple databases.



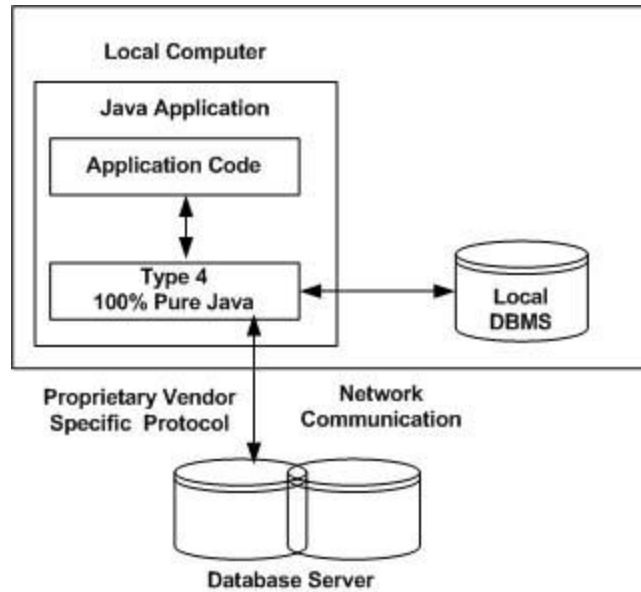
You can think of the application server as a JDBC "proxy," meaning that it makes calls for the client application. As a result, you need some knowledge of the application server's configuration in order to effectively use this driver type.

Your application server might use a Type 1, 2, or 4 driver to communicate with the database, understanding the nuances will prove helpful.

### **Type 4: 100% pure Java:**

In a Type 4 driver, a pure Java-based driver that communicates directly with vendor's database through socket connection. This is the highest performance driver available for the database and is usually provided by the vendor itself.

This kind of driver is extremely flexible, you don't need to install special software on the client or server. Further, these drivers can be downloaded dynamically.



MySQL's Connector/J driver is a Type 4 driver. Because of the proprietary nature of their network protocols, database vendors usually supply type 4 drivers.

### **Which Driver should be used?**

If you are accessing one type of database, such as Oracle, Sybase, or IBM, the preferred driver type is 4.

If your Java application is accessing multiple types of databases at the same time, type 3 is the preferred driver.

Type 2 drivers are useful in situations where a type 3 or type 4 driver is not available yet for your database.

The type 1 driver is not considered a deployment-level driver and is typically used for development and testing purposes only.

## Querying a database and processing the results

Once a connection is obtained we can interact with the database. The JDBC *Statement*, *CallableStatement*, and *PreparedStatement* interfaces define the methods and properties that enable to send SQL or PL/SQL commands and receive data from your database.

They also define methods that help bridge data type differences between Java and SQL data types used in a database.

The following table provides a summary of each interface's purpose to decide on the interface to use.

Interfaces	Recommended Use
Statement	Use this for general-purpose access to database. It Useful when we are using static SQL statements at runtime. The Statement interface cannot accept parameters.
PreparedStatement	Use this when you want to use the SQL statements many times. The PreparedStatement interface accepts input parameters at runtime.
CallableStatement	Use this when you want to access the database stored procedures. The CallableStatement interface can also accept runtime input parameters.

## The Statement Objects

### Creating Statement Object

Before use a Statement object to execute a SQL statement, need to create one using the Connection object's `createStatement()` method, as in the following example –

```
Statement stmt = null;
try {
    stmt = conn.createStatement();
    ...
}
catch (SQLException e) {
    ...
}
finally {
    ...
}
```



Once you've created a Statement object, then use it to execute an SQL statement with one of its three execute methods.

- **boolean execute (String SQL):** Returns a boolean value of true if a ResultSet object can be retrieved; otherwise, it returns false. Use this method to execute SQL DDL statements or when you need to use truly dynamic SQL.
- **int executeUpdate (String SQL):** Returns the number of rows affected by the execution of the SQL statement. Use this method to execute SQL statements for which you expect to get a number of rows affected - for example, an INSERT, UPDATE, or DELETE statement.
- **ResultSet executeQuery (String SQL):** Returns a ResultSet object. Use this method when you expect to get a result set, as you would with a SELECT statement.

### Closing Statement Object

Just as you close a Connection object to save database resources, for the same reason you should also close the Statement object.

A simple call to the close() method will do the job. If you close the Connection object first, it will close the Statement object as well. However, you should always explicitly close the Statement object to ensure proper cleanup.

```
Statement stmt = null;
try {
    stmt = conn.createStatement( );
    ...
}
catch (SQLException e) {
    ...
}
finally {
    stmt.close();
}
```

### The PreparedStatement Objects

The *PreparedStatement* interface extends the Statement interface, which gives added functionality with a couple of advantages over a generic Statement object.

This statement gives the flexibility of supplying arguments dynamically.

