

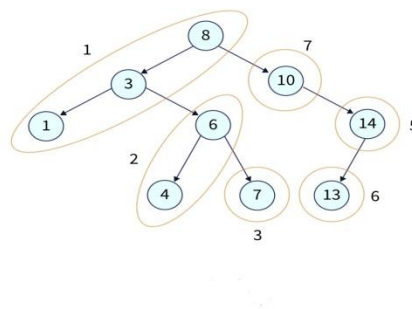
AIM:

DESCRIPTION:

In DFS, we continue to traverse downwards through linked nodes until we reach the end, then retrace our steps to check which connected nodes we haven't visited and repeat the process. In a depth-first search, we dive deep into the graph and then backtrack when we reach the bottom.

As we discussed above, the DFS is like solving a maze. We have to continue to walk along the path until we reach the end.

Let's have a look at the below example. We start with node 8, then go down to 3, then down to 1, and now we have hit the bottom, so start backtracking. Now at 3, we have one unvisited node, so go to 6, go down to 4, now hit the bottom, so backtrack again and reach node 6. Now we have one more unvisited node, i.e., 7, so go down to 7, now hit the bottom, so directly backtrack to node 8, now repeat the process.



The depth-first algorithm chooses one path and continues it until it reaches the end.

We created a graph with five nodes in the code. Our source node is 0. We have a visited array that stores all the nodes that have been visited and a component array that stores the answer. Then we call the dfs

function, passing it to the source node, visited array, component array, and graph. When we call the dfs function with any node, we first visit that node and add it to the answer array. Then we visit all of the adjacent node nodes of the given node.

ALGORITHM :

To implement DFS, we use the Stack data structure to keep track of the visited nodes. We begin with the root as the first element in the stack, then pop from it and add all the related nodes of the popped node to the stack. We repeated the process until the stack became empty.

Every time we reach a new node, we will take the following steps:

1. We add the node to the top of the stack.
2. Marked it as visited.
3. We check if this node has any adjacent nodes:
 1. If it has adjacent nodes, then we ensure that they have not been visited already, and then visited it.
 2. We removed it from the stack if it had no adjacent nodes.

With every node added to the stack, we repeat the above steps or recursively visit each node until we reach the dead end.

PROGRAM:

```
# Python program to print DFS traversal for complete graph
from collections import defaultdict
```

```
# This class represents a directed graph using adjacency
# list representation
class Graph:
```

```
    # Constructor
    def __init__(self):

        # default dictionary to store graph
        self.graph = defaultdict(list)

    # function to add an edge to graph
    def addEdge(self,u,v):
        self.graph[u].append(v)
```

```

# A function used by DFS
def DFSUtil(self, v, visited):

    # Mark the current node as visited and print it
    visited[v]= True
    print (v)

    # Recur for all the vertices adjacent to
    # this vertex
    for i in self.graph[v]:
        if visited[i] == False:
            self.DFSUtil(i, visited)

# The function to do DFS traversal. It uses
# recursive DFSUtil()
def DFS(self):
    V = len(self.graph) #total vertices

    # Mark all the vertices as not visited
    visited =[False]*(V)

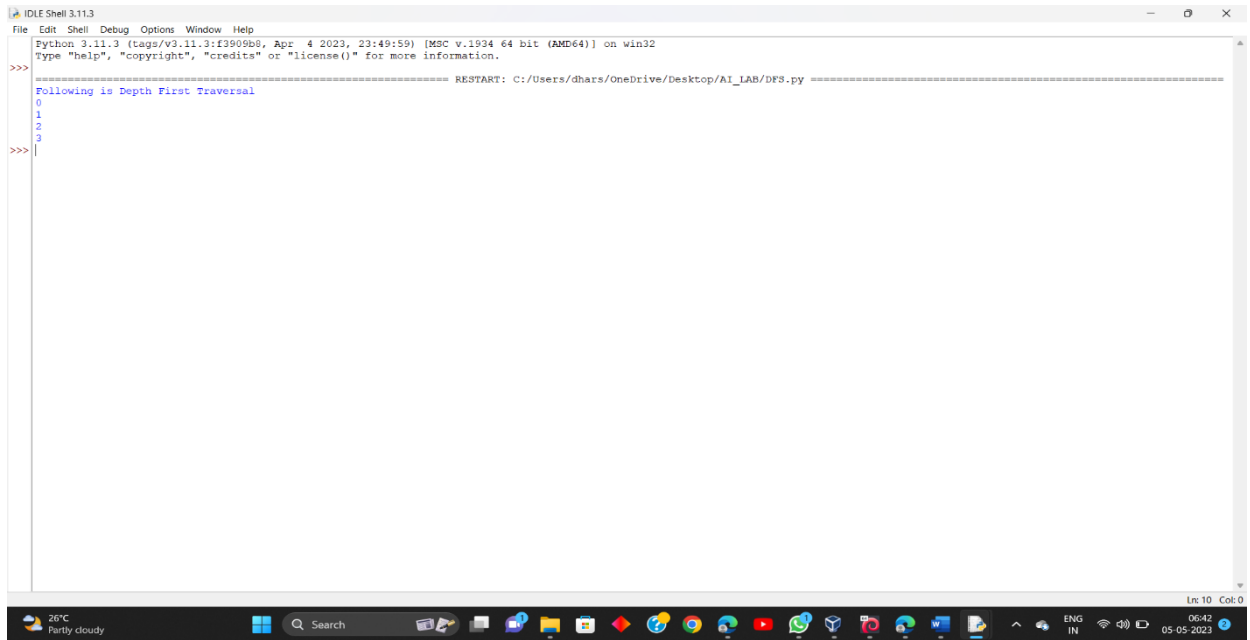
    # Call the recursive helper function to print
    # DFS traversal starting from all vertices one
    # by one
    for i in range(V):
        if visited[i] == False:
            self.DFSUtil(i, visited)

# Driver code
# Create a graph given in the above diagram
g = Graph()
g.addEdge(0, 1)
g.addEdge(0, 2)
g.addEdge(1, 2)
g.addEdge(2, 0)
g.addEdge(2, 3)
g.addEdge(3, 3)

print ("Following is Depth First Traversal")
g.DFS()

```

OUTPUT:



```
IDLE Shell 3.11.3
File Edit Shell Debug Options Window Help
Python 3.11.3 (tags/v3.11.3:f3908b8, Apr  4 2023, 23:49:59) [MSC v.1934 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: C:/Users/dhars/OneDrive/Desktop/AI_LAB/DFS.py =====
Following is Depth First Traversal
0
1
2
3
>>>
```

PAAVAI ENGINEERING COLLEGE (Autonomous)		
DESCRIPTION	MAX. MARKS	MARKS AWARDED
Preparation & Conduction	10	
Observation & Results	20	
Record Completion	05	
Viva Voce	05	
TOTAL	40	

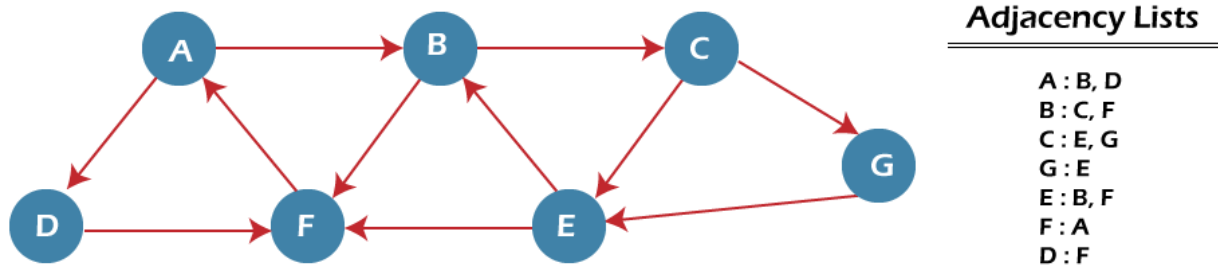
RESULT:

AIM:

DESCRIPTION:

Breadth-First Traversal (or Search) for a graph is similar to the Breadth-First Traversal of a tree. The only catch here is, that, unlike trees, graphs may contain cycles, so we may come to the same node again. To avoid processing a node more than once, we divide the vertices into two categories:

- Visited.
- Not visited.



