MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

DEPARTMENT OF INFORMATION & COMMUNICATION TECHNOLOGY

CERTIFICATE

This is to certify that Ms./Mr. …………………...……………………………….

Reg. No.: …..…………………… Section: …………… Roll No.: ……………...

has satisfactorily completed the lab exercises prescribed for Object Oriented Programming Lab [ICT -2164] of Third Semester B.Tech. [IT/CCE] Degree at MIT, Manipal, in the academic year 2020 - 2021.

Date: ....

Signature of the Faculty

Signature
Head of the Department

INDEX

Course Objectives:

- To understand the programming skills using Object Oriented Concepts in Java.
- To write, compile and debug programs in Java language.
- To learn the use of abstract classes and interfaces of Java language.
- To understand exception handling, multithreading, strings, input/output streams in Java.
- To develop simple web pages using applets.

Course Outcomes:

At the end of this course, students will be able to

- Implement Object Oriented Programming Concepts in Java.
- Write, compile and debug programs in Java language
- Learn the usage of abstract classes and interfaces in a Java program.
- Implement exception handling, multithreading, string programs, input/output streams in Java.
- Develop simple web pages using Applets.

Evaluation Plan:

Split up of 60 marks for Regular Lab Evaluation
Six regular evaluations will be carried out in alternate weeks. Record : 4 Marks Viva: 4 Marks Execution: 2 Marks Total = 10 Marks Total Internal Marks: 6 x 10 = 60 Marks
End Semester Lab evaluation: 40 marks (Duration 2 hours)
Write up: 15 Marks Execution: 25 Marks Total: 15+25 =40 Marks

INSTRUCTIONS TO THE STUDENTS

Pre-Lab Session Instructions:

1. Students should carry the Lab Manual Book and the required stationery to every lab session
2. Be in time and follow the institution dress code
3. Must sign in the log register provided
4. Make sure to occupy the allotted seat and answer the attendance
5. Adhere to the rules and maintain the decorum

In-Lab Session Instructions:

- Follow the instructions on the allotted exercises
- Show the program and results to the instructors on completion of experiments
- On receiving approval from the instructor, copy the program and results in the lab record
- Prescribed textbooks and class notes can be kept ready for reference if required

General Instructions for the exercises in Lab:

- Implement the given exercise individually and not in a group.
- The programs should meet the following criteria:
    - Programs should be interactive with appropriate prompt messages, error messages if any, and descriptive messages for outputs.
    - Programs should perform input validation (Data type, range error, etc.) and give appropriate error messages and suggest corrective actions.
    - Comments should be used to give the statement of the problem and every function should indicate the purpose of the function, inputs and outputs.
    - Statements within the program should be properly indented.
    - Use meaningful names for variables and functions.
    - Make use of constants and type definitions wherever needed.
- Plagiarism (copying from others) is strictly prohibited and would invite severe penalty in evaluation.
- The exercises for each week are divided under three sets:
    - Solved exercise – to be used as a reference to understand the concept

    - Lab exercises – to be completed during lab hours
    - Additional Exercises – to be completed outside the lab or in the lab to enhance the skill
- In case a student misses a lab class, he/she must ensure that the experiment is completed during the repetition class in case of genuine reason (medical certificate approved by HOD) with the permission of the faculty concerned
- Questions for lab tests and examination are not necessarily limited to the questions in the manual, but may involve some variations and/or combinations of the questions.
- A sample note preparation is given as a model for observation.

THE STUDENTS SHOULD NOT

- Bring mobile phones or any other electronic gadgets to the lab.
- Go out of the lab without permission.

LAB NO.: 1 **Date:**

JAVA FEATURES & SIMPLE PROGRAMS USING CONTROL STRUCTURES

Objectives:

1. To know the features of Java
2. Understand the Java Development Kit (JDK)
3. To write, compile, and run a Java program
4. To know the execution steps using Netbeans/Eclipse IDE & Command Prompt
5. Write Java programs using control structures

1.1 Features of Java Language

Java is truly object oriented programming language mainly used for Internet applications. It can also be used for standalone application development. Following are the main features of Java:

Simple: Java was designed to be easy for the professional programmer to learn and use effectively. Design goal was to make it much easier to write bug free code. The most important part of helping programmers write bug-free code is keeping the language simple. Java has the bare bones functionality needed to implement its rich feature set. It does not add unnecessary features.

Object Oriented: Java is a true object oriented language. Almost everything in Java is an object. The program code and data are placed within classes. Java comes with an extensive set of classes and these classes are arranged in packages.

Robust: Memory management can be a difficult and 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 de-allocation. (de-allocation is completely automatic, because Java provides garbage collection for unused objects.) Exceptional conditions in traditional environments often arise in situations such as division by zero or "file not found," and they must be managed with clumsy and hard-to-read constructs. Java helps in this area by providing object-oriented exception handling. In a well-written Java program, all run-time errors can and should be managed by the program.

Multithreaded: Java was designed to meet the real-world requirement of creating interactive, networked programs. To accomplish this, Java supports multithreaded programming, which allows to write programs that do many things simultaneously. The java run-time system comes with a sophisticated solution for multi-process synchronization that enables users to construct smoothly running interactive systems.

Compiled and Interpreted: Java is a two stage system because it combines two approaches namely, compiled and interpreted. First Java compiler translates source code into what is known as bytecode instructions. Bytecodes are not machine instructions and therefore in the second stage, Java interpreter generates machine code that can be directly executed by the machine that is running the Java program. Thus the Java is both a compiled and interpreted language.

Platform Independent and Portable: Java programs can be easily moved from one computer system to another, anywhere and anytime. Changes in upgrades in operating systems, processors and system resources will not force any changes in Java programs. Java ensures portability in two ways. First, Java compiler generates bytecode instructions that can be implemented on any machine. Secondly, the sizes of the data types are machine independent.

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.

Security: JVM is an interpreter which is installed in each client machine that is updated with latest **security** updates by internet. When this byte codes are executed, the JVM can take care of the **security**. So, **java** is said to be more **secure** than other programming languages.

1.2 Understand the Java Development Kit (JDK)

The JDK comes with a collection of tools that are used for developing and running Java programs which include:

_ appletviewer (for viewing Java applets)
_ javac (Java compiler)
_ java (Java interpreter)
_ javap (Java disassembler)
_ javah (for C header files)
_ javadoc (for creating HTML documents)
_ jdb (Java debugger)

Following table lists these tools and their descriptions:

Tool	Description
javac	Java compiler, which translates Java source code to bytecode files that the interpreter can understand
java	Java interpreter, which runs applets and applications by reading and interpreting bytecode files.
javadoc	Creates HTML format documentation from Java source code files.
javah	Produces header files for use with native methods.
javap	Java disassembler, which enables us to convert bytecode files into a program
jdb	Java debugger, which finds errors in programs.
applet-viewer	Enables us to run Java applets (without using a Java compatible browser)

The way these tools are applied to build and run application programs are shown below:

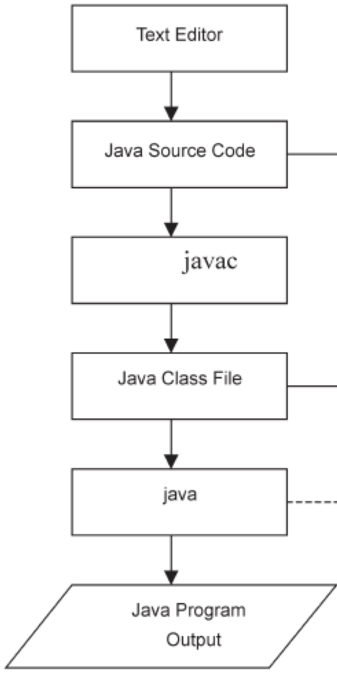

Fig. 1.1. Process of building and running Java application programs.

To create a Java program it needs to create a source code file using a text editor. The source code is compiled using javac and executed using Java interpreter. The Java debugger jdb is used to find errors. A compiled Java program can be converted into a source code using Java disassembler javap.

Java Virtual Machine (JVM)

All language compilers translate source code into machine code for a specific computer. Java compiler produces an intermediate code known as bytecode for a machine that does not exist. This machine is called as Java Virtual Machine and it exists only inside the computer memory. Following figure shows the process of compiling a Java program into bytecode which is also called as Java Virtual Machine code.

Fig. 1.2: Process of Compilation

The Java Virtual Machine code is not machine specific. The machine specific code (known as machine code) is generated by the Java interpreter by acting as an intermediate between the virtual machine and the real machine as shown in following Fig 1.3. The interpreter is different for different machines.

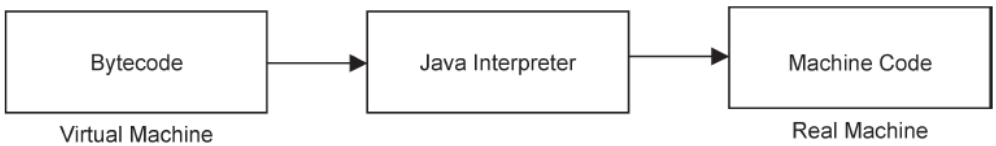

Fig. 1.3: Process of converting bytecode into machine code

1.3 Write, compile and run a Java program

First Sample Program: Program to display the message "Hello World"

Aim: To write a program in Java that displays a message "Hello World"

```
/*
        This is a simple a program.
        Call this file "HelloWorld.java".
*/

        class HelloWorld{
        // program begins with a call to main()
                public static void main(String args[]){
                        System.out.println("Hello World");
                }
        }
```

Sample output:
Hello World

BUILD SUCCESSFUL (total time: 7 seconds)

Entering the Program

The first thing about Java is that the name given to a source file is very important. For the example given above, the name of the source file should be **HelloWorld.java**. In Java, a source file is officially called a *compilation unit.* It is a text file that contains one or more class definitions. The Java compiler requires that a source file use the **.java** file name extension.

The name of the class defined by the program is also **HelloWorld**. This is not a coincidence. In Java, all code must reside inside a class. By convention, the name of that class should match the name of the file that holds the program. It should also make sure that the capitalization of the filename matches the class name. The reason for this is that Java is case-sensitive. At this point, the convention that filenames correspond to class names may seem arbitrary. However, this convention makes it easier to maintain and organize your programs.

Compiling the program

To compile the **HelloWorld** program, execute the compiler, **javac**, specifying the name of the source file on the command line, as shown below:

C:\\>javac HelloWorld.java

The **javac** compiler creates a file called **HelloWorld.class** that contains the bytecode version of the program. As discussed earlier, the Java bytecode is the intermediate representation of program that contains instructions the Java interpreter will execute. Thus, the output of **javac** is not code that can be directly executed.

To actually run the program, the Java interpreter is used which is , called **java**. To do so, pass the class name **HelloWorld** as a command-line argument, as shown below:

C:\\>java HelloWorld
When the program is run, the following output is displayed:
Hello World

When Java source code is compiled, each individual class is put into its own output file named after the class and using the **.class** extension. This is why it is a good idea to give the Java source files the same name as the class they contain—the name of the source file will match the name of the **.class** file. When the Java interpreter executes as just shown, by actually specifying the name of the class that the interpreter will execute. It will automatically search for a file by that name that has the **.class** extension. If it finds the file, it will execute the code contained in the specified class.

A Closer Look at the First Sample Program

The program begins with the following lines:

```
/*
    This is a simple Java program.
    Call this file "HelloWorld.java".
*/
```

This is a *comment.* Like most other programming languages, Java allows to enter a remark into a program's source file. The contents of a comment are ignored by the compiler. Instead, a comment describes or explains the operation of the program to anyone who is reading its source code. In this case, the comment describes the program and reminds that the source file should be called **HelloWorld.java**. In real applications, comments generally explain how some part of the program works or what a specific feature does.

Java supports three styles of comments. The one shown at the top of the program is called a *multiline comment.* This type of comment must begin with /* and end with */. Anything between these two comment symbols is ignored by the compiler. As the name suggests, a multiline comment may be several lines long.

The next line of code in the program is shown below:

```
class HelloWorld{
```

This line uses the keyword **class** to declare that a new class is being defined. **HelloWorld** is an *identifier* that is the name of the class. The entire class definition, including all of its members, will be between the opening curly brace ({) and the closing curly brace (}). The use of the curly braces in Java is identical to the way they are used in C++.

The next line in the program is the *single-line comment,* shown here:

```
//  program begins with a call to main().
```

This is the second type of comment supported by Java. A *single-line comment* begins with a // and ends at the end of the line. As a general rule, programmers use multi line comments for longer remarks and single-line comments for brief, line-by-line descriptions.

The next line of code is shown here:

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

This line begins the **main( )** method. As the comment preceding it suggests, this is the line at which the program will begin executing. All Java applications begin execution by calling **main( )**. (This is just like C/C++.) Since most of the programs will use this line of code, let's take a brief look at each part.

The **public** keyword is an *access specifier,* which allows the programmer to control the visibility of class members. When a class member is preceded by **public**, then that member may be accessed by code outside the class in which it is declared. (The opposite of **public** is **private**, which prevents a member from being used by code defined outside of its class.) In this case, **main( )** must be declared as **public**, since it must be called by code outside of its class when the program is started. The keyword **static** allows **main( )** to be called without having to instantiate a particular instance of the class. This is necessary since **main( )** is called by the Java interpreter before any objects are made. The keyword **void** simply tells the compiler that **main( )** does not return a value.

