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SJC INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU from 2024-25

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P.B. No. 20, B.B. Road, Chikkaballapur - 562 101, Karnataka.

Estd. 1986

Department Of Computer Science and Engineering

IV SEMESTER CSE -CBSE
DESIGN AND ANALYSIS OF ALGORITHMS LAB MANUAL
[18CSL47]

SJC INSTITUTE OF TECHNOLOGY

VISION

Preparing Competent Engineering and Management Professionals to Serve the Society.

MISSION

- **Providing Students with a Sound Knowledge in Fundamentals of their branch of Study.**
- **Promoting Excellence in Teaching, Training, Research and Consult**
- **Exposing Students to Emerging Frontiers in various domains enabling Continuous Learning.**
- **Developing Entrepreneurial acumen to venture into Innovative areas.**
- **Imparting Value based Professional Education with a sense of Social Responsibility.**

Department of C S E

Vision Building up-skilled Computer Professionals, enriched with interactive design skills as to serve the dynamic needs of the Industry and Society.

Mission

- **Develop innovative, Proficient and ethically strong Computer Design Engineers with design skills to meet Universal Challenges.**
- **Nurture competence as well as applied Research activities to solve concrete problems.**
- **Aspire for constant up-gradation of engineering skills to cater the needs of the corporate and Society.**
- **Imbibing the spirit of teamwork, core skills, professionalism and confidence to the Leadership role.**
- **Inculcate research culture to design and develop smart computing solutions for humanity and nation.**

INSTRUCTIONS

1. Arrive on time with all necessary materials like Pen, Observ
2. Log in with your assigned credentials and log out before leaving.
3. Save your work frequently and maintain backups in a folder named with your USN.
4. Follow the given tasks and faculty instructions during the session.
5. Write clean, structured, and well-commented code.
6. Seek help from faculty or lab assistants when facing difficulties.
7. Maintain silence and avoid distracting others.
8. Negligence of one candidate will result in penalty for the whole batch.
9. Use the systems only for academic purposes and avoid unauthor
10. Write original code and avoid copying from peers or online sources.
11. Log out, clean your workspace, and leave the equipment in good condition.

DESIGN AND ANALYSIS OF ALGORITHM LABORATORY

[As per Choice Based Credit System (CBCS) scheme]

(Effective from the academic year 2018 -2019)

SEMESTER – IV

Subject Code	**18CSL47**	**IA Marks**	**40**
Number of Lecture Hours/Week	**2:2**	**Exam Marks**	**60**
Total Number of Lecture Hours	**36**	**Exam Hours**	**03**

Course objectives: This course will enable students to

- Design and implement various algorithms in JAVA
- Employ various design strategies for problem solving.
- Measure and compare the performance of different algorithms.

Description

Design, develop, and implement the specified algorithms for the following problems using Java language under LINUX /Windows environment. Net beans/Eclipse IDE tool can be used for development and demonstration.

LIST OF EXPERIEMENTS

1a) Create a Java Class Called Student with the following details as variables within it

(i) USN
(ii) Name
(iii) Branch
(iv) Phone

Write a Java program to create n Student objects and print the USN, Name, Branch, and Phone of these objects with suitable headings.

1b) Write a Java program to implement the Stack using arrays. Write Push(), Pop(), and Display() methods to demonstrate its working.

2a) Design a super class called ***Staff*** with details as Staff Id, Name, Phone, Salary. Extend this class by writing three subclasses namely ***Teaching*** (domain, publications), ***Technical*** (skills), and ***Contract*** (period). Write a Java program to read and display at least 3 staff objects of all three categories.

2b) Write a Java class called ***Customer*** to store their name and date_of_birth. The date_of_birth format should be dd/mm/yyyy. Write methods to read customer data as <name, dd/mm/yyyy> and display as <name, dd, mm, yyyy> using StringTokenizer class considering the delimiter character as "/".

3a) Write a Java program to read two integers a and b. Compute a/b and print, when b is not zero. Raise an exception when b is equal to zero.

3b) Write a Java program that implements a multi-thread application that has three threads. First

thread generates a random integer for every 1 second; second thread computes the square of the number and prints; third thread will print the value of cube of the number.

4) Sort a given set of ***n*** integer elements using **Quick Sort** method and compute its time complexity. Run the program for varied values of n> 5000 and record the time taken to sort. Plot a graph of the time taken versus ***n***on graph sheet. The elements can be read from a file or can be generated using the random number generator. Demonstrate using Java how the divide-and-conquer method works along with its time complexity analysis: worst case, average case and best case.

5) Sort a given set of ***n*** integer elements using **Merge Sort** method and compute its time complexity. Run the program for varied values of n> 5000, and record the time taken to sort. Plot a graph of the time taken versus ***n***on graph sheet. The elements can be read from a file or can be generated using the random number generator. Demonstrate using Java how the divide- and-conquer method works along with its time complexity analysis: worst case, average case and best case.

6) Implement in Java, the **0/1 Knapsack** problem using (a) Dynamic Programming method (b) Greedy method.

7) From a given vertex in a weighted connected graph, find shortest paths to other vertices using **Dijkstra's algorithm**. Write the program in Java.

8) Find Minimum Cost Spanning Tree of a given connected undirected graph using **Kruskal'salgorithm.** Use Union-Find algorithms in your program.

9) Find Minimum Cost Spanning Tree of a given connected undirected graph using **Prim's algorithm**

10) Write Java programs to
(a) Implement All-Pairs Shortest Paths problem using **Floyd's algorithm**.
(b) Implement **Travelling Sales Person problem** using Dynamic programming.

11) Design and implement in Java to find a **subset** of a given set **S** = {Sl, S2, ,Sn} of ***n*** positive integers whose SUM is equal to a given positive integer ***d***. For example, if S ={1,2, 5, 6, 8} and ***d***= 9, there are two solutions {1,2,6}and {1,8}. Display a suitable message,if the given problem instance doesn't have a solution.

12) Design and implement in Java to find all **Hamiltonian Cycles** in a connected undirected Graph G of *n* vertices using backtracking principle.

Course Outcomes: The students should be able to:

- Design algorithms using appropriate design techniques (brute-force, greedy, dynamic programming, etc.)
- Implement a variety of algorithms such assorting, graph related, combinatorial, etc., in a high level language.
- Analyze and compare the performance of algorithms using language features.
- Apply and implement learned algorithm design techniques and data structures to solvereal-world problems.

Graduate Attributes

- Engineering Knowledge
- Problem Analysis
- Modern Tool Usage
- Conduct Investigations of Complex Problems
- Design/Development of Solutions

Marks distribution: Procedure + Conduction + Viva: 20 + 50 + 10 (80). Change of experiment is allowed only once and marks allotted to the procedure part to be made zero

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COURSE OUTCOMES

CO1: Design algorithms using appropriate design Techniques (brute-force,reedy, Dynamic programming, etc.)

CO2: Implement a variety of algorithms such as sorting, graph related,combinatorial, etc., in a high level language.

CO3: Analyze and compare the performance of algorithms using language features.

CO4: Apply and implement learned algorithm design techniques and datastructures to solve real-world problems.

CO5: Analyze algorithms to deduce their time complexities.

CO6: Choose appropriate algorithms techniques to solve computational problems.

CO-PO Mapping Table (In the scale of 3)													CO-PSO Mapping Table				
CO/PO	1	2	3	4	5	6	7	8	9	10	11	12	CO/PSO	1	2	3	4
1	3	3	3							2			1				
2	2	2								2			2				
3	3	3	2	2						2			3				
4	3	3	2	2	2					2			4		2		
5	3	3	1	1						2		2	5	3			
6	3	2	3	2	1	1			3	1	1	3	6	2			

CONTENTS

EXPERIMENT 1A

PROGRAM STATEMENT

Create a Java class called ***Student*** with the following details as variables within it.

(i) USN
(ii) Name
(iii) Branch
(iv) Phone

Write a Java program to create *n Student* objects and print the USN, Name, Branch, and Phone of these objects with suitable headings.

CONCEPT

In Java everything is encapsulated under classes. Class is the core of Java language. Class can be defined as a template/ blueprint that describe the behaviors /states of a particular entity. A class defines new data type. This type can be used to create object of that type. Object is an instance of class. You may also call it as physical existence of a logical template class.

A class is declared using **class** keyword. A class contains both data and code that operate on that data. The data or variables defined within a **class** are called **instance variables** and the code that operates on this data is known as **methods**.

A simple class example

```
class Student
{
    String USN,name , branch;
    int phoneno;
}
```

Object is an instance of a class created using a new operator. The new operator returns a reference to a new instance of a class. This reference can be assigned to a reference variable of the class. The process of creating objects from a class is called instantiation. An object encapsulates state and behavior.

An object reference provides a handle to an object that is created and stored in memory. In Java, objects can only be manipulated via references, which can be stored in variables.

Creating variables of your class type is similar to creating variables of primitive data types, such as integer or float. Each time you create an object, a new set of instance variables comes into existence which defines the characteristics of that object. If you want to create an objectof the class and have the reference variable associated with this object, you must also allocate memory for the object by using the **new operator** . This process is called instantiating an object or creating an object instance. In following statement **obj** is instance/object of Student class.

```
Student obj=new Student();
```

An array of objects is created just like an array of primitive type data items in the following way.

```
Student[] obj_Array = new Student[7];
```

However, in this particular case, we may use a for loop since all Student objects are created with the same default constructor.

```
for ( int i=0; i<obj_Array.length; i++)
 {
    obj_Array[i]=new Student();
}Constructor
```

Constructor in java is a *special type of method* that is used to initialize the object. Java constructor is *invoked at the time of object creation*. It constructs the values i.e. provides data for the object that is why it is known as constructor.

Types of java constructors

There are two types of constructors:

1. Default constructor (no-arg constructor)
2. Parameterized constructor

A constructor that have no parameter is known as default constructor.

```
 Student()
{
    //block of code
}
```

Object creation:

Student obj=new Student();

Constructor with arguments is known as parameterized constructor.

```
Student(int i,String n)
{
     id = i;
    name = n;
}
```

Object creation:

Student4 s1 = new Student4(111,"Karan");

PROGRAM

```
/* 1a. Create a Java class called Student with the following details as variables within it.
(i)  USN
(ii)  Name
(iii) Branch
(iv) Phone
Write a Java program to create nStudent objects and print the USN, Name, Branch, and Phone
of these objects with suitable headings.

*/

import java.util.Scanner;

 class Student
 {

    String USN, Name, Branch, Phone;

    Scanner input = new Scanner(System.in);

    void read()

    {
            System.out.println("Enter Student Details");
            System.out.println("Enter USN");
            USN = input.nextLine();

            System.out.println("Enter Name");
            Name = input.nextLine();

            System.out.println("Enter Branch");
            Branch = input.nextLine();

            System.out.println("Enter Phone");
            Phone = input.nextLine();
    }

    void display()
    {
            System.out.printf("%-20s %-20s %-20s %-20s", USN, Name, Branch, Phone);
    }
}

class studentdetails
{
```

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

            Scanner input = new Scanner(System.in);
            System.out.println("Enter number of student details to be created");
            int number = input.nextInt();

            Student s[] = new Student[number];

            // Read student details into array of student objects

            for (int i = 0; i < number; i++)
            {
                    s[i] = new Student();
                    s[i].read();
            }

            // Display student information

            System.out.printf("%-20s %-20s %-20s %-20s", "USN", "NAME", "BRANCH",
            "PHONE");
            for (int i = 0; i < number; i++)
            {
                            System.out.println();s[i].display();

            }
     input.close();
    }
}
```

OUTPUT

```
Enter number of student details to be created
3
Enter Student Details
Enter USN
1sj16cs097
Enter Name
ramu
Enter Branch
cse
Enter Phone
992345678
Enter Student Details
Enter USN

1sj15me45
Enter Name
harish
Enter Branch
med
Enter Phone
984512345
Enter Student Details
Enter USN
1sj17ec111
Enter Name
shalini
Enter Branch
ece
Enter Phone
9982345678
USN          NAME      BRANCH      PHONE
1sj16cs097     ramu      cse       992345678
1sj15me45      harish    med        984512345
1sj17ec111     shalini   ece       9982345678
```

NOTES AND OUTPUT:

EXPERIMENT 1B

PROGRAM STATEMENT

Write a Java program to implement the Stack using arrays. Write Push(), Pop(), and Display() methods to demonstrate its working

CONCEPT

In Java everything is encapsulated under classes. Class is the core of Java language. Class can be defined as a template/ blueprint that describe the behaviors /states of a particular entity. A class defines new data type. This type can be used to create object of that type. Object is an instance of class. You may also call it as physical existence of a logical template class. A class is declared using **class** keyword. A class contains both data and code that operate on that data. The data or variables defined within a **class** are called **instance variables** and the code that operates on this data is known as **methods**.

A simple class example

```
class Student
{
    String USN,name , branch; int phoneno;
}
```

Object is an instance of a class created using a new operator. The new operator returns a reference to a new instance of a class. This reference can be assigned to a reference variable of the class. The process of creating objects from a class is called instantiation. An object encapsulates state and behavior. An object reference provides a handle to an object that is created and stored in memory. In Java, objects can only be manipulated via references, which can be stored in variables. Creating variables of your class type is similar to creating variables of primitive data types, such as integer or float. Each timeyou create an object, a new set of instance variables comes into existence which defines the characteristics of that object. If you want to create an object of the class and have the reference variable associated with this object, you must also allocate memory for the object by using the **new operator**. This process is called instantiating an object or creating an object instance. In following statement **obj** is instance/object of Student class.

```
Student obj=new Student();
```

An array of objects is created just like an array of primitive type data items in the following way.

```
Student[] obj_Array = new Student[7];
```

However, in this particular case, we may use a for loop since all Student objects are created with the same default constructor.

```
for ( int i=0; i<obj_Array.length; i++)
 {
   obj_Array[i]=new Student();
```

}

Constructor

Constructor in java is a *special type of method* that is used to initialize the object. Java constructor is *invoked at the time of object creation*. It constructs the values i.e. provides data for the object that is why it is known as constructor.

Types of java constructors

There are two types of constructors:

1. Default constructor (no-arg constructor)
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A constructor that have no parameter is known as default constructor.

```
Student()
{
   //block of code
}
```

Object creation:

Student obj=new Student();

Constructor with arguments is known as parameterized constructor.