Step 1 - First, add A to queue1 and NULL to queue2.

1. QUEUE1 = {A}
2. QUEUE2 = {NULL}

Step 2 - Now, delete node A from queue1 and add it into queue2. Insert all neighbors of node A to queue1.

1. QUEUE1 = {B, D}
2. QUEUE2 = {A}

Step 3 - Now, delete node B from queue1 and add it into queue2. Insert all neighbors of node B to queue1.

1. QUEUE1 = {D, C, F}
2. QUEUE2 = {A, B}

Step 4 - Now, delete node D from queue1 and add it into queue2. Insert all neighbors of node D to queue1. The only neighbor of Node D is F since it is already inserted, so it will not be inserted again.

1. QUEUE1 = {C, F}
2. QUEUE2 = {A, B, D}

Step 5 - Delete node C from queue1 and add it into queue2. Insert all neighbors of node C to queue1.

1. QUEUE1 = {F, E, G}
2. QUEUE2 = {A, B, D, C}

Step 5 - Delete node F from queue1 and add it into queue2. Insert all neighbors of node F to queue1. Since all the neighbors of node F are already present, we will not insert them again.

1. QUEUE1 = {E, G}
2. QUEUE2 = {A, B, D, C, F}

Step 6 - Delete node E from queue1. Since all of its neighbors have already been added, so we will not insert them again. Now, all the nodes are visited, and the target node E is encountered into queue2.

1. QUEUE1 = {G}
2. QUEUE2 = {A, B, D, C, F, E}

ALGORITHM:

Step 1: Consider the graph you want to navigate.

Step 2: Select any vertex in your graph, Say v1, from which you want to traverse the graph.

Step 3: Examine any two data structure for traversing the graph.

Visited array(size of the graph)

Queue data structure

Step 4: Starting from the vertex, you will add to the visited array, and afterward, you will v1's adjacent vertices to the queue data structure.

Step 5: Now, using the FIFO concept, you must remove the element from the queue, put it into the visited array, and then return to the queue to add the adjacent vertices of the removed element.

Step 6: Repeat step 5 until the queue is not empty and no vertex is left to be visited.

PROGRAM:

```
# Python3 Program to print BFS traversal
# from a given source vertex. BFS(int s)
# traverses vertices reachable from s. from collections import defaultdict

# This class represents a directed graph
# using adjacency list representation
```

```
class Graph:
```

```
    # Constructor
    def __init__(self):

        # default dictionary to store graph
        self.graph = defaultdict(list)

    # function to add an edge to graph
    def addEdge(self, u, v):
        self.graph[u].append(v)

    # Function to print a BFS of graph
    def BFS(self, s):

        # Mark all the vertices as not visited
        visited = [False] * (max(self.graph) + 1)

        # Create a queue for BFS
        queue = []

        # Mark the source node as
        # visited and enqueue it
        queue.append(s)
        visited[s] = True
```

```

while queue:

    s = queue.pop(0)
    print(s, end=" ")

    # Get all adjacent vertices of the
    # dequeued vertex s. If a adjacent

    for i in self.graph[s]:
        if visited[i] == False:
            queue.append(i)

visited[i] = True

# Driver code

# Create a graph given in # the above diagram
g = Graph()
g.addEdge(0, 1)
g.addEdge(0, 2)
g.addEdge(1, 2)
g.addEdge(2, 0)
g.addEdge(2, 3)
g.addEdge(3, 3)

print("Following is Breadth First Traversal"
      " (starting from vertex 2)")
g.BFS(2)

```


OUTPUT:

```
=====
Following is Breadth First Traversal (starting from vertex 2)
2 0 3 1
>>>|
```

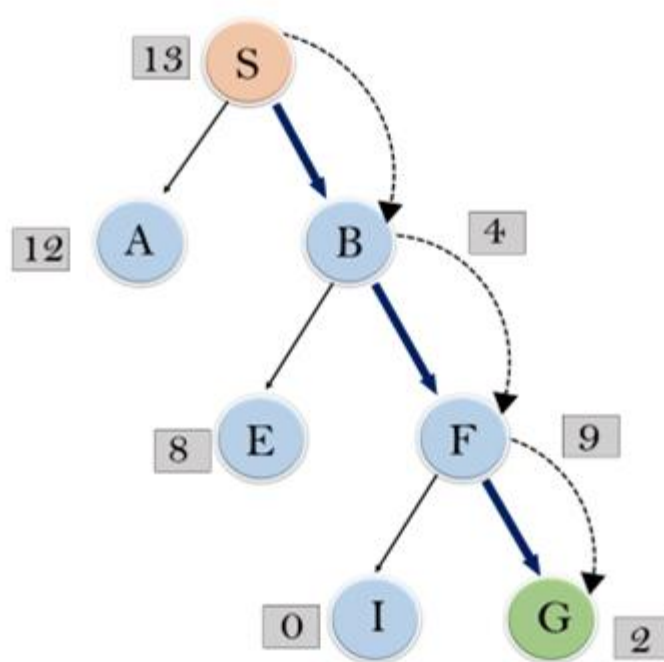
PAAVAI ENGINEERING COLLEGE (Autonomous)		
DESCRIPTION	MAX. MARKS	MARKS AWARDED
Preparation & Conduction	10	
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Record Completion	05	
Viva Voce	05	
TOTAL	40	

RESULT:

AIM:

DESCRIPTION:

The best First Search algorithm in artificial intelligence is used for finding the shortest path from a given starting node to a goal node in a graph. The algorithm works by expanding the nodes of the graph in order of increasing the distance from the starting node until the goal node is reached.



Initialization: Open [A, B], Closed [S]

Step 1: Open [A], Closed [S, B]

Step 2: Open [E, F, A], Closed [S, B]
Open [E, A], Closed [S, B, F]

Step 3: Open [I, G, E, A], Closed [S, B, F]
Open [I, E, A], Closed [S, B, F, G]

Hence the final solution path will be: **S----> B----->F----> G**

ALGORITHM:

Step 1: Start the Program.

Step 2: Create 2 empty lists: OPEN and CLOSED.

Step 3: Start from the initial node (say N) and put it in the 'ordered' OPEN list.

Step 4: Repeat the next steps until the GOAL node is reached. If the OPEN list is empty, then EXIT the loop returning 'False'.

Step 5: Stop the Program.