As stated, **main( )** is the method called when a Java application begins. Keep in mind that Java is case-sensitive. Thus, **Main** is different from **main**. It is important to understand that the Java compiler will compile classes that do not contain a **main( )** method. But the Java interpreter has no way to run these classes. So, if Main is typed **Main** instead of **main**, the compiler would still compile your program. However, the Java interpreter would report an error because it would be unable to find the **main( )** method. Any information which is needed to pass to a method is received by variables specified within the set of parentheses that follow the name of the method. These variables are called *parameters.* If there are no parameters required for a given method, it still need to include the empty parentheses. In **main( )**, there is only one parameter, **String args[ ]** that declares a parameter named **args**, which is an array of instances of the class **String**. (*Arrays* are collections of similar objects.) Objects of type **String** store character strings. In this case, **args** receives any command-line arguments present when the program is executed. This program does not make use of this information, but other programs may use this to enter inputs through command line arguments. The last character on the line is the **{**. This signals the start of **main( )**'s body. All of the code that comprises a method will occur between the method's opening curly brace and its closing curly brace.

NOTE: **main( )** is simply a starting place for the interpreter. A complex program will have many classes, only one of which will need to have a **main( )** method to get things started. When it begin creating applets, Java programs that are embedded in web browsers, it won't use **main( )** at all, since the web browser uses a different means of starting the execution of applets.

The next line of code is shown here. Notice that it occurs inside **main( )**.

This line outputs the string "Hello World." followed by a new line on the screen. Output is actually accomplished by the built-in **println( )** method. In this case, **println( )** displays the string which is passed to it. As seen , **println( )** can be used to display other types of information, too. The line begins with **System.out**. **System** is a predefined class that provides access to the system, and **out** is the output stream that is connected to the console.

Since most modern computing environments are windowed and graphical in nature, console I/O is used mostly for simple, utility programs and for demonstration programs. Notice that the **println( )** statement ends with a semicolon. All statements in Java end with a semicolon. The reason that the other lines in the program do not end in a semicolon is that they are not, technically, statements.

The first **}** in the program ends **main( )**, and the last **}** ends the **HelloWorld** class definition.

Second Sample Program

Program to display the area of a rectangle (Hint: area=length x breadth)

Aim: To write a program in Java to find the area of a rectangle and verify the same with various inputs(length, breadth).

Program:

```
//RectangleArea.java


//program to find area of a rectangle

class RectangleArea {
   public static void main(String args[]){
        int length,breadth;
        length=Integer.parseInt(args[0]);  //command line arguments
```

```
            breadth=Integer.parseInt(args[1]); //convert string to integer
            int area=length *breadth;
            System.out.println("length of rectangle ="+ length);
            System.out.println("breadth of rectangle ="+ breadth);
            System.out.println("area of rectangle ="+ area);
    }}
```

Sample input and output:

```
C:\\>javac RectangleArea.java
C:\\> java RectangleArea 10 8
    length of rectangle = 10
    breadth of rectangle = 8
    area of rectangle = 80;

C:\\> java RectangleArea 12 15
    length of rectangle = 12
    breadth of rectangle = 15
    area of rectangle =180;
```

NOTE: The **Integer** class provides **parseInt( )** method that returns the **int** equivalent of the numeric string with which it is called. (Similar methods and classes also exist for the other data types)

1.4 Execution steps using Netbeans

NetBeans is a sophisticated integrated development environment (IDE) that aims to help developers build any type of application. It allows us to quickly and easily develop desktop, mobile and web applications with Java, HTML5, PHP, C/C++ and more. NetBeans IDE is free, open source, and has a worldwide community of users and developers.

Following are step-by-step instructions to get started developing Java applications with NetBeans IDE. The basic steps described are as follows.

1. Create a new project
2. Set application as Java
3. Give name and location for the project
4. Compile and run a Java program

Setting Up the Project

1. To create an IDE project:
   - Start NetBeans IDE.
   - In the IDE, choose File > New Project, as shown below:

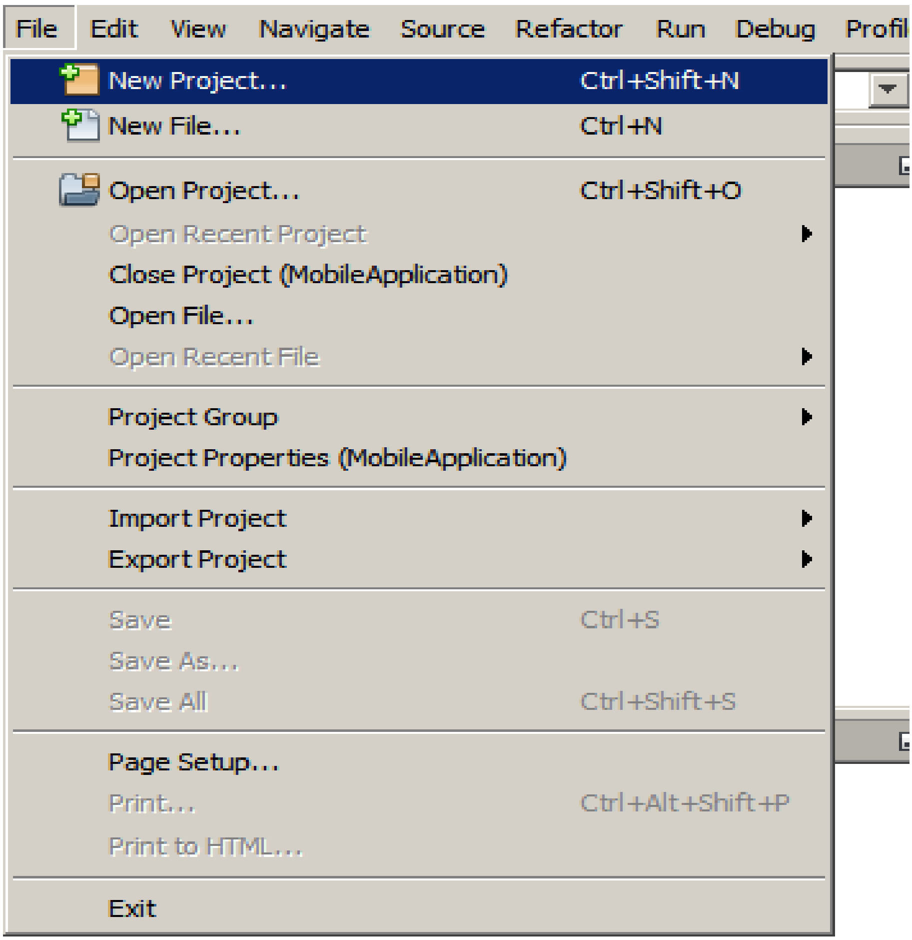

Fig. 1.4. To create a new project in Netbeans IDE.

2. In the New Project wizard, expand the Java category and select "Java Application" as shown in the Fig 1.5 below. Then click Next.

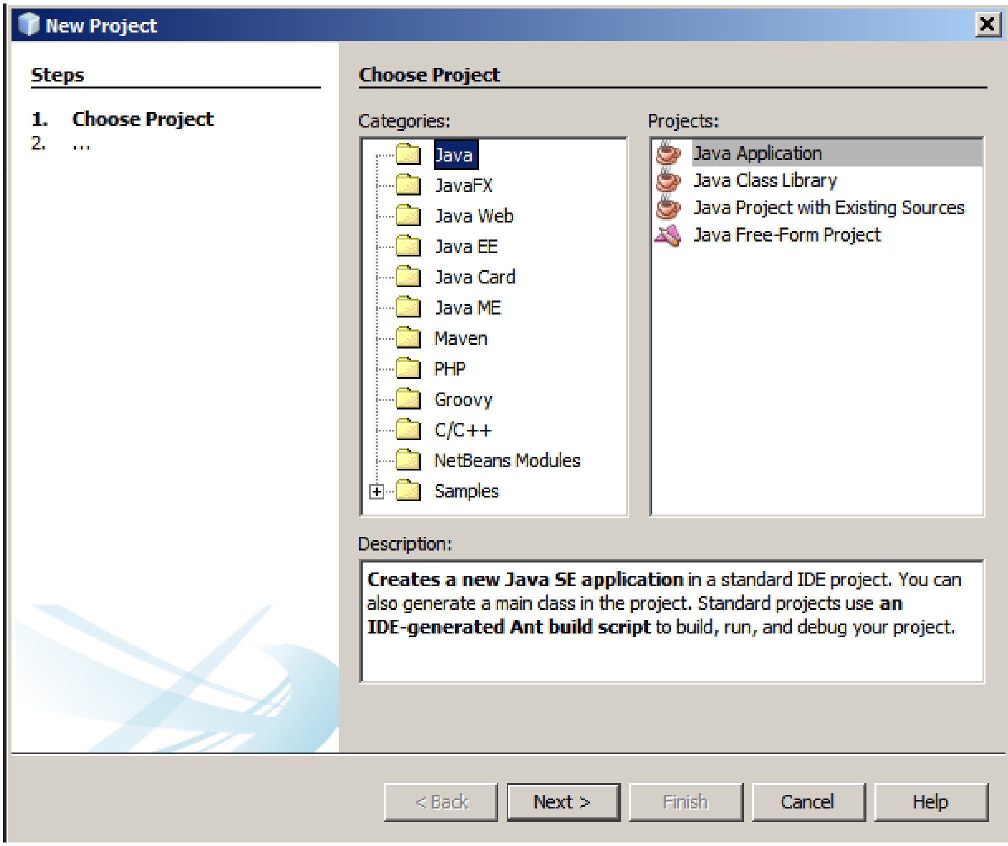

Fig. 1.5: Selection of Java Application from the categories Jva.

3. "Name and Location" page of the wizard, do the following (as shown in the fig 1.6. below):
   - In the Project Name field, type HelloWorldApp.
   - Leave the Use Dedicated Folder for Storing Libraries checkbox unselected.
   - In the Create Main Class field, type helloworldapp.HelloWorldApp.

4. Click Finish.

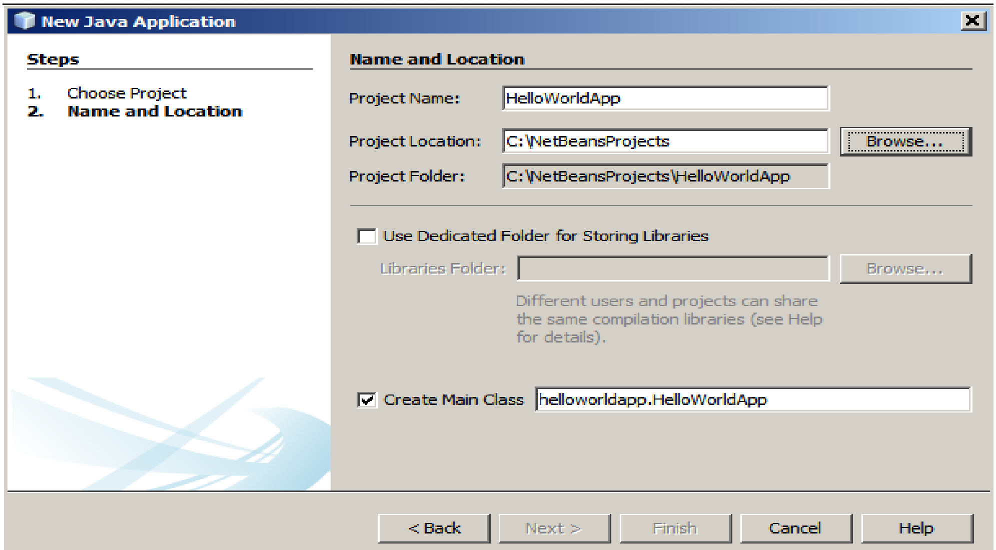

Fig. 1.6: Giving Name and Location to the newly created Project.

The project is created and opened in the IDE with the following components:

- The Projects window, which contains a tree view of the components of the project, including source files, libraries that your code depends on, and so on.
- The Source Editor window with a file called HelloWorldApp open.
- The Navigator window, can use to quickly navigate between elements within the selected class.

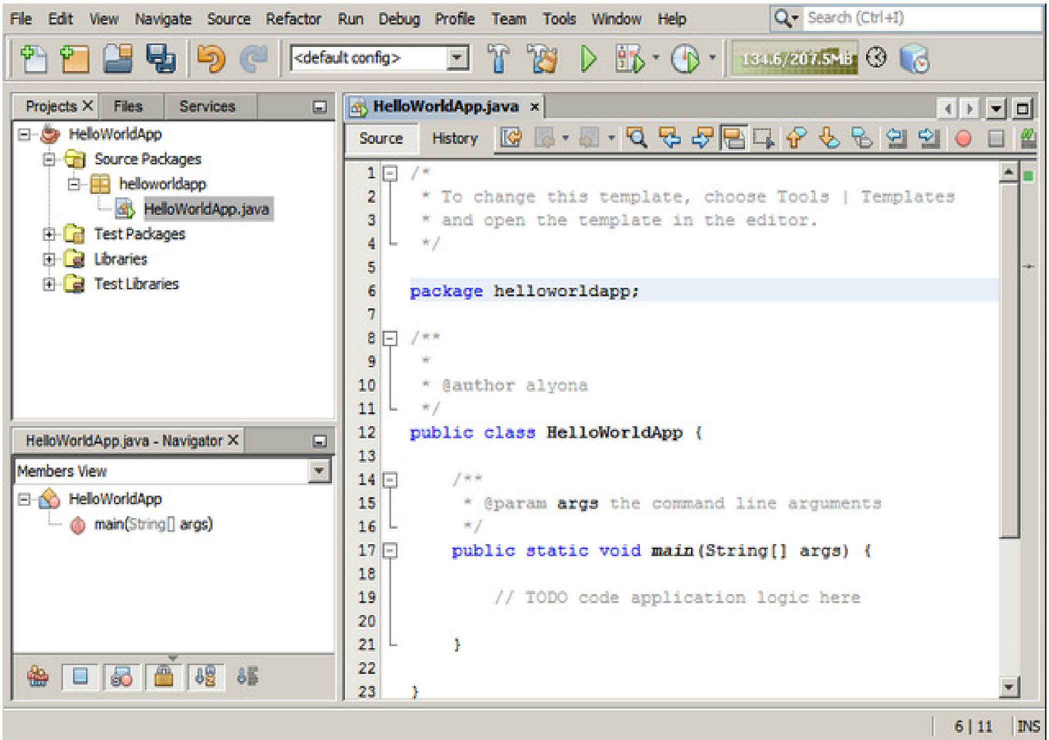

Fig. 1.7: Project window,Source Editor Window,Navigator Window opens up after project creation.

