Program 1: Vacuum Cleaner

```
#Vacuum Cleaner Problem
#Clean is 0 and Dirty is 1

def vacuumcleaner(rooms,n):
        i = 0
        j = 0
        clean = 0
        while(clean < n):
            if(rooms[i][j] == 1):
                print("Cell",i,j,"is dirty")
                print("Performing suck...")
                rooms[i][j] = 0
                clean = clean + 1
                print("Cell",i,j,"is clean")

            elif(rooms[i][j] == 0):
                clean = clean + 1
                print("Cell",i,j,"is already clean")

            if(j==0):
                j+=1
                print("Moving Right....")
            elif(j==1 and i==0):
                i+=1
                j=0
                print("Moving Down......")


if __name__ == "__main__":
    n = 4
    clean = 0
    rows = 2
    cols = 2
    rooms = []
    print("Enter the room matrix with one entry in each line:")
    for i in range(rows):
        a =[]
        for j in range(cols):
            a.append(int(input()))
        rooms.append(a)

    vacuumcleaner(rooms,n)
```

Output:

```
C:\Users\Admin\Downloads\1BM21CS259\AI>python vacuum.py
Enter the room matrix with one entry in each line:
1
0
1
0
Cell 0 0 is dirty
Performing suck...
Cell 0 0 is clean
Moving Right....
Cell 0 1 is already clean
Moving Down......
Cell 1 0 is dirty
Performing suck...
Cell 1 0 is clean
Moving Right....
Cell 1 1 is already clean
```

Program 2: 8 Puzzle Problem

```
# 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])):
```

```python
                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:

```
C:\Users\Admin\Downloads\1BM21CS259\AI>eightpuzzle.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
```

Program 3: Tic Tac Toe using Min-Max strategy

```
import random

def print_board(board):
    for row in board:
        print(" | ".join(row))
        print("---------")

def is_winner(board, player):
    # Check rows, columns, and diagonals for a win
    for row in board:
        if all(cell == player for cell in row):
            return True

    for col in range(3):
        if all(board[row][col] == player for row in range(3)):
            return True

    if all(board[i][i] == player for i in range(3)) or all(board[i][2 - i] == player for i in range(3)):
        return True

    return False

def is_board_full(board):
    return all(cell != " " for row in board for cell in row)

def get_empty_cells(board):
    return [(i, j) for i in range(3) for j in range(3) if board[i][j] == " "]

def minimax(board, depth, maximizing_player):
    if is_winner(board, "X"):
        return -1
    elif is_winner(board, "O"):
        return 1
    elif is_board_full(board):
        return 0

    if maximizing_player:
        max_eval = float('-inf')
        for i, j in get_empty_cells(board):
            board[i][j] = "O"
            eval = minimax(board, depth + 1, False)
            board[i][j] = " "
```

```
            max_eval = max(max_eval, eval)
        return max_eval
    else:
        min_eval = float('inf')
        for i, j in get_empty_cells(board):
            board[i][j] = "X"
            eval = minimax(board, depth + 1, True)
            board[i][j] = " "
            min_eval = min(min_eval, eval)
        return min_eval

def best_move(board):
    best_val = float('-inf')
    best_move = None
    for i, j in get_empty_cells(board):
        board[i][j] = "O"
        move_val = minimax(board, 0, False)
        board[i][j] = " "
        if move_val > best_val:
            best_move = (i, j)
            best_val = move_val
    return best_move

def play_tic_tac_toe():
    board = [[" " for _ in range(3)] for _ in range(3)]
    player_turn = True

    print_board(board)

    while True:
        if player_turn:
            row = int(input("Enter the row (0, 1, or 2): "))
            col = int(input("Enter the column (0, 1, or 2): "))
            if board[row][col] == " ":
                board[row][col] = "X"
                player_turn = False
            else:
                print("Cell already taken. Try again.")
                continue
        else:
            print("Computer's turn:")
            move = best_move(board)
            board[move[0]][move[1]] = "O"
            player_turn = True
```