PROGRAM:

```
from queue import PriorityQueue

v = 14
graph = [[] for i in range(v)]

# Function For Implementing Best First Search
# Gives output path having lowest cost

def best_first_search(actual_Src, target, n):
    visited = [False] * n
    pq = PriorityQueue()
    pq.put((0, actual_Src))
    visited[actual_Src] = True

    while pq.empty() == False:
        u = pq.get()[1]
        # Displaying the path having lowest cost
```

```
        print(u, end=" ")
    if u == target:
        break

    for v, c in graph[u]:
        if visited[v] == False:
            visited[v] = True
            pq.put((c, v))

    print()
```

Function for adding edges to graph

```
def addedge(x, y, cost):

    graph[x].append((y, cost))
    graph[y].append((x, cost))
```

The nodes shown in above example(by alphabets) are # implemented using integers addedge(x,y,cost);

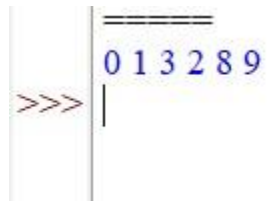
```
adddedge(0, 1, 3)
adddedge(0, 2, 6)
adddedge(0, 3, 5)
adddedge(1, 4, 9)
adddedge(1, 5, 8)
adddedge(2, 6, 12)
adddedge(2, 7, 14)
adddedge(3, 8, 7)
adddedge(8, 9, 5)
adddedge(8, 10, 6)
adddedge(9, 11, 1)
adddedge(9, 12, 10)
adddedge(9, 13, 2)
```

```
source = 0
```

```
target = 9
```

```
best_first_search(source, target, v)
```

OUTPUT:



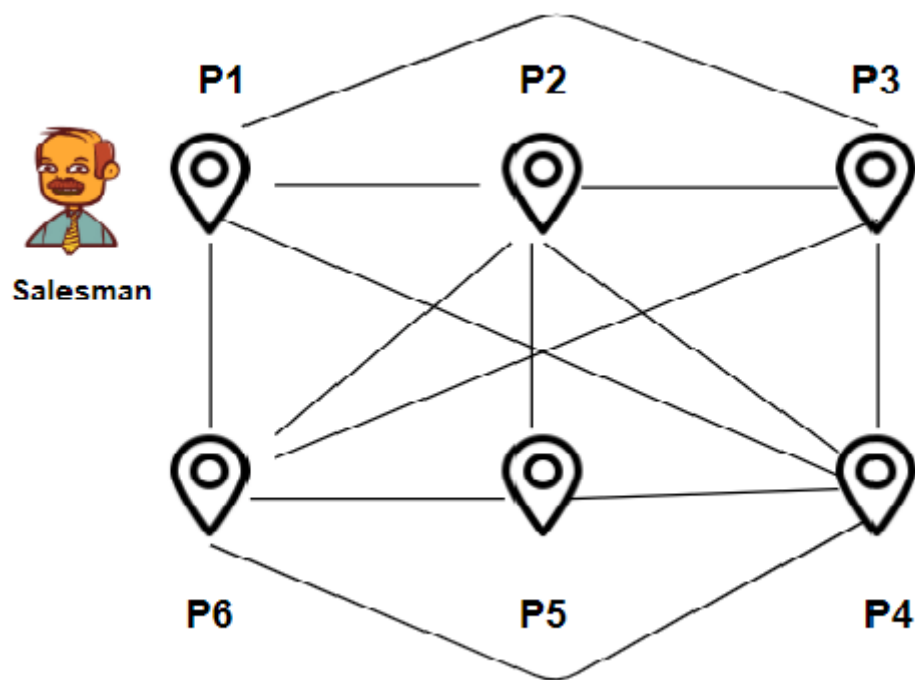
PAAVAI ENGINEERING COLLEGE (Autonomous)		
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TOTAL	40	

RESULT:

AIM:

DESCRIPTION:

You are given a list of n cities with the distance between any two cities. Now, you have to start with your office and to visit all the cities only once each and return to your office. What is the shortest path can you take? This problem is called the Traveling Salesman Problem (TSP).



ALGORITHM

Step 1: Start the Program.

Step 2: Consider city 1 as the starting and ending point.

Step 3: Generate all $(n-1)!$ Permutations of cities.

Step 4: Calculate the cost of every permutation and keep track of the minimum cost permutation.

Step 5: Return the permutation with minimum cost.

Step 6: Stop the Program.

PROGRAM:

```
# Python3 program to implement traveling salesman
```

```
# problem using naive approach.
```

```
from sys import maxsize
```

```
from itertools import permutations
```

```
V = 4
```

```
# implementation of traveling Salesman Problem
```

```
def travellingSalesmanProblem(graph, s):
```

```
    # store all vertex apart from source vertex
```

```
    vertex = []
```

```
    for i in range(V):
```

```
        if i != s:
```

```
            vertex.append(i)
```

```
    # store minimum weight Hamiltonian Cycle
```

```
    min_path = maxsize
```

```
    next_permutation=permutations(vertex)
```

```
    for i in next_permutation:
```

```
# store current Path weight(cost)

current_pathweight = 0


# compute current path weight

k = s

for j in i:

    current_pathweight += graph[k][j]

    k = j

current_pathweight += graph[k][s]


# update minimum

min_path = min(min_path, current_pathweight)


return min_path
```

```
# Driver Code
```

```
if __name__ == "__main__":
```


```
    # matrix representation of graph
```

```
    graph = [[0, 10, 15, 20], [10, 0, 35, 25],[15, 35, 0, 30], [20, 25, 30, 0]]
```

```
    s = 0
```

```
    print(travellingSalesmanProblem(graph, s))
```


OUTPUT:



```
IDLE Shell 3.11.3
File Edit Shell Debug Options Window Help
Python 3.11.3 (tags/v3.11.3:f3909b8, Apr 4 2023, 23:49:59) [MSC v.1934 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>> = RESTART: C:/Users/dhars/OneDrive/Desktop/AI_IAB/Travelling_Salesman_Problem.py
80
>>>
```

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DESCRIPTION	MAX. MARKS	MARKS AWARDED
Preparation & Conduction	10	
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RESULT:

AIM:**DESCRIPTION:**

You are given two jugs, a 4-gallon one and a 3-gallon one, a pump which has unlimited water which you can use to fill the jug, and the ground on which water may be poured. Neither jug has any measuring markings on it. How can you get exactly 2 gallons of water in the 4-gallon jug?

Let X represent the content of the water in 4-gallon jug.

Let Y represent the content of the water in 3-gallon jug.

Write a program in python to define a set of operators (Rules) that will take us from one state to another:

Start from initial state (X=0, Y=0)

Reach any of the Goal states

(X=2, Y=0)

(X=2, Y=1)

(X=2, Y=2)

(X=2, Y=3)

Find the minimum number of steps to reach any the above mentioned goal states.

Production Rules:-

R1: (x,y) --> (4,y) if $x < 4$

R2: (x,y) --> (x,3) if $y < 3$

R3: (x,y) --> (x-d,y) if $x > 0$

R4: (x,y) --> (x,y-d) if $y > 0$

R5: $(x,y) \rightarrow (0,y)$ if $x > 0$
 R6: $(x,y) \rightarrow (x,0)$ if $y > 0$
 R7: $(x,y) \rightarrow (4,y-(4-x))$
 if $x+y \geq 4$ and $y > 0$
 R8: $(x,y) \rightarrow (x-(3-y),y)$
 if $x+y \geq 3$ and $x > 0$
 R9: $(x,y) \rightarrow (x+y,0)$
 if $x+y \leq 4$ and $y > 0$
 R10: $(x,y) \rightarrow (0,x+y)$
 if $x+y \leq 3$ and $x > 0$

ALGORITHM:

Step 1: Start the Program.

Step 2: Empty the three gallon jug

Step 3: Now empty the remaining two gallons from the two gallon jug.

Step 4: Next refill the two gallon jug and empty one gallon from it into the three gallon jug. This gives four gallons.

Step 5: Stop the Program.

PROGRAM:

```

# This function is used to initialize the
# dictionary elements with a default value.

from collections import defaultdict

# jug1 and jug2 contain the value
# for max capacity in respective jugs
# and aim is the amount of water to be measured.

jug1, jug2, aim = 4, 3, 2

# Initialize dictionary with
# default value as false.