```
Student(int i,String n)
{
        id = i;
    name = n;
}
```

Object creation:

Student4 s1 = new Student4(111,"Karan");

PROGRAM

```
/* 1b. Write a Java program to implement the Stack using arrays. Write Push(), Pop(), and Display() methods
to demonstrate its working. */
import java.util.*;
class arrayStack
{
	int arr[];
	int top, max;
	arrayStack(int n)
	{
		max = n;
		arr = new int[max];
		top = -1;
	}

	void push(int i)
	{
		if (top == max - 1)
			System.out.println("Stack Overflow");
		else
			arr[++top] = i;
	}


	void pop()
	{
		if (top == -1)
		{
			System.out.println("Stack Underflow");
		}
		else
		{
			int element = arr[top--];
			System.out.println("Popped Element:  " + element);
		}
	}


	void display()
	{
		System.out.print("\nStack = ");
		if (top == -1)
		{
```

```
                System.out.print("Empty\n");
```

```
                return;
            }
            for (int i = top; i >= 0; i--)
                System.out.print(arr[i] + " ");
            System.out.println();
        }
}

class Stack
{
    public static void main(String[] args)
    {
        Scanner scan = new Scanner(System.in);
        System.out.println("Enter Size of Integer Stack ");
        int n = scan.nextInt();
        boolean done = false;
        arrayStack stk = new arrayStack(n);
        char ch;
        do
        {
            System.out.println("\nStack Operations");
            System.out.println("1. push");
            System.out.println("2. pop");
            System.out.println("3. display");
            System.out.println("4. Exit");
            int choice = scan.nextInt();
            switch (choice)
            {
            case 1:
                System.out.println("Enter integer element to push");
                stk.push(scan.nextInt());
                break;
            case 2:
                stk.pop();
                break;
            case 3:
                stk.display();
                break;
            case 4:
                done = true;
                break;

            default:
                System.out.println("Wrong Entry \n ");
```

```
                                    break;
                                }
                            } while (!done);
                        }
                }
```

OUTPUT

Enter Size of Integer Stack

5

Stack Operations

1. push

2. pop

3. display

4. Exit

1

Enter integer element to push

1

Stack Operations

1. push

2. pop

3. display

4. Exit

1

Enter integer element to push

2

Stack Operations

1. push

2. pop

3. display

4. Exit

1

Enter integer element to push

3

Stack Operations

1. push

2. pop

3. display

4. Exit

1

Enter integer element to push

4

Stack Operations

1. push

2. pop

3. display

4. Exit

1

Enter integer element to push

5

Stack Operations

1. push

2. pop

3. display

4. Exit

1

Enter integer element to push

6

Stack Overflow

Stack Operations

1. push

2. pop

3. display

4. Exit

3

Stack = 5 4 3 2 1

Stack Operations

1. push

2. pop

3. display

4. Exit

2

Popped Element: 5

Stack Operations

1. push

2. pop

3. display

4. Exit

2

Popped Element: 4

Stack Operations

1. push

2. pop

3. display

4. Exit

2

Popped Element: 3

Stack Operations

1. push

2. pop

3. display

4. Exit

2

Popped Element: 2

Stack Operations

1. push

2. pop

3. display

4. Exit

3

Stack = 1

Stack Operations

1. push

2. pop

3. display

4. Exit

2

Popped Element: 1

Stack Operations

1. push

2. pop

3. display

4. Exit

2

Stack Underflow

Stack Operations

1. push

2. pop

3. display

4. Exit

3

Stack = Empty

Stack Operations

1. push

2. pop

3. display

4. Exit

4

NOTES AND OUTPUT SPACE

EXPERIMENT 2A

PROGRAM STATEMENT:

Design a super class called Staff with details as StaffId, Name, Phone, Salary. Extend this class by writing three subclasses namely Teaching (domain, publications), Technical (skills), and Contract (period). Write a Java program to read and display at least 3 staff objects of all three categories.

CONCEPT:

Here in this given problem we shall use inheritance for extending Staff class into: Teaching, Technical and Contract 3 subclasses using extends keyword. Each class is having the variables as given in the bracket. We will import the util package Scanner class to read 3 objects of each class. Create a constructor of Staff class to initialize StaffId, Name, Phone, Salary. And one display function into the Staff class to display the entered values. All the data members of Staff will be inherited in Teaching, Technical and Contract using super keyword that calls the super class constructor to base class. Other additional data members of the subclasses would be initialized using there own constructor. Also along with there own constructors all 3 subclasses will have there own display method that invokes display method of super class Staff. Now in main() method using Scanner class we will read the values accordingly. To display these values we will create array of object of size 3 for each subclassTeaching, Technical and Contract. Using this array of objects we will display the values entered previously by invoking display method of each subclass. Below is the program that demonstrates the same.

PROGRAM:

/** Design a super class called Staff with details as StaffId, Name, Phone, Salary. Extend this class by writing three subclasses namely Teaching (domain, publications), Technical (skills), and Contract (period).
Write a Java program to read and display at least 3 staff objects of all three categories.*/

```
import java.util.Scanner;

class Staff
{
        String StaffID, Name, Phone, Salary;

        Scanner input = new Scanner(System.in);

        void read()
        {
                System.out.println("Enter StaffID");
                StaffID = input.nextLine();

                System.out.println("Enter Name");
                Name = input.nextLine();
```

```
                System.out.println("Enter Phone");
                Phone = input.nextLine();

                System.out.println("Enter Salary");
                Salary = input.nextLine();
        }

        void display()
        {
                System.out.printf("\n%-15s", "STAFFID: ");
                System.out.printf("%-15s \n", StaffID);
                System.out.printf("%-15s", "NAME: ");
                System.out.printf("%-15s \n", Name);
                System.out.printf("%-15s", "PHONE:");
                System.out.printf("%-15s \n", Phone);
                System.out.printf("%-15s", "SALARY:");
                System.out.printf("%-15s \n", Salary);
        }
}


class Teaching extends Staff
{
        String Domain, Publication;

        void read_Teaching()
        {
                super.read(); // call super class read method
                System.out.println("Enter Domain");
                Domain = input.nextLine();
                System.out.println("Enter Publication");
                Publication = input.nextLine();
        }

        void display()
        {
                super.display(); // call super class display() method
                System.out.printf("%-15s", "DOMAIN:");
                System.out.printf("%-15s \n", Domain);
                System.out.printf("%-15s", "PUBLICATION:");
                System.out.printf("%-15s \n", Publication);
        }
}


class Technical extends Staff
```

```
{
        String Skills;

        void read_Technical()
        {
                super.read(); // call super class read method
                System.out.println("Enter Skills");
                Skills = input.nextLine();
        }

        void display()
        {
                super.display(); // call super class display() method
                System.out.printf("%-15s", "SKILLS:");
                System.out.printf("%-15s \n", Skills);
        }
}


class Contract extends Staff
{
        String Period;

        void read_Contract()
        {
                super.read(); // call super class read method
                System.out.println("Enter Period");
                Period = input.nextLine();
        }

        void display()
        {
                super.display(); // call super class display() method
                System.out.printf("%-15s", "PERIOD:");
                System.out.printf("%-15s \n", Period);
        }
}

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

                Scanner input = new Scanner(System.in);

                System.out.println("Enter number of staff details to be created");
```

```
int n = input.nextInt();

Teaching steach[] = new Teaching[n];
Technical stech[] = new Technical[n];
Contract scon[] = new Contract[n];

// Read Staff information under 3 categories

for (int i = 0; i < n; i++)
{
        System.out.println("Enter Teaching staff information");
        steach[i] = new Teaching();
        steach[i].read_Teaching();
}

for (int i = 0; i < n; i++)
{
        System.out.println("Enter Technical staff information");
        stech[i] = new Technical();
        stech[i].read_Technical();
}

for (int i = 0; i < n; i++)
{

        System.out.println("Enter Contract staff information");
        scon[i] = new Contract();
        scon[i].read_Contract();
}

// Display Staff Information
System.out.println("\n STAFF DETAILS: \n");
System.out.println("-----TEACHING STAFF DETAILS ----- ");

for (int i = 0; i < n; i++)
{
        steach[i].display();
}

System.out.println();
System.out.println("-----TECHNICAL STAFF DETAILS----- ");
for (int i = 0; i < n; i++)
{
        stech[i].display();
}
```

```
                System.out.println();
                System.out.println("-----CONTRACT STAFF DETAILS ---- ");
                for (int i = 0; i < n; i++)
                {
                        scon[i].display();
                }

                input.close();
        }
}
```

```
Enter number of staff details to be created
1
Enter Teaching staff information
Enter StaffID
111
Enter Name
MAHESH n
Enter Phone
9916130045
Enter Salary
40000
Enter Domain
ise
Enter Publication
ijaret
Enter Technical staff information
Enter StaffID
222
Enter Name
kumar
Enter Phone
984512345
Enter Salary
10000
Enter Skills
c/c++
Enter Contract staff information
Enter StaffID
123
Enter Name
rajesh
Enter Phone
789123545
Enter Salary
8000
Enter Period
1 year

 STAFF DETAILS:

-----TEACHING STAFF DETAILS-----
```

```
STAFFID:        111
NAME:           MAHESH n
PHONE:          9916130045
SALARY:         40000
DOMAIN:         ise
PUBLICATION:    ijaret

-----TECHNICAL STAFF DETAILS-----

STAFFID:        222
NAME:           kumar
PHONE:          984512345
SALARY:         10000
SKILLS:         c/c++

-----CONTRACT STAFF DETAILS-----

STAFFID:        123
NAME:           rajesh
PHONE:          789123545
SALARY:         8000
PERIOD:         1 year
```

NOTES AND OUTPUT SPACE

EXPERIMENT 2B

PROGRAM STATEMENT

Write a Java class called Customer to store their name and date_of_birth. The date_of_birth format should be dd/mm/yyyy. Write methods to read customer data as <name, dd/mm/yyyy> and display as <name,dd,mm,yyyy> using StringTokenizer class considering the delimiter character as "/".

CONCEPT

The **java.util.StringTokenizer** class allows you to break a string into tokens. It is simple way to break string.The StringTokenizer methods do not distinguish among identifiers, numbers, and quoted strings, nor do they recognize and skip comments. The set of delimiters (the characters that separate tokens) may be specified either at creation time or on a per-token basis.

Constructors of StringTokenizer class

There are 3 constructors defined in the StringTokenizer class.

Constructor	Description
StringTokenizer(Strin str)	creates StringTokenizer with specified string.
StringTokenizer(String str, String delim)	creates StringTokenizer with specified string and delimiter.
StringTokenizer(String str,String delim,Boolean returnValue)	creates StringTokenizer with specified string, delimiter and returnValue. If return value is true, delimiter characters are considered to be tokens. If it is false, delimiter characters serve to separate tokens.

The 6 useful methods of StringTokenizer class are as follows:

Public method	Description
boolean hasMoreTokens()	checks if there is more tokens available.
String nextToken()	returns the next token from the StringTokenizer object.
String nextToken(String delim)	returns the next token based on the delimeter.
boolean hasMoreElements()	same as hasMoreTokens() method.
Object nextElement()	same as nextToken() but its return type is Object.

int countTokens()	returns the total number of tokens.

PROGRAM :

/* 2b. Write a Java class called Customer to store their name and date_of_birth. The date_of_birth format should be dd/mm/yyyy. Write methods to read customer data as <name, dd/mm/yyyy> and display as <name, dd, mm, yyyy> using StringTokenizer class considering the delimiter character as "/".

***/**

```
import java.util.Scanner;
import java.util.StringTokenizer;

public class Customer
{
	public static void main(String[] args)
	{
		String name;
		Scanner scan = new Scanner(System.in);
		System.out.println("Enter Name and Date_of_Birth in the format
					<Name,DD/MM/YYYY>");
		name = scan.next();

		// create stringTokenizer with delimiter "/"
		StringTokenizer st = new StringTokenizer(name, ",/");

		// Count the number of tokens
		int count = st.countTokens();

		// Print one token at a time and induce new delimiter ","
		for (int i = 1; i <= count && st.hasMoreTokens(); i++)
		{
			System.out.print(st.nextToken());
			if (i < count)
				System.out.print(",");
		}
	}
}
```

OUTPUT:-

Enter Name and Date_of_Birth in the format <Name,DD/MM/YYYY>

rajesh,05/04/1984

rajesh,05,04,1984

NOTES AND OUTPUT SPACE

EXPERIMENT 3A

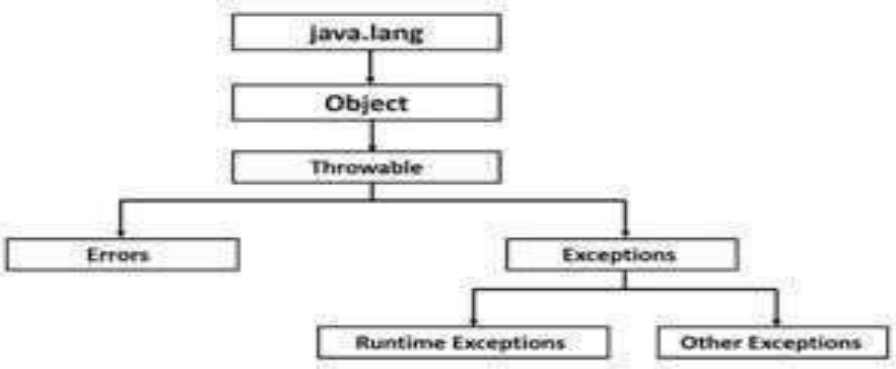
PROGRAM STATEMENT

Write a java program to read two integers and b. Compute a/b and print when b is not zero. Raise an exception when b is equal to zero.

CONCEPT

Exception Handling

1. An exception (or exceptional event) is a problem that arises during the execution of a program. When an Exception occurs the normal flow of the program is disrupted and the program/Application terminates abnormally, which is not recommended, therefore, these exceptions are to be handled.
2. All exception classes are subtypes of the java.lang.Exception class. The exception class is a subclass of the Throwable class. Other than the exception class there is another subclass called Error which is derived from the Throwable class.
3. The code which is prone to exceptions is placed in the try block. When an exception occurs, that exception occurred is handled by catch block associated with it. Every try block should be immediately followed either by a catch block or finally block.



PROGRAM

```
/* 3a. Write a Java program to read two integers a and b. Compute a/b and print, when b is
       not zero. Raise an exception when b is equal to zero.*/
import java.util.Scanner;

class exception
{

        public static void main(String[] args)
        {
                int a, b, result;
```