```
        print_board(board)

        if is_winner(board, "X"):
            print("Congratulations! You win!")
            break
        elif is_winner(board, "O"):
            print("Computer wins! Better luck next time.")
            break
        elif is_board_full(board):
            print("It's a tie!")
            break

if __name__ == "__main__":
    play_tic_tac_toe()
```

Output:

Program 4: Iterative Deepening Depth First Search

```
from collections import defaultdict
import networkx as nx
import matplotlib.pyplot as plt

class Graph:

    def __init__(self,vertices):

        self.V = vertices
        self.graph = defaultdict(list)
    def addEdge(self,u,v):
        self.graph[u].append(v)

    def DLS(self,src,target,maxDepth):
        if src == target : return True

        if maxDepth <= 0 : return False


        for i in self.graph[src]:
                if(self.DLS(i,target,maxDepth-1)):
                    return True
        return False

    def IDDFS(self,src, target, maxDepth):

        for i in range(maxDepth):
            if (self.DLS(src, target, i)):
                return True
        return False

g = Graph (7);
g.addEdge(0, 1)
g.addEdge(0, 2)
g.addEdge(1, 3)
g.addEdge(1, 4)
g.addEdge(2, 5)
g.addEdge(2, 6)

G = nx.DiGraph()
G.add_edges_from(
  [('A', 'B'), ('A', 'C'), ('B', 'D'), ('B', 'E'), ('C', 'F'), ('C', 'G')])
```

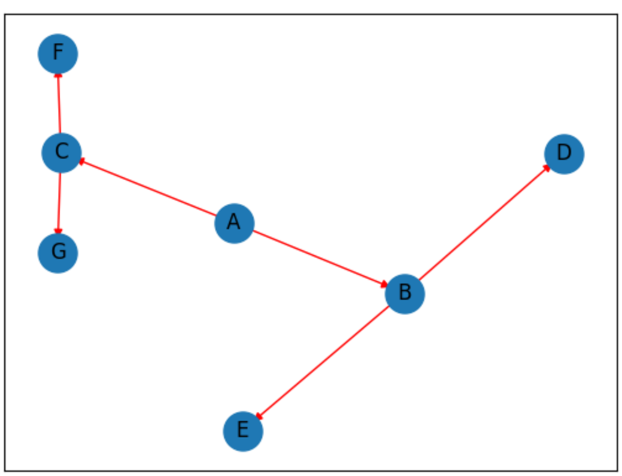
```
pos = nx.spring_layout(G)
nx.draw_networkx_nodes(G, pos, cmap=plt.get_cmap('jet'), node_size = 500)
nx.draw_networkx_labels(G, pos)
nx.draw_networkx_edges(G, pos, edge_color='r', arrows=True)


target = 6; maxDepth = 3; src = 0
target = int(input(("Enter the target:")))
maxDepth = int(input(("Enter the max depth:")))
src = int(input(("Enter the source:")))

if g.IDDFS(src, target, maxDepth) == True:
	print ("Target is reachable from source " + str(src) + " within max depth")
else :
	print ("Target is NOT reachable from source " + str(src) + " within max depth")
plt.show()
```

Output

```
C:\Users\Admin\Downloads\1BM21CS259\AI>d.py
C:\Users\Admin\AppData\Local\Programs\Python\Python312\Lib\site-packages\networkx\drawing\nx_pylab.py:437: UserWarning:
No data for colormapping provided via 'c'. Parameters 'cmap' will be ignored
  node_collection = ax.scatter(
Enter the target:4
Enter the max depth:3
Enter the source:0
Target is reachable from source 0 within max depth
```



Program 5: A* Search

Input: Graph (G), Heuristic values (H), Start node (S), Goal node (G)

1. Initialize the open set with the start node: open_set = [(H[S], S)]
2. Initialize the closed set: closed_set = set()
3. Initialize g-values and f-values for all nodes with infinity: g_values = {node: inf for node in G}, f_values = {node: inf for node in G}
4. Set g-value for the start node to 0: g_values[S] = 0
5. Set f-value for the start node using the heuristic: f_values[S] = H[S]
6. Initialize came_from dictionary: came_from = {node: None for node in G}

7. While the open set is not empty:
   a. Pop the node with the lowest f-value from the open set: current_node = pop_node(open_set)
   b. If current_node is the goal node, reconstruct and return the path
   c. Add current_node to the closed set

   d. For each neighbor of current_node:
      i. If the neighbor is in the closed set, skip to the next neighbor
      ii. Calculate tentative g-value: tentative_g = g_values[current_node] + cost(current_node, neighbor)
      iii. If tentative_g is less than g_values[neighbor]:
         - Update g_values[neighbor] with tentative_g
         - Update f_values[neighbor] with tentative_g + H[neighbor]
         - Add (f_values[neighbor], neighbor) to the open set
         - Update came_from[neighbor] with current_node

8. If the open set becomes empty, no path is found. Return None.

9. Reconstruct and return the path using the came_from dictionary.

Function pop_node(open_set):
   Implement a function to pop the node with the lowest f-value from the open set (heap or other suitable data structure).

Function cost(current_node, neighbor):
   Implement a function to return the cost of moving from current_node to neighbor.

Program

```
import heapq

def astar(graph, heuristic, start, goal):
    came_from = {node: None for node in graph}

    open_set = [(0, start)]  # Priority queue with (f, node)
    closed_set = set()
    g_values = {node: float('inf') for node in graph}
    g_values[start] = 0
    f_values = {node: float('inf') for node in graph}
    f_values[start] = heuristic[start]

    while open_set:
        current_f, current_node = heapq.heappop(open_set)

        if current_node == goal:
            path = reconstruct_path(came_from, start, goal)
            return path

        closed_set.add(current_node)

        for neighbor, cost in graph[current_node]:
            if neighbor in closed_set:
                continue

            tentative_g = g_values[current_node] + cost

            if tentative_g < g_values[neighbor]:
                g_values[neighbor] = tentative_g
                f_values[neighbor] = tentative_g + heuristic[neighbor]
                heapq.heappush(open_set, (f_values[neighbor], neighbor))

    return None  # No path found

def reconstruct_path(came_from, start, goal):
    path = [goal]
    while goal != start:
        goal = came_from[goal]
        if goal is None:
            break  # To handle cases where there is no valid path
        path.append(goal)
    return path[::-1]
```

```
# Example usage:
n = int(input("Enter the number of nodes: "))
m = int(input("Enter the number of edges: "))

graph = {i: [] for i in range(n)}
heuristic = {}

for _ in range(m):
    src, dest, cost = map(int, input("Enter edge (source destination cost): ").split())
    graph[src].append((dest, cost))

for i in range(n):
    heuristic[i] = int(input(f"Enter heuristic value for node {i}: "))

s = int(input("Enter source node: "))
d = int(input("Enter destination node: "))

path = astar(graph, heuristic, s, d)

if path:
    print(f"Shortest path from {s} to {d}: {path}")
else:
    print(f"No path found from {s} to {d}.")
```

```
PS C:\Users\Admin\Desktop\1BM22CS096> python -u "c:\Users\Admin\Desktop\1BM22CS096\m.py"
Enter the number of nodes: 3
Enter the number of edges: 2
Enter edge (source destination cost): 0 1 2
Enter edge (source destination cost): 1 2 3
Enter heuristic value for node 0: 2
Enter heuristic value for node 1: 3
Enter heuristic value for node 2: 6
Enter source node: 0
Enter destination node: 2
Shortest path from 0 to 2: [2]
PS C:\Users\Admin\Desktop\1BM22CS096>
```

Program 6: Simulated Annealing Algorithm

```
function simulated_annealing_tsp(distances, initial_tour, initial_temperature, cooling_rate,
max_iterations):
    current_tour = initial_tour
    best_tour = current_tour

    for iteration in range(max_iterations):
        temperature = initial_temperature * (cooling_rate**iteration)

        neighbor_tour = generate_neighbor(current_tour)
        current_distance = total_distance(current_tour, distances)
        neighbor_distance = total_distance(neighbor_tour, distances)

        if neighbor_distance < current_distance or random.uniform(0, 1) < exp((current_distance -
neighbor_distance) / temperature):
            current_tour = neighbor_tour

        if total_distance(neighbor_tour, distances) < total_distance(best_tour, distances):
            best_tour = neighbor_tour

    return best_tour

function generate_neighbor(tour):
    tour_copy = copy(tour)
    i, j = random.sample(range(length(tour)), 2)
    tour_copy[i], tour_copy[j] = tour_copy[j], tour_copy[i]
    return tour_copy

function total_distance(tour, distances):
    total = 0
    for i from 0 to length(tour) - 2:
        total += distances[tour[i]][tour[i + 1]]
    total += distances[tour[-1]][tour[0]]  // Return to the starting point
    return total
```

Program

```
import math
import random

def euclidean_distance(point1, point2):
    """Calculate Euclidean distance between two points."""
```

```
    return math.sqrt((point1[0] - point2[0])**2 + (point1[1] - point2[1])**2)

def total_distance(tour, distances):
    """Calculate the total distance of a tour."""
    total = 0
    for i in range(len(tour) - 1):
        total += distances[tour[i]][tour[i + 1]]
    total += distances[tour[-1]][tour[0]]  # Return to the starting point
    return total

def generate_neighbor(tour):
    """Generate a neighboring tour by swapping two random cities."""
    tour_copy = tour.copy()
    i, j = random.sample(range(len(tour)), 2)
    tour_copy[i], tour_copy[j] = tour_copy[j], tour_copy[i]
    return tour_copy

def simulated_annealing_tsp(distances, initial_tour, initial_temperature, cooling_rate,
max_iterations):
    current_tour = initial_tour
    best_tour = current_tour

    for iteration in range(max_iterations):
        temperature = initial_temperature * (cooling_rate**iteration)

        neighbor_tour = generate_neighbor(current_tour)
        current_distance = total_distance(current_tour, distances)
        neighbor_distance = total_distance(neighbor_tour, distances)

        if neighbor_distance < current_distance or random.uniform(0, 1) <
math.exp((current_distance - neighbor_distance) / temperature):
            current_tour = neighbor_tour

        if total_distance(neighbor_tour, distances) < total_distance(best_tour, distances):
            best_tour = neighbor_tour

    return best_tour

# Example Usage:

# Define cities and their coordinates
cities = {
    'A': (0, 0),
    'B': (1, 2),
```

```
    'C': (3, 1),
    'D': (5, 2),
    'E': (6, 0)
}

# Calculate distances between cities
distances = {city1: {city2: euclidean_distance(cities[city1], cities[city2]) for city2 in cities} for city1 in cities}

# Initial tour (can be random or a predefined order)
initial_tour = list(cities.keys())

# Input parameters from the user
initial_temperature = float(input("Enter the initial temperature: "))
cooling_rate = float(input("Enter the cooling rate: "))
max_iterations = int(input("Enter the maximum number of iterations: "))

# Run simulated annealing for TSP
best_tour = simulated_annealing_tsp(distances, initial_tour, initial_temperature, cooling_rate, max_iterations)

# Print the best tour and its total distance
print("Best Tour:", best_tour)
print("Total Distance:", total_distance(best_tour, distances))
```

```
PS C:\Users\Admin\Desktop\1BM22CS096> python -u "c:\Users\Admin\Desktop\1BM22CS096\m.py"
Enter the initial temperature: 1000
Enter the cooling rate: 0.95
Enter the maximum number of iterations: 1000
Best Tour: ['E', 'D', 'B', 'A', 'C']
Total Distance: 14.79669127533634
PS C:\Users\Admin\Desktop\1BM22CS096>
```

Program 6: Create a knowledge base using propositional logic and show that the given query entails the knowledge base or not.

//Truth Table Approach