```

```
visited = defaultdict(lambda: False)
```

```
# Recursive function which prints the
```

```
# intermediate steps to reach the final
```

```
# solution and return boolean value
```

```
# (True if solution is possible, otherwise False).
```

```
# amt1 and amt2 are the amount of water present
```

```
# in both jugs at a certain point of time.
```

```
def waterJugSolver(amt1, amt2):
```

```
    # Checks for our goal and
```

```
    # returns true if achieved.
```

```
    if (amt1 == aim and amt2 == 0) or (amt2 == aim and amt1 == 0):
```

```
        print(amt1, amt2)
```

```
        return True
```

```
    # Checks if we have already visited the
```

```
    # combination or not. If not, then it proceeds further.
```

```
    if visited[(amt1, amt2)] == False:
```

```
        print(amt1, amt2)
```

```
    # Changes the boolean value of
```

```
    # the combination as it is visited.
```

```
    visited[(amt1, amt2)] = True
```

```
    # Check for all the 6 possibilities and
```

```
    # see if a solution is found in any one of them.
```

```
    return (waterJugSolver(0, amt2) or
```

```
            waterJugSolver(amt1, 0) or
```

```
            waterJugSolver(jug1, amt2) or
```

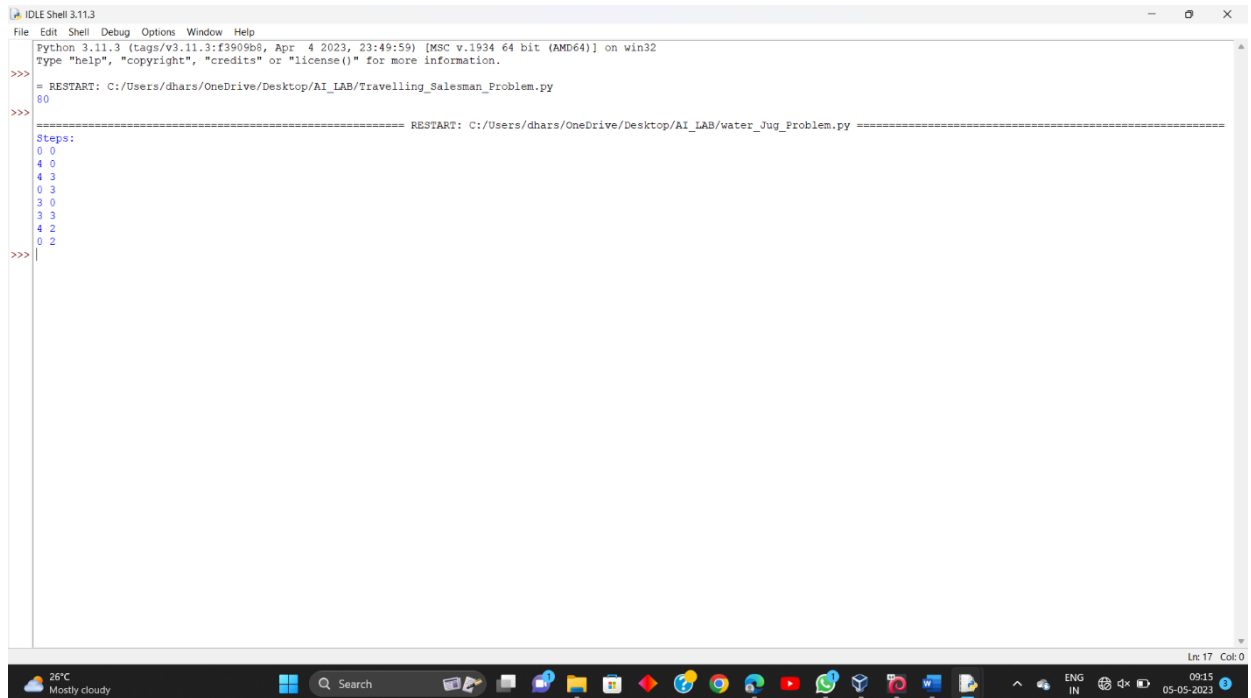
```
waterJugSolver(amt1, jug2) or  
waterJugSolver(amt1 + min(amt2, (jug1-amt1)),  
amt2 - min(amt2, (jug1-amt1))) or  
waterJugSolver(amt1 - min(amt1, (jug2-amt2)),  
amt2 + min(amt1, (jug2-amt2)))
```

```
# Return False if the combination is  
# already visited to avoid repetition otherwise  
# recursion will enter an infinite loop.  
else:  
    return False
```

```
print("Steps: ")
```

```
# Call the function and pass the  
# initial amount of water present in both jugs.  
waterJugSolver(0, 0)
```

OUTPUT:



The screenshot shows an IDLE Shell window with the following content:

```
Python 3.11.3 (tags/v3.11.3:f3909b0, Apr 4 2023, 23:49:59) [MSC v.1934 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
= RESTART: C:/Users/dhars/OneDrive/Desktop/AI_LAB/Travelling_Salesman_Problem.py
60
>>>
===== RESTART: C:/Users/dhars/OneDrive/Desktop/AI_LAB/water_Jug_Problem.py =====
Steps:
0 0
4 0
4 3
0 3
3 0
3 3
4 2
0 2
>>>
```

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DESCRIPTION	MAX. MARKS	MARKS AWARDED
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RESULT:

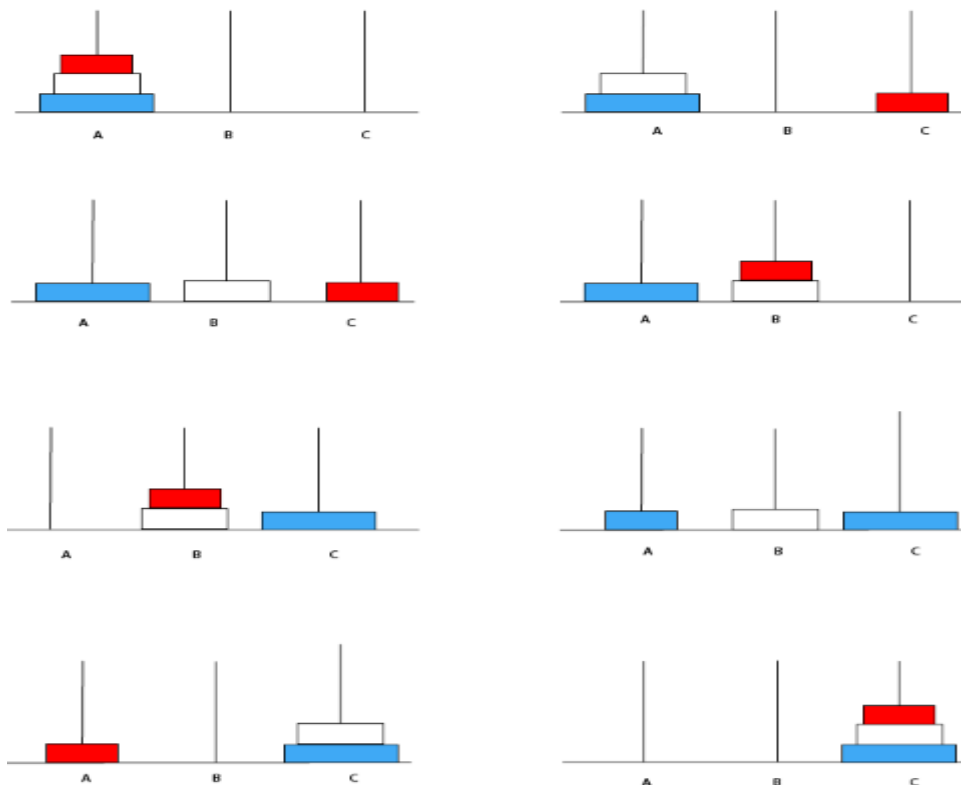
AIM:

DESCRIPTION:

The Tower of Hanoi (also called “The problem of Benares Temple” or “Tower of Brahma” or Lucas' Tower and sometimes pluralized as Towers, or simply pyramid puzzle) is a mathematical game or puzzle consisting of three rods and a number of disks of various diameters, which can slide onto any rod.

This object of this famous puzzle is to move N disks from the left peg to the right peg using the center peg as an auxiliary holding peg. At no time can a larger disk be placed upon a smaller disk. The following diagram depicts the starting setup for $N=3$ disks.