```
                Scanner input = new Scanner(System.in);
                System.out.println("Input two integers");

                a = input.nextInt();
                b = input.nextInt();

                try
                {
                        result = a / b;
                        System.out.println("Result = " + result);
                }


                catch (ArithmeticException e)
                {
                        System.out.println("Exception caught: Division by zero.");
                }
        }
}
```

OUTPUT

RUN1

Input two integers
4
5
Result = 0

RUN2

Input two integers
5
4
Result = 1

RUN3

Input two integers
5
4
Result = 1

NOTES AND OUTPUT SPACE

EXPERIMENT 3B

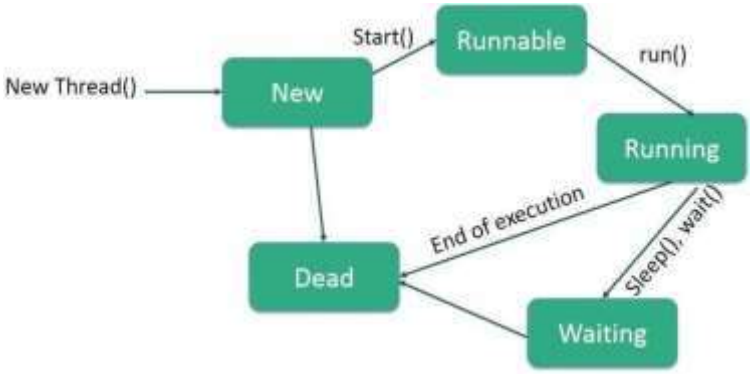
PROGRAM STATEMENT

Write a Java program that implements a multi-thread application that hashtree threads. First thread generates a random integer for every 1 second; second thread computes the square of the number and prints; third thread will print the value of cube of the number.

CONCEPT:

Thread is basically a lightweight sub-process, a smallest unit of processing. Java is a *multi-threaded programming language* which means we can develop multi-threaded program using Java. A multi-threaded program contains two or more parts that can run concurrently and each part can handle a different task at the same time making optimal use of the available resources specially when your computer has multiple CPUs.

Life Cycle of a Thread



Following are the stages of the life cycle −

- **New** − A new thread begins its life cycle in the new state. It remains in this state until the program starts the thread. It is also referred to as a **born thread**.
- **Runnable** − After a newly born thread is started, the thread becomes runnable. A thread in this state is considered to be executing its task.
- **Waiting** − Sometimes, a thread transitions to the waiting state while the thread waits for another thread to perform a task. A thread transitions back to the runnable state only when another thread signals the waiting thread to continue executing.
- **Timed Waiting** − A runnable thread can enter the timed waiting state for a specified interval of time. A thread in this state transitions back to the runnable state when that time interval expires or when the event it is waiting for occurs.

- **Terminated (Dead)** − A runnable thread enters the terminated state when it completes its task or otherwise terminates.

Create a Thread by Extending a Thread Class

The second way to create a thread is to create a new class that extends **Thread** class using the following two simple steps. This approach provides more flexibility in handling multiple threads created using available methods in Thread class.

Step 1: You will need to override **run( )** method available in Thread class. This method provides an entry point for the thread and you will put your complete business logic inside this method. Syntax of run() method − public void run( )

Step 2 : Once Thread object is created, you can start it by calling **start()** method, which executes a call to run( ) method. Syntax of start() method − void start( );

Synchronization :

Inter thread communication is important when you develop an application where two or more threads exchange some information. At times when more than one thread try to access a shared resource, we need to ensure that resource will be used by only one thread at a time. The process by which this is achieved is called **synchronization**. To do this we can use either Synchronized block or Synchronized method.

There are three simple methods which makes thread communication possible, listed below – \

Sr.No.	Method &Description
1	**public void wait()** Causes the current thread to wait until another thread invokes the notify().
2	**public void notify()** Wakes up a single thread that is waiting on this object's monitor.
3	**public void notifyAll()** Wakes up all the threads that called wait( ) on the same object.

These methods have been implemented as **final** methods in Object, so they are available in all the classes. All three methods can be called only from within a **synchronized** context.

PROGRAM

MultiThread.java

/* 3b. Write a Java program that implements a multi-thread application that has three threads. First thread generates a random integer for every 1 second; second thread computes the square of the number and prints; third thread will print the value of cube of the number */

```
import java.util.Random;
class SquareThread implements Runnable
{
	int x;

	SquareThread(int x)
	{
		this.x = x;
	}

	public void run()
	{
	    System.out.println("Thread Name:Square Thread and Square of " + x + " is: " + x * x);
	}
}

class CubeThread implements Runnable
{
	int x;

	CubeThread(int x)
	{
		this.x = x;
	}

	public void run()
	{
	   System.out.println("Thread Name:Cube Thread and Cube of " + x + " is: " + x * x * x);
	}
}

class RandomThread implements Runnable
```

```
{
        Random r;
        Thread t2, t3;

        public void run()
        {
                int num;
                r = new Random();
                try
                {

                        while (true)
                        {
                                num = r.nextInt(10);
                                System.out.println("Main Thread and Generated Number is " + num);
                                t2 = new Thread(new SquareThread(num));
                                t2.start();

                                t3 = new Thread(new CubeThread(num));
                                t3.start();

                                Thread.sleep(1000);
                                System.out.println("-----------------------------------------");
                        }
                }
                catch (Exception ex)
                {
                        System.out.println("Interrupted Exception");
                }
        }
}

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

                RandomThread thread_obj = new RandomThread();
                Thread t1 = new Thread(thread_obj);
                t1.start();
```

```
        }
}
```

OUTPUT

```
Main Thread and Generated Number is 3
Thread Name:Square Thread and Square of 3 is: 9
Thread Name:Cube Thread and Cube of 3 is: 27
-----------------------------------------
Main Thread and Generated Number is 6
Thread Name:Square Thread and Square of 6 is: 36
Thread Name:Cube Thread and Cube of 6 is: 216
-----------------------------------------
Main Thread and Generated Number is 6
Thread Name:Square Thread and Square of 6 is: 36
Thread Name:Cube Thread and Cube of 6 is: 216
-----------------------------------------
Main Thread and Generated Number is 0
Thread Name:Square Thread and Square of 0 is: 0
Thread Name:Cube Thread and Cube of 0 is: 0
-----------------------------------------
Main Thread and Generated Number is 4
Thread Name:Square Thread and Square of 4 is: 16
Thread Name:Cube Thread and Cube of 4 is: 64
-----------------------------------------
Main Thread and Generated Number is 5
Thread Name:Square Thread and Square of 5 is: 25
```

Thread Name:Cube Thread and Cube of 5 is: 125

Main Thread and Generated Number is 6

Thread Name:Square Thread and Square of 6 is: 36

Thread Name:Cube Thread and Cube of 6 is: 216

Main Thread and Generated Number is 8

Thread Name:Square Thread and Square of 8 is: 64

Thread Name:Cube Thread and Cube of 8 is: 512

Main Thread and Generated Number is 2

Thread Name:Square Thread and Square of 2 is: 4

Thread Name:Cube Thread and Cube of 2 is: 8

Main Thread and Generated Number is 0

Thread Name:Square Thread and Square of 0 is: 0

Thread Name:Cube Thread and Cube of 0 is: 0

Main Thread and Generated Number is 6

Thread Name:Square Thread and Square of 6 is: 36

Thread Name:Cube Thread and Cube of 6 is: 216

Main Thread and Generated Number is 0

Thread Name:Square Thread and Square of 0 is: 0

Thread Name:Cube Thread and Cube of 0 is: 0

Main Thread and Generated Number is 9

Thread Name:Square Thread and Square of 9 is: 81

Thread Name:Cube Thread and Cube of 9 is: 729

Main Thread and Generated Number is 3

Thread Name:Square Thread and Square of 3 is: 9

Thread Name:Cube Thread and Cube of 3 is: 27

Main Thread and Generated Number is 6

Thread Name:Cube Thread and Cube of 6 is: 216

Thread Name:Square Thread and Square of 6 is: 36

Main Thread and Generated Number is 1

Thread Name:Cube Thread and Cube of 1 is: 1

Thread Name:Square Thread and Square of 1 is: 1

Main Thread and Generated Number is 2

Thread Name:Square Thread and Square of 2 is: 4

Thread Name:Cube Thread and Cube of 2 is: 8

NOTES AND OUTPUT SPACE

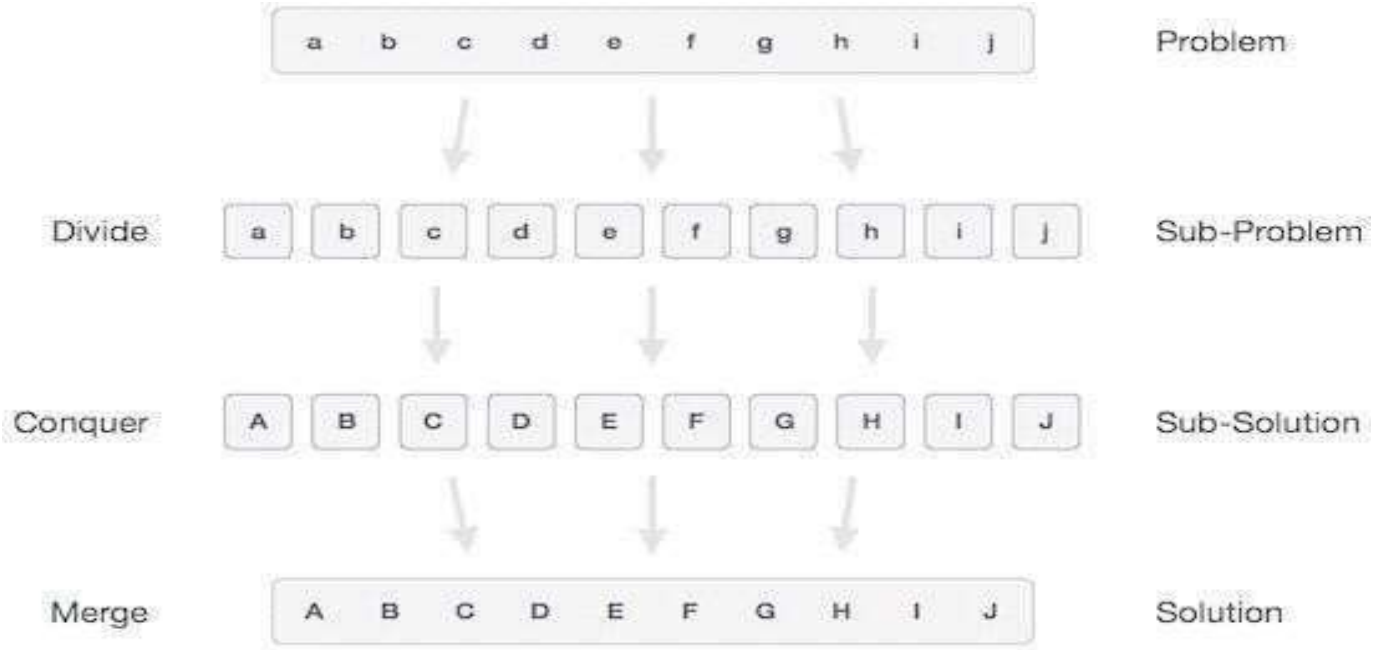
EXPERIMENT 4

PROGRAM STATEMENT

Sort a given set of n integer elements using Quick Sort method and compute its time complexity. Run the program for varied values of n > 5000 and record the time taken to sort. Plot a graph of the time taken versus n on graph sheet. The elements can be read from a file or can be generated using the random number generator. Demonstrate using Java how the divide- and-conquer method works along with its time complexity analysis: worst case, average case and best case.

CONCEPT

Divide and Conquer: In divide and conquer approach, the problem in hand, is divided into smaller sub-problems and then each problem is solved independently. When we keep on dividing the subproblems into even smaller sub-problems, we may eventually reach a stage where no more division is possible. Those "atomic" smallest possible sub-problem (fractions) are solved. The solution of all sub-problems is finally merged in order to obtain the solution of an original problem.



Broadly, we can understand **divide-and-conquer** approach in a three-step process.
Divide/Break: This step involves breaking the problem into smaller sub-problems. Sub-problems should represent a part of the original problem. This step generally takes a recursive approach to divide the problem until no sub-problem is further divisible. At this stage, sub-problems become atomic in nature but still represent some part of the actual problem.
Conquer/Solve: This step receives a lot of smaller sub-problems to be solved. Generally, at this level, the problems are considered 'solved' on their own.
Merge/Combine: When the smaller sub-problems are solved, this stage recursively combines them until they formulate a solution of the original problem. This algorithmic approach works recursively and conquer & merge steps works so close that they appear as one.
The following computer algorithms are based on **divide-and-conquer** programming approach .

- Merge Sort
- Quick Sort Method:

  Quick Sort divides the array according to the value of elements. It rearranges elements of a given array A[0..n-1] to achieve its partition, where the elements before position s are smaller than or equal to A[s] and all the elements after position s are greater than or equal to A[s].

A[0]…A[s-1]	A[s]	A[s+1]…A[n-1]
All are <=A[s]		all are >=A[s]

Algorithm : QUICKSORT(a[l..r]) //Sorts a subarray by quicksort
//Input: A subarray A[l..r] of A[0..n-1],defined by its left and right indices l and r
//Output: Subarray A[l..r] sorted in nondecreasing order

```
{
        if l<r
        {
                s← Partition(A[l..r]) //s is a split position
                QUICKSORT(A[l..s-1])
                QUICKSORT(A[s+1..r])
        }
}
```

Algorithm :
Partition(A[l..r])
//Partition a subarray by using its first element as its pivot
//Input:A subarray A[l..r] of A[0..n-1],defined by its left and right indices l and r (l<r)
//Output:A partition of A[l..r],with the split position returned as this function's value
{

```
p ← A[l]
i ← l; j ← r+1 repeat
{
        repeat i ← i+1 until A[i] >=p
        repeat j ← j-1 until A[j] <=p
        swap(A[i],A[j]) } until i>=j
        swap(A[i],A[j]) // undo last swap when i>=j
         swap(A[l],A[j]) return j
}
```

Complexity: $C_{best}(n) = 2C_{best}(n/2) + n$ for $n>1$
$C_{best}(1) = 0$ Cworst (n) (n^2)
Cavg (n) $\approx 1.38 n \log_2 n$

PROGRAM

```
/*Program 4.
Sort a given set of n integer elements using Quick Sort method and compute its time
complexity. Run the program for varied values of n > 5000 and record the time taken to
sort. Plot a graph of the time taken versus n on graph sheet. The elements can be read
from a file or can be generated using the random number generator. Demonstrate using
Java how the divide-and-conquer method works along with its time complexity analysis:
worst case, average case and best case.
*/


import java.util.Scanner;
import java.util.Arrays;
import java.util.Random;

public class QuickSortComplexity
{
        static final int MAX = 10005;
        static int[] a = new int[MAX];
        public static void main(String[] args)
        {
                // for keyboard entry
                Scanner input = new Scanner(System.in);
                System.out.print("Enter Max array size: ");
                int n = input.nextInt();
                Random random = new Random();
                System.out.println("Enter the array elements: ");
                for (int i = 0; i < n; i++)
                        a[i] = input.nextInt();
```

```
            // for Random entry
        // a[i] = random.nextInt(1000); // generate
    // random numbers – uniform distribution

            // a = Arrays.copyOf(a, n); // keep only non zero elements
            // Arrays.sort(a); // for worst-case time complexity

            System.out.println("Input Array:");
            for (int i = 0; i < n; i++)
                    System.out.print(a[i] + " ");
            // set start time
            long startTime = System.nanoTime();
            QuickSortAlgorithm(0, n - 1);
            long stopTime = System.nanoTime();
            long elapsedTime = stopTime - startTime;
            System.out.println("\nSorted  Array:");
            for (int i = 0; i < n; i++)
                    System.out.print(a[i] + " ");
            System.out.println();
        System.out.println("Time Complexity in ms for n=" + n + " is: " + (double) elapsedTime / 1000000);
        }

        public static void QuickSortAlgorithm(int p, int r)
        {
            int i, j, temp, pivot;
            if (p < r)
            {
                i = p;
                j = r + 1;
                pivot = a[p]; // mark first element as pivot
                while (true)
                {
                    i++;
                    while (a[i] < pivot && i < r)
                        i++;
                    j--;
                    while (a[j] > pivot)
                        j--;
                    if (i < j)
                    {
                        temp = a[i];
                        a[i] = a[j];
                        a[j] = temp;
                    } else
                        break; // partition is over
```

```
                }
                a[p] = a[j];
                a[j] = pivot;
                QuickSortAlgorithm(p, j - 1);
                QuickSortAlgorithm(j + 1, r);
            }
        }
}
```

OUTPUT