```
from itertools import product

def is_entailed(knowledge_base, query):
    symbols = set()
    symbols.update(*(clause.free_symbols for clause in knowledge_base))
    symbols.update(query.free_symbols)

    truth_table = list(product([False, True], repeat=len(symbols)))

    for assignment in truth_table:
        assignment_dict = dict(zip(symbols, assignment))

        kb_eval = all(clause.subs(assignment_dict) for clause in knowledge_base)
        query_eval = query.subs(assignment_dict)

        if kb_eval and not query_eval:
            return False

    return True

if __name__ == "__main__":
    from sympy import symbols, Implies, Not

    # Define symbols
    R, W, G = symbols('R W G')

    # Knowledge base
    knowledge_base = [
        Implies(R, W),
        Implies(W, G)
    ]

    # Query
    query = Implies(R, G)

    # Check if the query is entailed by the knowledge base using truth table
    entailed = is_entailed(knowledge_base, query)

    # Output result
```

```
 print("knowledge_base:")
  print(knowledge_base)
  print("query:")
  print(query)

if entailed:
      print("The query is entailed by the knowledge base.")
  else:
      print("The query is not entailed by the knowledge base.")
```

Output

```
PS C:\Users\Admin\Desktop\1BM22CS096> python -u "c:\Users\Admin\Desktop\1BM22CS096\m.py"
knowledge_base:
[Implies(R, W), Implies(W, G)]
query:
Implies(W, R)
The query is not entailed by the knowledge base.
PS C:\Users\Admin\Desktop\1BM22CS096>
```

```
PS C:\Users\Admin\Desktop\1BM22CS096> python -u "c:\Users\Admin\Desktop\1BM22CS096\m.py"
knowledge_base:
[Implies(R, W), Implies(W, G)]
query:
Implies(R, G)
The query is entailed by the knowledge base.
PS C:\Users\Admin\Desktop\1BM22CS096>
```

Program 7: Create a knowledge base using propositional logic and show that the given query entails the knowledge base or not.

```
from sympy import symbols, Or, Not, Implies, satisfiable

def resolution(kb, query):
    symbols = set()
    symbols.update(*(clause.free_symbols for clause in kb))
    symbols.update(query.free_symbols)

    # Convert to CNF
    cnf_kb = And(*kb)
    cnf_query = And(Not(query))

    # Negate the query and add it to the knowledge base
    extended_kb = And(cnf_kb, cnf_query)

    # Check for satisfiability (contradiction)
    return not satisfiable(extended_kb)

if __name__ == "__main__":
    # Define symbols
    P, Q, R, S = symbols('P Q R S')

    # Knowledge base
    kb = [
        Or(P, Q),
        Or(Not(P), R),
        Or(Not(Q), S),
        Or(Not(R), Not(S))
    ]

    # Query
    query = Not(P)

    # Check if the query is proven by the knowledge base using resolution
    proven = resolution(kb, query)
    print("knowledge_base:")
    print(kb)
    print("query:")
    print(query)

    # Output result
    if proven:
```

```python
    print("The query is proven by the knowledge base using resolution.")
else:
    print("The query is not proven by the knowledge base using resolution.")
```

```
PS C:\Users\Admin\Desktop\1BM22CS096> python -u "c:\Users\Admin\Desktop\1BM22CS096\m.py"
knowledge_base:
[P | Q, R | ~P, S | ~Q, ~R | ~S]
query:
~P
The query is not proven by the knowledge base using resolution.
```

```
PS C:\Users\Admin\Desktop\1BM22CS096> python -u "c:\Users\Admin\Desktop\1BM22CS096\m.py"
knowledge_base:
[P | Q, R | ~P, S | ~Q, ~R | ~S]
query:
P | S
The query is proven by the knowledge base using resolution.
PS C:\Users\Admin\Desktop\1BM22CS096>
```

Program 8: Implement unification in first order logic.