Let us we have three disks stacked on a peg



1. Only one disk will be shifted at a time.
2. Smaller disk can be placed on larger disk.

Let $T(n)$ be the total time taken to move n disks from peg A to peg C

1. Moving $n-1$ disks from the first peg to the second peg. This can be done in $T(n-1)$ steps.
2. Moving larger disks from the first peg to the third peg will require first one step.
3. Recursively moving $n-1$ disks from the second peg to the third peg will require again $T(n-1)$ step.

So, total time taken $T(n) = T(n-1) + 1 + T(n-1)$

ALGORITHM:

Step 1: Start

Step 2: Let the three towers be the source, dest, aux.

Step 3: Read the number of disks, n from the user.

Step 4: Move $n-1$ disks from source to aux.

Step 5: Move n th disk from source to dest.

Step 6: Move $n-1$ disks from aux to dest.

Step 7: Repeat Steps 3 to 5, by decrementing n by 1.

Step 8: Stop

PROGRAM:

Recursive Python function to solve tower of hanoi

```
def TowerOfHanoi(n, from_rod, to_rod, aux_rod):  
    if n == 0:  
        return  
  
    TowerOfHanoi(n-1, from_rod, aux_rod, to_rod)  
    print("Move disk", n, "from rod", from_rod, "to rod", to_rod)  
    TowerOfHanoi(n-1, aux_rod, to_rod, from_rod)
```



```
# Driver code
```

```
N = 3
```

```
# A, C, B are the name of rods
```

```
TowerOfHanoi(N, 'A', 'C', 'B')
```

OUTPUT:

```
Move disk 1 from rod A to rod C
Move disk 2 from rod A to rod B
Move disk 1 from rod C to rod B
Move disk 3 from rod A to rod C
Move disk 1 from rod B to rod A
Move disk 2 from rod B to rod C
Move disk 1 from rod A to rod C
```

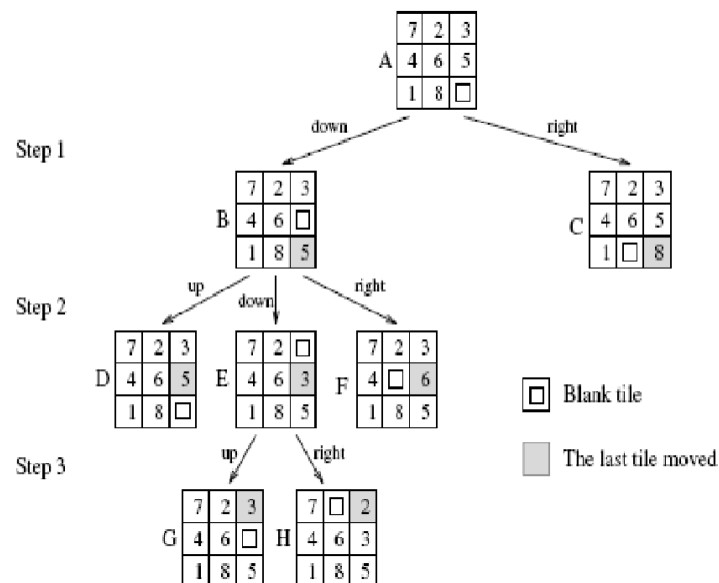
PAAVAI ENGINEERING COLLEGE (Autonomous)		
DESCRIPTION	MAX. MARKS	MARKS AWARDED
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TOTAL	40	

RESULT:

AIM:

DESCRIPTION:

The 8-puzzle problem is a puzzle invented and popularized by Noyes Palmer Chapman in the 1870s. It is played on a 3-by-3 grid with 8 square blocks labeled 1 through 8 and a blank square. Your goal is to rearrange the blocks so that they are in order. You are permitted to slide blocks horizontally or vertically into the blank square. The following shows a sequence of legal moves from an initial board position (left) to the goal position (right).



ALGORITHM:

Step 1: Start

Step 2: We first move the empty space in all the possible directions in the start state and calculate the f-score for each state.

Step 3: After expanding the current state, it is pushed into the closed list and the newly generated states are pushed into the open list. A state with the least f-score is selected and expanded again.

Step 4: This is called expanding the current state. This process continues until the goal state occurs as the current state.

Step 5: Basically, here we are providing the algorithm a measure to choose its actions. The algorithm chooses the best possible action and proceeds in that path.

Step 6: This solves the issue of generating redundant child states, as the algorithm will expand the node with the least f-score.

Step 7: Stop

PROGRAM:

```
# Python3 program to print the path from root
```

```
# node to destination node for N*N-1 puzzle
```

```
# algorithm using Branch and Bound
```

```
# The solution assumes that instance of
```

```
# puzzle is solvable
```

```
# Importing copy for deepcopy function
```

```
import copy
```

```
# Importing the heap functions from python
```

```
# library for Priority Queue
```

```
from heapq import heappush, heappop
```

```
# This variable can be changed to change
```

```
# the program from 8 puzzle(n=3) to 15
```

```
# puzzle(n=4) to 24 puzzle(n=5)...
```

```
n = 3
```

```
# bottom, left, top, right
```

```
row = [ 1, 0, -1, 0 ]
```

```
col = [ 0, -1, 0, 1 ]
```

```
# A class for Priority Queue
```

```
class priorityQueue:
```

```
# Constructor to initialize a
```

```
# Priority Queue
```

```
def __init__(self):
```

```
    self.heap = []
```

```
# Inserts a new key 'k'
```

```
def push(self, k):
```

```
    heappush(self.heap, k)
```

```
# Method to remove minimum element
```

```
# from Priority Queue
```

```
def pop(self):
```

```
    return heappop(self.heap)
```

```
# Method to know if the Queue is empty
```

```
def empty(self):
```

```
    if not self.heap:
```

```
        return True
```

```
    else:
```

```
        return False
```

```
# Node structure
class node:

    def __init__(self, parent, mat, empty_tile_pos, cost, level):

        # Stores the parent node of the
        # current node helps in tracing
        # path when the answer is found
        self.parent = parent

        # Stores the matrix
        self.mat = mat

        # Stores the position at which the
        # empty space tile exists in the matrix
        self.empty_tile_pos = empty_tile_pos

        # Stores the number of misplaced tiles
        self.cost = cost

        # Stores the number of moves so far
        self.level = level

        # This method is defined so that the
        # priority queue is formed based on
        # the cost variable of the objects
        def __lt__(self, nxt):
            return self.cost < nxt.cost

        # Function to calculate the number of
```

```

# misplaced tiles ie. number of non-blank

# tiles not in their goal position
def calculateCost(mat, final) -> int:

    count = 0
    for i in range(n):
        for j in range(n):
            if ((mat[i][j]) and
                (mat[i][j] != final[i][j])):
                count += 1

    return count

def newNode(mat,empty_tile_pos,new_empty_tile_pos,level, parent, final) -> node:

    # Copy data from parent matrix to current matrix
    new_mat = copy.deepcopy(mat)

    # Move tile by 1 position
    x1 = empty_tile_pos[0]
    y1 = empty_tile_pos[1]
    x2 = new_empty_tile_pos[0]
    y2 = new_empty_tile_pos[1]
    new_mat[x1][y1],new_mat[x2][y2]=new_mat[x2][y2], new_mat[x1][y1]

    # Set number of misplaced tiles
    cost = calculateCost(new_mat, final)

    new_node = node(parent, new_mat, new_empty_tile_pos, cost, level)
    return new_node