## Creating PreparedStatement Object

```
PreparedStatement pstmt = null;
try {
    String SQL = "Update Employees SET age = ? WHERE id = ?";
    pstmt = conn.prepareStatement(SQL);
    ...
}
catch (SQLException e) {
    ...
}
finally {
    ...
}
```

All parameters in JDBC are represented by the ? symbol, which is known as the parameter marker. You must supply values for every parameter before executing the SQL statement.

All of the **Statement object's** methods for interacting with the database (a) execute(), (b) executeQuery(), and (c) executeUpdate() also work with the PreparedStatement object.

## Closing PreparedStatement Object

To close a Statement object, for the same reason should also close the PreparedStatement object.

A simple call to the close() method will do the job. To close the Connection object first, it will close the PreparedStatement object as well. However, It should always explicitly close the PreparedStatement object to ensure proper cleanup.

```
PreparedStatement pstmt = null;
try {
    String SQL = "Update Employees SET age = ? WHERE id = ?";
    pstmt = conn.prepareStatement(SQL);
    ...
}
catch (SQLException e) {
    ...
}
finally {
    pstmt.close();
}
Updating data with jdbc.
```

## The CallableStatement Objects

Just as a Connection object creates the Statement and PreparedStatement objects, it also creates the CallableStatement object, which would be used to execute a call to a database stored procedure.

### Closing CallableStatement Object

Just like other Statement object, also close the CallableStatement object.

A simple call to the close() method will do the job. If you close the Connection object first, it will close the CallableStatement object as well

However, always explicitly close the CallableStatement object to ensure proper cleanup.

```
CallableStatement cstmt = null;
try {
    String SQL = "{call getEmpName (?, ?)}";
    cstmt = conn.prepareCall (SQL);
    ...
}
catch (SQLException e) {
    ...
}
finally {
    cstmt.close();
}
```

## Processing Results

The SQL statements that read data from a database query, return the data in a result set. The SELECT statement is the standard way to select rows from a database and view them in a result set. The java.sql.ResultSet interface represents the result set of a database query

A ResultSet object maintains a cursor that points to the current row in the result set. The term "result set" refers to the row and column data contained in a ResultSet object.

The methods of the ResultSet interface can be broken down into three categories

- Navigational methods: Used to move the cursor around.
- Get methods: Used to view the data in the columns of the current row being pointed by the cursor.
- Update methods: Used to update the data in the columns of the current row. The updates can then be updated in the underlying database as well. The cursor is movable based on

the properties of the ResultSet. These properties are designated when the corresponding Statement that generates the ResultSet is created.

JDBC provides the following connection methods to create statements with desired ResultSet

1. `createStatement(int RSType, int RSConcurrency);`
2. `prepareStatement(String SQL, int RSType, int RSConcurrency);`
3. `prepareCall(String sql, int RSType, int RSConcurrency);`

The first argument indicates the type of a ResultSet object and the second argument is one of two ResultSet constants for specifying whether a result set is read-only or updatable.

### Type of ResultSet

The possible RSType are given below. If you do not specify any ResultSet type, It will automatically get one that is TYPE\_FORWARD\_ONLY.

Type	Description
ResultSet.TYPE_FORWARD_ONLY	The cursor can only move forward in the result set.
ResultSet.TYPE_SCROLL_INSENSITIVE	The cursor can scroll forward and backward, and the result set is not sensitive to changes made by others to the database that occur after the result set was created.
ResultSet.TYPE_SCROLL_SENSITIVE.	The cursor can scroll forward and backward, and the result set is sensitive to changes made by others to the database that occur after the result set was created.

### Viewing a Result Set

The ResultSet interface contains various methods for getting the data of the current row.

There is a get method for each of the possible data types, and each get method has two versions:

- One that takes in a column name.
- One that takes in a column index.

For example, if the column you are interested in viewing contains an int, need to use one of the getInt() methods of ResultSet:

S.N.	Methods & Description
1	<b>public int getInt(String columnName) throws SQLException</b> Returns the int in the current row in the column named columnName.
2	<b>public int getInt(int columnIndex) throws SQLException</b> Returns the int in the current row in the specified column index. The column index starts at 1, meaning the first column of a row is 1, the second column of a row is 2, and so on.

### **Updating data with JDBC**

Updates records in a table by using JDBC, need to execute the UPDATE query by using the executeUpdate() method

This is generally used for altering the databases. Generally DROP, INSERT, UPDATE, DELETE statements will be used in this. The output will be in the form of int. this int value denotes the number of rows affected by the query

Syntax: int executeUpdate(String sql) throws SQLException

Ex: int i= stmt.executeUpdate(query);

### **EXAMPLE PROGRAM ON JAVA DATABASE CONNECTIVITY**

Write a java program that connects to a database using JDBC and does add, delete, modify and retrieve operations.

```
import javax.sql.*;
import java.util.*;
public class CRUD
{
public static void main(String[] args)
{
Connection cn; Statement st; ResultSet rs; try
{
Class.forName("com.mysql.jdbc.Driver");
cn = DriverManager.getConnection("jdbc:mysql://localhost:3306/IARE", "root", "98765432");
st = cn.createStatement();
```

```

System.out.println("Welcome To Institute of Aeronautical Engineering College");
System.out.println("-----MENU      ");
System.out.println("1.Insert");
System.out.println("2.EDIT");
System.out.println("3.Delete");
System.out.println("4.Display");
System.out.println("5.Exit");
System.out.println("  ");
String opt = "";
String htno = "", sname = "", mobile = "", sql = "";
Scanner sc = new Scanner(System.in);
while (opt != "5")
{
System.out.println("Enter Your Option");
opt = sc.next();
switch (opt)
{
case "1":
{
System.out.println("Enter Htno");
htno = sc.next(); System.out.println("Enter Name");
sname = sc.next(); System.out.println("Enter Mobile");
mobile = sc.next();
sql = "insert into stu values(" + "" + htno + "" + "," + "" + sname + "" + "," + "" + mobile + ""
+ ")";
if (st.executeUpdate(sql) > 0)
{
System.out.println("Record Inserted");
}
break;

System.out.println("Enter Htno");
htno = sc.next();
System.out.println("Enter Name");
sname = sc.next();
System.out.println("Enter Mobile");
mobile = sc.next();
sql = "insert into stu values(" + "" + htno + "" + "," + "" + sname + "" + "," + "" + mobile + ""
+ ")";
if (st.executeUpdate(sql) > 0)
{
System.out.println("Record Inserted");
}

case "2":
{

```

```

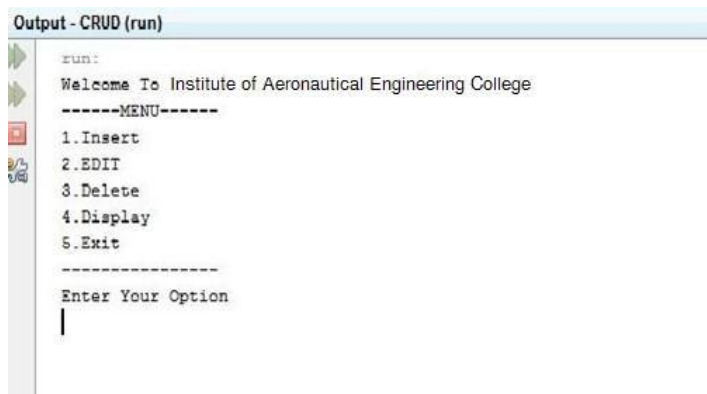
System.out.println("Enter Htno to Update");
htno = sc.next();
System.out.println("Enter Name");
sname = sc.next();
System.out.println("Enter Mobile");
mobile = sc.next();
sql = "update stu set sname=" + "" + sname + "" + "," + "mobile=" + "" + mobile + "" + "
where htno=" + htno + """;
if
(st.executeUpdate(sql) > 0)
{
System.out.println("Record Updated");
}
else
{
System.out.println("Operation Failed");
}
}
break;
case "3":
{
System.out.println("Enter Htno to delete");
htno = sc.next();
sql = "delete from stu where Htno=" + "" + htno + """;

if
(st.executeUpdate(sql) > 0)
{
System.out.println("Record deleted");
}
else
{
System.out.println("Operation Failed");
}
}
break;
case "4": {
sql = "select * from stu";
rs = st.executeQuery(sql);
System.out.println("Htno\tSname\tMobile");
while (rs.next()) {
System.out.println(rs.getString("Htno") + "\t" + rs.getString("SName") + "\t" +
rs.getString("mobile"));
}
rs.close();
}
}

```

```
break; case "5":
{
opt = "5"; System.out.println("Thank You"); st.close();
cn.close();
}
break;
default: {
System.out.println("Choose Option between 1 and 5 only"); }
}
}
}
catch (Exception ex)
{
System.out.println(ex.getMessage());
}
}
}
```

## OUTPUT:



```
Output - CRUD (run)
run:
Welcome To Institute of Aeronautical Engineering College
-----MENU-----
1.Insert
2.EDII
3.Delete
4.Display
5.Exit
-----
Enter Your Option
|
```



Output - CRUD (run)

```
-----MENU-----
1.Insert
2.EDIT
3.Delete
4.Display
5.Exit
-----
Enter Your Option
1
Enter Htno
101
Enter Name
RavikumarRanga
Enter Mobile
9849211983
Record Inserted
Enter Your Option
4
Htno   Sname   Mobile
101   RavikumarRanga  9849211983
Enter Your Option
2
Enter Htno to Update
101
Enter Name
RavikumarRanga
Enter Mobile
9849211983
Record Updated
Enter Your Option
3
Enter Htno to delete
101
Record deleted
```