```
Enter Max array size: 10
Enter the array elements:
10
4
6
8
1
3
5
2
9
7
Input Array:
10 4 6 8 1 3 5 2 9 7
Sorted Array:
1 2 3 4 5 6 7 8 9 10
Time Complexity in ms for n=10 is: 0.009056
```

NOTES AND OUTPUT SPACE

EXPERIMENT 5

PROGRAM STATEMENT

Sort a given set of n integer elements using Merge Sort method and compute its time complexity. Run the program for varied values of n > 5000, and record the time taken to sort. Plot a graph of the time taken versus n on graph sheet. The elements can be read from a file or can be generated using the random number generator. Demonstrate using Java how the divide- and-conquer method works along with its time complexity analysis: worst case, average case and best case.

CONCEPT

Merge sort is a perfect example of a successful application of the divide-and-conquer technique.

- Split array A[1..*n*] in two and make copies of each half in arrays B[1.. *n*/2] and C[1.. *n*/2]
- Sort arrays B and C
- Merge sorted arrays B and C into array A as follows:
  a) Repeat the following until no elements remain in one of the arrays:
    (i) compare the first elements in the remaining unprocessed portions of the arrays
    (ii) copy the smaller of the two into A, while incrementing the index indicating the unprocessed portion of that array
  b) Once all elements in one of the arrays are processed, copy the remaining unprocessed elements from the other array into A.

Algorithm: MergeSort (A [0...n-1])
//This algorithm sorts array A [0...n-1] by recursive mergesort.
//Input: An array A [0...n-1] of orderable elements.
//Output**:** Array A [0...n-1] sorted in non-decreasing order
{
if n>1
{
Copy A [0… ⌊n/2⌋-1] to B [0… ⌊n/2⌋-1]
Copy A [⌊n/2⌋┐… n-1] to C [0… ⌈n/2⌉-1]
MergeSort (B [0… ⌊n/2⌋-1])
MergeSort (C [0… ⌈n/2⌉-1]) Merge (B, C,A)
}
}

Algorithm: Merge (B [0…p-1], C [0...q-1], A [0...p+q-1])
//Merges two sorted arrays into one sorted array.
//Input: Arrays B [0…p-1] and C [0...q-1] both sorted.
//Output**:** Sorted array A [0...p+q-1] of the elements of B and C.
{

```
i ← 0; j←0; k←0
 while i<p and j<q do
{
        if B[i] <= C[j]
        A[k] ← B[i]; i← i+1
        else
        A[k] ← C[j];
         j← j+1 k ← k+1;
}
if i=p
copy C [j…q-1] to A[k…p+q-1]
else
copy B [i…p-1] to A[k…p+q-1]
}
```

Complexity:

All cases have same efficiency: $\Theta(n \log n)$

Number of comparisons is close to theoretical minimum for comparison-based sorting: $\log n ! \approx n \lg n - 1.44 n$

PROGRAM:

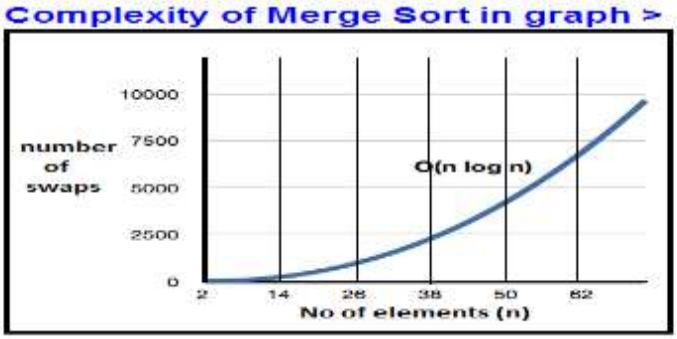
```
/* Program 5
Sort a given set of n integer elements using Merge Sort method and compute its time
complexity. Run the program for varied values of n > 5000, and record the time taken to
sort. Plot a graph of the time taken versus n on graph sheet. The elements can be read
from a file or can be generated using the random number generator. Demonstrate using
Java how the divide-and-conquer method works along with its time complexity analysis:
worst case, average case and best case.
*/
import java.util.Random;
import java.util.Scanner;

public class MergeSort2
{
        static final int MAX = 10005;
        static int[] a = new int[MAX];

        public static void main(String[] args)
        {
                Scanner input = new Scanner(System.in);
                System.out.print("Enter Max array size: ");
                int n = input.nextInt();
                Random random = new Random();
                //20
                System.out.println("Enter the array elements: ");
```

```
		for (int i = 0; i < n; i++)
		//		a[i] = input.nextInt(); // for keyboard entry
		 a[i] = random.nextInt(1000); // generate random numbers –
// uniform distribution
		for (int i = 0; i < n; i++)
		System.out.println(a[i] + " ");  // display unsorted numbers(input values)
		long startTime = System.nanoTime();
		MergeSortAlgorithm(0, n - 1);
		long stopTime = System.nanoTime();
		long elapsedTime = stopTime - startTime;
		System.out.println("Time Complexity (ms) for n = " +
		n + " is : " + (double) elapsedTime / 1000000);
		System.out.println("Sorted Array (Merge Sort):");
		for (int i = 0; i < n; i++)
			System.out.print(a[i] + " ");
		input.close();
	}

	public static void MergeSortAlgorithm(int low, int high)
	{
		int mid;
		if (low < high)
		{
			mid = (low + high) / 2;
			MergeSortAlgorithm(low, mid);
			MergeSortAlgorithm(mid + 1, high);
			Merge(low, mid, high);
		}
	}

	public static void Merge(int low, int mid, int high)
	{
		int[] b = new int[MAX];
		int i, h, j, k;
		h = i = low;
		j = mid + 1;
		while ((h <= mid) && (j <= high))
			if (a[h] < a[j])
				b[i++] = a[h++];
			else
				b[i++] = a[j++];

		if (h > mid)
			for (k = j; k <= high; k++)
				b[i++] = a[k];
		else
```

```
                for (k = h; k <= mid; k++)
                        b[i++] = a[k];

                for (k = low; k <= high; k++)
                        a[k] = b[k];
        }
}
```

OUTPUT

```
Enter Max array size: 20
208
536
750
299
530
689
73
819
528
815
49
7
413
209
423
861
682
744
885
24
Time Complexity (ms) for n = 20 is : 0.304288
Sorted Array (Merge Sort):
        7 24 49 73 208 209 299 413 423 528 530 536 682 689 744 750 815 819 861 885
```



NOTES AND OUTPUT SPACE

EXPERIMENT 6A

PROGRAM STATEMENT

Implement in Java, the 0/1 Knapsack problem using Dynamic Programming method

CONCEPT

Dynamic-Programming Solution to the 0-1 Knapsack Problem: Dynamic programming is used where we have problems, which can be divided into similar sub-problems, so that their results can be re-used. Mostly, these algorithms are used for optimization. Before solving the in-hand sub-problem, dynamic algorithm will try to examine the results of the previously solved sub-problems. The solutions of sub-problems are combined in order to achieve the best solution.w_i.In the knapsack problem we are given a set of n items, where each item i is specified by a size and a value v_i. We are also given a size bound W (the size of our knapsack). The goal is to find the subset of items of maximum total value such that sum of their sizes is at most W (they all fit into the knapsack).Now, instead of being able to take a certain weight of an item, you can only either take the item or not take the item.

Algorithm:

W_iV_i(n items, W weight of sack)

//Input: n and W – all integers

//Output: V(n,W)

//Initialization of first column and first row elements

Repeat for i = 0 to n

set V(i,0) = 0

- Repeat for j = 0 to W

Set V(0,j) = 0

//complete remaining entries row by row

- Repeat for i = 1 to n

repeat for j = 1 to W

w_i v_i

if (w_i <= j) V(i,j)) = max{ V(i-1,j), V(i-1,j- W_i) + V_i }

if (w_i > j) V(i,j) = V(i-1,j)

Print V(n,W)

PROGRAM

```
/* Knapsack DP */

import java.util.Scanner;

public class KnapsackDP
{
	static final int MAX = 20; // max. no. of objects
	static int w[ ];		// weights 0 to n-1
	static int p[ ]; // profits 0 to n-1
	static int n;		// no. of objects
	static int M;		// capacity of Knapsack
	static int V[ ][ ];		// DP solution process - table
	static int Keep[ ][ ]; // to get objects in optimal solution

	public static void main(String args[ ])
	{
		w = new int[MAX];
		p = new int[MAX];
		V = new int [MAX][MAX];
		Keep = new int[MAX][MAX];
		int optsoln;
		ReadObjects();
		for (int i = 0; i <= M; i++)
			V[0][i] = 0;
		for (int i = 0; i <= n; i++)
			V[i][0] = 0;
		optsoln = Knapsack();
		System.out.println("Optimal solution = " + optsoln);
	}

	static int Knapsack()
	{
		int r; // remaining Knapsack capacity
		for (int i = 1; i <= n; i++)
			for (int j = 0; j <= M; j++)
				if ((w[i] <= j) && (p[i] + V[i - 1][j - w[i]] > V[i - 1][j]))
				{
					V[i][j] = p[i] + V[i - 1][j - w[i]];
					Keep[i][j] = 1;
				}
```

```
                    else
                    {
                        V[i][j] = V[i - 1][j];
                        Keep[i][j] = 0;
                    }


            // Find the objects included in the Knapsack
            r = M;
            System.out.println("Items = ");
            for (int i = n; i > 0; i--) // start from Keep[n,M]
                if (Keep[i][r] == 1)
                {
                    System.out.println(i + " ");
                    r = r - w[i];
                }
            System.out.println();
            return V[n][M];
        }

        static void ReadObjects()
        {
            Scanner scanner = new Scanner(System.in);
            System.out.println("Knapsack Problem - Dynamic Programming Solution: ");
            System.out.println("Enter the max capacity of knapsack: ");
            M = scanner.nextInt();
            System.out.println("Enter number of objects:  ");
            n = scanner.nextInt();
            System.out.println("Enter Weights: ");
            for (int i = 1; i <= n; i++)
                w[i] = scanner.nextInt();
            System.out.println("Enter Profits: ");
            for (int i = 1; i <= n; i++)
                p[i] = scanner.nextInt();
            scanner.close();
        }
}
```

OUTPUT

```
Knapsack Problem - Dynamic Programming Solution:
Enter the max capacity of knapsack:
15
Enter number of objects:
4
Enter Weights:
2
5
```

```
7
3
Enter Profits:
23
78
34
12
Items =
3
2
1

Optimal solution = 135
```

NOTES AND SPACE AREA

EXPERIMENT 6B

PROGRAM STATEMENT

Implement in Java, the Fractional Knapsack problem using Greedy method

CONCEPT

Greedy Solution to the Fractional Knapsack Problem

The basic idea of greedy approach is to calculate the ratio value/weight for each item and sort the item on basis of this ratio. Then take the item with highest ratio and add them until we can't add the next item as whole and at the end add the next item as much as we can. This will always be optimal solution of this problem.

Algorithm:

- Assume knapsack holds weight W and items have value v_i and weight w_i
- Rank items by value/weight ratio: v_i / w_i Thus: $v_i / w_i \geq v_j / w_j$, for all $i \leq j$
- Consider items in order of decreasing ratio
- Take as much of each item as possible

PROGRAM

```
/* Knapsack Greedy */

import java.util.Scanner;
class KObject
{                                       // Knapsack object details
        float w;
        float  p;
        float r;
}
public class KnapsackGreedy2
{
        static final int MAX = 20;      // max. no. of objects
        static int n;                           // no. of objects
        static float M;                         // capacity of Knapsack

        public static void main(String args[])
        {
                Scanner scanner = new Scanner(System.in);
                System.out.println("Enter number of objects: ");
                n = scanner.nextInt();
                KObject[] obj = new KObject[n];
                for(int i = 0; i<n;i++)
                        obj[i] = new KObject();// allocate memory for members

                ReadObjects(obj);
```

```
        Knapsack(obj);
        scanner.close();
}

static void ReadObjects(KObject obj[])
{
        KObject temp = new KObject();
        Scanner scanner = new Scanner(System.in);
        System.out.println("Enter the max capacity of knapsack: ");
        M = scanner.nextFloat();

        System.out.println("Enter Weights: ");
        for (int i = 0; i < n; i++)
                obj[i].w = scanner.nextFloat();

        System.out.println("Enter Profits: ");
        for (int i = 0; i < n; i++)
                obj[i].p = scanner.nextFloat();

        for (int i = 0; i < n; i++)
                obj[i].r = obj[i].p / obj[i].w;

        // sort objects in descending order, based on p/w ratio
        for(int i = 0; i<n-1; i++)
                for(int j=0; j<n-1-i; j++)
                        if(obj[j].r < obj[j+1].r)
                        {
                                temp = obj[j];
                                obj[j] = obj[j+1];
                                obj[j+1] = temp;
                        }
         scanner.close();
}


static void Knapsack(KObject kobj[])
{
        float x[] = new float[MAX];
        float totalprofit;
        int i;
        float U; // U place holder for M
        U = M;
        totalprofit = 0;
        for (i = 0; i < n; i++)
                x[i] = 0;
        for (i = 0; i < n; i++)
        {
```

```
                if (kobj[i].w > U)
                        break;
                else
                {
                        x[i] = 1;
                        totalprofit = totalprofit + kobj[i].p;
                        U = U - kobj[i].w;
                }
        }

        System.out.println("i = " + i);
        if (i < n)
                x[i] = U / kobj[i].w;
        totalprofit = totalprofit + (x[i] * kobj[i].p);
        System.out.println("The Solution vector, x[]: ");
        for (i = 0; i < n; i++)
                System.out.print(x[i] + " ");
        System.out.println("\nTotal profit is = " + totalprofit);
    }
}

/*Enter number of objects:
4
Enter the max capacity of knapsack:
20
Enter Weights:
5
9
12
3
Enter Profits:
45
78
45
65
i = 3
The Solution vector, x[]:
1.0 1.0 1.0 0.25
Total profit is = 199.25
*/
```

RUN 2