```

```

# Function to print the N x N matrix
def printMatrix(mat):

    for i in range(n):
        for j in range(n):
            print("%d " % (mat[i][j]), end = " ")

        print()

# Function to check if (x, y) is a valid
# matrix coordinate
def isSafe(x, y):

    return x >= 0 and x < n and y >= 0 and y < n

# Print path from root node to destination node
def printPath(root):

    if root == None:
        return

    printPath(root.parent)
    printMatrix(root.mat)
    print()

# Function to solve N*N - 1 puzzle algorithm
# using Branch and Bound. empty_tile_pos is
# the blank tile position in the initial state.
def solve(initial, empty_tile_pos, final):
    # Create a priority queue to store live

```



```
# nodes of search tree

pq = priorityQueue()

# Create the root node
cost = calculateCost(initial, final)
root = node(None, initial,
            empty_tile_pos, cost, 0)

# Add root to list of live nodes
pq.push(root)

# Finds a live node with least cost,
# add its children to list of live
# nodes and finally deletes it from
# the list.
while not pq.empty():

    # Find a live node with least estimated
    # cost and delete it from the list of
    # live nodes
    minimum = pq.pop()

    # If minimum is the answer node
    if minimum.cost == 0:

        # Print the path from root to
        # destination;
        printPath(minimum)
        return
```

```

# Generate all possible children
for i in range(4):
    new_tile_pos = [
        minimum.empty_tile_pos[0] + row[i],
        minimum.empty_tile_pos[1] + col[i], ]

    if isSafe(new_tile_pos[0], new_tile_pos[1]):

        # Create a child node
        child = newNode(minimum.mat, minimum.empty_tile_pos, new_tile_pos,
                        minimum.level + 1, minimum, final,)

        # Add child to list of live nodes
        pq.push(child)

# Driver Code

# Initial configuration
# Value 0 is used for empty space
initial = [ [ 1, 2, 3 ],
            [ 5, 6, 0 ],
            [ 7, 8, 4 ] ]

# Solvable Final configuration
# Value 0 is used for empty space
final = [ [ 1, 2, 3 ],
          [ 5, 8, 6 ],
          [ 0, 7, 4 ] ]

# Blank tile coordinates in

```

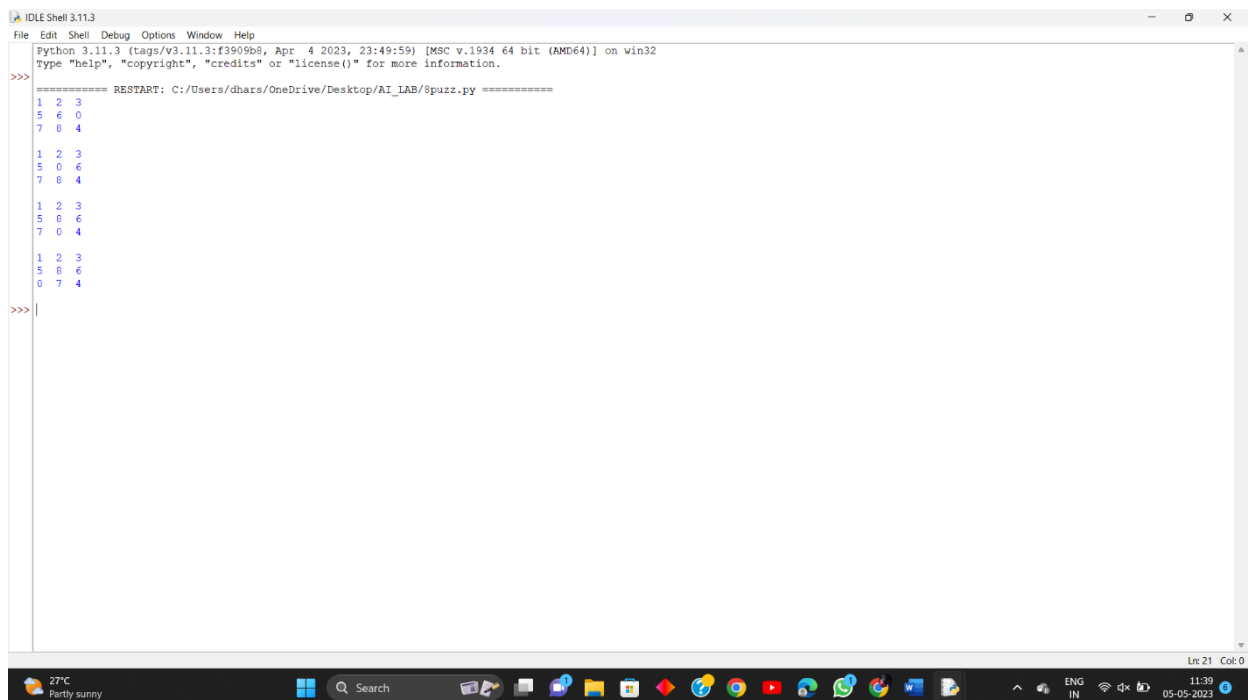
```
# initial configuration
```

```
empty_tile_pos = [ 1, 2 ]
```

```
# Function call to solve the puzzle
```

```
solve(initial, empty_tile_pos, final)
```

OUTPUT:



```
IDLE Shell 3.11.3
File Edit Shell Debug Options Window Help
Python 3.11.3 (tags/v3.11.3:f3909b8, Apr 4 2023, 23:49:59) [MSC v.1934 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: C:/Users/dhars/OneDrive/Desktop/AI_LAB/8puzz.py =====
1 2 3
5 6 0
7 8 4

1 2 3
5 0 6
7 8 4

1 2 3
5 8 6
7 0 4

1 2 3
5 8 6
0 7 4
>>>
```

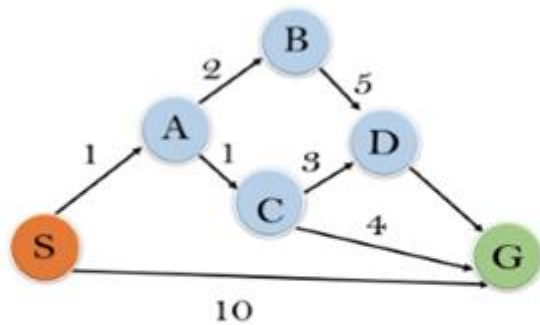
PAAVAI ENGINEERING COLLEGE (Autonomous)		
DESCRIPTION	MAX. MARKS	MARKS AWARDED
Preparation & Conduction	10	
Observation & Results	20	
Record Completion	05	
Viva Voce	05	
TOTAL	40	

RESULT:

AIM:

DESCRIPTION:

A* Search Algorithm is a simple and efficient search algorithm that can be used to find the optimal path between two nodes in a graph. It will be used for the shortest path finding. It is an extension of Dijkstra's shortest path algorithm



State	$h(n)$
S	5
A	3
B	4
C	2
D	6
G	0

Initialization: $\{(S, 5)\}$

Step 1: $\{(S \rightarrow A, 4), (S \rightarrow G, 10)\}$

Step 2: $\{(S \rightarrow A \rightarrow C, 4), (S \rightarrow A \rightarrow B, 7), (S \rightarrow G, 10)\}$

Step 3: $\{(S \rightarrow A \rightarrow C \rightarrow G, 6), (S \rightarrow A \rightarrow C \rightarrow D, 11), (S \rightarrow A \rightarrow B, 7), (S \rightarrow G, 10)\}$

Step 4 will give the final result, as **S--->A--->C--->G** it provides the optimal path with cost 6.

ALGORITHM:

Step 1: Initialize the open list.

Step 2: Initialize the closed list put the starting node on the open list (you can leave its f at zero).