Compiling and Running the Program

The IDE has Compile on Save feature. The user need not manually compile the project in order to run it in the IDE. When saved as a Java source file, the IDE automatically compiles it.

The Compile on Save feature can be turned off in the Project Properties window. Right-click your project, select Properties. In the Properties window, choose the Compiling tab. The Compile on Save checkbox is right at the top. Note that in the Project Properties window it can configure numerous settings for your project: project libraries, packaging, building, running, etc.

To run the program:

- Choose Run > Run Project.

For the above program output appears as follows in Fig 1.8

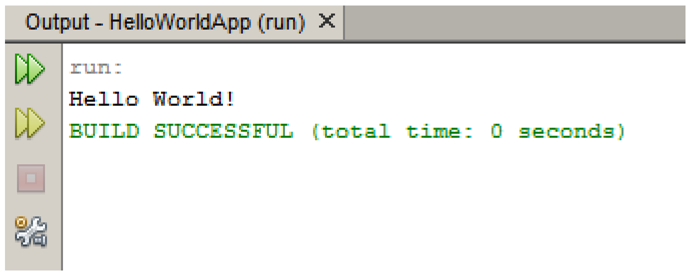

Fig. 1.8: Output of the program

Lab Exercises:

1. Write a Java program to find area and circumference of a rectangle.
   (Hint: circumference = 2 (length + breadth) ; area= length x breadth).
2. Write a Java program to enter 10 numbers and display the number of positive,negative and zeros number.
3. Write a Java program to generate odd numbers from 1 to 100.

Additional Exercises:

1. Write a program to check whether a number is palindrome or not.
2. Write a Java programs to print factorial of a given no.
3. Write a Java program to print table of number entered by user .

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LAB NO.: 2 **Date:**

JAVA DATA TYPES, TYPE CONVERSION, OPERATORS

Objectives:

1. To learn the different data types in Java
2. To understand Java type conversion and casting
3. To be familiar with bit-wise, arithmetic, Boolean, logical and relational operators
4. To write simple Java programs to demonstrate the usage of taking input from keyboard, data types, type conversion, and operators

2.1 Java 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:

i) Integers: This group includes **byte**, **short**, **int**, and **long**, which are for whole valued signed numbers.

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	8	– 128 to 127

ii) Floating-point numbers: This group includes **float** and **double**, which represent numbers with fractional precision.

Name	**Width in Bits**	**Range**
double	64	1.7e–308 to 1.7e+308
float	32	3.4e–038 to 3.4e+038

iii) Characters: This group includes **char**, which represents symbols in a character set, like letters and numbers. Java uses unicode to represent characters. *Unicode* defines a fully international character set that can represent all of the characters found in all human languages. In Java **char** is a 16-bit type. The range of a **char** is 0 to 65,536. There are no negative **char**s. The standard set of characters known as ASCII ranges from 0 to 127

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

This program displays the following output:
ch1 and ch2: X Y

iv) Boolean: This group includes **boolean**, which is a special type for representing true/false values. 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**.

2.2 Java type conversion and casting

i) Automatic type conversion: When one type of data is assigned to another type of variable, an *automatic type conversion* will take place if the following two conditions are met:

• 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. For widening conversions, the numeric types, including integer and floating-point types, are compatible with each other. However, the numeric types are not compatible with **char** or **Boolean**. Also, **char** and **Boolean** are not compatible with each other.

ii) Casting incompatible types: Although the automatic type conversions are helpful, they will not fulfill all needs. For example, if it wants to assign an **int** value to a **byte** variable, the conversion will not be performed automatically, because a **byte** is smaller than an **int**. This kind of conversion is sometimes called a *narrowing conversion,* since explicitly making the value narrower so that it will fit into the target type. A *cast* is simply an explicit type conversion. It has this general form: (*target-type*) *value*

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

iii) Type promotion rules: First, all **byte** and **short** values are promoted to **int**. Then, if one operand is a **long operand**, the whole expression is promoted to **long**. If one operand is a **float** operand, the entire expression is promoted to **float**. If any of the operands is **double**, the result is **double**. It is illustrated in the below fig. 2.1

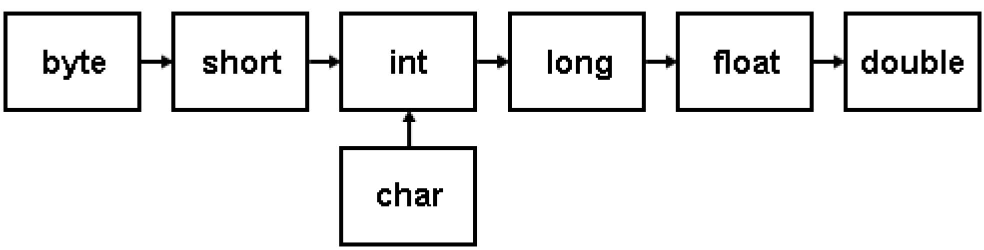

Fig. 2.1: Type Promotion Rules

2.3 Short-Circuit Logical Operators

Java provides two interesting Boolean operators not found in most other computer languages. These are secondary versions of the Boolean AND and OR operators, and are known as short-circuit logical operators. As seen from the preceding table, the OR operator results in true when A is true, no matter what B is. Similarly, the AND operator results in false when A is false, no matter what B is. If operator results in false when A is false, no matter what B is. If used the | | and && forms, rather than the | and & forms of these operators, java will not bother to evaluate the right-hand operand alone. This is very useful when the right-hand operand depends on the left one being true or false in order to function properly. For example, the following code fragment shows how it can take advantage of short-circuit logical evaluation to be sure that a division operation will be valid before evaluating it:

```
if ( denom != 0 && num / denom >10)
```

Since the short-circuit form of AND (&&) is used, there is no risk of causing a run-time exception when denom is zero. If this line of code were written using the single & version of AND, both sides would have to be evaluated, causing a run-time exception when denom is zero.

It is standard practice to use the short-circuit forms of AND and OR in cases involving Boolean logic, leaving the single-character versions exclusively for bitwise operations. However, there are exceptions to this rule. For example, consider the following statement:

```
if ( c==1 & e++ < 100 ) d = 100;
```

Here, using a single & ensures that the increment operation will be applied to e whether c is equal to 1 or not.

2.4 Bit-wise 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 as given below:

Operator	**Description**
~	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

2.5 Reading keyboard input

Java provides Scanner class to get input from the keyboard which is present in java.util package. Therefore this package should be imported to the program. First create an object of Scanner class and then use the methods of Scanner class.

Scanner a = new Scanner(System.in);

Here “Scanner” is the class name, “a” is the name of object, “new” keyword is used to allocate the memory and “System.in” is the input stream. Following methods of Scanner class are used in the program below :-

1) nextInt to input an integer
2) nextFloat to input a float
3) nextLine to input a string
4) nextDouble to input a double

This program firstly asks the user to enter a string followed by an integer number and a float value. Immediately after entering each input, the value entered by the user will be printed on the screen.

```
import java.util.Scanner;
class GetInputFromUser{
  public static void main(String args[])   {
          int a;
          float b;
          String s;
          Scanner in = new Scanner(System.in);
          System.out.println("Enter a string");
          s = in.nextLine();
          System.out.println("You entered string "+s);
          System.out.println("Enter an integer");
          a = in.nextInt();
          System.out.println("You entered integer "+a);
          System.out.println("Enter a float");
          b = in.nextFloat();
          System.out.println("You entered float "+b);
  }
}
```

Lab Exercises:

1. Write a Java program to find whether a given year is leap or not using boolean data type. [Hint: leap year has 366 days;]
   Algorithm:
   if (*year* is not exactly divisible by 4) **then** (it is a common year)
   else
   if (*year* is not exactly divisible by 100) **then** (it is a leap year)
   else
   if (*year* is not exactly divisible by 400) **then** (it is a common year)
   else (it is a leap year**)**
2. Write a Java program to read an int number, double number and a char from keyboard and perform the following conversions:- int to byte, char to int, double to byte, double to int
3. Write a Java program to multiply and divide a number by 2 using bitwise operator. [Hint: use left shift and right shift bitwise operators]
4. Write a Java program to execute the following statements. Observe and analyze the outputs.
   a. **int** x =10;
      double y = x;
      System.out.println(y);

   b. double x = 10.5;
      int y = x;
      System.out.println(y);

   c. double x=10.5;
      int y = (int) x
      System.out.println(y);
5. Create the equivalent of a four-function calculator. The program should request the user to enter a number, an operator, and another number. (Use floating point.) It should then carry out the specified arithmetic operation: adding, subtracting, multiplying, or dividing the two numbers. Use a switch statement to select the operation. Finally, display the result. When it finishes the calculation, the program should ask if the user wants to do another calculation. The response can be 'y' or 'n'. [Hint: use do-while loop]

   Example

   Enter first number, operator, second number: 10 / 3

   Answer = 3.333333

   Do another (y/n)? n

Additional Exercises:

1. Write a Java program to find the result of the following expressions for various values of a & b:
   a. (a << 2) + (b >> 2)
   b. (b > 0)
   c. (a + b * 100) / 10
   d. a & b

2. Write a Java program to find largest and smallest among 3 numbers using ternary operator.

3. Write a Java program to execute the following statements. Observe and analyze the outputs
   a. **boolean** x =**true**;
      int y = x;
   b. **boolean** x =**true**;
      int y =(int)x;

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LAB NO.: 3 **Date:**

CONTROL STATEMENTS

Objectives:

1. To learn the syntax & usage of control statements in Java
2. To write simple Java programs to demonstrate the usage of Selection ,Iteration and Jump statements in Java

3.1 Java Selection Statement

(i) Simple if – else

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

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

The if works like this: If the condition is true, then statement1 is executed, otherwise statement2 (if it exists) is executed. For example, consider the following:

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

Here, if a is less than b, then a is set to zero. Otherwise, b is set to zero.

(ii) Nested if

A nested if is an if statement that is the target of another if or else. When nested ifs are used, the main thing to remember is that an else statement always refers to the nearest if statement that is within the same block as the else and that is not already associated with an else. Here is an example:

```
if(i == 10) {
if(j < 20) a = b;
if(k > 100) c = d; // this if is
else a = c; // associated with this else
}
else a = d; // this else refers to if(i == 10)
```

(iii) If – else – if ladder

A common programming construct that is based upon a sequence of nested ifs is the if-else-if ladder.

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

The if statements are executed from the top down. As soon as one of the conditions controlling the if is true, the statement associated with that if is executed, and the rest of the ladder is bypassed. If none of the conditions is true, then the final else statement will be executed. The final else acts as a default condition; that is, if all other conditional tests fail, then the last else statement is performed. If there is no final else and all other conditions are false, then no action will take place.

```
// Demonstrate if-else-if statements.
class IfElse {
public static void main(String args[]) {
int month = 4; // April
String season;
if(month == 12 || month == 1 || month == 2)
season = "Winter";
else if(month == 3 || month == 4 || month == 5)
season = "Spring";
else if(month == 6 || month == 7 || month == 8)
season = "Summer";
else if(month == 9 || month == 10 || month == 11)
season = "Autumn";
else
```

```
season = "Bogus Month";
System.out.println("April is in the " + season + ".");
}}
```

Output:April is in the Spring.

(iv) Switch

The switch statement is Java's multiway branch statement. It provides an easy way to dispatch execution to different parts of the 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. The general form of a switch statement is given below:

```
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.

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

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

```
// A simple example of the switch.
class SampleSwitch {
public static void main(String args[]) {
for(int i=0; i<6; i++) {
switch(i) {
case 0:
System.out.println("i is zero.");
break;

case 1:
System.out.println("i is one.");
break;
case 2:
System.out.println("i is two.");
break;
case 3:

System.out.println("i is three.");
break;

default:
System.out.println("i is greater than 3.");
} // switch
}// for
}// main
}//SampleSwitch
```

Output:
i is zero.
i is one.

i is two.
i is three.
i is greater than 3.
i is greater than 3.

As can be seen, each time through the loop, the statements associated with the case constant that matches i are executed. All others are bypassed. After i is greater than 3, no case statements match, so the default statement is executed. The break statement is optional. If the break is omitted, execution will continue with the next case. It is sometimes desirable to have multiple cases without break statements between them.

3.2 Iteration Statement

(i) 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.

```
// Demonstrate the while loop.
class While {
public static void main(String args[]) {
int n = 10;
while(n >5) {
System.out.println("tick " + n);

n—;
} // while
} // main
}//While class
```

Output:
tick 10
tick 9
tick 8
tick 7
tick 6

Since the while loop evaluates its conditional expression at the top of the loop, the body of the loop will not execute even once if the condition is false to begin with.

(ii) do – while
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. In other words, there are times when to test the termination expression at the end of the loop rather than at the beginning. The do-while loop always executes its body at-least once, because its conditional expression is at the bottom of the loop. Its general form is:

```
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 >5); }}
```

Output:
tick 10
tick 9
tick 8
tick 7
tick 6

(iii) for

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

```
// Demonstrate the for loop.
class ForTick {
public static void main(String args[]) {
int n;
for(n=10; n>5; n—)
System.out.println("tick " + n);}}
```

Output:
tick 10
tick 9
tick 8
tick 7
tick 6

(iv) The for-each loop introduced in Java5.
It is mainly used to traverse array or collection elements. The advantage of for-each loop is that it eliminates the possibility of bugs and makes the code more readable.

Advantage of for-each loop:

- It makes the code more readable.
- It elimnates the possibility of programming errors.)

 Syntax of for-each loop:

 for(data_type variable : array | collection){}

 Example of for-each loop for traversing the array elements:

```
class ForEachExample1{
  public static void main(String args[]){
   int arr[]={12,13,14,44};

   for(int i:arr){
     System.out.println(i);
   }

  }
}
```

o/p:- Output:12
13
14
44

(v) nested loops
Java allows loops to be nested. That is, one loop may be inside another.

```
// Loops may be nested.
class Nested {
public static void main(String args[]) {
int i, j;
for(i=0; i<5; i++) {
for(j=i; j<5; j++)
System.out.print(".");
System.out.println();
```

```
}
}
}
```

Output:

```
..........
.........
........
.......
......
```

3.3 Jump Statement

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

i) Break: In Java, the break statement has three uses. First, 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.

ii) Continue: Sometimes it is useful to force an early iteration of a loop. That is, to continue running the loop, but stop processing the remainder of the code in its body for this particular iteration. This is, in effect, a goto just past the body of the loop, to the loop's end. The continue statement performs such an action. In while and do-while loops, a continue statement causes control to be transferred directly to the conditional expression that controls the loop. In a for loop, control goes first to the iteration portion of the for statement and then to the conditional expression. For all three loops, any intermediate code is bypassed.

iii) 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. At any time in a method the return statement can be used to cause execution to branch back to the caller of the method. Thus, the return statement immediately terminates the method in which it is executed.

Lab Exercises:

1. Write a program to compute whether a no . is an Armstrong number or not. Use any of the iteration statements.
2. Write a Java program to find area and circumference of a rectangle.

   (Hint: circumference = 2 (length + breadth) ; area= length x breadth)
3. Write a Java program to display the numbers in the following format using nested for loop.

   1
   2 2
   3 3 3
   4 4 4 4
   5 5 5 5 5
4. Write a Java program to generate prime numbers between n and m.(Hint: A prime number is a natural number greater than 1 that has no positive divisors other than 1 and itself. Eg: 2, 3, 5,7,11 etc.)
5. Write a java program to search for a value in a 1 dimensional array using for each loop construct. Assume that the array is initialized at the time of declaration and user enters the value to be searched on request.

   Input: a[]={1,2,3,1,2,1,5,6,7} searchValue= 1
   Expected Output : The value is found at locations: a[0] ,a[3],a[5] .

Additional Exercises:

1. Write a program to print all combinations of four digit number. A four digit number is generated using only four digits {1, 2, 3, 4}.
   - Case 1: Duplication of digit is allowed.
   - Case 2: Duplication of digit is not allowed.
2. Write a Java programs to evaluate the following series
   a. Sin(x) =x - (x^3/3!) + (x^5/5!)-…
   b. Sum=1 + (1/2)2 + (1/3)3 +…
3. Write a Java program to display the numbers in the following format using for-each loop.

   1
   2 3
   4 5 6
   7 8 9 10

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LAB: 4 **Date:**

ARRAYS

Objectives:

1. To learn the syntax & usage of arrays in Java
2. To write simple Java programs to demonstrate the usage of arrays in Java.

4.1 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.

i) One-dimensional arrays: A one-dimensional array is, essentially, a list of like-typed variables. The general form of a one dimensional array declaration is : *type var-name[ ];*

int month_days[]; // declares an array named month_days with the type "array of int".

Although this declaration establishes the fact that month_days is an array variable, no array actually exists. The value of month_days is set to null, which represents an array with no value. To link month_days with an actual, physical array of integers, it must allocate one using new and assign it to month_days. new is a special operator that allocates memory.

```
array-var= new type[size];
month_days = new int[12];
```

It is possible to combine the declaration of the array variable with the allocation of the array itself, as shown below:

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

// example to know the usage of array

```
class AutoArray {
public static void main(String args[]) {
int month_days[] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31,30, 31 };
System.out.println("April has " + month_days[3] + " days."); }}
```

ii) Multi-dimensional arrays: Multidimensional arrays are arrays of arrays. 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];
```

```
// 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();
}
}
}
```

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

Alternate array declaration syntax: type[ ] var-name;

```
int al[ ] = new int[3];
int[ ] a2 = new int[3];
```

Lab Exercises:

i. Write a Java program to display non diagonal elements and find their sum. [Hint: **Non Principal diagonal**: The diagonal of a diagonal matrix from the top right to the bottom left corner is called non principal diagonal.]

ii. Write a Java program to display principal diagonal elements and find their sum. [Hint: Principal Diagonal: The principal diagonal of a rectangular matrix is the diagonal which runs from the top left corner and steps down and right, until the right edge or the bottom edge is reached].

iii. Find whether a given matrix is symmetric or not. [Hint: A = AT]

iv. Write a program to add and multiply two integer matrices. The algorithm for matrix multiplications are give below:
   a) To multiply two matrixes sufficient and necessary condition is "number of columns in matrix A = number of rows in matrix B".
   b) Loop for each row in matrix A.
   c) Loop for each columns in matrix B and initialize output matrix C to 0.
   d) This loop will run for each rows of matrix A.
   e) Loop for each columns in matrix A.
   f) Multiply A[i,k] to B[k,j] and add this value to C[i,j]
   g) Return output matrix C.

v. Write a Java program to find whether the matrix is a magic square or not. [Hint: Compare the sum for every row, the sum with every column, the sum of the principal diagonal and the sum of the non-principal diagonal elements. If they are all same, then the matrix is a magic square matrix].

Additional Exercises:

1. Print all the prime numbers in a given 1D array.
2. Find the largest and smallest element in 1D array.
3. Search for an element in a given matrix and count the number of its occurrences.
4. Write a program to merge two arrays in third array. Also sort the third array in ascending order.
5. Find the trace and norm of a given square matrix. [Hint: Trace= sum of principal diagonal elements; Norm= Sqrt(sum of squares of the individual elements of an array)]

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LAB NO.: 5 **Date:**

CLASSES AND METHODS

Objectives:

1. To understand the fundamentals of class
2. To know the usage and importance of constructors
3. To be familiar with method overloading and constructor overloading
4. To write simple Java programs to demonstrate the usage of classes, constructors and overloading concepts of Java

5.1 Fundamentals of class

A class defines the structure and behavior (data and code) that will be shared by a set of objects. A class is a template for an object, and an object is an instance of a class. When a class is created it will specify the code and data constituting that class. Collectively, these elements are called members of the class. Specifically, the data defined by the class are referred to as member variables or instance variables. The code that operates on that data is referred to as member methods or just methods. The methods define how the member variables can be used. This means that the behavior and interface of a class are defined by the methods that operate on its instance data.

General form of a class is as shown below:

```
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
}
}
```

```
/* A simple Java program to illustrate the class concept.
Call this file BoxDemo.java
*/
class Box {
double width;
double height;
double depth;
}
// This class declares an object of type Box.
class BoxDemo {
public static void main(String args[]) {
        Box mybox = new Box();
        double vol;
        // assign values to mybox's instance variables
        mybox.width = 10;
        mybox.height = 20;
        mybox.depth = 15;
        // compute volume of box
        vol = mybox.width * mybox.height * mybox.depth;

        System.out.println("Volume is " + vol);
}
}
```

```
C://>javac BoxDemo.java
C://>java BoxDemo
Voulme is 3000
```

5.2 Constructors

A *constructor* initializes an object immediately upon creation. It has the same name as the class in which it resides and is syntactically similar to a method. Once defined, the constructor is automatically called immediately after the object is created, before the **new** operator completes. Constructors look a little strange because they have no return type, not even **void**. This is because the implicit return type of a class constructor is the class type itself. It is the constructor's job to initialize the internal state of an object so that the code creating an instance will have a fully initialized, usable object immediately.

```
/*  Box uses a constructor to initialize the dimensions of a box.*/
class Box {
        double width;
        double height;
        double depth;
        // This is the constructor for Box.
        Box() {
        System.out.println("Constructing Box");
        width = 10;
        height = 10;
        depth = 10;
        }
// compute and return volume
double volume() {
return width * height * depth;
} }

class BoxDemoConstructor {
        public static void main(String args[]) {
        // declare, allocate, and initialize Box objects
        Box mybox1 = new Box();
        Box mybox2 = new Box();
        double vol;
        // get volume of first box
        vol = mybox1.volume();
        System.out.println("Volume is " + vol);
        // get volume of second box
        vol = mybox2.volume();
        System.out.println("Volume is " + vol);
        }}
```

Output:

```
Constructing Box
Constructing Box
Volume is 1000.0
Volume is 1000.0
```

5.3 Method overloading and Constructor overloading

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.

When an overloaded method is invoked, Java uses the type and/or number of arguments as its guide to determine which version of the overloaded method to actually call. Thus, overloaded methods must differ in the type and/or number of their parameters. While overloaded methods may have different return types, the return type alone is insufficient to distinguish two versions of a method. When Java encounters a call to an overloaded method, it simply executes the version of the method whose parameters match the arguments used in the call.

```
// 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(123.2);
        System.out.println("Result of ob.test(123.2): " + result);
        }
}
```

This program generates the following output:

```
No parameters
a: 10
a and b: 10 20
double a: 123.2
Result of ob.test(123.2): 15178.24
```

In this example, **test( )** is overloaded four times. The first version takes no parameters, the second takes one integer parameter, the third takes two integer parameters, and the fourth takes one **double** parameter. The fact that the fourth version of **test( )** also returns a value is of no consequence relative to overloading, since return types do not play a role in overload resolution.

```
/* sample program for constructor overloading
 Box defines three constructors to initialize the dimensions of a box various
ways.
*/
class Box {
        double width;
        double height;
        double 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;
}
}
class OverloadCons {
public static void main(String args[]) {
        // create boxes using the various constructors
        Box mybox1 = new Box(10, 20, 15);
        Box mybox2 = new Box();
        Box mycube = new Box(7);
        double vol;
        // get volume of first box
        vol = mybox1.volume();
        System.out.println("Volume of mybox1 is " + vol);
        // get volume of second box
        vol = mybox2.volume();
        System.out.println("Volume of mybox2 is " + vol);
        // get volume of cube
        vol = mycube.volume();
        System.out.println("Volume of mycube is " + vol);
}}
```

The output produced by this program is shown here:

Volume of mybox1 is 3000.0

Volume of mybox2 is -1.0

Volume of mycube is 343.0

Lab Exercises:

1. Create a class Box that uses a parameterized method to initialize the dimensions of a box. (dimensions are width, height, depth of double type). The class should have a method that can return volume. Obtain an object and print the corresponding volume in main() function.

2. Define a class Employee with data members: employee name, city, basic salary, dearness allowance (DA%) and house rent (HRA%). Define getdata(), calculate(), and display() functions. Calculate method should find the total salary and display method should display it.

   Total = basic+basic*da/100+basic*hra/100;

3. Create a Time class that has separate integer member data for hours, minutes and seconds. One constructor should initialize these data to zero and another should initialize to fixed value. A method should display time in hh:mm:ss format. Finally a method should add 2 objects of time passed as argument.

4. Create a complex class. Use method overloading to find the sum.

   add(integer, complex number)

   add(complex number, complex number)

5. Create class Number with only one private instance variable as a double primitive type. Include the following methods (include respective constructors) isZero( ), isPositive(), isNegative( ), isOdd( ), isEven( ), isPrime(), isArmstrong(). The above methods return boolean primitive type.

6. Write a program to define a class called Book with title,author and edition fields. Define suitable constructors for the Book class. Create a list of 6 Book objects and write them to a file. From this file display the books of the author "Harry" on the screen.

Additional Exercises:

1. The annual examination results of 3 students are tabulated as follows:-

Roll No.	Subject 1	Subject 2	Subject 3

Create a class Result with 2D array and 1D array as its data members. And write methods to perform the following tasks:-

a. Store marks of 3 subjects obtained by 3 students in 2D array
b. To store total marks obtained by each student in 1D array.
c. To find the highest marks in each subject and the roll number of the student who secured it.
d. To find the student who obtained the highest total marks.

2. Create a class with integer array of size 10 and write methods to perform following:-
   a. Input values into an array
   b. Display the values
   c. Display the largest value
   d. Display the average
   e. Sort the array in ascending order
3. Swap two values using call by value and call by reference.
4. Write a Java program to implement stack class.
5. Write a JAVA program which contains a method square() such that square(3) returns 9, square(0.2) returns 0.04.

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LAB NO.: 6 **Date:**

CLASS INHERITANCE

Objectives:

1. To understand the basics of inheritance
2. To learn the concept of method overriding
3. To study the dynamic method dispatch
4. To write Java programs using the concepts of inheritance, method overriding and dynamic method dispatch

6.1 Basics of inheritance

Inheritance allows the creation of hierarchical classifications. Using inheritance, it can create a general class that defines traits common to a set of related items. This class can then be inherited by other, more specific classes, each adding those things that are unique to it. In the terminology of Java, a class that is inherited is called a *superclass.* The class that does the inheriting is called a *subclass.* Therefore, a subclass is a specialized version of a superclass. It inherits all of the instance variables and methods defined by the superclass, and add its own unique elements. A keyword called "***extends***" is used for inheritance.

The general form of a **class** declaration that inherits a superclass is shown below:

```
class subclass-name extends superclass-name {
        // body of class
}
```

It can only specify one superclass for any subclass because Java does not support the inheritance of multiple super classes into a single subclass. But, it is possible to create a hierarchy of inheritance in which a subclass becomes a superclass of another subclass. However, no class can be a superclass of itself.

NOTE:

- A sub class cannot access those members of the superclass that have been declared as **private**.
- A reference variable of a superclass can be assigned a reference to any subclass derived from that superclass.
- Whenever a subclass needs to refer to its immediate superclass, it can do so by use of the keyword super.

- **super** has two general forms. The first form calls the superclass constructor. The second is used to access a member of the superclass that has been hidden by a member of a subclass.
- In a class hierarchy, constructors are called in order of derivation, from superclass to subclass. Further, since super( ) must be the first statement executed in a subclass constructor, this order is the same whether or not super( ) is used.

```
// 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();
        }
}
```

The output from this program is shown here:

```
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
```

6.2 Method overriding

In a class hierarchy, when a method in a subclass has the same name and type signature as a method in its superclass, then the method in the subclass is said to *override* the method in the superclass. When an overridden method is called from within a subclass, it will always refer to the version of that method defined by the subclass. The version of the method defined by the superclass will be hidden

```
// 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

6.3 Dynamic method dispatch

Dynamic method dispatch is the mechanism by which a call to an overridden function is resolved at run time, rather than compile time. Dynamic method dispatch is important because this is how Java implements run-time polymorphism.

When an overridden method is called through a superclass reference, Java determines which version of that method to execute based upon the type of the object being referred to at the time the call occurs. Thus, this determination is made at run time. When different types of objects are referred to, different versions of an overridden method will be called. In other words, *it is the type of the object being referred to* (not the type of the reference variable) that determines which version of an overridden method will be executed. Therefore, if a superclass contains a method that is overridden by a subclass, then when different types of objects are referred to through superclass reference variable, different versions of the method are executed.

```
// 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
}
}
```

The output from the program is shown below:
Inside A's callme method
Inside B's callme method
Inside C's callme method

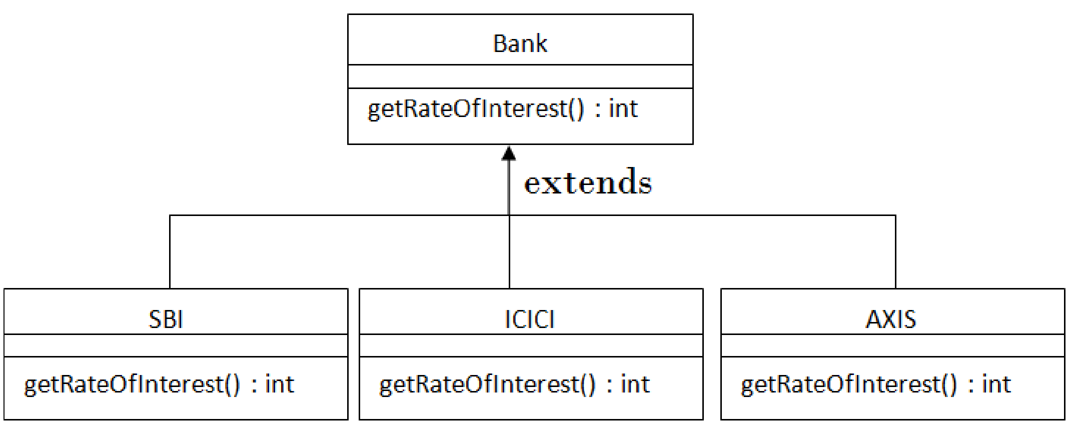
Lab Exercises:

1. Create an Account class that stores customers name, acc-no and type of account. From this derive class current account and savings bank account. Include necessary methods in order to achieve following tasks:-
   a) Accept the deposit from a customer and update the balance
   b) Display the balance
   c) Compute and deposit interest
   d) Permit withdraw and update the balance
   e) Check for minimum balance impose penalty if necessary and update the balance

   For savings bank account the facilities given are computing interest, withdraw facility. No interest on current bank account and should maintain a minimum balance and if balance is less than this level, service tax is imposed.

2. Create a base class for student having registration number, name and age. From this class create two new class UG and PG student with semester and fees as its data members. Use proper member function for demonstrating inheritance.

3. Create a base class called Bank that provides functionality to get rate of interest. But, rate of interest varies according to banks. For example, SBI, ICICI and AXIS banks could provide 8%, 7% and 9% rate of interest. Write a Java program to demonstrate the concept of method overriding and dynamic method dispatch.



Additional Exercises:

1. Create a base class “Game” with method called “type” that prints “indoor & outdoor games”. Create a subclass cricket with a method called “type” that prints “cricket is an outdoor game”. Create one more subclass of “Game” called “chess” with a method “type” that prints “chess is an indoor game”. Write a complete Java program for the above to understand the Dynamic method dispatch concept.

2. Create two classes Bike and Splendar. Splendar class extends Bike class and overrides its run() method. Write a complete Java program to implement the runtime polymorphism. Include a member called “speedlimit” in both the classes with different values. The run() method should give the information of speed limit. Check whether the runtime polymorphism can be achieved through the data members.

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LAB NO.: 7 **Date:**

CLASSES-ACCESS CONTROL, STATIC KEYWORD, NESTED & INNER CLASS, FINAL ,WRAPPER CLASS

Objectives:
1. To know the different access specifiers used with the class
2. To learn the concept of nested, inner and wrapper classes
3. To study the variations of static keyword when used with methods and variables
4. To write Java programs using the concepts of access specifiers, nested, inner, wrapper class, usage of static keyword with methods and variables.

7.1 Access Specifiers

Java provides a number of access modifiers to set access levels for classes, variables, methods, and constructors. The four access levels are −
- Visible to the package, the default. No modifiers are needed.
- Visible to the class only (private).
- Visible to the world (public).
- Visible to the package and all subclasses (protected).
  Default Access Modifier - No Keyword

7.2 Variation of using static keyword

The static keyword is used in java mainly for memory management. It is used with variables, methods, blocks and nested class. It is a keyword that are used for share the same variable or method of a given class. This is used for a constant variable or a method that is the same for every instance of a class. The main method of a class is generally labeled static.

No object needs to be created to use static variable or call static methods, just put the class name before the static variable or method to use them. Static method can not call non-static method.

In java language static keyword can be used for following:
- variable (also known as class variable)
- method (also known as class method)
- block
- nested class

Static variable
Any variable declared as static is known as **static variable**.

Static variable is used to fulfill the common requirement. For Example company name of employees, college name of students etc. Name of the college is common for all students.

The static variable allocate memory only once in class area at the time of class loading.

Advantage of static variable
Using static variable a program memory can be made efficient (i.e it saves memory).

When and why to use static variable
For example to store record of all employee of any company, in this case employee id is unique for every employee but company name is common for all. When a static variable such as a company name is created then only once memory is allocated otherwise it allocate a memory space each time for every employee.

Syntax to declare static variable:
public static variableName;

Syntax for declare static method:
```
public static  void methodName()
{
.......
.......
}
```

Syntax for access static methods and static variable:

```
className.variableName=10;
className.methodName();
Example
public static final double PI=3.1415;
public static void main(String args[])
{
......
......
}
```

Difference between static and final keyword

static keyword always fixed the memory that means that will be located only once in the program where as final keyword always fixed the value that means it makes variable values constant.

7.3 Nested,Inner,Wrapper Class

a) Nested & Inner Class

The Java programming language allows it to define a class within another class. Such a class is called a nested class and is illustrated here:

```
class OuterClass {
   ...
   class NestedClass {
      ...
   }
}
```

Terminology: Nested classes are divided into two categories: static and non-static. Nested classes that are declared static are called static nested classes. Non-static nested classes are called inner classes.

```
class OuterClass {
   ...
   static class StaticNestedClass {
      ...
   }
   class InnerClass {
      ...
   }
}
```

A nested class is a member of its enclosing class. Non-static nested classes (inner classes) have access to other members of the enclosing class, even if they are declared private. Static nested classes do not have access to other members of the enclosing class. As a member of the OuterClass, a nested class can be declared private, public, protected, or package private. (Recall that outer classes can only be declared public or package private.)

Why Use Nested Classes?

Compelling reasons for using nested classes include the following:

It is a way of logically grouping classes that are only used in one place: If a class is useful to only one other class, then it is logical to embed it in that class and keep the two together. Nesting such "helper classes" makes their package more streamlined.

It increases encapsulation: Consider two top-level classes, A and B, where B needs access to members of A that would otherwise be declared private. By hiding class B within class A, A's members can be declared private and B can access them. In addition, B itself can be hidden from the outside world.

It can lead to more readable and maintainable code: Nesting small classes within top-level classes places the code closer to where it is used.

b) Wrapper Class

Wrapper classes are used to convert any data type into an Object type. The primitive data types are not objects. They do not belong to any class. They are defined in the language itself.

All the wrapper classes (Integer, Long, Byte, Double, Float, Short) are subclasses of the abstract class Number.

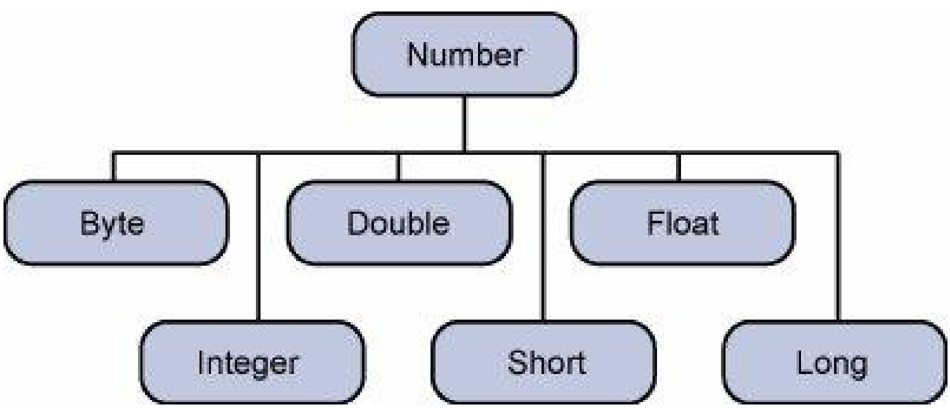

Fig. 8.1: The hierarchy of the class Number.

Converting primitive data types into object is called boxing, and this is taken care by the compiler. Therefore, while using a wrapper class pass the value of the primitive data type to the constructor of the Wrapper class to convert primitive data into an Object of its owen type.

The Wrapper object can be converted back to a primitive data type, and the process is called unboxing. The Number class is part of the java.lang package.

Following is an example of boxing and unboxing −

Example

```
public class Test {

   public static void main(String args[]) {
      Integer x = 5; // boxes int to an Integer object
      x =  x + 10;   // unboxes the Integer to a int
      System.out.println(x);
   }
}
```

o/p:15

Lab Exercises:

1. Write a java program to store student record of college named “MIT”. Class Student_Detail should contain name, id, college_name as its members.display_details() method should display the details of the students.
2. Write a counter program to count the number of objects created.
3. Write a java program to illustrate autoboxing and unboxing.

Additional Exercises:

1) Write output of the following and analyze the code.

```
class Example1{
  //Static class
  static class X{
     static String
str="Inside Class X";
  }
  public static void
main(String args[])
  {
     X.str="Inside Class
Example1";

System.out.println("String
stored in str is- "+ X.str);
  }
}
```

```
class Example2{
   int num;
   //Static class
   static class X{
      static String
str="Inside Class X";
      num=99;
   }
   public static void
main(String args[])
   {
      Example2.X obj =
new Example2.X();

System.out.println("Value
of num="+obj.str);
   }
}
```

```
class Example3{
   static int num;
   static String mystr;
   static{
      num = 97;
      mystr = "Static keyword
in Java";
   }
   public static void
main(String args[])
   {

System.out.println("Value
of num="+num);

System.out.println("Value
of mystr="+mystr);
   }
}
```

```
class Example4{
   static int num;
   static String mystr;
   //First Static block
   static{

System.out.println("Static
Block 1");
      num = 68;
      mystr = "Block1";
  }
  //Second static block
  static{

System.out.println("Static
Block 2");
      num = 98;
```

```
class Example5{
   static int i;
   static String s;
   public static void
main(String args[]) //Its a
Static Method
   {
      Example5 obj=new
Example5();
      //Non Static variables
accessed using object obj

System.out.println("i:"+ob
j.i);

System.out.println("s:"+ob
j.s);
```

```
class Example6{
  static int i;
  static String s;
  //Static method
  static void display()
  {
    //Its a Static method
    Example6 obj1=new
Example6();

System.out.println("i:"+obj
1.i);

System.out.println("i:"+obj
1.i);
  }
```

mystr = "Block2";
}
public static void main(String args[])
{
System.out.println("Value of num="+num);
System.out.println("Value of mystr="+mystr);
}
}
	}
	}
		void funcn()
		{
		//Static method called in non-static method
		display();
		}
		public static void main(String args[]) //Its a Static Method
		{
		//Static method called in another static method
		display();
		}
		}

LAB NO.: 8 **Date:**

INTERFACE & ABSTRACT CLASS

Objectives:

1. To learn the use of abstract class
2. To understand the interfaces
3. To write Java programs to illustrate usage of interfaces and abstract classes

8.1 Abstract class

An abstract class is a superclass that cannot be instantiated and is used to state or define general characteristics. An object cannot be formed from a Java abstract class; trying to instantiate an abstract class only produces a compiler error. The abstract class is declared using the keyword abstract.

Abstract classes serve as templates for their subclasses. For example, the abstract class Tree and subclass, Banyan_Tree, has all the characteristics of a tree as well as characteristics that are specific to the banyan tree.

Declaring an Abstract Class in Java

In Java a class can be made an abstract by adding the abstract keyword to the class declaration. Here is a Java abstract class example:

```
public abstract class MyAbstractClass {
}
```

If it is required that certain methods be overridden by subclasses by specifying the abstract type modifier, then these methods are referred to as sub-classes responsibility because they have no implementation specified in the superclass. Thus, a subclass must override them. It cannot simply use the version defined in the superclass. To declare an abstract method, use this general form:

```
abstract type name(parameter-list);
```

Any class that contains one or more abstract methods must also be declared 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();
            }
    }
```

Notice that no objects of class **A** are declared in the program. As mentioned, it is not possible to instantiate an abstract class. One other point: class **A** implements a concrete method called **callmetoo( )**. This is perfectly acceptable. Abstract classes can include as much implementation as they see fit.

8.2 Interfaces

Interfaces are syntactically similar to classes, but they lack instance variables, and their methods are declared without any body. In practice, this means that an interface defines which don't make assumptions about how they are implemented. Once it is defined, any number of classes can implement an **interface**. Also, one class can implement any number of interfaces.

To implement an interface, a class must create the complete set of methods defined by the interface. However, each class is free to determine the details of its own implementation. By providing the interface keyword, Java allows to fully utilize the "one interface, multiple methods" aspect of polymorphism.

An interface is defined much like a class. This is the general form of an interface:

access interface *name* {
return-type method-name1(*parameter-list*)*;*
return-type method-name2(*parameter-list*)*;*

type final-varname1 = value;
type final-varname2 = value;
// ...
return-type method-nameN(parameter-list);
type final-varnameN = value;
}

Variables can be declared inside of interface declarations. They are implicitly **final** and **static**, meaning they cannot be changed by the implementing class. They must also be initialized with a constant value.

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
}

//simple program to demonstrate the interfaces

```
interface Callback {
        void callback(intparam);
}

class Client implements Callback {
        // Implement Callback's interface
        public void callback(int p) {
        System.out.println("callback called with " + p);
        }
}
```

Note: When an interface's method is implemented , it must be declared as ***public***.

The variables can be declared as object references that use an interface rather than a class type. Any instance of any class that implements the declared interface can be stored in such a variable. When a method is called through one of these references, the correct version will be called based on the actual instance of the interface being referred to. This is one of the key features of interfaces. The method to be executed is looked up dynamically at run time, allowing classes to be created later than the code which calls methods on them.

The following example calls the **callback( )** method via an interface reference variable:

```
class TestIface {
        public static void main(String args[]) {
        Callback c = new Client();
        c.callback(42);
        }
}
```

The output of this program is shown here:
callback called with 42

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.

Lab Exercises:

1. Imagine a company that markets both hardware and software. Create an interface that will be implemented by two classes hardware and software, where hardware item holds the category of item and its original manufacturer and software holds type of software and operating system under which it works. Calculate the total sales for hardware as well as software item recorded for last 3months
2. Write a program to compute the areas of a rectangle and a circle by using abstract class.
3. Use interface for the previous question instead of abstract class.

Additional Exercises:

1. Write a program to compute the area of a square and a triangle by using abstract class.
2. Use interface for the previous question instead of abstract class.
3. Create an interface called “sports” with methods getNumberOfGoals and dispTeam. Create classes Hockey and football that uses the interface “sports”. Write the appropriate code for the methods.

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LAB NO.: 9 **Date:**

STRING HANDLING

Objectives:

1. To understand the basics of String Handling and String Class
2. To develop string based applications.

9.1 Basics of String Handling and String Class

Java implements strings as objects of type **String**. It has methods to compare two strings, search for a substring, concatenate two strings, and change the case of letters within a string. Also, **String** objects can be constructed in number of ways, making it easy to obtain a string when needed. Once a **String** object has been created, that cannot be changed. To modify the string a new **String** object is created and the original string is left unchanged. This approach is used because fixed, immutable strings can be implemented more efficiently than changeable ones. For those cases in which a modifiable string is desired, there is a companion class to **String** called **StringBuffer**, whose objects contain strings that can be modified after they are created.

Both the **String** and **StringBuffer** classes are defined in **java.lang**. Thus, they are available to all programs automatically.

Following are the constructors of String class:

String(char chars[])
String(char *chars*[ ], int *startIndex*, int *numChars*)
String(String *strObj*)
String(byte *asciiChars*[ ])
String(byte *asciiChars*[ ], int *startIndex*, int *numChars*)

The table 9.1 shows the methods of String Class

Table 9.1 Methods of String Class

Modifier and Type	Method and Description
char	**charAt**(int index) Returns the char value at the specified index.
int	**codePointAt**(int index) Returns the character (Unicode code point) at the specified index.
Modifier and Type	**Method and Description**
int	**compareTo**(String anotherString) Compares two strings lexicographically.
int	**compareToIgnoreCase**(String str) Compares two strings lexicographically, ignoring case differences.
String	**concat**(String str) Concatenates the specified string to the end of this string.
boolean	**contains**(CharSequence s) Returns true if and only if this string contains the specified sequence of char values.
boolean	**endsWith**(String suffix) Tests if this string ends with the specified suffix.
boolean	**equals**(Object anObject) Compares this string to the specified object.
boolean	**equalsIgnoreCase**(String anotherString) Compares this String to another String, ignoring case considerations.
static String	**format**(Locale l, String format, Object... args) Returns a formatted string using the specified locale, format string, and arguments.
byte[ ]	**getBytes**() Encodes this String into a sequence of bytes using the platform's default charset, storing the result into a new byte array.

void	**getChars**(int srcBegin, int srcEnd, char[] dst, int dstBegin) Copies characters from this string into the destination character array.
int	**indexOf**(int ch) Returns the index within this string of the first occurrence of the specified character.
boolean	**isEmpty**() Returns true if, and only if, length() is 0.
Int	**lastIndexOf**(int ch) Returns the index within this string of the last occurrence of the specified character.

Note: The strings within objects of type **String** are unchangeable means that the contents of the **String** instance cannot be changed after it has been created. However, a variable declared as a **String** reference can be changed to point at some other **String** object at any time.

```
// Construct one String from another.
class MakeString {
public static void main(String args[ ]) {
        char c[ ] = {'J', 'a', 'v', 'a'};
        String s1 = new String(c);
        String s2 = new String(s1);
        System.out.println(s1);
        System.out.println(s2); } }
```

The output produced by the above program is shown below:
Java
Java

BUILD SUCCESSFUL (total time: 2 seconds)

In the above example strings s1 and s2 are created using character array. So s1 and s2 contains the same string.

Lab Exercises:

(Hint: use the appropriate built in methods of String class to write the following Java programs)

1. Write a Java program to count and display the number of characters, words, lines, and vowels in a String.
2. Write a Java program to replace an entered word to all repeating characters.
3. Write a menu driven program to do the following:
   a. To check whether a string is palindrome or not
   b. Write the string in an alphabetical order
   c. Reverse the string
   d. Concatenate the original string and the reversed string
4. Write a menu driven program to do the following:-
   a. To compare two strings
   b. To convert the uppercase character to lower and vice-versa
   c. To display whether an entered string is a substring of the other or not
   d. If the entered string is a substring of the other, replace it with “Hello”

Additional Exercises:

1. Write a program to accept an array of strings and arrange them in alphabetical order.
2. Develop a program for searching a student from a class. Assume a set of 10 students with their details as Registration number, First Name, Last Name and Degree in an array of Student objects. Search a student either by First Name or Last Name.
3. Write a program to accept five strings separately, concatenate and display them as a single string.
4. Write a program that inputs a telephone number as a string in the form **(555) 555-5555**. Use **String** method to extract the area code as a token, the first three digits of the phone number as a token and the last four digits of the phone number as a token. Display area code and seven digit phone number separately.
5. Write a program that reads a five-letter word from the user and produces all possible three letter words that can be derived from the letters of the five letter word. For example, the three letter words produced from the word “bathe” include the commonly used words “ate,” “bat,” “bet,” “tab,”, “hat,” “the” and “tea.”

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LAB NO.: 10 **Date:**

EXCEPTION AND FILE HANDLING

Objectives:

1. To understand the basic concept of exception handling in Java.
2. To know the exception types.
3. To write simple Java programs that handle exceptions.
4. To understand data handling using streams.
5. To explore File class and its constructors and methods.
6. To develop an application which takes an input from a file and sends its output to another file.

10.1 Basics of Exception Handling

A Java exception is an object that describes an exceptional (that is, error) condition that has occurred in a piece of code. When an 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 the code. Exceptions thrown by Java relate to fundamental errors that violate the rules of the Java language or the constraints of the Java execution environment. Manually generated exceptions are typically used to report some error condition to the caller of a method.

Java exception handling is managed via five keywords: **try**, **catch**, **throw**, **throws**, and **finally**. Program statements that want to monitor for exceptions are contained within a **try** block. If an exception occurs within the **try** block, it is thrown. The code can catch this exception (using **catch**) and handle it in some rational manner. To manually throw an exception, use the keyword **throw**. Any exception that is thrown out of a method must be specified as such by a **throws** clause. Any code that absolutely must be executed before a method returns is put in a **finally** block.

The general form of an exception handling block is given below:

```
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
}
```

Here, *ExceptionType* is the type of exception that has occurred.

10.2 Exception Types

Java defines several exception classes inside the standard package **java.lang**. 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 **RuntimeExceptions** 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.

Table 10.1. Java's Unchecked Runtime Exception Subclasses

Exception	Meaning
ArithmeticException	Arithmetic error, such as divide by zero.
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.
ArrayIndexOutOfBoundsException	Array index is out of bounds.
LlegalStateException	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.
StringIndexOutOfBounds	Attempt to index outside the bounds of a string.
NegativeArraySizeException	Array created with a negative size.
NullPointerException	Invalid use of a null reference.
NumberFormatException	Invalid conversion of a string to a numeric format.
UnsupportedOperationException	An unsupported operation was encountered.

Table 10.2. Java's Checked Exceptions defined in java.lang

Exception	Meaning
ClassNotFoundException	Class not found
IllegalAccessException	Access to a class is denied.
InstantiationException	Attempt to create an object of an abstract class or interface.
InterruptedException	One thread has been interrupted by another thread.
NoSuchFieldException	A requested field does not exist.
NoSuchMethodException	A requested method does not exist.

10.3 Simple Java program that handles exception

```
//Program which handles Arithmetic Exception (division by 0)\

import java.util.Scanner;
class ArithmeticExceptionTest
{
 public static void main(String args[]){
		Scanner sc=new Scanner(System.in);
		int a,b,x=0;
		System.out.println("DIVISION");
		System.out.print("Enter a number - ");
		a=sc.nextInt();
		System.out.print("Enter a number - ");
		b=sc.nextInt();
		try{
			x=a/b;
		    }catch(ArithmeticException A){
			System.out.println("Error");
		    }
		finally{
			System.out.println("a/b="+x);
		 }
 }}
```

The output produced by the above program is shown below:

```
DIVISION
Enter a number - 2
Enter a number - 4
a/b=0
BUILD SUCCESSFUL (total time: 13 seconds)

DIVISION
Enter a number - 5
Enter a number - 0
Error
a/b=0
BUILD SUCCESSFUL (total time: 11 seconds)
```

10.4 Data handling using Streams

Java programs perform Input /Output through streams. A *stream* is an abstraction that either produces or consumes information. A stream is linked to a physical device by the Java I/O system. All streams behave in the same manner, even if the actual physical devices to which they are linked differ. Thus, the same I/O classes and methods can be applied to any type of device. An input stream can abstract many different kinds of input such as a disk file, a keyboard, or a network socket. Likewise, an output stream may refer to the console, a disk file, or a network connection. Java implements streams within class hierarchies defined in the **java.io** package.

Java defines two types of streams: byte and character. *Byte streams* provide a convenient means for handling input and output of bytes. Byte streams are used, for example, when reading or writing binary data. *Character streams* provide a convenient means for handling input and output of characters. They use Unicode and, therefore, can be internationalized. Also, in some cases, character streams are more efficient than byte streams. The character based streams simply provide a convenient and efficient means for handling characters.

10.5 File Class

A **File** object is used to obtain or manipulate the information associated with a disk file, such as the permissions, time, date, and directory path, and to navigate subdirectory hierarchies. Files are a primary source and destination for data within many programs. A directory in Java is treated simply as a **File** with one additional property with a list of filenames that can be examined by the **list( )** method.

The following constructors can be used to create **File** objects:

> File(String *directoryPath*)
> File(String *directoryPath,* String *filename*)
> File(File *dirObj*, String *filename*)
> File(URI *uriObj*)

Here, *directoryPath* is the path name of the file, *filename* is the name of the file, *dirObj* is a **File** object that specifies a directory, and *uriObj* is a **URI** object that describes a file.

File defines many methods that obtain the standard properties of a **File** object. For example, **getName( )** returns the name of the file, **getParent( )** returns the name of the parent directory, and **exists( )** returns **true** if the file exists, **false** if it does not.

```
import java.io.*;

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

                FileInputStream f;
                f = new FileInputStream("study1.txt");
                boolean eof = false;
                int count = 0;

                while (!eof)
                {
                        int i = f.read();
                        System.out.print(i + " ");
                        if (i == -1)
                        eof = true;
                        else
                        count++;
                }
        f.close();
        System.out.println("\n Total number of bytes read from the file are: " +count);
        } catch (Exception e) {
                        System.out.println(e);
        }
        }
}
```

----

study1.txt contains following data

Examples on File Handling

The output of the above program is as follows.

69 120 97 109 112 108 101 115 32 111 110 32 70 105 108 101 32 72 97 110 100 108 105 110 103 -1

Total number of bytes read from the file are: 25

BUILD SUCCESSFUL (total time: 1 second)

In the above program, contents of the file study1.txt are read and displayed. Further program counts and display the total number of bytes in the file using boolean variable **eof**.

Lab Exercises:

1. Write a menu driven program to do the following: Write to a file, Read from the file, Copy bytes from one file to another file [Hint : Use read and write methods]
2. To read and write primitive data using random access file and also append some information.[Hint : Use RandomAccessFile class]
3. To count the number of characters, vowels, lines and words in a given file.[Hint :Use read method]
4. Write a program to encrypt and decrypt the file.[Hint: Use any encryption technique]
5. Write a program to store the information of students using object serialization and read the same using object de-serialization. Calculate the percentage and grade them and write the information again to the file. [Hint : Write Object]
6. Write a program to store the information of employees of an organization using object serialization and read the same using object de-serialization. Calculate the total allowances and deductions and the net salary and display the same along with writing this information again to the file.[Hint : Use read Object]
7. Write a program that handles NumberFormatException. [Hint: Invalid conversion of a string to a number]
8. Write a program that handles ArrayOverflowException. [Hint: Consider the array size]
9. Write a program to enter student's Name, Roll Number and Marks in three subjects and find the percentage, grade and handle NumberFormatException.

10. Create a user defined exception class which displays error message.
11. Write a program for validating matrix. [Hint: Square matrix]
12. Write a program for checking the negative root of a number. [Hint: Input negative number]

Additional Exercises:

1. Design a class Input_Exception for validating an input taken from the user during runtime and continue to perform the sum of the numbers entered until a -1 is input. In case the user enters a -1, the sum is calculated and displayed. In case the user enters any floating point numbers, then the method that takes the input should raise the user defined exception and the same should be handled in the main.
2. Write a program to throw the NegativeArraySizeException, when the size of an array is negative.
3. Write a program to raise EvenNumberException if the number is even.
4. Write a program to find the exception marks out of bounds. In this program create a class called Student. If the mark is greater than 100 it must create an exception called MarkOutofBoundsException and throw it.
5. Write a program to display all the files and directories of a directory using File object.
6. Write a program to store the employee details having the fields Name, Employee Number, Salary and Address in a file. Sort according to Name and store all the details in another file.
7. Write a program that reads a text file and makes an alphabetical list of all the words in that file. The list of words is output to another file. Also keeps track of the number of times that each word occurs in the file. Write two lists to the output file. The first list contains the words in alphabetical order. The number of times that the word occurred in the file should be listed along with the word. Then write a second list to the output file in which the words are sorted according to the number of times that they occurred in the files. The word that occurred most often should be listed first.
8. Write a program that counts the number of lines in each file that is specified on the command line. Assume that the files are text files. Note that multiple files can be specified, as in "java LineCounts file1.txt file2.txt file3.txt". Write each file name,

along with the number of lines in that file, to standard output. If an error occurs while trying to read from one of the files, it should print an error message for that file, but it should still process all the remaining files.

9. Write a phone directory program that keeps the list of names and phone numbers in a file. The user of the program should be able to look up a name in the directory to find the associated phone number. The user should also be able to make changes to the data in the directory. Every time the program starts up, it should read the data from the file. Before the program terminates, if the data has been changed while the program was running, the file should be rewritten with the new data.

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LAB NO.: 11 **Date:**

MULTITHREADED PROGRAMMING & SWINGS

Objectives:

1. To understand basics of multitasking and multithreading.
2. To develop multitasking applications using threads.
3. To understand basic concepts of a java swing.
4. To develop simple java application using swings.

11.1 Basics of Multitasking and Multithreading

Java was designed to meet the real-world requirement of creating interactive, networked programs. To accomplish this, Java supports multithreaded programming, which allows us to write programs that do many things simultaneously. Java's easy-to-use approach to multithreading allows us to think about the specific behavior of program. Java provides built-in support for *multithreaded programming.* A multithreaded program contains two or more parts that can run concurrently. Each part of such a program is called a *thread,* and each thread defines a separate path of execution. Thus, multithreading is a specialized form of multitasking (performs more than one task at a time).

There are two distinct types of multitasking: process-based and thread-based. Process-based multitasking is the feature that allows computer to run two or more programs concurrently. For example, process-based multitasking enables to run the Java compiler at the same time that are using a text editor. In process-based multitasking, a program is the smallest unit of code that can be dispatched by the scheduler. In a *thread-based* multitasking environment, the thread is the smallest unit of dispatchable code. This means that a single program can perform two or more tasks simultaneously. For instance, a text editor can format text at the same time that it is printing, as long as these two actions are being performed by two separate threads.

Multitasking threads require less overhead than multitasking processes. Processes are heavyweight tasks that require their own separate address spaces. Multithreading enables to write very efficient programs that make maximum use of the CPU, because idle time can be kept to a minimum. This is especially important for the interactive, networked environment in which Java operates, because idle time is common.

There are two ways to create a thread.

1. By extending a Thread class
2. By implementing Runnable Interface.

Following code is the general form of thread creation block:

```
class NewThread implements Runnable {
        public void run()
        {  //---
        }
}

class Threadex {
        public static void main(String args[]) {
        new NewThread(); // create a new thread
        //-----
        }
 }

//Example to create a thread.
        class SampleThread implements Runnable
        {
                public void run()
                {
                        for(int i=0;i<5;i++)
                        {
                                System.out.println("Hello World");
                        }
                }
        }
        public class MyThread
        {
                public static void main(String ar[])
                {
                        SampleThreadthrd=new SampleThread();
                        Thread newThread=new Thread(thrd);
                        newThread.start();
                }
        }
```

The output produced by the above program is shown below:

```
Hello World
Hello World
Hello World
Hello World
Hello World

BUILD SUCCESSFUL (total time: 3 seconds)
```

In the above example thread is created by implementing Runnable interface. Start() method is called to start the execution of a thread.

11.2 Basics of SWINGs

Swing library is an official Java GUI toolkit released by Sun Microsystems. It is used to create Graphical user interfaces with Java. The main characteristics of the Swing toolkit:

- platform independent
- customizable
- extensible
- configurable
- lightweight

The Swing API has 18 public packages:

- javax.accessibility
- javax.swing
- javax.swing.border
- javax.swing.colorchooser
- javax.swing.event
- javax.swing.filechooser
- javax.swing.plaf
- javax.swing.plaf.basic
- javax.swing.plaf.metal
- javax.swing.plaf.multi
- javax.swing.plaf.synth
- javax.swing.table
- javax.swing.text
- javax.swing.text.html
- javax.swing.text.html.parser

- javax.swing.text.rtf
- javax.swing.tree
- javax.swing.undo

Swing is an advanced GUI toolkit. It has a rich set of widgets. From basic widgets like buttons, labels, scrollbars to advanced widgets like trees and tables. Swing itself is written in Java. Swing is a part of JFC, Java Foundation Classes. It is a collection of packages for creating full featured desktop applications. JFC consists of AWT, Swing, Accessibility, Java 2D, and Drag and Drop. Swing was released in 1997 with JDK 1.2.

11.3 The swing layout

The Java Swing toolkit has two kind of components: containers and children. The containers group children into suitable layouts. To create layouts, use *layout managers*. It is possible to go without a layout manager. There might be situations where it might not need a layout manager. But in most cases to create truly portable, complex applications, it need layout managers. Without layout manager, to position components use absolute values.

Example 1:

```
\\ Positioning of components without layout manager.
import javax.swing.JButton;
import javax.swing.JFrame;
import javax.swing.SwingUtilities;

public class AbsoluteExample extends JFrame {
   public AbsoluteExample() {
      initUI();
   }
   public final void initUI() {
      setLayout(null);
      JButton ok = new JButton("OK");
      ok.setBounds(50, 50, 80, 25);
      JButton close = new JButton("Close");
      close.setBounds(150, 50, 80, 25);
      add(ok);
      add(close);
      setTitle("Absolute positioning");
```

```
        setSize(300, 250);
        setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        setLocationRelativeTo(null);
    }

    public static void main(String[] args) {
        SwingUtilities.invokeLater(new Runnable() {
            public void run() {
                AbsoluteExample ex = new AbsoluteExample();
                ex.setVisible(true);
            }
        });
} }
```

This simple example shows two buttons.
setLayout(null);If used absolute positioning by providing null to the setLayout() method.
ok.setBounds(50, 50, 80, 25);
The setBounds() method positions the ok button. The parameters are the x, y location values and the width and height of the component.

The main layout forms supported by swings are:
1. Flow layout
2. Grid layout
3. Border layout
4. Box layout

11.4 Flow Layout manager

This is the simplest layout manager in the Java Swing toolkit. It is mainly used in combination with other layout managers. When calculating its children size, a flow layout lets each component assume its natural (preferred) size.

The manager puts components into a row. In the order, they were added. If they do not fit into one row, they go into the next one. The components can be added from the right to the left or vice versa. The manager allows to align the components. Implicitly, the components are centered and there is 5px space among components and components and the edges of the container.

FlowLayout()
FlowLayout(int align)
FlowLayout(int align, int hgap, int vgap)

There are three constructors available for the FlowLayout manager. The first one creates a manager with implicit values. Centered with 5px horizontal and vertical spaces. The others allow to specify those parameters.

Example 2: Flow Layout Example

```
import java.awt.Dimension;
import javax.swing.JButton;
import javax.swing.JFrame;
import javax.swing.Jpanel;
import javax.swing.JTextArea;
import javax.swing.JTree;
import javax.swing.SwingUtilities;

public class FlowLayoutExample extends JFrame {
   public FlowLayoutExample() {
      initUI();
   }
   public final void initUI() {
      JPanel panel = new JPanel();
      JTextArea area = new JTextArea("text area");
      area.setPreferredSize(new Dimension(100, 100));
      JButton button = new JButton("button");
      panel.add(button);
      JTree tree = new JTree();
      panel.add(tree);
      panel.add(area);
      add(panel);
      pack();
      setTitle("FlowLayout Example");
      setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
      setLocationRelativeTo(null);
   }
   public static void main(String[] args) {
```

```
        SwingUtilities.invokeLater(new Runnable() {
            public void run() {
                FlowLayoutExample ex = new FlowLayoutExample();
                 ex.setVisible(true);
            }
        });
    } }
```

The example shows a button, a tree and a text area component in the window. Interestingly, if to create an empty tree component, there are some default values inside the component.

```
JPanel panel = new JPanel();
```

The implicit layout manager of the JPanel component is a flow layout manager. It need not require to be set manually.

```
JTextArea area = new JTextArea("text area");
area.setPreferredSize(new Dimension(100, 100));
```

The flow layout manager sets a *preferred* size for its components. This means, that in our case, the area component will have 100x100px. If it doesn't set the preferred size, the component would have a size of its text. Without the text, the component would not be visible at all.

```
panel.add(area);
```

To put a component inside a container, simply call the add() method.

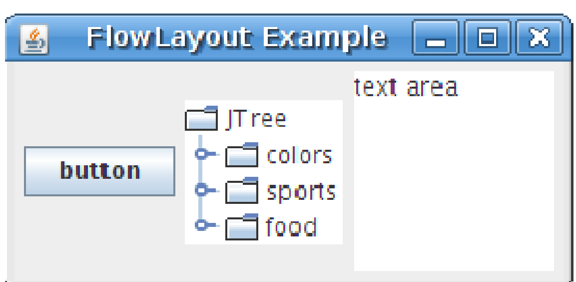

Figure 11.1: FlowLayout example

11.5 GridLayout

The GridLayout layout manager lays out components in a rectangular grid. The container is divided into equally sized rectangles. One component is placed in each rectangle.

Example 3: Grid Layout Format

```
import java.awt.GridLayout;
import javax.swing.BorderFactory;
import javax.swing.JButton;
import javax.swing.JFrame;
import javax.swing.JLabel;
import javax.swing.JPanel;
import javax.swing.SwingUtilities;
public class GridLayoutExample extends JFrame {
    public GridLayoutExample() {
        initUI();
    }
    public final void initUI() {
        JPanel panel = new JPanel();
        panel.setBorder(BorderFactory.createEmptyBorder(5, 5, 5, 5));
        panel.setLayout(new GridLayout(5, 4, 5, 5));
        String[] buttons = {
"Cls", "Bck", "", "Close", "7", "8", "9", "/", "4", "5", "6", "*", "1", "2", "3", "-", "0", ".",
"=", "+"
        };
        for (int i = 0; i < buttons.length; i++) {
            if (i == 2)
                panel.add(new JLabel(buttons[i]));
            else
                panel.add(new JButton(buttons[i]));
        }
        add(panel);
        setTitle("GridLayout");
        setSize(350, 300);
        setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        setLocationRelativeTo(null);
    }
    public static void main(String[] args) {
        SwingUtilities.invokeLater(new Runnable() {
            public void run() {
              GridLayoutExample ex = new GridLayoutExample();
```

```
            ex.setVisible(true);
        }
    });
} }
```

The example shows a skeleton of a simple calculator tool (Grid layout example in figure 11.2). It is an ideal example for grid layout manager. Put 19 buttons and one label into the manager. Notice that each button is of the same size.
panel.setLayout(new GridLayout(5, 4, 5, 5));

Here it set the grid layout manager for the panel component. The layout manager takes four parameters. The number of rows, the number of columns and the horizontal and vertical gaps between components.

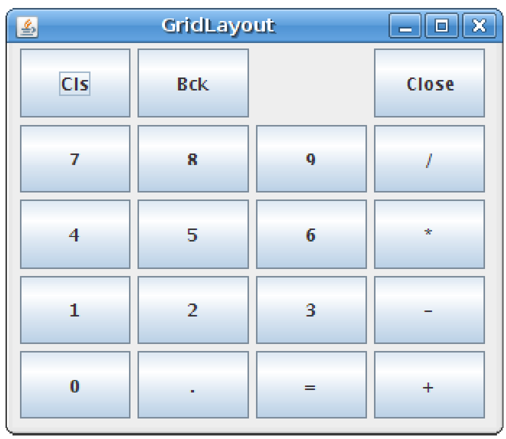

Figure 11.2: GridLayout Example

11.3 Java Swing events

Events are an important part in any GUI program. All GUI applications are event-driven. An application reacts to different event types which are generated during its life. Events are generated mainly by the user of an application. But they can be generated by other means as well, e.g. Internet connection, window manager, timer. In the event model, there are three participants:

- event source
- event object
- event listener

The *Event source* is the object whose state changes. It generates Events. The *Event object* (Event) encapsulates the state changes in the event source. The *Event listener* is the object that wants to be notified. Event source object delegates the task of handling an event to the event listener.

Event handling in Java Swing toolkit is very powerful and flexible. Java uses Event Delegation Model. It specify the objects that are to be notified when a specific event occurs.

11.4 An event object

When something happens in the application, an event object is created. For example, when it click on the button or select an item from a list. There are several types of events, including ActionEvent, TextEvent, FocusEvent, and ComponentEvent. Each of them is created under specific conditions.

An event object holds information about an event that has occurred. In the next example, it will analyse an ActionEvent in more detail.

Example 4: An ActionEvent

```
import java.awt.Container;
import java.awt.Dimension;
import java.awt.EventQueue;
import java.awt.event.ActionEvent;
import java.text.DateFormat;
import java.util.Date;
import java.util.Locale;
import javax.swing.AbstractAction;
import javax.swing.BorderFactory;
import javax.swing.DefaultListModel;
import javax.swing.GroupLayout;
import javax.swing.JButton;
import javax.swing.JFrame;
import static javax.swing.JFrame.EXIT_ON_CLOSE;
import javax.swing.JList;

public class EventObjectEx extends JFrame {
    private JList list;
    private DefaultListModel model;
```

```
public EventObjectEx() {
   initUI();
}
private void initUI() {

   Container pane = getContentPane();
   GroupLayout gl = new GroupLayout(pane);
   pane.setLayout(gl);
   model = new DefaultListModel();
   list = new JList(model);
   list.setMinimumSize(new Dimension(250, 150));
   list.setBorder(BorderFactory.createEtchedBorder());
   JButton okButton = new JButton("OK");
   okButton.addActionListener(new ClickAction());
   gl.setAutoCreateContainerGaps(true);
   gl.setHorizontalGroup(gl.createSequentialGroup()
         .addComponent(okButton)
         .addGap(20)
         .addComponent(list)
   );
   gl.setVerticalGroup(gl.createParallelGroup()
         .addComponent(okButton)
         .addComponent(list)
   );
   pack();
   setTitle("Event object");
   setLocationRelativeTo(null);
   setDefaultCloseOperation(EXIT_ON_CLOSE);
}

private class ClickAction extends AbstractAction {
      public void actionPerformed(ActionEvent e) {
      Locale locale = Locale.getDefault();
      Date date = new Date(e.getWhen());
      String tm = DateFormat.getTimeInstance(DateFormat.SHORT,
            locale).format(date);
      if (!model.isEmpty()) {
```

```
            model.clear();
        }
        if (e.getID() == ActionEvent.ACTION_PERFORMED) {
            model.addElement("Event Id: ACTION_PERFORMED");
        }
        model.addElement("Time: " + tm);
        String source=e.getSource().getClass().getName();
        model.addElement("Source: " + source);
        int mod = e.getModifiers();
      StringBuffer buffer= new StringBuffer("Modifiers: ");
        if ((mod & ActionEvent.ALT_MASK) > 0) {
            buffer.append("Alt ");
        }
        if ((mod & ActionEvent.SHIFT_MASK) > 0) {
            buffer.append("Shift ");
        }
        if ((mod & ActionEvent.META_MASK) > 0) {
            buffer.append("Meta ");
        }
        if ((mod & ActionEvent.CTRL_MASK) > 0) {
            buffer.append("Ctrl ");
        }

        model.addElement(buffer);
    }
}

public static void main(String[] args) {
    EventQueue.invokeLater(new Runnable() {
        public void run() {
            EventObjectEx ex = new EventObjectEx();
            ex.setVisible(true);
        }
    });
}
}
```

The code example shows a button and a list. If clicked on the button, the information about the event is displayed in the list. In our case, talking about an ActionEvent class. The data will be the time when the event occurred, the id of the event, the event source, and the modifier keys.

```
okButton.addActionListener(new ClickAction());
```

The ClickAction listens to the events of the OK button.

```
private class ClickAction extends AbstractAction {
   public void actionPerformed(ActionEvent e) {
      ...
   }
}
```

The actionPerformed() method is invoked when an action occurs. Its parameter is an ActionEvent object.

```
Locale locale = Locale.getDefault();
Date date = new Date(e.getWhen());
String s = DateFormat.getTimeInstance(DateFormat.SHORT, locale).format(date);
```

Thus obtained the time when the event occurred. The getWhen() method returns time value in milliseconds. So it must format it appropriately.

```
String source = e.getSource().getClass().getName();
model.addElement("Source: " + source);
```

Here add the name of the source of the event to the list. In our case the source is a JButton.

```
int mod = event.getModifiers();
```

This above function get the modifier keys. It is a bitwise-or of the modifier constants.

```
if ((mod & ActionEvent.SHIFT_MASK) > 0)
   buffer.append("Shift ");
```

Here it determine whether the user have pressed a Shift key(as shown in figure 11.3).

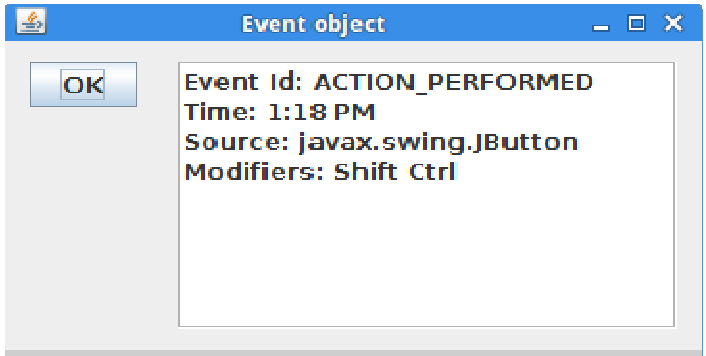

Figure 11.3: Event Object

11.5 Java Swing API:

The javax.swing package provides classes for java swing API such as JButton, JTextField, JTextArea, JRadioButton, JCheckbox, JMenu, JColorChooser etc. The hierarchy of java swing API is as shown in Figure 11.4.

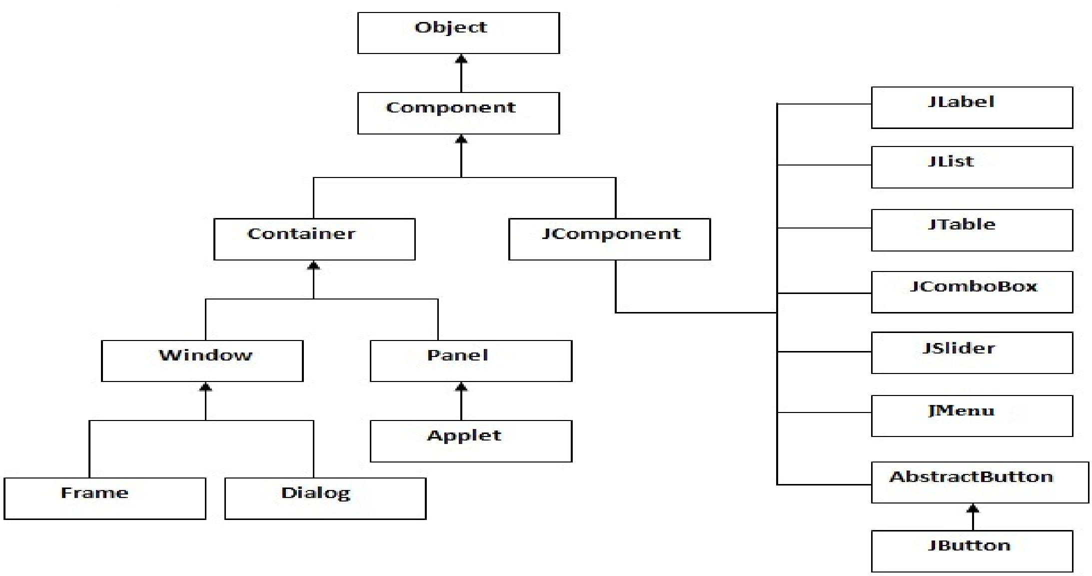

Figure 11.4: Hierarchy of Java swing API

There are two ways to create a frame:

- By creating the object of Frame class (association)
- By extending Frame class (inheritance)

The code of swing, can be written inside the main (), constructor or any other method.

Example 5: First Swing Example to create button:

```
import javax.swing.*;
public class  ButtonExample {
public static void main(String[] args) {
JFrame f=new JFrame();
JButton b=new JButton("click");
b.setBounds(130,100,100, 40);
f.add(b);
f.setSize(400,500);
f.setLayout(null);
f.setVisible(true);
}  }
```

Example 6: Creation of Swing by Association inside constructor

```
import javax.swing.*;
public class Simple {
JFrame f;
Simple(){
f=new JFrame();//creating instance of JFrame

JButton b=new JButton("click");//creating instance of JButton
b.setBounds(130,100,100, 40);
f.add(b);//adding button in JFrame

f.setSize(400,500);//400 width and 500 height
f.setLayout(null);//using no layout managers
f.setVisible(true);//making the frame visible
}

public static void main(String[] args) {
new Simple();
}  }
```

Example 7: Creation of Swing by inheritance

```
import javax.swing.*;
public class Simple2 extends JFrame{
JFrame f;
Simple2(){
JButton b=new JButton("click");
b.setBounds(130,100,100, 40);
add(b);
setSize(400,500);
setLayout(null);
setVisible(true);
}
public static void main(String[] args) {
new Simple2();
}}
```

Lab Exercises:

1. Write a menu driven program to create thread using runnable interface and inheriting thread class.[Hint : Make use of Extends and Implements keywords]
2. Write a program to create multiple threads. [Hint : Multiple instances of thread]
3. Demonstrate isAlive() and join() methods in checking status of a thread.
4. Write a program to set priority and check for an InterruptedException.
5. Write a program to synchronize two different threads
    a. Using synchronize method.
    b. Using synchronize statements.
6. Write a java application using swings(hello world swing) to display “HELLO WORLD” as shown in the figure 11.5.

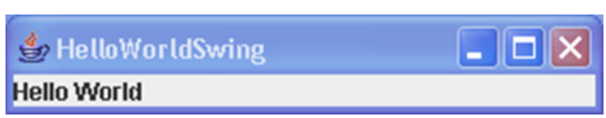

Fig. 11.5.

7. Write an GUI application(Counter) as shown in the Fig 11.6. Each time the "Count" button is clicked, the counter value shall increase by 6.

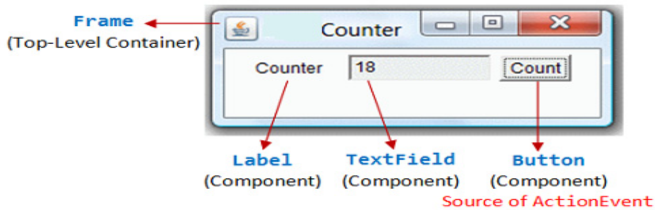

Fig. 11.6.

Additional Exercises:

1. Implement the producer, consumer program using wait() and notify().
2. Write a program to explain the multithreading with the use of multiplication tables. Three threads must be defined. Each one must create one multiplication table; they are 5 table, 7 table and 13 table.
3. Write a program to name the thread. In the main program change the name of the thread.
4. Write a program to illustrate thread priority. Create three threads and assign three different priorities.
5. Write a program to illustrate thread sleep. Create and run a thread. Then make it sleep.
6. Write a multithreaded java program to do the following.
   a. Using first thread generate Fibonacci numbers within 10000 and store.
   b. Using second thread generate Prime numbers within 10000 and store.
   c. The main thread should read and display the numbers which are common.

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