```
Enter number of objects:
5
Enter the max capacity of knapsack:
25
Enter Weights:
12
```

10
9
6
14
Enter Profits:
45
67
12
78
54
i = 2
The Solution vector, x[]:
1.0 1.0 0.64285713 0.0 0.0
Total profit is = 179.7143

NOTES AND SPACE AREA

EXPERIMENT 7

PROGRAM STATEMENT

From a given vertex in weighted connected graph, find shortest path to other vertices using Dijkstras algorithm. Write the program in java.

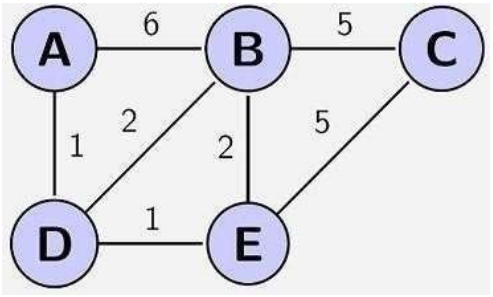
CONCEPT

It is a greedy algorithm which finds the shortest path from the source vertex to all other vertices of the graph.

Steps

1. Input a cost matrix for graph. Read the source vertex and n from user
2. Create the array d [1…n] which stores the distance from source vertex to all other vertices of graph. Initialize distance to source vertex as 0(i.e. d [source] =0) and remaining vertices as 999.
3. Create the array visited [1…n] which keeps track of all the visited nodes. Visit the source vertex and initialize visited [source] =1.
4. For all adjacent vertices[v_i,v_{i+1},…] for source vertex calculate distance using formula d[v_i]=min(d[v_i], d[source]+ cost[source][v1]). Update the array d [1…n].
5. For all adjacent vertices find vertex v_i which has minimum distance from source vertex.
6. Initialize source = v_i. Repeat the steps 4, 5 until there all some vertices which are unvisited.
7. Stop

Example



		=min(999,2+5)=7			

d[A]	d[B]	d[C]	d[D]	d[E]
0	3	7	1	2
visited[A]	visited[B]	visited[C]	visited[D]	visited[E]
1	1	0	1	1

Step 4

Source Vertex	Adjacent vertices which are unvisited	d[v]= min(d[v], d[u] + cost[u][v])	Find d[v] such that it is minimum	New source	Visited vertex
B	C	d[C]=min(d[C],d[B] + cost[C][B]) =min(7,3+5)=7	v=C	C	C

d[A]	**d[B]**	**d[C]**	**d[D]**	**d[E]**
0	**3**	**7**	**1**	**2**
visited[A]	visited[B]	visited[C]	visited[D]	visited[E]
1	1	1	1	1

Hence distance from A to A = 0
Hence distance from A to B = 3
Hence distance from A to C = 7
Hence distance from A to D = 1
Hence distance from A to E = 2

		d[D]=min(999,1)=1			

d[A]	d[B]	d[C]	d[D]	d[E]
0	6	999	1	999
visited[A]	visited[B]	visited[C]	visited[D]	visited[E]
1	0	0	1	0

Step 2:

Source Vertex	Adjacent vertices which are unvisited	d[v]= min(d[v], d[u] + cost[u][v])	Find d[v] such that it is minimum	New source	Visited vertex
D	B,E	d[B]=min(d[B],d[D] + cost[B][D]) =min(6,1+2)=3	v=E	E	E
		d[E]=min(d[E],d[D]+cost[E][D]) =min(999,1+1)=2			

d[A]	d[B]	d[C]	d[D]	d[E]
0	3	999	1	2
visited[A]	visited[B]	visited[C]	visited[D]	visited[E]
1	0	0	1	1

Step 3

Source Vertex	Adjacent vertices which are unvisited	d[v]= min(d[v], d[u] + cost[u][v])	Find d[v] such that it is minimum	New source	Visited vertex
E	B,C	d[B]=min(d[B],d[E] + cost[B][E]) =min(3,2+2)=3	v=B	B	B
		d[C]=min(d[C],d[E]+cost[C][E])			

Hence distance from A to A = 0
Hence distance from A to B = 3
Hence distance from A to C = 7
Hence distance from A to D = 1
Hence distance from A to E = 2

PROGRAM

```
/* Dijikstra's */

import java.util.*;

public class DijkstrasClass
{

        final static int MAX = 20;
        final static int infinity = 9999;
        static int n;               // No. of vertices of G
        static int a[][];           // Cost matrix
        static Scanner scan = new Scanner(System.in);

        public static void main(String[] args)
        {
                ReadMatrix();
                int s = 0;                  // starting vertex
                System.out.println("Enter starting vertex: ");
                s = scan.nextInt();
                Dijkstras(s);    // find shortest path
        }

        static void ReadMatrix()
        {
                a = new int[MAX][MAX];
                System.out.println("Enter the number of vertices:");
                n = scan.nextInt();
                System.out.println("Enter the cost adjacency matrix:");
                for (int i = 1; i <= n; i++)
                        for (int j = 1; j <= n; j++)
                                a[i][j] = scan.nextInt();
        }

        static void Dijkstras(int s)
        {
                int S[] = new int[MAX];
```

```
        int d[] = new int[MAX];
        int u, v;
        int i;
        for (i = 1; i <= n; i++)
        {
                S[i] = 0;
                d[i] = a[s][i];
        }
        S[s] = 1;
        d[s] = 1;
        i = 2;
        while (i <= n)
        {
                u = Extract_Min(S, d);
                S[u] = 1;
                i++;
                for (v = 1; v <= n; v++)
                 {
                        if (((d[u] + a[u][v] < d[v]) && (S[v] == 0)))
                                d[v] = d[u] + a[u][v];
                }
        }
        for (i = 1; i <= n; i++)
                if (i != s)
                        System.out.println(i + ":" + d[i]);
    }

    static int Extract_Min(int S[], int d[])
    {
        int i, j = 1, min;
        min = infinity;
        for (i = 1; i <= n; i++)
        {
                if ((d[i] < min) && (S[i] == 0))
                {
                        min = d[i];
                        j = i;
                }
        }
        return (j);
    }
}
```

OUTPUT

```
Enter the number of vertices:
4
Enter the cost adjacency matrix:
999 1 6 4
999 999 999 2
999 3 999 999
999 999 1 999
Enter starting vertex:
1
2:1
3:4
4:3
```

NOTES AND OUPUT AREA

EXPERIMENT 8

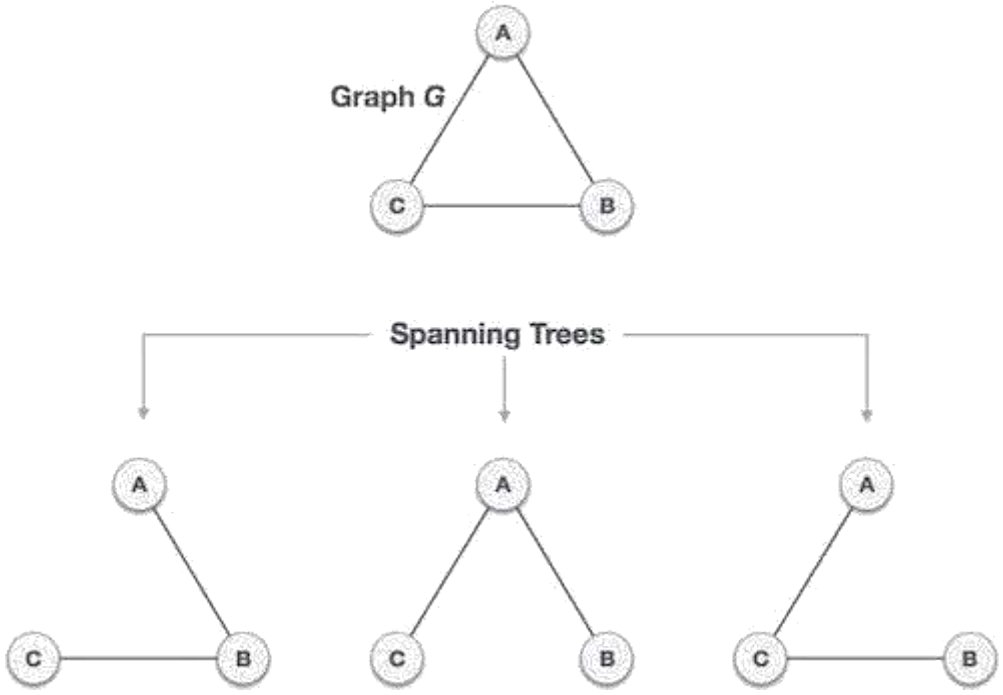
PROGRAM STATEMENT

Find Minimum Cost Spanning Tree of a given connected undirected graph using **Kruskal's algorithm.** Implement the program in Java. Use Union-Find algorithm in your program.

CONCEPT

A spanning tree is a subset of Graph G, which has all the vertices covered with minimum possible number of edges. Hence, a spanning tree does not have cycles and it cannot be disconnected.

By this definition, we can draw a conclusion that every connected and undirected Graph G has at least one spanning tree. A disconnected graph does not have any spanning tree, as it cannot be spanned to all its vertices.



We found three spanning trees off one complete graph. A complete undirected graph can have maximum $\mathbf{n^{n-2}}$ number of spanning trees, where **n** is the number of nodes. In the above addressed example, $\mathbf{3^{3-2} = 3}$ spanning trees are possible.

General Properties of Spanning Tree

We now understand that one graph can have more than one spanning tree. Following are a few properties of the spanning tree connected to graph G −

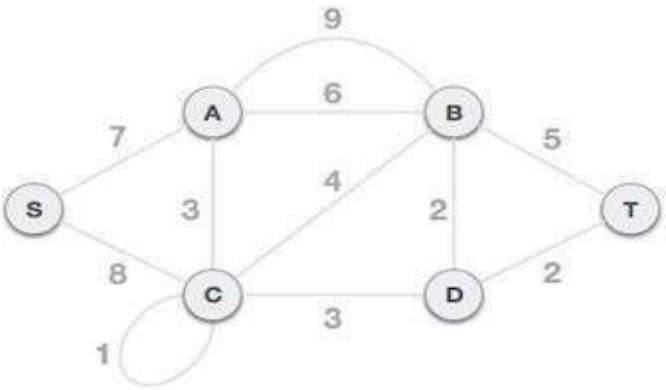
- A connected graph G can have more than one spanning tree.
- All possible spanning trees of graph G, have the same number of edges and vertices.
- The spanning tree does not have any cycle (loops).
- Removing one edge from the spanning tree will make the graph disconnected, i.e. the spanning tree is **minimally connected**.
- Adding one edge to the spanning tree will create a circuit or loop, i.e. the spanning tree is **maximally acyclic**.

Minimum Spanning Tree

Given a connected and undirected graph, a *spanning tree* of that graph is a subgraph that is a tree and connects all the vertices together. A single graph can have many different spanning trees. A *minimum spanning tree (MST)* or minimum weight spanning tree for a weighted, connected and undirected graph is a spanning tree with weight less than or equal to the weight of every other spanning tree. The weight of a spanning tree is the sum of weights given to each edge of the spanning tree.

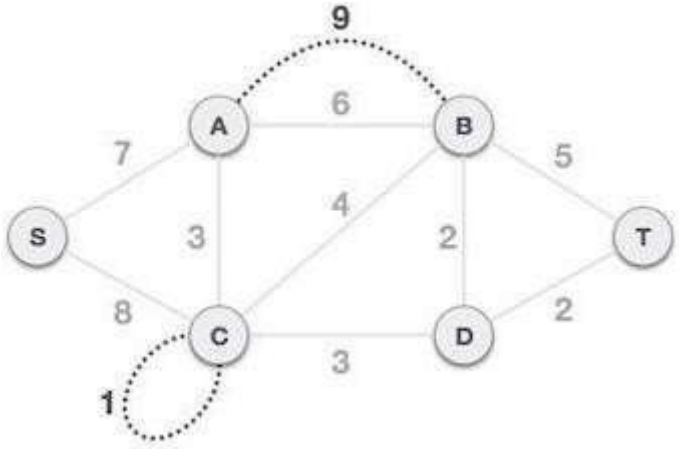
Kruskal's algorithm to find the minimum cost spanning tree uses the greedy approach. This algorithm treats the graph as a forest and every node it has as an individual tree. A tree connects to another only and only if, it has the least cost among all available options and doesnot violate MST properties.

To understand Kruskal's algorithm let us consider the following example −



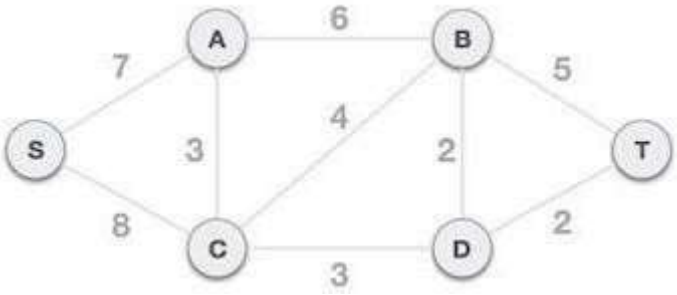
Step 1 - Remove all loops and Parallel Edges

Remove all loops and parallel edges from the given graph.



B, D	D, T	A, C	C, D	C, B	B, T	A, B	S, A	S, C
2	2	3	3	4	5	6	7	8

In case of parallel edges, keep the one which has the least cost associated and remove all others.

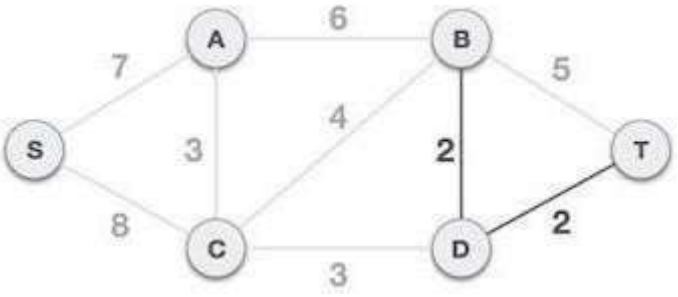


Step 2 - Arrange all edges in their increasing order of weight

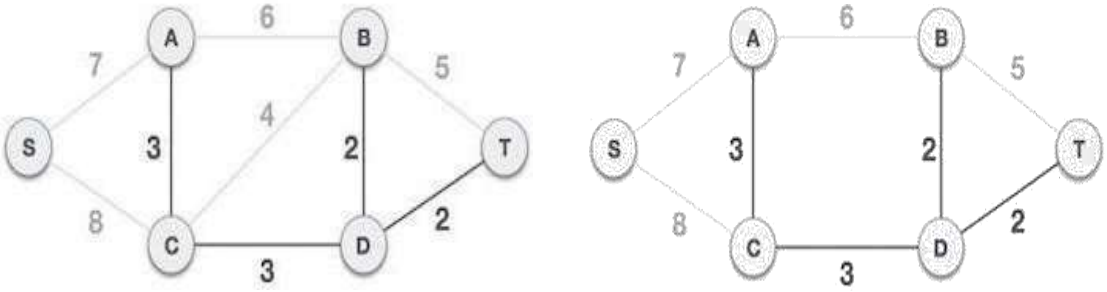
The next step is to create a set of edges and weight, and arrange them in an ascending order of weightage (cost).

Step 3 - Add the edge which has the least weightage

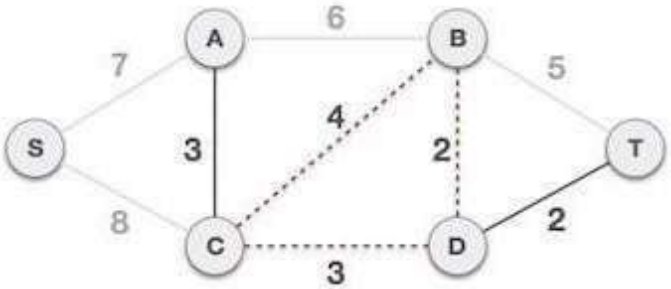
Now we start adding edges to the graph beginning from the one which has the least weight. Throughout, we shall keep checking that the spanning properties remain intact. In case, by adding one edge, the spanning tree property does not hold then we shall consider not to include the edge in the graph.



The least cost is 2 and edges involved are B,D and D,T. We add them. Adding them does not violate spanning tree properties, so we continue to our next edge selection.
Next cost is 3, and associated edges are A,C and C,D. We add them again −

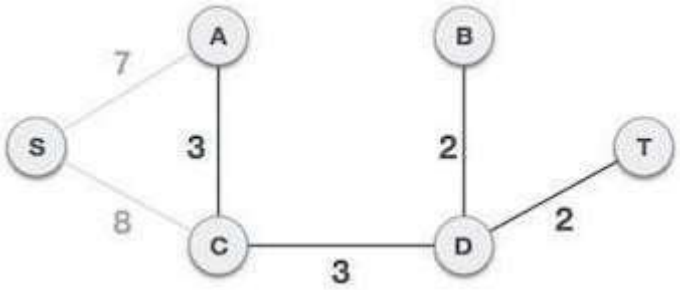


Next cost in the table is 4, and we observe that adding it will create a circuit in the graph. −

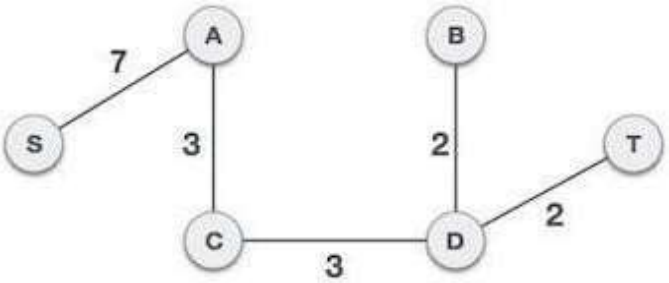


We ignore it. In the process we shall ignore/avoid all edges that create a circuit.

We observe that edges with cost 5 and 6 also create circuits. We ignore them and move on.



Now we are left with only one node to be added. Between the two least cost edges available 7 and 8, we shall add the edge with cost 7.



By adding edge S,A we have included all the nodes of the graph and we now have minimum cost spanning tree.

PROGRAM

```
/* 8. Kruskals */

import java.util.Scanner;

public class KruskalsClass
{

        final static int MAX = 20;
        static int n; // No. of vertices of G
        static int cost[ ][ ]; // Cost matrix
        static Scanner scan = new Scanner(System.in);

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

```
{
        ReadMatrix();
        Kruskals();
}

static void ReadMatrix()
{

        int i, j;
        cost = new int[MAX][MAX];

        System.out.println("Implementation of Kruskal's algorithm");
        System.out.println("Enter the no. of vertices");
        n = scan.nextInt();

        System.out.println("Enter the cost adjacency matrix");
        for (i = 1; i <= n; i++)
        {
                for (j = 1; j <= n; j++)
                {
                        cost[i][j] = scan.nextInt();
                        if (cost[i][j] == 0)
                                cost[i][j] = 999;
                }
        }
}

static void Kruskals()
{

        int a = 0, b = 0, u = 0, v = 0, i, j, ne = 1, min, mincost = 0;

        System.out.println("The edges of Minimum Cost Spanning Tree are");
        while (ne < n)
        {
                for (i = 1, min = 999; i <= n; i++)
                {
                        for (j = 1; j <= n; j++)
                        {
                                if (cost[i][j] < min)
                                {
                                        min = cost[i][j];
                                        a = u = i;
                                        b = v = j;
                                }
                        }
```

```
                }
                u = find(u);
                v = find(v);
                if (u != v)
                {
                        uni(u, v);
                        System.out.println(ne++ + "edge (" + a + "," + b + ") =" + min);
                        mincost += min;
                }
                cost[a][b] = cost[b][a] = 999;
        }
        System.out.println("Minimum cost :" + mincost);
    }

    static int find(int i)
    {
        int parent[] = new int[9];
        while (parent[i] == 1)
            i = parent[i];
        return i;
    }

    static void uni(int i, int j)
    {
        int parent[] = new int[9];
        parent[j] = i;
    }
}
```

OUTPUT

```
Implementation of Kruskal's algorithm
Enter the no. of vertices
4
Enter the cost adjacency matrix
999 1 6 4
999 999 999 2
999 3 999 999
999 999 1 999
The edges of Minimum Cost Spanning Tree are
1edge (1,2) =1
2edge (4,3) =1
3edge (2,4) =2
Minimum cost :4
```

NOTES AND OUTPUT SPACE

EXPERIMENT 9

PROGRAM STATEMENT

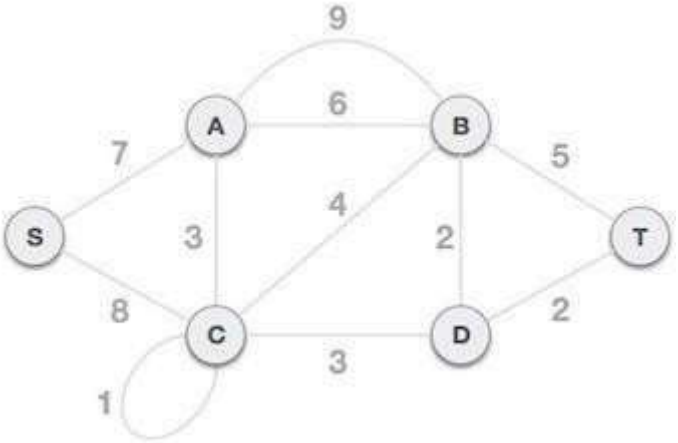
Find Minimum Cost Spanning Tree of a given connected undirected graph using **Prim's algorithm.**

CONCEPT

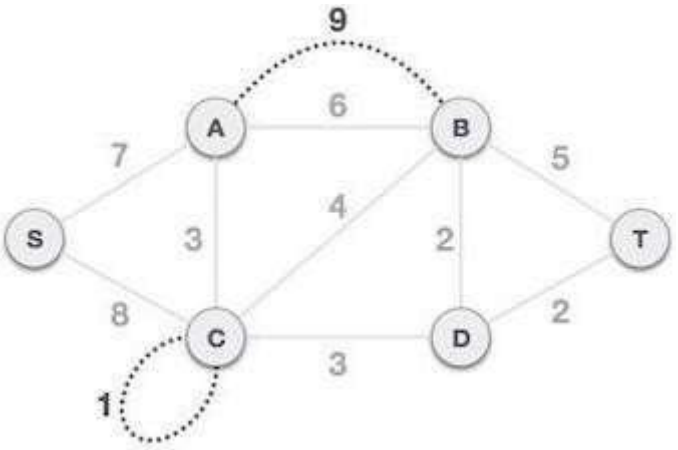
Prim's algorithm to find minimum cost spanning tree uses the greedy approach. Prim's algorithm shares a similarity with the **shortest path first** algorithms.

Prim's algorithm, in contrast with Kruskal's algorithm, treats the nodes as a single tree and keeps on adding new nodes to the spanning tree from the given graph.

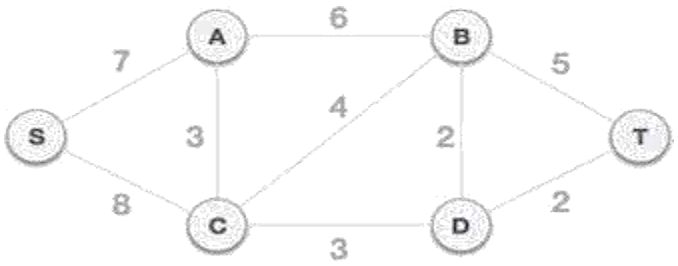
To contrast with Kruskal's algorithm and to understand Prim's algorithm better, we shall use the same example −



Step 1 - Remove all loops and parallel edges



Remove all loops and parallel edges from the given graph. In case of parallel edges, keep the one which has the least cost associated and remove all others.

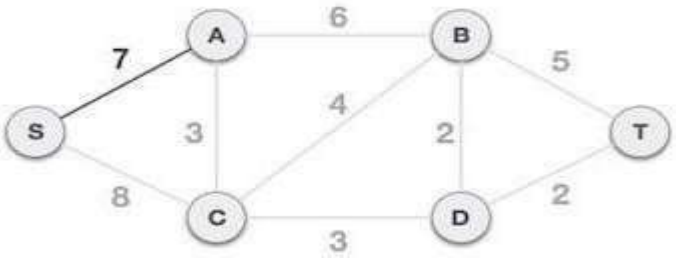


Step 2 - Choose any arbitrary node as root node

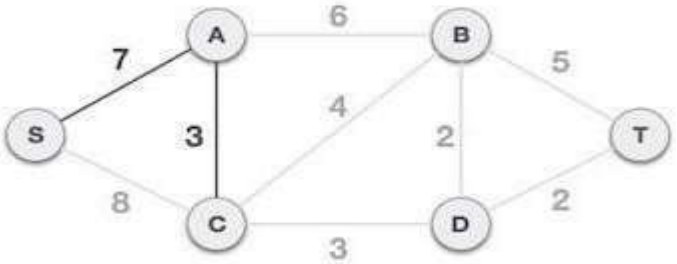
In this case, we choose **S** node as the root node of Prim's spanning tree. This node is arbitrarily chosen, so any node can be the root node. One may wonder why any video can bea root node. So the answer is, in the spanning tree all the nodes of a graph are included and because it is connected then there must be at least one edge, which will join it to the rest ofthe tree.

Step 3 - Check outgoing edges and select the one with less cost

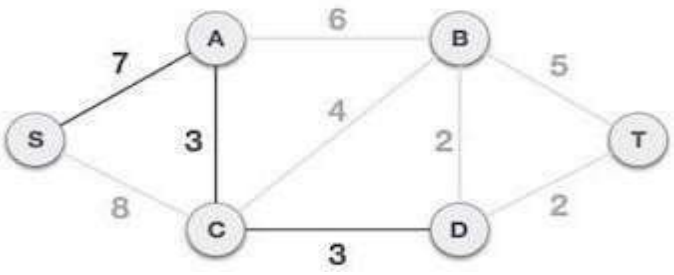
After choosing the root node **S**, we see that S,A and S,C are two edges with weight 7 and 8, respectively. We choose the edge S,A as it is lesser than the other.



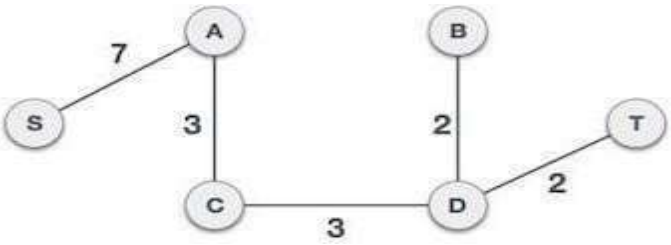
Now, the tree S-7-A is treated as one node and we check for all edges going out from it. We select the one which has the lowest cost and include it in the tree.



After this step, S-7-A-3-C tree is formed. Now we'll again treat it as a node and will check all the edges again. However, we will choose only the least cost edge. In this case, C-3-D is the new edge, which is less than other edges' cost 8, 6, 4, etc.



After adding node **D** to the spanning tree, we now have two edges going out of it having the same cost, i.e. D-2-T and D-2-B. Thus, we can add either one. But the next step will again yield edge 2 as the least cost. Hence, we are showing a spanning tree with both edges included.



PROGRAM

/* 9. Prim's */

```
import java.util.Scanner;

public class PrimsClass
 {
    final static int MAX = 20;
    static int n; // No. of vertices of G
    static int cost[][]; // Cost matrix
    static Scanner scan = new Scanner(System.in);

            public static void main(String[] args)
            {
            ReadMatrix();
            Prims();
            }

            static void ReadMatrix()
             {
```

```
        int i, j;
        cost = new  int[MAX][MAX];
        System.out.println("\n Enter the number of nodes:");
        n = scan.nextInt();
        System.out.println("\n Enter the adjacency matrix:\n");
        for (i = 1; i <= n; i++)
        for (j = 1; j <= n; j++)
         {
                cost[i][j] = scan.nextInt();
                if (cost[i][j] == 0)
                        cost[i][j] = 999;
        }
}

        static void Prims()
         {
                int visited[] = new int[10];
                int ne = 1, i, j, min, a = 0, b = 0, u = 0, v = 0;
                int mincost = 0;
                visited[1] = 1;
                while (ne < n)
                 {
                        for (i = 1, min = 999; i <= n; i++)
                                for (j = 1; j <= n; j++)
                                        if (cost[i][j] < min)
                                                if (visited[i] != 0)
                                                 {
                                                        min = cost[i][j];
                                                        a = u = i;
                                                        b = v = j;
                                                }
                        if (visited[u] == 0 || visited[v] == 0)
                        {
                           System.out.println("Edge" + ne++ + ":(" + a + "," + b + ")" + "cost:" +
min);
                                mincost += min;
                                visited[b] = 1;
                        }
                        cost[a][b] = cost[b][a] = 999;
                }
                System.out.println("\n Minimun cost" + mincost);
```

```
        }
    }
```

OUTPUT

```
Enter the number of nodes:
4

Enter the adjacency matrix:

999 7 2 4
999 999 999 5
999 4 999 999
999 999 1 999
Edge1:(1,3)cost:2
Edge2:(1,4)cost:4
Edge3:(3,2)cost:4

Minimun cost10
```

NOTES AND OUTPUT SPACE

EXPERIMENT 10A

PROGRAM STATEMENT

Implement All-Pairs Shortest Paths problem using Floyd's algorithm.

CONCEPT

The Floyd Warshall Algorithm is for solving the All Pairs Shortest Path problem.
The problem is to find shortest distances between every pair of vertices in a given edge weighted directed Graph. Following Algorithm is used to find shortest path:
given: w[i][j] is the wieghted matrix that contains weights k is the iteration variable for intermidiate vertices Following is the algorithm
function floyd for i=1 to n for j=1 to n
w[i][j]=infinity//if entered w[i][j] == 0 for each edge (i,j) in E
dmatrix[i][i] = amatrix[i][j];//copy the entered weighted matrix to distance matrix //calculate distance matrix
for k=1 to n for i=1 to n for j=1 to n
if (dmatrix[i][k] + dmatrix[k][j]< dmatrix[i][j])
dmatrix[i][j] = dmatrix[i][k] + dmatrix[k][j];

PROGRAM

```
import java.util.Scanner;
public class FloydsClass
{
        static final int MAX = 20;     // max. size of cost matrix
        static int a[][];                       // cost matrix
        static int n;                           // actual matrix size

        public static void main(String args[])
        {
                a = new int[MAX][MAX];
                ReadMatrix();
                Floyds();                               // find all pairs shortest path
                PrintMatrix();
        }

        static void ReadMatrix()
        {
                System.out.println("Enter the number of vertices\n");
                Scanner scanner = new Scanner(System.in);
                n = scanner.nextInt();
                System.out.println("Enter the Cost Matrix (999 for infinity) \n");
                for (int i = 1; i <= n; i++)
```

```
            {
                for (int j = 1; j <= n; j++)
                {
                    a[i][j] = scanner.nextInt();
                }
            }
            scanner.close();
        }

        static void Floyds()
        {
            for (int k = 1; k <= n; k++)
            {
                for (int i = 1; i <= n; i++)
                    for (int j = 1; j <= n; j++)
                        if ((a[i][k] + a[k][j]) < a[i][j])
                            a[i][j] = a[i][k] + a[k][j];
            }
        }

        static void PrintMatrix()
        {
            System.out.println("The All Pair Shortest Path Matrix is:\n");
            for(int i=1; i<=n; i++)
            {
                for(int j=1; j<=n; j++)
                    System.out.print(a[i][j] + "\t");
                System.out.println("\n");
            }
        }
}
```

OUTPUT

```
Enter the number of vertices

4
Enter the Cost Matrix (999 for infinity)

999 1 4 6
999 999 7 4
2 999 999 3
999 999 999 999
The All Pair Shortest Path Matrix is:

6       1       4       5
```

9 10 7 4

2 3 6 3

999 999 999 999

NOTES AND OUTPUT SPACE

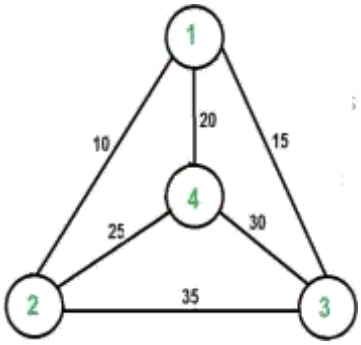
EXPERIMENT 10B

PROGRAM STATEMENT

Write a Java program to implement 4 Salesman Problem using Dynamic programming

CONCEPT

Given a set of cities and distance between every pair of cities, the problem is to find the shortest possible route that visits every city exactly once and returns to the starting point. Note the difference between Hamiltonian Cycle and TSP. The Hamiltonian cycle problem is to find if there exist a tour that visits every city exactly once. Here we know that Hamiltonian Tour exists (because the graph is complete) and in fact many such tours exist, the problem is to find a minimum weight Hamiltonian Cycle.



For example, consider the above graph. A TSP tour in the graph is 1-2-4-3-1. The cost of the tour is 10+25+30+15 which is 80.

PROGRAM

```
/* 10b. TSP - DP */

import java.util.Scanner;

public class TravSalesPerson
{
        static int MAX = 100;
        static final int infinity = 999;

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

```
{
        int cost = infinity;
        int c[][] = new int[MAX][MAX];      // cost matrix
        int tour[] = new int[MAX];          // optimal tour
        int n;                                                  // max. cities
        System.out.println("Travelling Salesman Problem using Dynamic Programming\n");
        System.out.println("Enter number of cities: ");
        Scanner scanner = new Scanner(System.in);
        n = scanner.nextInt();
        System.out.println("Enter Cost matrix:\n");
        for (int i = 0; i < n; i++)
                for (int j = 0; j < n; j++)
                {
                        c[i][j] = scanner.nextInt();
                        if (c[i][j] == 0)
                                c[i][j] = 999;
                }
        for (int i = 0; i < n; i++)
                tour[i] = i;
        cost = tspdp(c, tour, 0, n);
        // print tour cost and tour
        System.out.println("Minimum Tour Cost: " + cost);
        System.out.println("\nTour:");
        for (int i = 0; i < n; i++)
        {
                System.out.print(tour[i] + " -> ");
        }
        System.out.println(tour[0] + "\n");
        scanner.close();
}

static int tspdp(int c[][], int tour[], int start, int n)
{
        int i, j, k;
        int temp[] = new int[MAX];
        int mintour[] = new int[MAX];
        int mincost;
        int cost;
        if (start == n - 2)
                return c[tour[n - 2]][tour[n - 1]] + c[tour[n - 1]][0];
        mincost = infinity;
        for (i = start + 1; i < n; i++)
        {
                for (j = 0; j < n; j++)
                        temp[j] = tour[j];
                temp[start + 1] = tour[i];
```

```
                temp[i] = tour[start + 1];
                if (c[tour[start]][tour[i]] + (cost = tspdp(c, temp, start + 1, n)) < mincost) {
                        mincost = c[tour[start]][tour[i]] + cost;
                        for (k = 0; k < n; k++)
                                mintour[k] = temp[k];
                }
        }
        for (i = 0; i < n; i++)
                tour[i] = mintour[i];
        return mincost;
    }
}
```

OUTPUT

Travelling Salesman Problem using Dynamic Programming

Enter number of cities:
4
Enter Cost matrix:

0 1 2 4
1 0 999 1
2 999 0 1
4 1 1 0
Minimum Tour Cost: 5

Tour:
0 -> 1 -> 3 -> 2 -> 0

NOTES AND OUTPUT SPACE

EXPERIMENT 11

PROGRAM STATEMENT

Find a subset of a given set S = {sl,s2, ... ,sn} of n positive integers whose sum is equal to a given positive integer d. For example, if S= {1, 2, 5, 6, 8} and d = 9 there are two solutions{1,2,6}and{1,8}.A suitable message is to be displayed if the given problem instance doesn't have a solution.

CONCEPT

Subset-Sum Problem is to find a subset of a given set S= {s1, s2… sn} of n positive integers whose sum is equal to a given positive integer d. It is assumed that the set's elements are sorted in increasing order. The state-space tree can then be constructed as a binary tree and applying backtracking algorithm, the solutions could be obtained. Some instances of the problem may have no solutions.

PROGRAM

```
import java.util.Scanner;

public class SumOfsubset
{
        final static int MAX = 10;
        static int n;
        static int S[];
        static int soln[];
        static int d;

        public static void main(String args[])
        {
                S = new int[MAX];
                soln = new int[MAX];
                int sum = 0;
                Scanner scanner = new Scanner(System.in);
                System.out.println("Enter number of elements: ");
                n = scanner.nextInt();

                System.out.println("Enter the set in increasing order: ");
                for (int i = 1; i <= n; i++)
                        S[i] = scanner.nextInt();
                System.out.println("Enter the max. subset value(d): ");
                d = scanner.nextInt();
                for (int i = 1; i <= n; i++)
                        sum = sum + S[i];
                if (sum < d || S[1] > d)
                        System.out.println("No Subset possible");
```

```
            else
                SumofSub(0, 0, sum);
            scanner.close();
        }

        static void SumofSub(int i, int weight, int total)
        {
            if (promising(i, weight, total) == true)
                if (weight == d) {
                    for (int j = 1; j <= i; j++)
                    {
                        if (soln[j] == 1)
                            System.out.print(S[j] + "  ");
                    }
                    System.out.println();
                }
                else
                {
                    soln[i + 1] = 1;
                    SumofSub(i + 1, weight + S[i + 1], total - S[i + 1]);
                    soln[i + 1] = 0;
                    SumofSub(i + 1, weight, total - S[i + 1]);
                }
        }


        static boolean promising(int i, int weight, int total)
        {
            return ((weight + total >= d) && (weight == d || weight + S[i + 1] <= d));
        }
}
```

OUTPUT

```
Enter number of elements:
4
Enter the set in increasing order:
4
6
9
12
Enter the max. subset value(d):
13
4  9
```

NOTES AND OUTPUT SPACE

EXPERIMENT 12

PROGRAM STATEMENT

Design and implement in java to find all Hamiltonian Cycles in a connected undirected graph G with n vertices using backtracking principle.

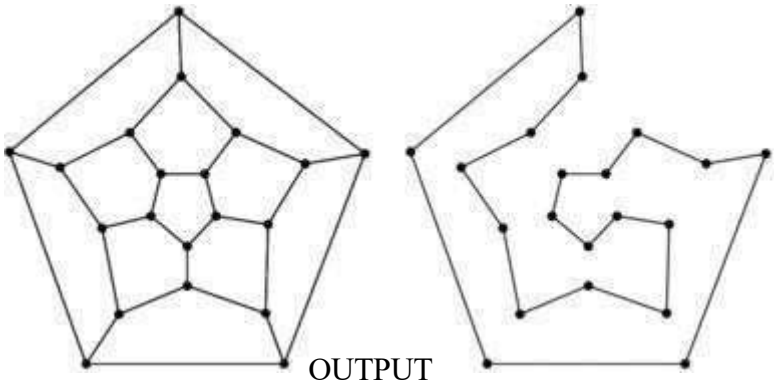
CONCEPT

A *Hamiltonian cycle*, *Hamiltonian circuit* is a cycle that visits each vertex exactly once (except for the vertex that is both the start and end, which is visited twice). A graph that contains a Hamiltonian cycle is called a **Hamiltonian graph**.

Following is one way of checking whether a graph contains a Hamiltonian Cycle or not.

A Hamiltonian Path in a graph having N vertices is nothing but a permutation of the vertices of the graph [v_1, v_2, v_3, ... v_{N-1}, v_N], such that there is an edge between v_i and v_{i+1} where $1 \leq i \leq N-1$. So it can be checked for all permutations of the vertices whether it represents a Hamiltonian Cycle or not.

INPUT



OUTPUT

PROGRAM

```
/* 12. Hamiltonian cycle */

import java.util.Scanner;

public class Hamiltonian
{
        boolean found = false;
        int G[][];// = new int[n + 1][n + 1];
        int x[];// = new int[n + 1];
        int n;

        public static void main(String args[])
        {
                Hamiltonian hamiltonian = new Hamiltonian();
                hamiltonian.getData();
```

```
		System.out.println("\nSolution:");
		hamiltonian.HamiltonianMethod(2);
		hamiltonian.printNoSlnPossible();

	}

	public void printNoSlnPossible()
	{
		if (found == false)
			System.out.println("No Solution possible!");
	}

	public void getData()
	{
		Scanner scanner = new Scanner(System.in);
		System.out.println("\t\t\t\tHamiltonian Cycle");
		System.out.print("\nEnter the number of the vertices: ");
		// int n;
		n = scanner.nextInt();
		G = new int[n + 1][n + 1];
		x = new int[n + 1];
		System.out.print("\nIf edge between the following vertices enter 1 else 0:\n");
		for (int i = 1; i <= n; i++)
			for (int j = 1; j <= n; j++)
			{
				if ((i != j) && (i < j))
				{
					System.out.print(i + " and " + j + ": ");
					G[j][i] = G[i][j] = scanner.nextInt();
				}
				if (i == j)
					G[i][j] = 0;
			}
		for (int i = 1; i <= n; i++)
			x[i] = 0;
		x[1] = 1;

		scanner.close();
	}

	void HamiltonianMethod(int k)
	{
		while (true)
		{
			NextValue(k, G, x, n);
			if (x[k] == 0)
```

```
                    return;
                if (k == n)
                {
                    for (int i = 1; i <= k; i++)
                        System.out.print(x[i] + " ");
                    System.out.println(x[1]);
                    System.out.println();
                    found = true;
                    return;
                }
                else
                    HamiltonianMethod(k + 1);
            }
        }

        void NextValue(int k, int G[][], int x[], int n)
        {
            while (true)
            {
                x[k] = (x[k] + 1) % (n + 1);
                if (x[k] == 0)
                    return;
                if (G[x[k - 1]][x[k]] != 0)
                {
                    int j;
                    for (j = 1; j < k; j++)
                        if (x[k] == x[j])
                            break;
                    if (j == k)
                        if ((k < n) || ((k == n) && G[x[n]][x[1]] != 0))
                            return;
                }
            }
        }
}
```

OUTPUT Hamiltonian Cycle

```
Enter the number of the vertices: 4

If edge between the following vertices enter 1 else 0:
1 and 2: 1
1 and 3: 1
1 and 4: 1
```

2 and 3: 1
2 and 4: 1
3 and 4: 1

Solution:
1 2 3 4 1

1 3 2 4 1

1 4 2 3 1

NOTES AND OUTPUT SPACE

ADDITIONAL PROGRAMS

1) **All pair shortest paths problem using Floyd's algorithm. Parallelize this algorithm , implement it using OPenMP and determine the speed-up achieved.**

.

```
# include< stdio.h>
# include <omp.h>
void floyds(int a[10][10],int n);
int min(int a,int b);
int  main( )
 {
    int thread_id,i,j,n,a[10][10];
   double starttime,endtime;
   system("clear");
     printf(" Enter the no of vertices");
      scanf("%d",&n);
      printf("Enter the weight matrix \n");
      printf(" Enter 0 for self loops and 999 for no edge\n");
      for ( i=1; i<=n; i++ )
          for ( j=1; j<=n; j++ )
              {
                scanf("%d",&a[i][j]);
                }
          starttime=omp_get_wtime();
          floyds(a,n);
         endtime= omp_get_wtime();
    printf("Speed up achieved is %f",endtime-starttime);
 }
 int min( int a,int b)
   {
     return(a<b ?a:b);
   }
void floyds(int a[10][10],int n)
 {
    int b[10][10],i,j,k,thread_id;
       for ( i=1; i<=n; i++ )
         for ( j=1; j<=n; j++ )
          b[i][j]=a[i][j];
          omp_set_num_threads(2);
          # pragma omp parallel for shared(b) private(i,j,k)
        for ( i=1; i<=n; i++ )
          {
             for ( j=1; j<=n; j++ )
             for(k=1; k<=n; k++)
              {
                    thread_id=omp_get_thread_num();
```

```
            b[i][j]=min(b[i][j],b[i][k]+b[k][j]);
            printf("Thread %d:b[%d][%d]=%d\n",thread_id,i,j,b[i][j]);
        }
    }
        printf(" All pairs shortest path \n");
        for ( i=1; i<=n; i++ )
        {
            for ( j=1; j<=n; j++ )
                printf("%5d", b[i][j]);
                printf("\n");
            }
        return;
        }
```

Output:

Enter the Number of vertices
3
Enter 0 for self loops and 999 for noedges
0 5 999
999 0 3
2 999 0
All pairs shortest path is
0 5 8
5 0 3
2 7 0

2) Implement N-Queens problem using Backtracking method

```
# include< stdio.h>
# include < conio.h>
# include <process.h>
#include <math.h >

 int x[10];
 void main( )
 {
     int k, i, j, n, count=1;
     int place (int);
     clrscr( );
     printf( " Enter the number of Queens\n");
     scanf("%d",&n);
      if( n= = 0 || n= = 2 || n= = 3 )
        printf(" No Solution");
      else
        k=1;
        x[1]=0;
        while(k)
         {
           x[k]= x[k]+1;
           while( ( x[k] <=n) && (!place(k) ) )
                x[k]= x[k]+1;
             if( x[k]<=n )
               {
                  if(k= = n)
                    {
                        getch( );
                        printf("Solution %d \n",count++);
                        for ( i=1; i<=n; i++ )
                          {
                               for ( j=1; j<x[i]; j++ )
                               printf(" * ");
                               printf(" Q" );
                               for ( j=x[i]+1; j<=n; j++ )
                                    printf(" * ");
                                     printf(" \n" );
                          }
                     }
                   else
                      {
                          k + = 1;
                          x[k]=0;
                       }
```

```
                    }
                else
                    k - = 1;
            }

            getch( );
        }

    int place( int p)
      {
            int i;
            for ( i=1; i<=(p-1); i++ )
            if( (x[i]= = x[p] ) || ( ( abs( x[i]- x[p]) ) = = (abs(i-p) ) ) )
                return 0;
              return 1;
       }
```

Output:

Enter the no of queens
4
Solution 1

```
Q * *
* * * Q
Q * * *
* * Q *
```

Solution 2

```
* * Q *
Q * * *
* * * Q
* Q * *
```

VIVA VOICE QUESTIONS

1. **What is an Algorithm? (L2)**

   Algorithm is a Step by step procedure to Solve a given problem for a finite number of input producing finite number of output with desired output.

2. **What is a Flow Chart?(L2)**

   Flow chart is a Graphical Representation of a solution to the Problem.

3. **What is the difference between Algorithm, Flow Chart, Program?(L2)**

- Algorithm specifies the different things to be followed for solving a Problem.
- Flow Chart is a Graphical Representation of a Solution to the Problem. Both Algorithm and Flow Chart are Machine Independent.
- Program is a Set of Instructions which is used as a tool to communicate to the machine to get our work done,Program is Machine Dependent for particular Machine.

4. **What is the Aim of DAA lab or why we need to study DAA Lab?(L3)**

   DAA is a discipline, where we are dealing with designing or writing the algorithm keeping in Consideration of Space and Time Complexity, Such that Our Algorithm should execute in a very minimum amount of time by Minimum Space or RAM.

5. **Define Space and Time Complexity? Among this which one is more prioritized?(L3)**

   Space Complexeity is a measure of Amount of Space taken by a Program to finish its Execution.

   Time Complexeity is a measure of amount of time taken by a program to complte its Execution.Depending Upon Application it is considered,EX:For Mobile or Handheld Devices,We give Prefernce for both Space and time.

   For a Huge and Inter active Systems like Web Applications we give more Preferences to time Complexeity.

6. **What is Design and what is Analysis of a Program?(L2)**

   Design is a Process of Writing an algorithm to a given Problem so that it should accept finite number of input and finite number of output with a definite output and Should Exit appropriately.

   Analysis:Analysis is a next Phase of Writing an Algorithm ,in this phase we calculate the Efficiency of an Algorithm i.e time and space needed by an algorithm.

7. **Write the general plan for analyzing the recursive algorithms.(L2)**

   Identify the inputs.

   Identify the output is depended only on number of inputs.

Identify the Basic Operation in ALgorithm.

Form or write the Recursive Relation to the Algorithm.

8. What are the various notations used to write an algorithm? (L2)

(i) Pseudocode (ii)Natural Language and etc..

9. What is a Pseudocode?(L2)

It's a notation which is having the combination of Programming Constructs and English like Statements.

10. What is Asymptotic Notations?Explain Various notations used for the same.(L2)

Asymptotic Notation is a way of Representing an algorithm time Complexeity in terms of Best,Average,Worst.

There are 3 Notations used to represent (i)Ω(n)-Best Case :-Here the algorithm runing time g(n) is less than f(n). for all $n>=n_o$ .Such that there exist a constant C.

$f(n)>=c.g(n)$,for all $n>n_o$

Refer Text book for Graph.

(ii) O-Worst Case:-Here the Algorithm runing time g(n) is greater than F(n) for all $n>=n_o$.

$f(n)<=c.g(n)$,for all $n>=n_o$, Such that there exist a constant C.

Refer Text book for Graph.

(iii) Θ-Average Case:When there is more than one parameter controlling the Execution time and We should go for Amortized analysis or Series of Execution for the Same Input and the Resultant Would be Average Case is which is $c1.g(n)<f(n)<c2.g(n)$,for all $n>=n_o$, Such that there exist a constant C.

Refer Text book for Graph.

11. List out the few topics you have studied or Explain few topics of your Favourite list.(L2)

1.Mention a topics Which you are really good in,the topics like

- Searching-Explain any one Searching Algorithm
- Sorting-Explain Any one Sorting Algorithm.
- String Matching-Explain any one method ,Select either Brute Force or Horspool Method.
- Divide and Conquer-Explain either Merge sort or Quick sort which You are More Comfortable.
- Greedy Technique-Define Greedy and Explain Any problem with Greedy Method

Ex:Knapsack Problem,Job Sequencing with Deadlines,Prims ,Kruskals and etc..

- dynamic Programming-Explain any Problem with Dynamic Programming Approach

- Decrease and Conquer:Explain any problem which can be Solved Using decrease and Conquer,EX:DFS,BFS,Topological Sorting.
- Limitations of Algorithms:Explain few things about Decision trees and its use in solving a Problem.

- Coping with Limitations of Algorithms:Explain Backtracking and one problem which illustrates about Backtacking method and Wind Up.

12. What is the Time Complexeity of Bubble Sort,Selection Sort ,Merge Sort,Quick Sort?(L3)

Bubble Sort-$n^{2,}$

Selection Sort- n^2

Merge Sort-nlog.n

Quick Sort -nLogn, Worst case for Quick Sort- n2

13. Which sorting agorithm is more Efficient and why?(L3)

Quick Sorting is More Efficient ,because this algorithm is instable algorithm and inplace.

14. What do you mean by the term Instable Algorithms?(L2)

The Instable Algorithms are one, which divides the array as certainly depending upon pivot or key element and hence i index precedes index j

15. Which algorithms are faster?(L3)

Instable Algorithms are much Faster compared to Stable Algorithms.

16. For what type of instance Merge sort do better than Quick Sort?(L3)

For a Larger input and a sorted input values.

17. For what type of instance Quick sort do better than Merge Sort? (L3)

For Smaller Set of input numbers.

18. What are Inplace Algorithms?

Inplace Algorithms are the one which doesn't occupies Extra Space.

19. Write the order of growth terms as per the time Execution in Ascending Order.(L3)

logn,n,nlogn,n^2,n^3,. .... n^n,2^n,n!

20. What is Brute Force Technique? When We Should Use? (L3)

Brute Force is a straight Forward Technique to solve a problem, We used to solve a Problem through this approach when we don't have sufficient data to solve a problem in Efficient Way.

21. What is the difference between Divide and Conquer, Decrease and Conquer? (L2)

Divide and Conquer can be solved to solve a problem with a larger data set and when there is no dependency between any of the data sets.

- ❖ Divide and Solve as Small as Small sets.
- ❖ Conquer or Merge it get one final resultant data set.

Decrease and Conquer is almost similar to Divide and Conquer but we are finding a solutions to the problem in a different variations,EX:Decrease by Constant (Usually by One),Decrease by Constant factor which is almost similar to Divide and Conquer Technique(Usually by two),Decrease by Variable(The Dividing Criteria changes for each iteration depends upon the data set.

22. Define Greedy Technique. (L2)

Greedy Technique is always applied for the problem of the type optimization type, which reduces loss and increases profit.

23. Define Optimal and Feasible Solution. (L2)

Optimal Solution is a solution which is best among N Feasible Solution.

Feasible Solution is a solution which Satisfies a Problem Constraints/conditions.

24. Can A Problem solved by all the algorithmic Techniques.(L3)

Yes,but some problems will give better results with some Algorithmic Technique and it may give worst result when it is applied with other technique.

25. State and Explain Knapsack Problem. (L2)

Filling the Maximum number of items to the Knapsack (Container) Which Increases the profit and decreases the Loss.

26. State Few Algorithmic Techniques which you have studied. (L2)

Brute Force Technique

Divide and Conquer

Greedy Technique

Dynamic Programming

Decrease and Conquer

27. Which one is Most Admired algorithmic Technique?(L3)

Dynamic Programming.

28. What is Spanning tree and Minimum Spanning tree?(L2)

A tree Without Cycles are called as Spanning tree .

A Minimum Spanning Tree is a spanning tree which yeilds the very less Cost when all the edges cost summed up.

29. How Many Spanning Tree can a Tree can have?(L3)

A tree can have 1 to many number of Possible ways of Spanning Tree.

30. Differentiate between Prims and Kruskals Algorithm for finding MST.(L2)

In Prims We consider any one vertex in the graph as Source and We compute the distance from that source to other vertices ,after computing the vertices which has minimum value among (n-1) vertices is added to tree vertices and that respective edges added to tree Edges Set.The above mentioned Process continues till we reach (n-1) vertices.

In Kruskals we first arrange the edges in Ascending Order and then we start to form the tree which wont form cycles,if adding that edges forms cycles then that edges is dropped from adding to tree edges.The above said process is continues till we reach the count of

(n-1) Vertices.

31. What is the Application of Prims and Kruskals Algorithm?(L3)

In Networks to remove the Cyclicity of the Network.

32. Explain Job Sequencing With Deadlines?(L2)

Placing or scheduling the maximum number of Jobs to a machine without violating the deadlines constraint of any of the Jobs in Sequence.

33. Why the Name Bubble Sort named?(L3)

Because in first Pass the first highest data will bubbles up,so since the largest element bubbles up in the first and second largest element bubbles up in the Second pass and so on, so hence the name bubble sort.

34. Why the Name Selection Sort?(L3)

The Selection sort is named because we initially first select an arrays first element as minimum and will compare with other elements ,so in pass one first least element goes to the first position and so on so forth for 2nd,3rd and so on. Selecting

35. What is the difference between Brute force strings matching to Horspool String Matching Method? (L2) In brute Force we compare each and every element of the text to the pattern by shifting the text positionby one and in Horspool method we shift it by number of shift positions recorded in the shift table.

36. Explain Merge Sort?(L2)

In Merge Sort will divide the entire input set by 2 until we reach low<high and later will find a solution to each item by comparing half of the array data set to the other half array data set and finally we mergeit to form a sinle array(conquer)

37. What is the Basic Operations in Merge sort and Quick sort?(L2)

In Merge Sort the Basic Operations is Comparisions and in Quick sort basic Operations is Partitioning and hence also known as partitioning sort.

38. Why the Insertion Sort?(L3)

We are Inserting an element to its suitable place by comparing n elements for each pass.

39. What is the Use of DFS and BFS?(L2)

DFS and BFS both used to check the Connectivity of a graph,Cyclicity in a graph,Spanning tree of a graph.

40. Differentiate between DFS and BFS.(L2)

DFS and BFS are both the Graph Traversing Technique,in which DFS Traverse the Graph in a depth wise(Vertical) and BFS Traverse the Graph from left to right(Horizontal)

41. Which Data structures used in BFS and DFS.(L2)

BFS USes Queue as its data structure and DFS uses as stack its Data structure.

42. What are back edges in DFS and Cross Edges in BFS.(L2)

Back Edges and Cross edges are the Edges which already visited by a ancestor node.

43. What is Topological Sorting?(L2)

Topological Sorting is a Sorting Technique used for sorting Vertices in the Graph.

44. What is the Conditions necessary for a Topological Sorting? (L3)

For a Topological Sorting the Graph Should be DAG(Directed Acyclic Graph)

45. What are the Different methods used to solve a topological Sorting ?(L3)

(i) Source Removal Method

(ii) Using DFS based Scheme.

46. What is the Use of Topological Sorting?(L3)

Use of Topological Ordering is in the field of Operating System for Scheduling and in Networks,Automation and Robotics.

47. What is Dijikstra's Algorithm?(L2)

Dijikstra's Algorithm is Used to find the Single shortest Path from source to the other vertex.

48. What is a graph?(L2)

Graph is a component which is having a set of Edges and vertices G={V,E}

49. What are the different ways that can be represents a graph?(L2)

Adjaceny Matrix and Adjacency List.

50. What is Adjacency Matrix?(L2)

Is a Matrix which illustrates the Graph in the form of Matrix,if it is a weights Graph then we initialize the value of the cost in that position(i,j) or else simply we write 1 to mention ther exist an edge between (i,j) OR else we use 0 or 9999 to mention non connectivity of a graph.

51. What is the limitations of Algorithms?(L2)

Algorithm can't find the better the soltions when we come across the tight lower bound,So we can find the better solutins which is not possible with Algorithmic way.To find the Tight lower bound we use Decision Trees.

52. What is Tight lower Bound?(L2)

It is a Lower bound which is a best lower bound for an problem,beyond that no algorithm will produce better results.

53. What are Decision Trees?(L2)

Decision trees are also known as Comparision Trees used to find the tight lower bound for a particular Problem EX:Tight Lower Bound For Sorting is n.logn

and tight lower bound for Searching is logn which is not possible to get the better result.

54. What is a polynomial problem (P-type) (L2)

P-type problem are decision problems in which we can find the solutions in a polynomial time and is of type deterministic.

55. What is NP-problem?(L2)

NP-Problem belongs to decision problem and these problems are Non Deterministic Polynomial i.e for which the problem doesn't have deterministic solutions and Can be solved in Polynomial time

There are 2 phases in solving a problem.

(i) Guessing(Non-Deterministic stage) Producing N number of Candidate Outputs.

(ii) Verification(Deterministic Stage) Verifying The correctness of N Number of Candidate Outputs.

56. What is NP-Complete Problems? (L2)

Np_Complete Problems belongs to Decision problems and NP type Problems .

These problems can be find the solutions by converting or reducing to the problem which we know the Solutions.

57. What is a trivial lower bound?(L2)

Trivial bound can be derived by formulating the number of inputs that has to be given and number of outputs that has to be generated.

58. Explain Bactracking W.r.t

(I)Subset Problem (ii)N-Queens Problem

59. Explain Subset Problem.(L2)

In a given Set S ,find the Subset,in which the sum of all subset elements is equal to the sum d which is predefined in a problem.

60. Explain N-Queens Problem.(L2)

N-Queens Problem is of Placing a N-Queens in a N*N Chess board such that No 2-Queens Should be placed in the same Row,Column and same diagnol(N=Should consider both principal diagonal elements)

61. What is Hamiltonian Circuit?(L2)

Hamiltonian circuit is a problem in which that circuit starts from a source vertex and has other vertex in any order without repeating and Should end with the Source vertex only i.e source and Destination vertex should be same.

62. Explain the Problem of TSP.(L2)

Travelling Sales Person Problem is a problem in which he should Visit N number of cities with a minimum number of Cost by visiting every city Exactly one and the city what he is started should end with same city.

63. What is the Concept of Dynamic Programming?(L3)

Deriving a Solution to the basic Condition and Extracting the solutions for the rest of the other data sets by Previously drawnd Solution.Computer to other algorithmic Technique Dynamic Programming because it avoids lot of reworking on the same Solution what we have solved in the earlier phases of deriving the solution to the problem.

64. What is the goal of Warshalls Algorithm?(L3)

Warshall's algorithm is to find the shortest distance between a node to all the other nodes in the graph.

It Uses the Property of Transitive Closure i.e if there exist a path between (i,k) and (k,j) then there surely exist a path between (i,j)

(i,k) & (k,j)---→(I,J)

65. What is the use of Floyds algorithm?(L3)

It is use to find the All pairs shortest Path of an Graph.

66. What is Parallel Programming?(L2)

Parallel programming is a technique of writing a Program to Execute a series of instructions parallel to gain Speed up in Execution.

67. What is openMp?(L2)

OpenMp is an abbreviation of Open Multi programming and it is a programming tool which creates an environment to execute a program in the Parallel fashion i.e, N number of Instructions at the same time so as to achieve the spped up.

68. When one can go for Parallel Programming?(L3)

Parallel Programming Fashion is can be opted when there is no dependency between the series of Instructions that has to be Executed Parallely.

69. What is the Command used to compile a parallel Program?

(L2) Command is **cc-fopen filename.c**

70. What is cc stands for and –fopenmp stands for?(L2)

Cc stands for invoking a turbo C Compiler and –fopenmp is an option to the command which directs a compiler to invoke or use the parallel programming API so as to Execute the program in a parallel Way.

71. What are the Maximum Number of Possible Ways for a travelling Sales Person with N number of Cities?(L4)

(N-1)! i.e for 5 cities (5-1)!= 4 !=24 ways.

72. Give Some Examples for a problem of type NP and NP-Complete?(L2)

Knapsack,Job Sequenncing with Deadlines,N-Queens Problem,Subset Problem,TSP and Hamiltonian circuit.

73. Give few Examples for a problem of type P?(L2)

Sorting Searching,String Matching and Hashing Problem.

74. What is the difference between Functions,Procedures,SubRoutines,Macros and Pseudo Code.

Functions:are the Constructs which consists of set of Instructions which is meant to Perform some Specific Task.It is the Programming Constructs used in Middle Level/High Level Languages like C/C++.(L3)