Step 3: while the open list is not empty

a) find the node with the least f on the open list, call it "q".

b) pop q off the open list.

c) generate q's 8 successors and set their parents to q.

d) for each successor.

i) if successor is the goal, stop search

ii) else, compute both g and h for successor $\text{successor.g} = \text{q.g} + \text{distance between successor and successor.h} = \text{distance from goal to successor}$ (This can be done using many ways, we will discuss three heuristics-Manhattan, Diagonal and Euclidean Heuristics) $\text{successor.f} = \text{successor.g} + \text{successor.h}$

iii) if a node with the same position as successor is in the OPEN list which has a lower f than successor, skip this successor

iv) if a node with the same position as successor is in the CLOSED list which has a lower f than successor, skip this successor otherwise, add the node to the open list end (for loop)

e) push q on the closed list end (while loop).

PROGRAM:

```
from collections import deque
```

```
class Graph:
```

```
    # example of adjacency list (or rather map)
```

```
    # adjacency_list = {
```

```
# 'A': [('B', 1), ('C', 3), ('D', 7)],
```

```
# 'B': [('D', 5)],
```

```
# 'C': [('D', 12)]
```

```
# }
```

```
def __init__(self, adjacency_list):  
    self.adjacency_list = adjacency_list
```

```
def get_neighbors(self, v):  
    return self.adjacency_list[v]
```

```
# heuristic function with equal values for all nodes
```

```
def h(self, n):
```

```
    H = {  
        'A': 1,  
        'B': 1,  
        'C': 1,  
        'D': 1  
    }
```

```
    return H[n]
```

```
def a_star_algorithm(self, start_node, stop_node):
```

```
    open_list = set([start_node])  
    closed_list = set([])
```

```
    # g contains current distances from start_node to all other nodes
```

```
    # the default value (if it's not found in the map) is +infinity
```

```
    g = { }
```

```
    g[start_node] = 0
```

```
    # parents contains an adjacency map of all nodes
```

```

parents = { }
parents[start_node] = start_node

while len(open_list) > 0:
    n = None

    # find a node with the lowest value of f() - evaluation function
    for v in open_list:
        if n == None or g[v] + self.h(v) < g[n] + self.h(n):
            n = v;

    if n == None:
        print('Path does not exist!')
        return None

    # if the current node is the stop_node
    # then we begin reconstructin the path from it to the start_node
    if n == stop_node:
        reconst_path = []

        while parents[n] != n:
            reconst_path.append(n)
            n = parents[n]

        reconst_path.append(start_node)

        reconst_path.reverse()

        print('Path found: {}'.format(reconst_path))
        return reconst_path

    # for all neighbors of the current node do
    for (m, weight) in self.get_neighbors(n):
        # if the current node isn't in both open_list and closed_list

```



```

# add it to open_list and note n as it's parent
if m not in open_list and m not in closed_list:
    open_list.add(m)
    parents[m] = n
    g[m] = g[n] + weight

# otherwise, check if it's quicker to first visit n, then m
# and if it is, update parent data and g data
# and if the node was in the closed_list, move it to open_list
else:
    if g[m] > g[n] + weight:
        g[m] = g[n] + weight
        parents[m] = n

    if m in closed_list:
        closed_list.remove(m)
        open_list.add(m)

# remove n from the open_list, and add it to closed_list
# because all of his neighbors were inspected
open_list.remove(n)
closed_list.add(n)

print('Path does not exist!')
return None

```

```

adjacency_list = {
    'A': [('B', 1), ('C', 3), ('D', 7)],
    'B': [('D', 5)],
    'C': [('D', 12)]
}

graph1 = Graph(adjacency_list) graph1.a_star_algorithm('A', 'D')

```

OUTPUT:

```
Path found: ['A', 'B', 'D']  
['A', 'B', 'D']
```

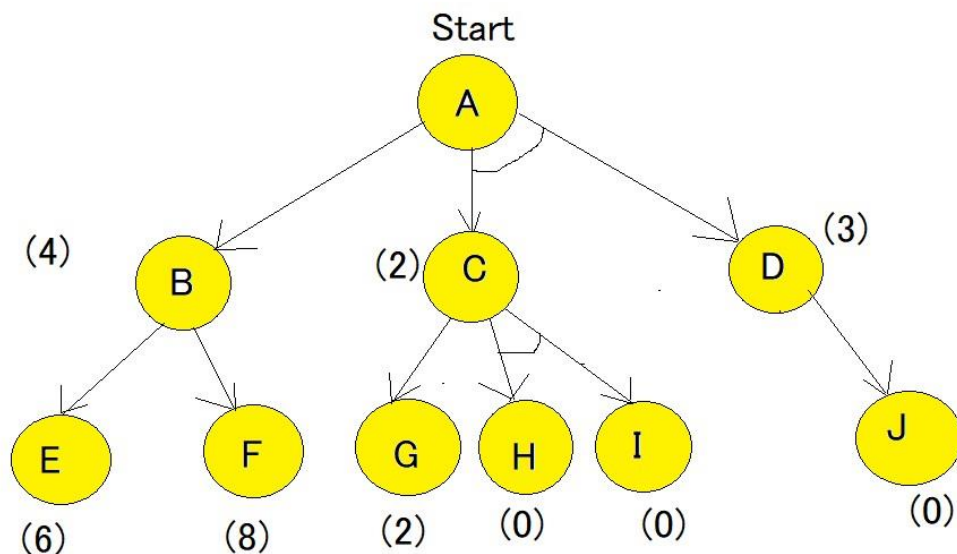
PAAVAI ENGINEERING COLLEGE (Autonomous)		
DESCRIPTION	MAX. MARKS	MARKS AWARDED
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RESULT:

AIM:

DESCRIPTION:

The AO* algorithm is a knowledge-based search technique, meaning the start state and the goal state is already defined , and the best path is found using heuristics. The time complexity of the algorithm is significantly reduced due to the informed search technique.



Step-1:

Starting from node A, we first calculate the best path.

$f(A-B) = g(B) + h(B) = 1+4= 5$, where 1 is the default cost value of travelling from A to B and 4 is the estimated cost from B to Goal state.

$f(A-C-D) = g(C) + h(C) + g(D) + h(D) = 1+2+1+3 = 7$, here we are calculating the path cost as both C and D because they have the AND-Arc. The default cost value of travelling from A-C is 1, and from A-D is 1, but the heuristic value given for C and D are 2 and 3 respectively hence making the cost as 7.

Step-2:

Using the same formula as step-1, the path is now calculated from the B node,

$$f(B-E) = 1 + 6 = 7.$$

$$f(B-F) = 1 + 8 = 9$$

Hence, the B-E path has lesser cost. Now the heuristics have to be updated since there is a difference between actual and heuristic value of B. The minimum cost path is chosen and is updated as the heuristic, in our case the value is 7. And because of change in heuristic of B there is also change in heuristic of A which is to be calculated again.

$$f(A-B) = g(B) + \text{updated}((h(B))) = 1+7=8$$

Step-3:

Comparing path of $f(A-B)$ and $f(A-C-D)$ it is seen that $f(A-C-D)$ is smaller. Hence $f(A-C-D)$ needs to be explored.

Now the current node becomes C node and the cost of the path is calculated,

$$f(C-G) = 1+2 = 3$$

$$f(C-H-I) = 1+0+1+0 = 2$$

$f(C-H-I)$ is chosen as minimum cost path, also there is no change in heuristic since it matches the actual cost. Heuristic of path of H and I are 0 and hence they are solved, but Path A-D also needs to be calculated, since it has an AND-arc.

$f(D-J) = 1+0 = 1$, hence heuristic of D needs to be updated to 1. And finally the $f(A-C-D)$ needs to be updated.

$$f(A-C-D) = g(C) + h(C) + g(D) + \text{updated}((h(D))) = 1+2+1+1 = 5.$$

ALGORITHM:

Step 1: Place the starting node into OPEN.

Step 2: Compute the most promising solution tree say T0.

Step 3: Select a node n that is both on OPEN and a member of T0. Remove it from OPEN and place it in CLOSE.

Step 4: If n is the terminal goal node then levelled n as solved and levelled all the ancestors of n as solved. If the starting node is marked as solved then success and exit.

Step 5: If n is not a solvable node, then mark n as unsolvable. If starting node is marked as unsolvable, then return failure and exit.

Step 6: Expand n. Find all its successors and find their h (n) value, push them into OPEN.

Step 7: Return to Step 2.

Step 8: Exit.

PROGRAM:

```
# Cost to find the AND and OR path def Cost(H, condition, weight = 1):
    cost = { }

    if 'AND' in condition:
        AND_nodes = condition['AND']

        Path_A = ' AND '.join(AND_nodes)

        PathA = sum(H[node]+weight for node in AND_nodes)
        cost[Path_A] = PathA

    if 'OR' in condition:
        OR_nodes = condition['OR']

        Path_B = ' OR '.join(OR_nodes)

        PathB = min(H[node]+weight for node in OR_nodes)
        cost[Path_B] = PathB
    return cost

# Update the cost def update_cost(H, Conditions, weight=1):
Main_nodes = list(Conditions.keys())
Main_nodes.reverse()
least_cost= { }
for key in Main_nodes:
    condition = Conditions[key]

    print(key,':', Conditions[key], '>>>', Cost(H, condition, weight))

    c = Cost(H, condition, weight)

    H[key] = min(c.values())

    least_cost[key] = Cost(H, condition, weight)

    return least_cost

# Print the shortest path def shortest_path(Start, Updated_cost, H):
    Path = Start

    if Start in Updated_cost.keys():

        Min_cost = min(Updated_cost[Start].values())
        key = list(Updated_cost[Start].keys())
        values = list(Updated_cost[Start].values())
```

```

        Index = values.index(Min_cost)

        # FIND MINIMUM PATH KEY
        Next = key[Index].split()

        # ADD TO PATH FOR OR PATH
        if len(Next) == 1:
            Start =Next[0]

            Path += '<--' +shortest_path(Start, Updated_cost, H)

        # ADD TO PATH FOR AND PATH
        else:
            Path += '<--(' +key[Index]+' ) '

            Start = Next[0]

            Path += '[' +shortest_path(Start, Updated_cost, H) + ' + '

            Start = Next[-1]

            Path += shortest_path(Start, Updated_cost, H) + ']'

    return Path

H = {'A': -1, 'B': 5, 'C': 2, 'D': 4, 'E': 7, 'F': 9, 'G': 3, 'H': 0, 'I':0, 'J':0}

Conditions = {
'A': {'OR': ['B'], 'AND': ['C', 'D']},
'B': {'OR': ['E', 'F']},
'C': {'OR': ['G'], 'AND': ['H', 'I']},
'D': {'OR': ['J']}
}

# weight weight = 1 # Updated cost print('Updated Cost :')
Updated_cost = update_cost(H, Conditions, weight=1)

print('*'*75) print('Shortest Path :\n',shortest_path('A', Updated_cost,H))

```

OUTPUT:

```
Updated Cost :
D : {'OR': ['J']} >>> {'J': 1}
C : {'OR': ['G'], 'AND': ['H', 'I']} >>> {'H AND I': 2, 'G': 4}
B : {'OR': ['E', 'F']} >>> {'E OR F': 8}
A : {'OR': ['B'], 'AND': ['C', 'D']} >>> {'C AND D': 5, 'B': 9}
*****
Shortest Path :
A<--(C AND D) [C<--(H AND I) [H + I] + D<--J]
```

PAAVAI ENGINEERING COLLEGE (Autonomous)		
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TOTAL	40	

RESULT:

AIM:

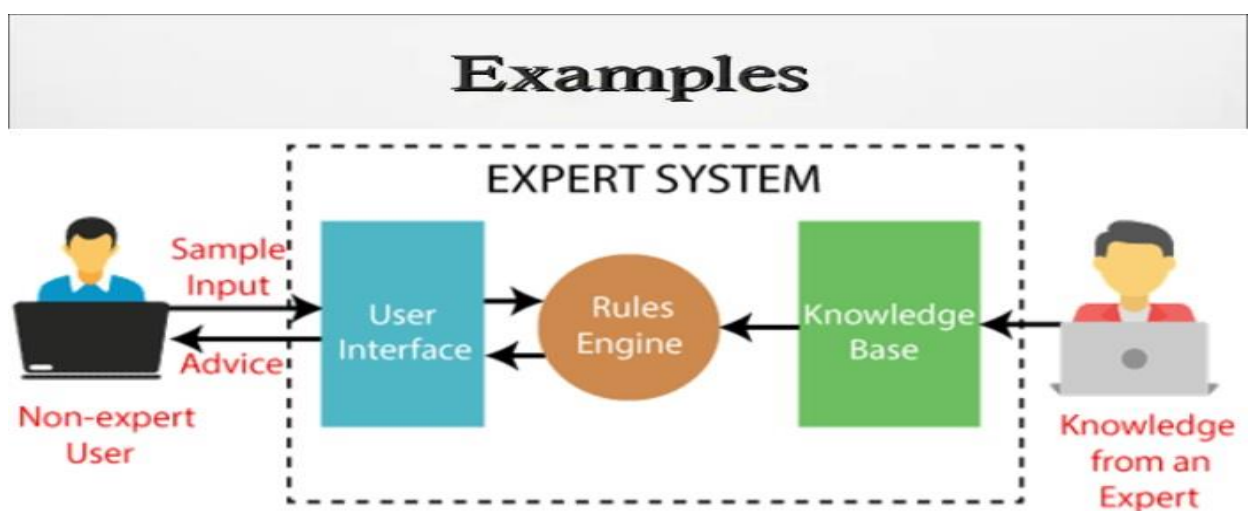
DESCRIPTION:

An expert system is a computer program that uses artificial intelligence (AI) technologies to simulate the judgment and behavior of a human or an organization that has expertise and experience in a particular field. Expert systems are usually intended to complement, not replace, human experts.

Modern expert knowledge systems use machine learning and artificial intelligence to simulate the behavior or judgment of domain experts. These systems can improve their performance over time as they gain more experience, just as humans do.

Expert systems accumulate experience and facts in a knowledge base and integrate them with an inference or rules engine -- a set of rules for applying the knowledge base to situations provided to the program.

EXAMPLES OF EXPERT SYSTEM:



APPLICATIONS OF EXPERT SYSTEM:

Expert System in Education : In the field of education, many of the expert system's application are embedded inside the Intelligent Tutoring System (ITS) by using techniques from adaptive hypertext and hypermedia.

Expert system in Agriculture : The expert system for agriculture is same as like other fields. Here also the expert system uses the rule based structure and the knowledge of a human expert is captured in the form of IF-THEN rules and facts which are used to solve problems by answering questions typed at a keyboard attached to a computer.

Other examples may be MYCIN, DENDRAL, and CALEX etc.

Expert System for a particular decision problem : The expert system can be used as a stand alone advisory system for the specific knowledge domain. It also can provide decision support for a high level human expert.

Expert System for Text Animation (ESTA) : The idea behind creating an expert system is that it can enable many people to benefit from the knowledge of one person – the expert. By providing it with a knowledge base for a certain subject area, ESTA can be used to create an expert system for the subject:

$$\text{ESTA} + \text{Knowledge base} = \text{Expert System}$$

IBM Watson : IBM is a **data analytics processor** that uses natural language processing, a technology that analyzes human speech for meaning and syntax. IBM Watson performs analytics on vast repositories of data that it processes to answer human-posed questions, often in a fraction of a second.

ALGORITHM:

Step 1: Start the program.

Step 2: Collect knowledge about the specific domain.

Step 3: Feed to the system.

Step 4: Practice Inference Engine to make decisions From Knowledge Base.

Step 5: Stop the process.

PROGRAM:

OUTPUT:

PAAVAI ENGINEERING COLLEGE (Autonomous)		
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RESULT: