VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

Artificial Intelligence (23CS5PCAIN)

Submitted by

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in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
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B.M.S. College of Engineering,
Bull Temple Road, Bangalore 560019
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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Artificial Intelligence (23CS5PCAIN)" carried out by **SriKrishna Pejathaya P S (1BM22CS290),** who is a bonafide student of **B.M.S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum. The Lab report has been approved as it satisfies the academic requirements in respect of an Artificial Intelligence (23CS5PCAIN) work prescribed for the said degree.

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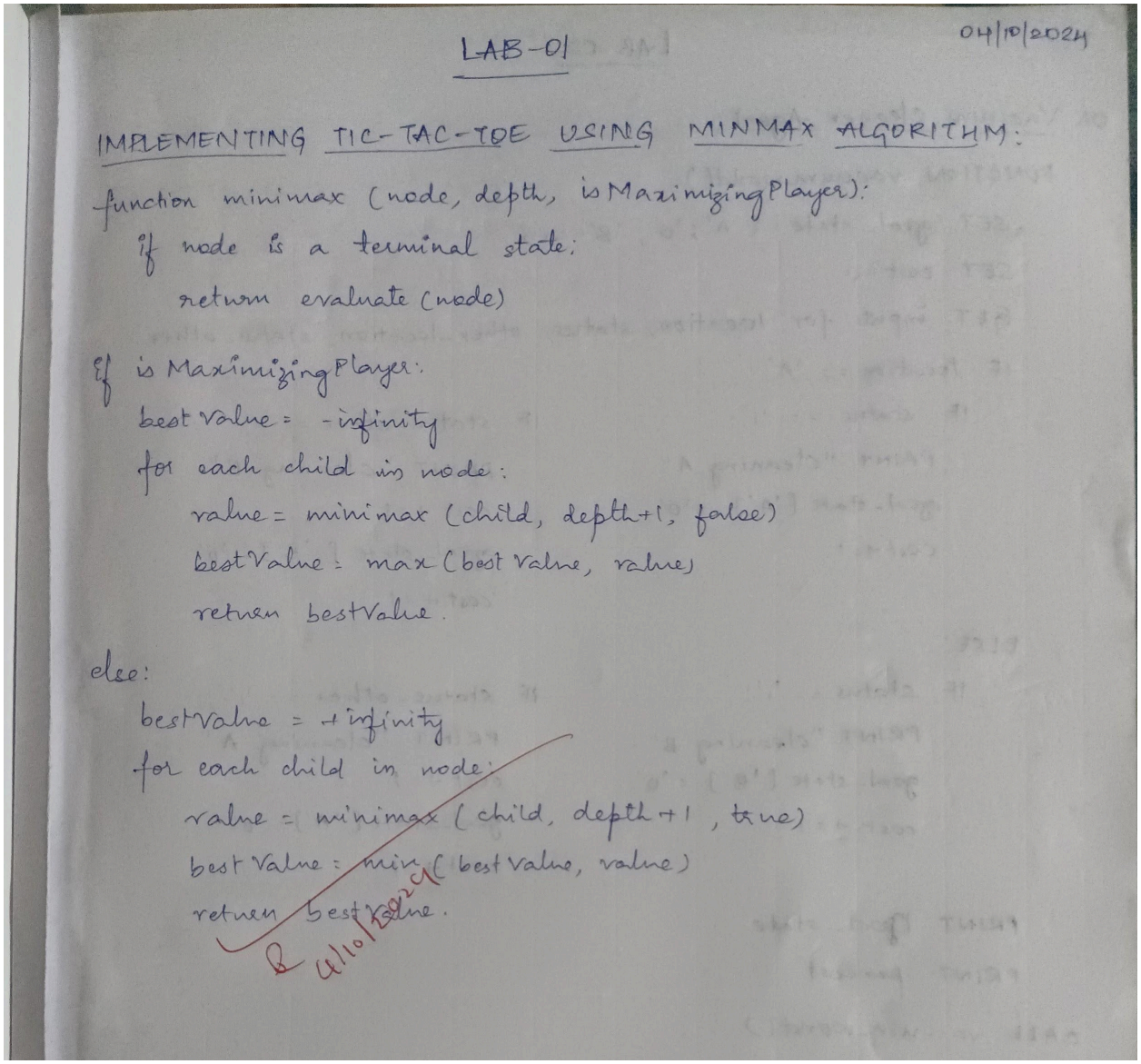
Github Link:
AI Lab Github Link

1. a) Implement Tic-Tac-Toe Game.

Algorithm:



LAB-01

04/10/2024

IMPLEMENTING TIC-TAC-TOE USING MINMAX ALGORITHM:

```
function minimax (node, depth, isMaximizingPlayer):
    if node is a terminal state:
        return evaluate (node)

If is MaximizingPlayer:
    best value = -infinity
    for each child in node:
        value = minimax (child, depth+1, false)
        bestValue = max (best value, value)
        retuen bestValue.

else:
    bestValue = +infinity
    for each child in node:
        value = minimax (child, depth+1, true)
        best Value = min (best value, value)
        retuen bestValue.
```

4/10/2024

Code:

```
board = {1: ' ', 2: ' ', 3: ' ',
        4: ' ', 5: ' ', 6: ' ',
        7: ' ', 8: ' ', 9: ' '}

output_printed = False

def printBoard(board):
    global output_printed
    if not output_printed:
```

```
        print('Output: 1BM22CS290')
        output_printed = True
    print(board[1] + '|' + board[2] + '|' + board[3])
    print('-+-+-')
    print(board[4] + '|' + board[5] + '|' + board[6])
    print('-+-+-')
    print(board[7] + '|' + board[8] + '|' + board[9])
    print('\n')

def spaceFree(pos):
    return board[pos] == ' '

def checkWin():
    win_conditions = [(1, 2, 3), (4, 5, 6), (7, 8, 9),  # Horizontal
                      (1, 4, 7), (2, 5, 8), (3, 6, 9),  # Vertical
                      (1, 5, 9), (3, 5, 7)]             # Diagonal
    for a, b, c in win_conditions:
        if board[a] == board[b] == board[c] and board[a] != ' ':
            return True
    return False

def checkMoveForWin(move):
    win_conditions = [(1, 2, 3), (4, 5, 6), (7, 8, 9),  # Horizontal
                      (1, 4, 7), (2, 5, 8), (3, 6, 9),  # Vertical
                      (1, 5, 9), (3, 5, 7)]             # Diagonal
    for a, b, c in win_conditions:
        if board[a] == board[b] == board[c] and board[a] == move:
            return True
    return False

def checkDraw():
    return all(board[key] != ' ' for key in board.keys())

def insertLetter(letter, position):
    if spaceFree(position):
        board[position] = letter
        printBoard(board)

        if checkWin():
            if letter == 'X':
                print('Bot wins!')
            else:
                print('You win!')
            return True
        elif checkDraw():
            print('Draw!')
```

```
            return True
        else:
            print('Position taken, please pick a different position.')
            position = int(input('Enter new position: '))
            return insertLetter(letter, position)

        return False

player = 'O'
bot = 'X'

def playerMove():
    position = int(input('Enter position for O: '))
    return insertLetter(player, position)

def compMove():
    bestScore = -1000
    bestMove = 0
    for key in board.keys():
        if board[key] == ' ':
            board[key] = bot
            score = minimax(board, False)
            board[key] = ' '
            if score > bestScore:
                bestScore = score
                bestMove = key

    return insertLetter(bot, bestMove)

def minimax(board, isMaximizing):
    if checkMoveForWin(bot):
        return 1
    elif checkMoveForWin(player):
        return -1
    elif checkDraw():
        return 0

    if isMaximizing:
        bestScore = -1000
        for key in board.keys():
            if board[key] == ' ':
                board[key] = bot
                score = minimax(board, False)
                board[key] = ' '
                bestScore = max(score, bestScore)
        return bestScore
```

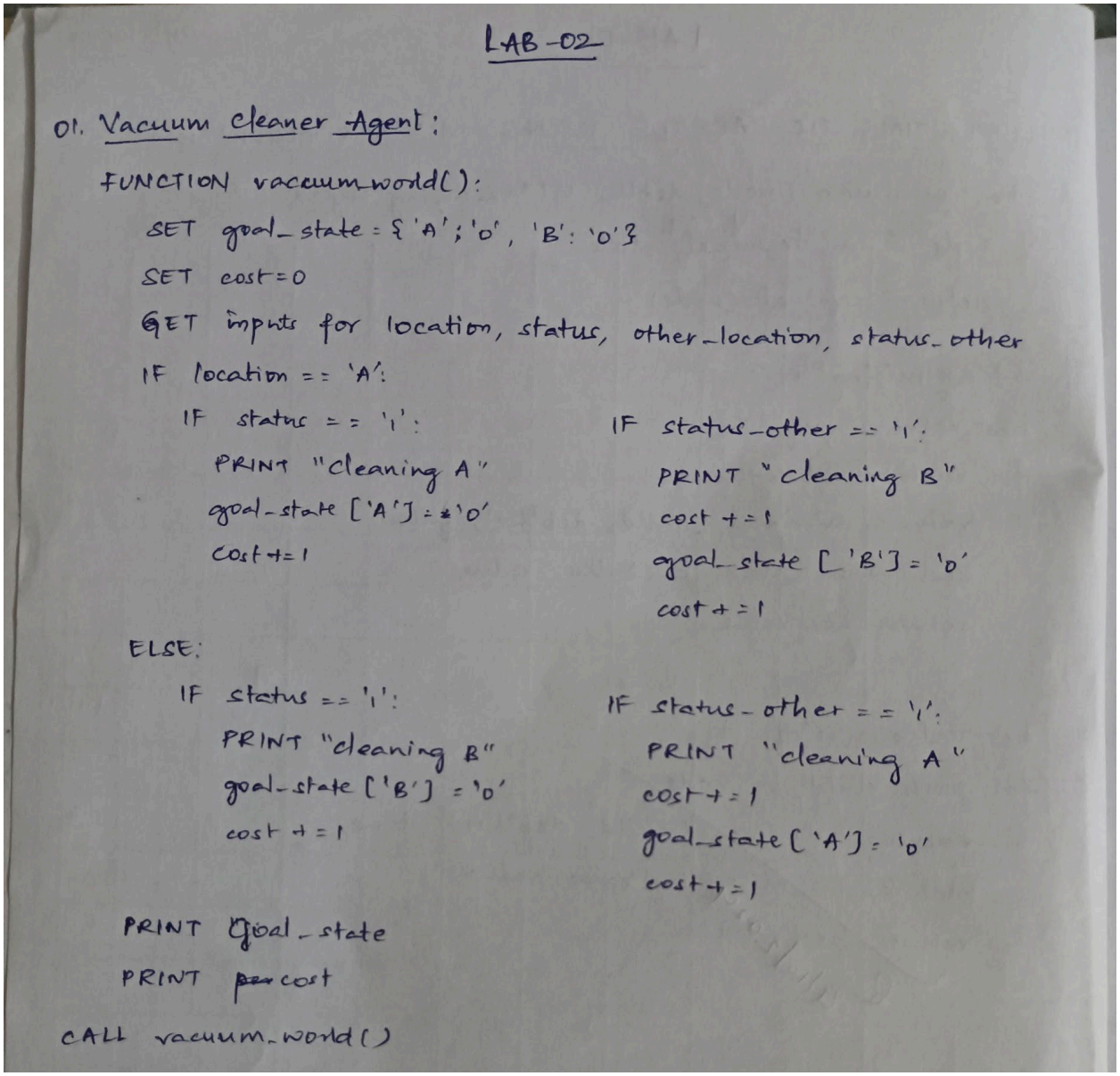
```
    else:
        bestScore = 1000
        for key in board.keys():
            if board[key] == ' ':
                board[key] = player
                score = minimax(board, True)
                board[key] = ' '
                bestScore = min(score, bestScore)
        return bestScore

game_over = False
while not game_over:
    game_over = compMove()
    if not game_over:
        game_over = playerMove()
```

Output:

```
Output: 1BM22CS290
X| |
-+-+-
 | |
-+-+-
 | |

Enter position for O: 5
X| |
-+-+-
 |O|
-+-+-
 | |

X|X|
-+-+-
 |O|
-+-+-
 | |

Enter position for O: 3
X|X|O
-+-+-
 |O|
-+-+-
 | |

X|X|O
-+-+-
 |O|
-+-+-
X| |

Enter position for O: 4
X|X|O
-+-+-
O|O|
-+-+-
X| |

X|X|O
-+-+-
O|O|X
-+-+-
X| |

Enter position for O: 7
Position taken, please pick a different position.
Enter new position: 8
X|X|O
-+-+-
O|O|X
-+-+-
X|O|

X|X|O
-+-+-
O|O|X
-+-+-
X|O|X

Draw!
```

b) Implement Vacuum Cleaner Agent.

Algorithm:



LAB-02

01. Vacuum cleaner Agent:

FUNCTION vacuum_world():
SET goal_state = {'A':'0', 'B':'0'}
SET cost=0
GET inputs for location, status, other_location, status_other
IF location == 'A':
IF status == '1':
PRINT "cleaning A"
goal_state ['A'] = '0'
cost+=1
IF status_other == '1':
PRINT "cleaning B"
cost += 1
goal_state ['B'] = '0'
cost += 1
ELSE:
IF status == '1':
PRINT "cleaning B"
goal_state ['B'] = '0'
cost += 1
IF status_other == '1':
PRINT "cleaning A"
cost += 1
goal_state ['A'] = '0'
cost += 1
PRINT goal_state
PRINT cost
CALL vacuum_world()

Code:

```
def vacuum_world():
    goal_state = {'A': '0', 'B': '0'}
    cost = 0
    location_input = input("Enter Location of Vacuum (A or B): ").strip().upper()
    status_input = input(f"Enter status of A (0 for Clean, 1 for Dirty): ").strip()
    status_input_complement = input("Enter status of B (0 for Clean, 1 for Dirty): ").strip()

    print("Initial Location Condition: " + str(goal_state))
```

```
if location_input == 'A':
    print("Vacuum is placed in Location A")
    if status_input == '1':
        print("Location A is Dirty.")
        goal_state['A'] = '0'
        cost += 1
        print("Cost for cleaning A: " + str(cost))
        print("Location A has been Cleaned.")

        if status_input_complement == '1':
            print("Location B is Dirty.")
            print("Moving right to Location B.")
            cost += 1
            print("Cost for moving RIGHT: " + str(cost))
            goal_state['B'] = '0'
            cost += 1
            print("Cost for suck: " + str(cost))
            print("Location B has been Cleaned.")
        else:
            print("Location B is already clean.")
    else:
        print("Location A is already clean.")
        if status_input_complement == '1':
            print("Location B is Dirty.")
            print("Moving RIGHT to Location B.")
            cost += 1
            print("Cost for moving RIGHT: " + str(cost))
            goal_state['B'] = '0'
            cost += 1
            print("Cost for suck: " + str(cost))
            print("Location B has been Cleaned.")
        else:
            print("Location B is already clean.")

elif location_input == 'B':
    print("Vacuum is placed in Location B")
    if status_input == '1':
        print("Location B is Dirty.")
        goal_state['B'] = '0'  # Clean B
        cost += 1  # Cost for sucking
        print("Cost for cleaning B: " + str(cost))
        print("Location B has been Cleaned.")

        if status_input_complement == '1':
            print("Location A is Dirty.")
            print("Moving LEFT to Location A.")
```

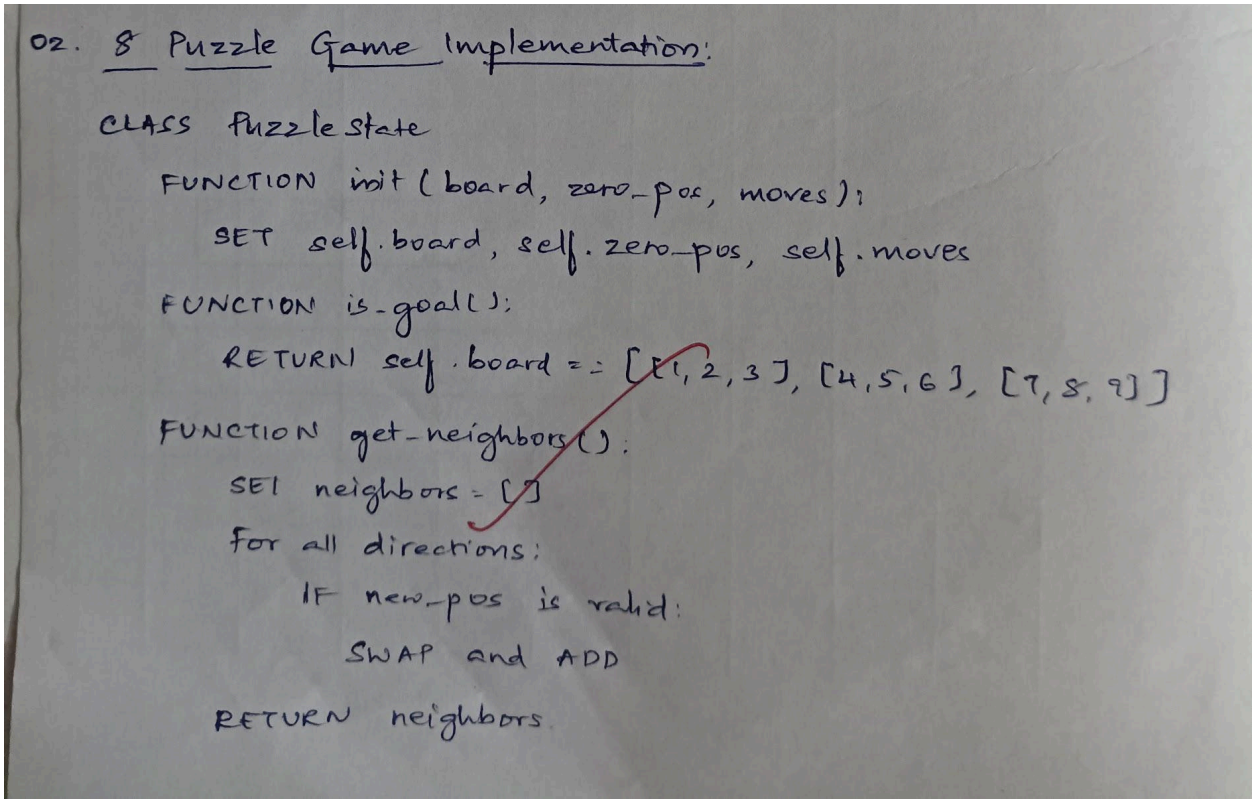
```
            cost += 1  # Cost for moving left
            print("Cost for moving LEFT: " + str(cost))
            goal_state['A'] = '0'
            cost += 1
            print("Cost for suck: " + str(cost))
            print("Location A has been Cleaned.")
        else:
            print("Location A is already clean.")
    else:
        print("Location B is already clean.")
        if status_input_complement == '1':
            print("Location A is Dirty.")
            print("Moving LEFT to Location A.")
            cost += 1
            print("Cost for moving LEFT: " + str(cost))
            goal_state['A'] = '0'
            cost += 1
            print("Cost for suck: " + str(cost))
            print("Location A has been Cleaned.")
        else:
            print("Location A is already clean.")
  print("GOAL STATE: ")
  print(goal_state)
  print("Performance Measurement: " + str(cost))
vacuum_world()
print("-------------------------")
print("Output: 1BM22CS290")
```

Output:

```
Enter Location of Vacuum (A or B): A
Enter status of A (0 for Clean, 1 for Dirty): 0
Enter status of B (0 for Clean, 1 for Dirty): 1
Initial Location Condition: {'A': '0', 'B': '0'}
Vacuum is placed in Location A
Location A is already clean.
Location B is Dirty.
Moving RIGHT to Location B.
Cost for moving RIGHT: 1
Cost for suck: 2
Location B has been Cleaned.
GOAL STATE:
{'A': '0', 'B': '0'}
Performance Measurement: 2
-------------------------
Output: 1BM22CS290
```

2. a) Implement 8 puzzle problems using Depth First Search (DFS).

Algorithm:



02. 8 Puzzle Game Implementation:

CLASS Puzzle state

FUNCTION init (board, zero_pos, moves):

SET self.board, self.zero_pos, self.moves

FUNCTION is_goal():

RETURN self.board == [[1, 2, 3], [4, 5, 6], [7, 8, 9]]

FUNCTION get_neighbors():

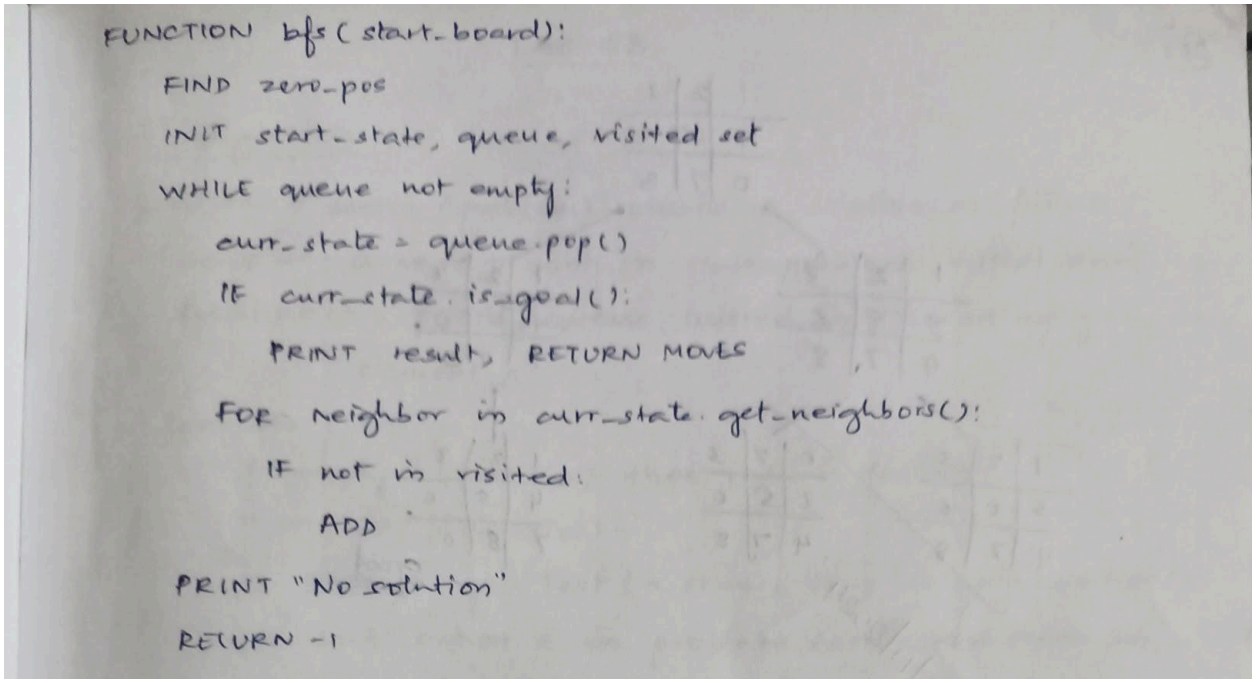
SET neighbors = []

For all directions:

IF new_pos is valid:

SWAP and ADD

RETURN neighbors



FUNCTION bfs (start_board):

FIND zero_pos

INIT start_state, queue, visited set

WHILE queue not empty:

curr_state = queue.pop()

IF curr_state.is_goal():

PRINT result, RETURN MOVES

FOR neighbor in curr_state.get_neighbors():

IF not in visited:

ADD

PRINT "No solution"

RETURN -1

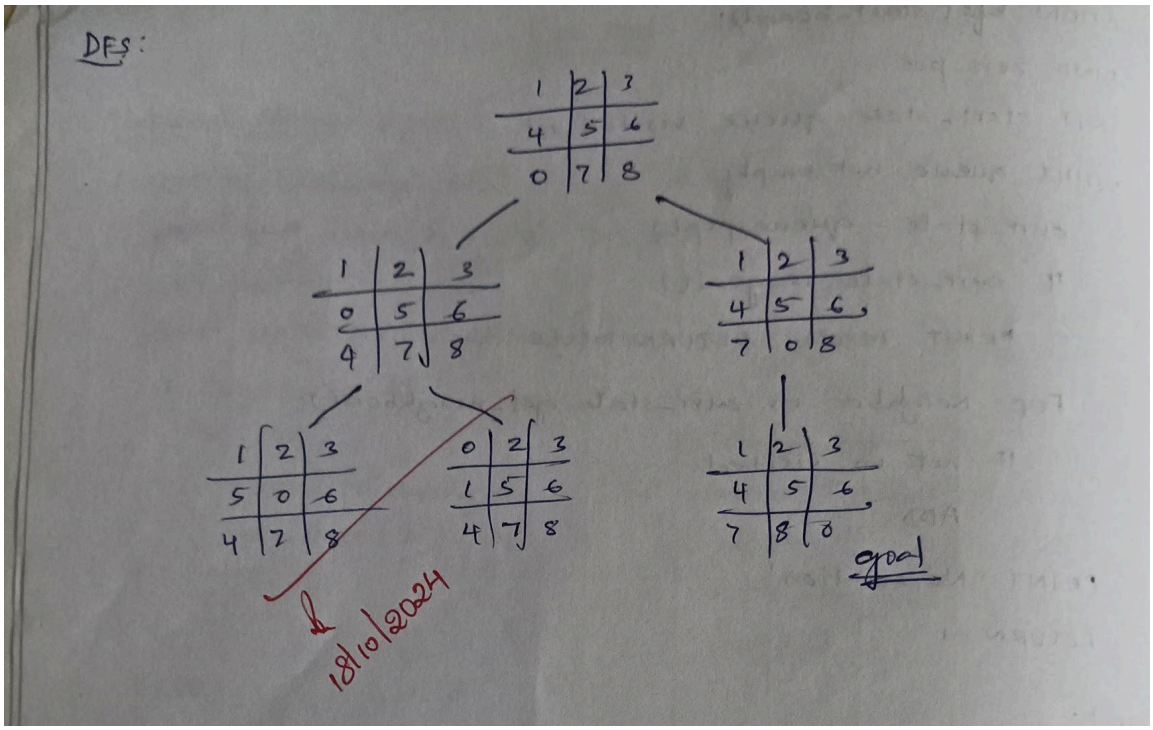
Code:

```
from collections import deque

def is_solvable(state):
    inv_count = 0
    state_flat = [tile for row in state for tile in row if tile != 0]
    for i in range(len(state_flat)):
        for j in range(i + 1, len(state_flat)):
            if state_flat[i] > state_flat[j]:
                inv_count += 1
    return inv_count % 2 == 0

def find_blank(state):
    for i, row in enumerate(state):
        for j, val in enumerate(row):
            if val == 0:
                return i, j

def get_neighbors(state):
    neighbors = []
    blank_i, blank_j = find_blank(state)
    directions = [(0, 1), (1, 0), (0, -1), (-1, 0)]
    for di, dj in directions:
        new_i, new_j = blank_i + di, blank_j + dj
        if 0 <= new_i < 3 and 0 <= new_j < 3:
            new_state = [row[:] for row in state]
                new_state[blank_i][blank_j], new_state[new_i][new_j] = new_state[new_i][new_j],
new_state[blank_i][blank_j]
            neighbors.append(new_state)
    return neighbors

def dfs(initial_state, goal_state):
    stack = [(initial_state, [])]
    visited = set()
    while stack:
        state, path = stack.pop()
        state_tuple = tuple(tuple(row) for row in state)
        if state_tuple in visited:
            continue
        visited.add(state_tuple)
        if state == goal_state:
            return path + [state]
        for neighbor in get_neighbors(state):
            stack.append((neighbor, path + [state]))
    return None

def bfs(initial_state, goal_state):
```

```
    queue = deque([(initial_state, [])])
    visited = set()
    while queue:
        state, path = queue.popleft()
        state_tuple = tuple(tuple(row) for row in state)
        if state_tuple in visited:
            continue
        visited.add(state_tuple)
        if state == goal_state:
            return path + [state]
        for neighbor in get_neighbors(state):
            queue.append((neighbor, path + [state]))
    return None

def display_path(path):
    for step, state in enumerate(path):
        print(f"Step {step}:")
        for row in state:
            print(row)
        print()

if __name__ == "__main__":
    print("Output: 1BM22CS290")
    print("Enter the initial state (3x3 grid, 0 for blank):")
    initial_state = [list(map(int, input().split())) for _ in range(3)]
    print("Enter the goal state (3x3 grid, 0 for blank):")
    goal_state = [list(map(int, input().split())) for _ in range(3)]
    if not is_solvable(initial_state):
        print("The given puzzle is not solvable.")
    else:
        print("Choose the method to solve the puzzle:")
        print("1. Depth-First Search (DFS)")
        print("2. Breadth-First Search (BFS)")
        choice = int(input("Enter your choice (1 or 2): "))
        match choice:
            case 1:
                print("Solving using DFS...")
                dfs_solution = dfs(initial_state, goal_state)
                if dfs_solution:
                    display_path(dfs_solution)
                else:
                    print("No solution found using DFS.")

            case 2:
                print("Solving using BFS...")
                bfs_solution = bfs(initial_state, goal_state)
```

```
        if bfs_solution:
            display_path(bfs_solution)
        else:
            print("No solution found using BFS.")
    case _:
        print("Invalid choice. Please select 1 or 2.")
```

Output:



Output:

Initial board:

1 2 3

4 0 6

7 5 8

Goal reached in 2 moves.

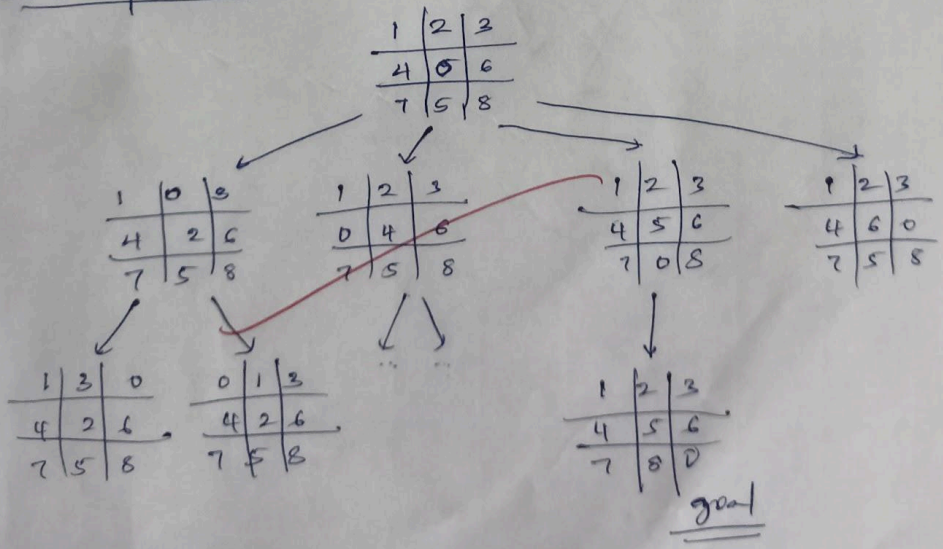
Solution:

1 2 3

4 5 6

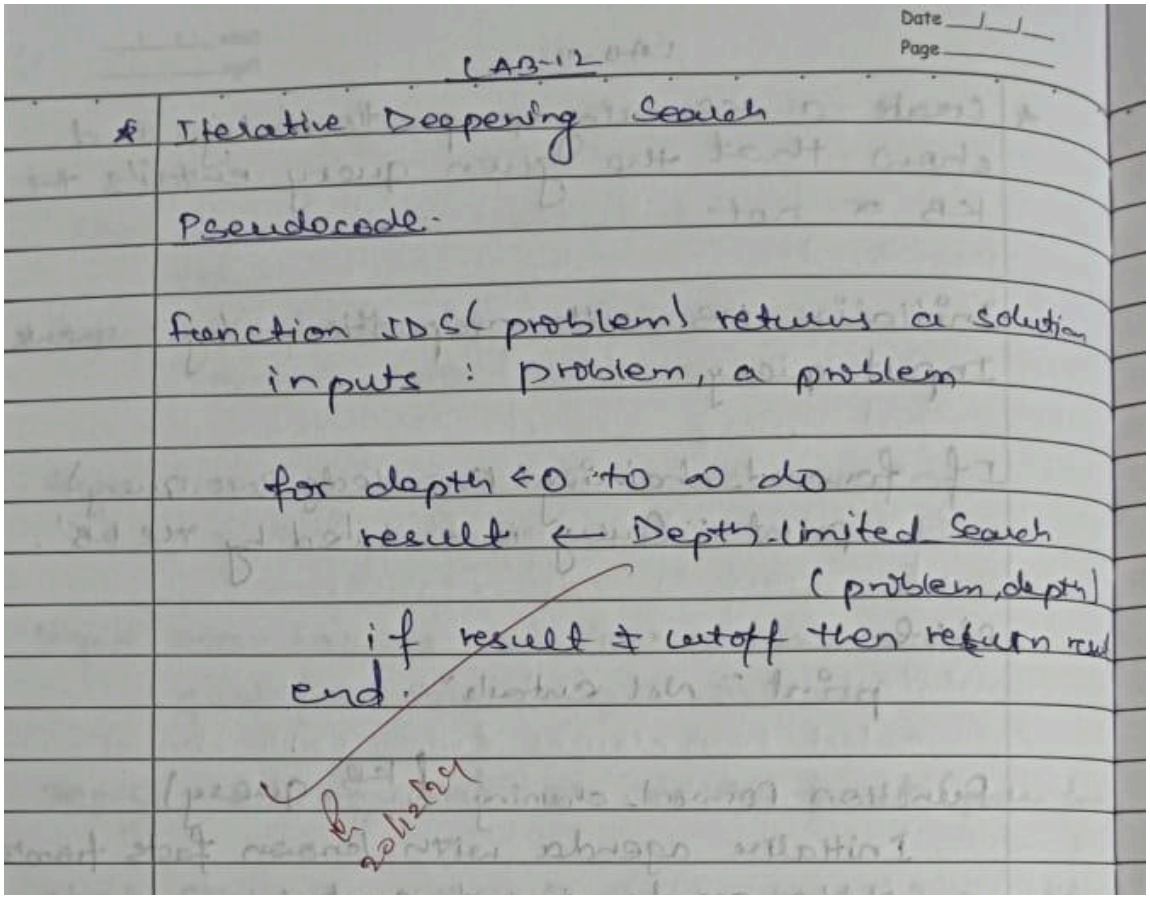
7 8 0

State Space Tree:



b) Implement Iterative deepening search algorithm.

Algorithm:



Code:

```
from collections import defaultdict

class Graph:
    def __init__(self):
        self.graph = defaultdict(list)

    def add_edge(self, u, v):
        """Add an edge to the graph."""
        self.graph[u].append(v)

    def dls(self, node, target, depth):
        """
        Perform Depth-Limited Search (DLS) from the current node.
```

```
        :param node: Current node
        :param target: Target node
        :param depth: Maximum depth to explore
        :return: True if target is found, False otherwise
        """
        if depth == 0:
            return node == target
        if depth > 0:
            for neighbor in self.graph[node]:
                if self.dls(neighbor, target, depth - 1):
                    return True
        return False

    def iddfs(self, start, target, max_depth):
        """
        Perform Iterative Deepening Depth-First Search (IDDFS).

        :param start: Starting node
        :param target: Target node to search for
        :param max_depth: Maximum depth limit for IDDFS
        :return: True if target is found, False otherwise
        """
        for depth in range(max_depth + 1):
            print(f"Searching at depth: {depth}")
            if self.dls(start, target, depth):
                return True
        return False


# Example Usage
if __name__ == "__main__":
    g = Graph()
    # Construct the graph
    g.add_edge(0, 1)
    g.add_edge(0, 2)
```

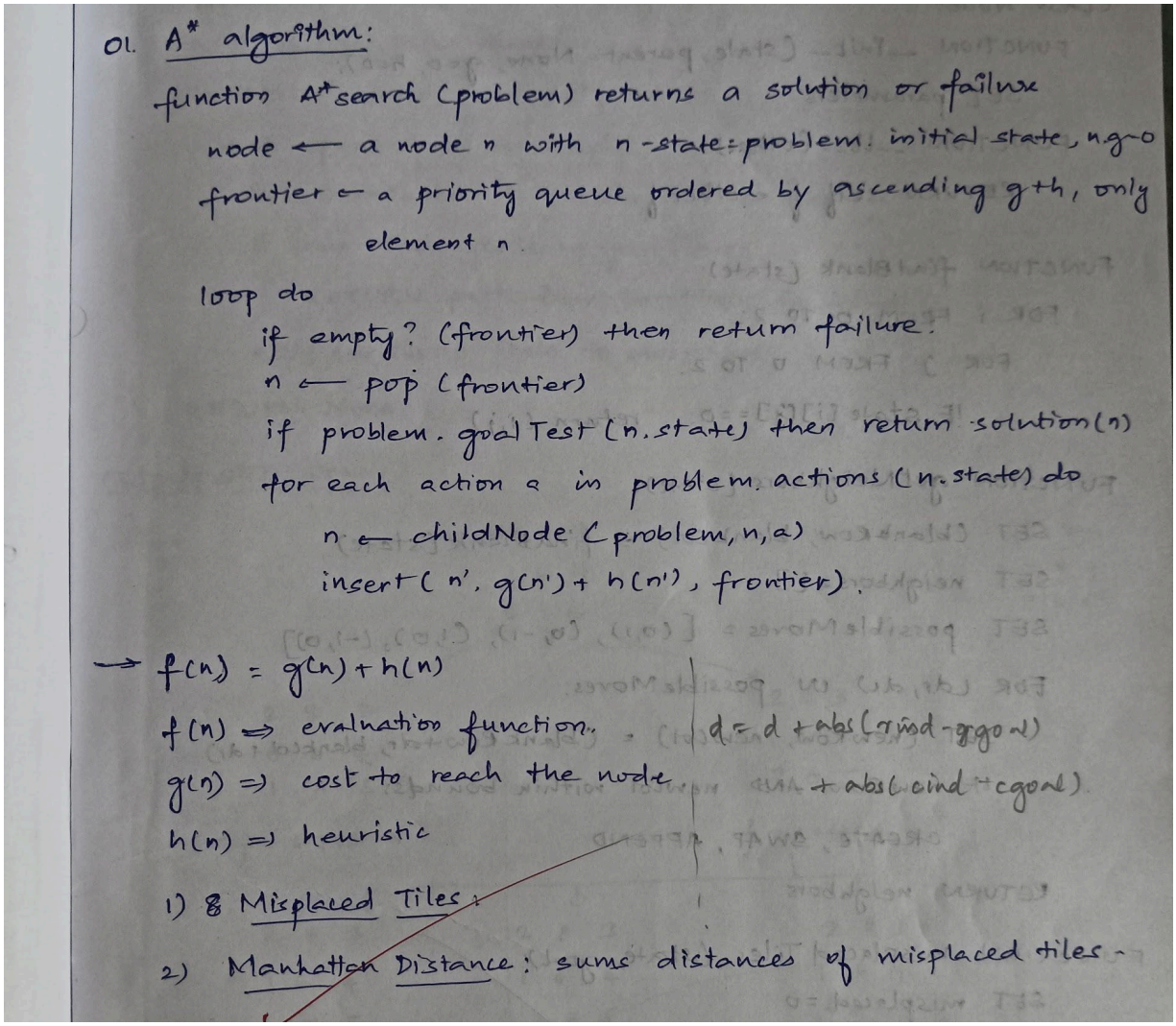
```
    g.add_edge(1, 3)
    g.add_edge(1, 4)
    g.add_edge(2, 5)
    g.add_edge(2, 6)

    start_node = 0
    target_node = 5
    max_depth = 3

    # Perform IDDFS
    if g.iddfs(start_node, target_node, max_depth):
        print(f"Target node {target_node} found within depth {max_depth}")
    else:
        print(f"Target node {target_node} NOT found within depth {max_depth}")
```

Output:

```
Searching at depth: 0
Searching at depth: 1
Searching at depth: 2
Target node 5 found within depth 3
```

3. Implement A* search algorithm.

Algorithm:



01. A* algorithm:

function A* search (problem) returns a solution or failure

node ← a node n with n-state=problem. initial state, n.g=0

frontier ← a priority queue ordered by ascending g+h, only element n.

loop do

if empty? (frontier) then return failure.

n ← pop (frontier)

if problem.goalTest (n.state) then return solution(n)

for each action a in problem.actions (n.state) do

n' ← childNode (problem, n, a)

insert (n', g(n') + h(n'), frontier).

→ f(n) = g(n) + h(n)

f(n) ⇒ evaluation function.

g(n) ⇒ cost to reach the node.

h(n) ⇒ heuristic

1) # Misplaced Tiles:

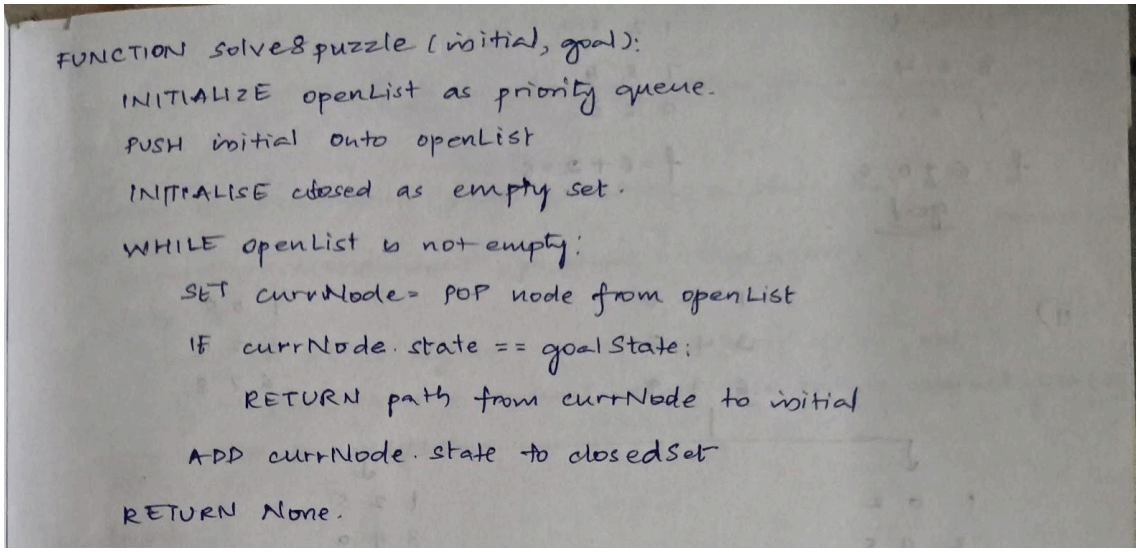
2) Manhattan Distance: sums distances of misplaced tiles.

d = d + abs(rind - rgoal)

+ abs(cind - cgoal)

Pseudocode:

```
CLASS Node:
    FUNCTION __init__(state, parent=None, g=0, h=0):
        SET parameters
    FUNCTION __lt__(other):
        RETURN self.f < other.f

FUNCTION findBlank(state):
    FOR i FROM 0 TO 2:
        FOR j FROM 0 TO 2:
            IF state[i][j]==0:  return (i,j)

FUNCTION getNeighbors(state):
    SET (blankRow, blankCol) = findBlank(state)
    SET neighbors=[]
    SET possibleMoves = [(0,1), (0,-1), (1,0), (-1,0)]
    FOR (dr, dc) IN possibleMoves:
        SET (newRow, newCol) = (blankRow+dr, blankCol+dc)
        IF newRow AND newCol within bounds:
            CREATE, SWAP, APPEND
    RETURN neighbors.

FUNCTION misplacedTiles(state, goal):
    SET misplaced=0
    FOR i FROM 0 to 2:
        FOR j FROM 0 TO 2:
            IF state[i][j]!=goal[i][j] AND !=0:
                INCR misplaced.
    RETURN misplaced.

FUNCTION manhattanDistance(state, goal):
    SET dist=0
    FOR i from 0 to 2:
        FOR j from 0 to 2:
            IF state[i][j]!=0:
                FIND & ADD.
```



Code:

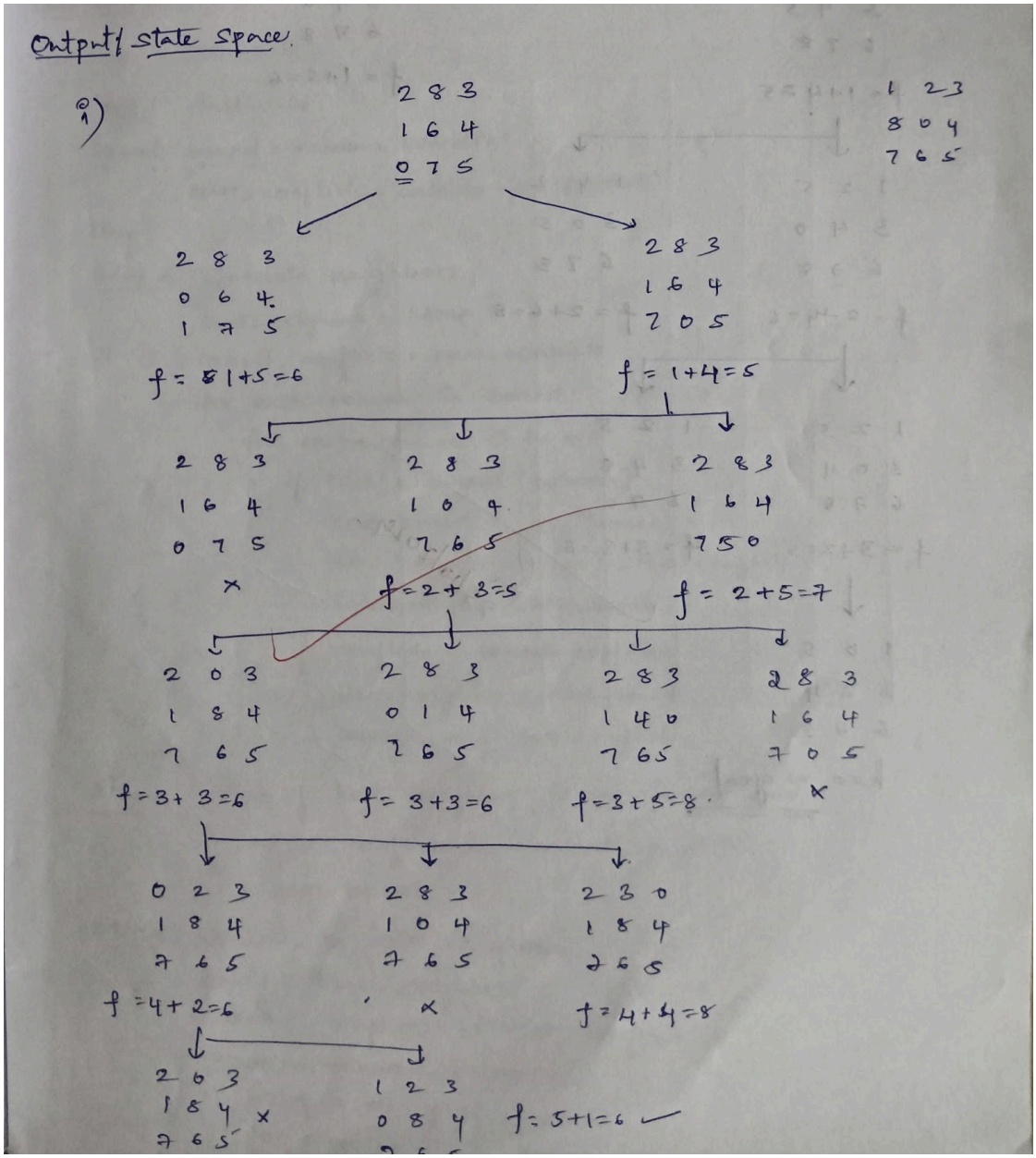
```
import heapq

class Node:
    def __init__(self, state, parent=None, g=0, h=0):
        self.state = state
        self.parent = parent
        self.g = g
        self.h = h
        self.f = g + h

    def __lt__(self, other):
        return self.f < other.f

def findBlank(state):
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
                return i, j

def getNeighbors(state):
    blankRow, blankCol = findBlank(state)
    neighbors = []
    possibleMoves = [(0, 1), (0, -1), (1, 0), (-1, 0)]
    for dr, dc in possibleMoves:
        newRow, newCol = blankRow + dr, blankCol + dc
        if 0 <= newRow < 3 and 0 <= newCol < 3:
            newState = [row[:] for row in state]
                                    newState[blankRow][blankCol],  newState[newRow][newCol]  =
newState[newRow][newCol], newState[blankRow][blankCol]
```

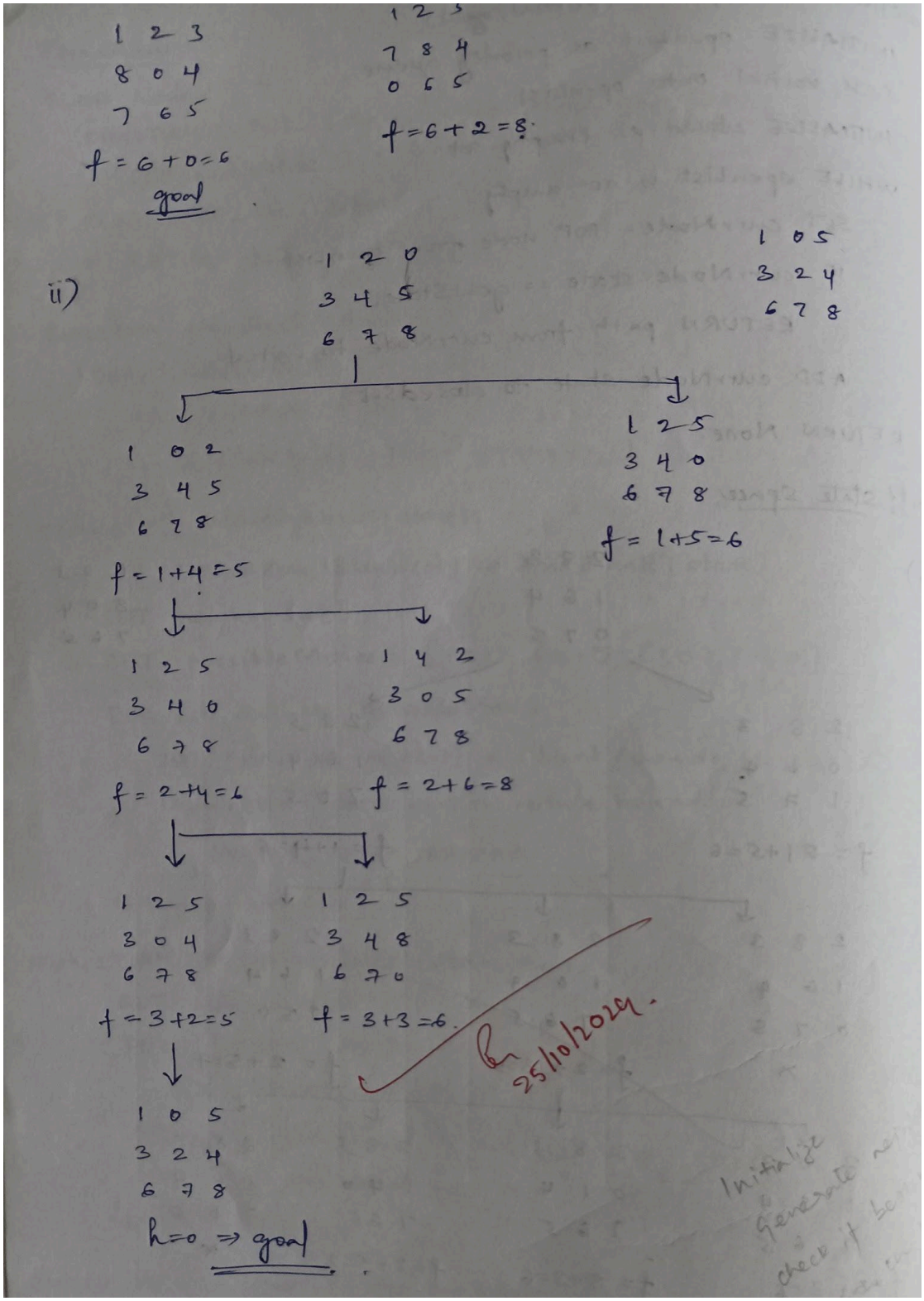
```
            neighbors.append(newState)
    return neighbors

def misplacedTiles(state, goal):
    misplaced = 0
    for i in range(3):
        for j in range(3):
            if state[i][j] != goal[i][j] and state[i][j] != 0:
                misplaced += 1
    return misplaced

def manhattanDistance(state, goal):
    distance = 0
    for i in range(3):
        for j in range(3):
            if state[i][j] != 0:
                goalRow, goalCol = -1, -1
                for x in range(3):
                    for y in range(3):
                        if state[i][j] == goal[x][y]:
                            goalRow, goalCol = x, y
                            break
                distance += abs(i - goalRow) + abs(j - goalCol)
    return distance

def solve8puzzle(initialState, goalState, heuristic):
    openList = []
    if heuristic == "manhattan":
        h = manhattanDistance(initialState, goalState)
    else:
        h = misplacedTiles(initialState, goalState)


    heapq.heappush(openList, Node(initialState, None, 0, h))
    closed_set = set()

    while openList:
        currNode = heapq.heappop(openList)

        if tuple(map(tuple, currNode.state)) == tuple(map(tuple, goalState)):
            path = []
            while currNode:
                path.append(currNode.state)
                currNode = currNode.parent
            return path[::-1]
```

```
        closed_set.add(tuple(map(tuple, currNode.state)))

        for neighbor_state in getNeighbors(currNode.state):
            if tuple(map(tuple, neighbor_state)) not in closed_set:
                g = currNode.g + 1
                if heuristic == "manhattan":
                    h = manhattanDistance(neighbor_state, goalState)
                else:
                    h = misplacedTiles(neighbor_state, goalState)
                neighbor_node = Node(neighbor_state, currNode, g, h)
                heapq.heappush(openList, neighbor_node)

    return None

initialState = []
goalState = []

print("Output: 1BM22CS290")
print("Enter the initial state (3x3 matrix, use 0 for the blank tile):")
for i in range(3):
   row = list(map(int, input().split()))
    initialState.append(row)

print("Enter the goal state (3x3 matrix, use 0 for the blank tile):")
for i in range(3):
    row = list(map(int, input().split()))
    goalState.append(row)

# Prompt the user to choose the heuristic
heuristic = input("Choose a heuristic (1 for Misplaced Tiles, 2 for Manhattan Distance): ")
if heuristic == '1':
    heuristic = "misplaced"
elif heuristic == '2':
    heuristic = "manhattan"
else:
    print("Invalid choice. Defaulting to Manhattan Distance.")
    heuristic = "manhattan"

path = solve8puzzle(initialState, goalState, heuristic)

if path:
    print("Solution found!")
    for i, state in enumerate(path):
        print(f"Step {i}:")
        for row in state:
            print(row)
```

```
    print("Number of moves:", len(path) - 1)
else:
    print("No solution found.")
```

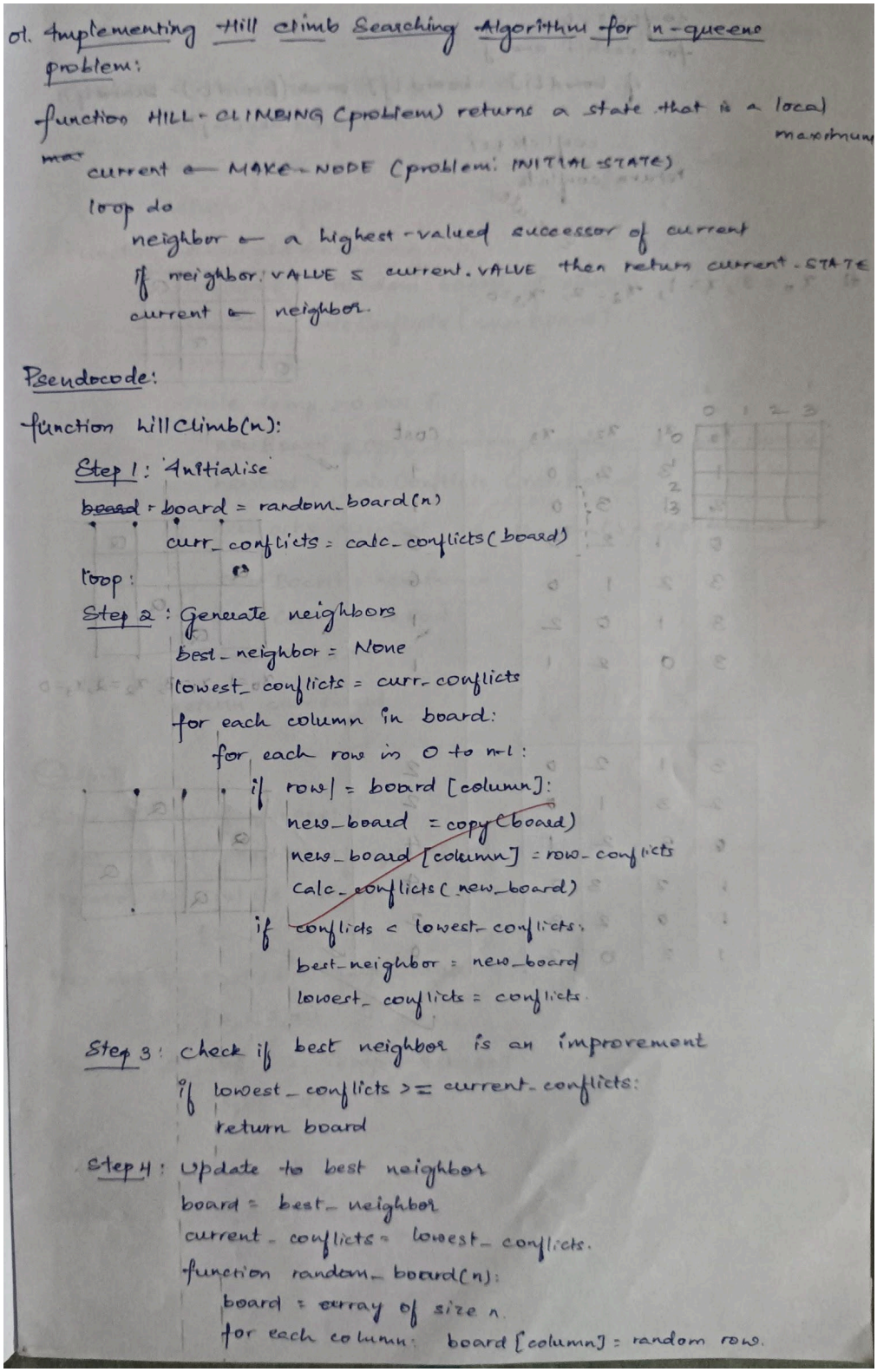
Output:




1 2 3
8 0 4
7 6 5
f = 6 + 0 = 6
goal
1 2 3
7 8 4
0 6 5
f = 6 + 2 = 8
ii)
1 2 0
3 4 5
6 7 8
1 0 5
3 2 4
6 7 8
1 0 2
3 4 5
6 7 8
f = 1 + 4 = 5
1 2 5
3 4 0
6 7 8
f = 1 + 5 = 6
1 2 5
3 4 0
6 7 8
f = 2 + 4 = 6
1 4 2
3 0 5
6 7 8
f = 2 + 6 = 8
1 2 5
3 0 4
6 7 8
f = 3 + 2 = 5
1 2 5
3 4 8
6 7 0
f = 3 + 3 = 6
1 0 5
3 2 4
6 7 8
h = 0 ⇒ goal
25/10/2024.

4. Implement Hill Climbing search algorithm to solve N-Queens problem.

Algorithm:



01. Implementing Hill climb Searching Algorithm for n-queens problem:

function HILL-CLIMBING (problem) returns a state that is a local maximum

current ← MAKE-NODE (problem. INITIAL-STATE)

loop do

neighbor ← a highest-valued successor of current

if neighbor.VALUE ≤ current.VALUE then return current.STATE

current ← neighbor

Pseudocode:

function hillClimb(n):

Step 1: Initialise

board = random_board(n)

curr_conflicts = calc_conflicts(board)

loop:

Step 2: Generate neighbors

best_neighbor = None

lowest_conflicts = curr_conflicts

for each column in board:

for each row in 0 to n-1:

if row != board[column]:

new_board = copy(board)

new_board[column] = row_conflicts

calc_conflicts(new_board)

if conflicts < lowest_conflicts:

best_neighbor = new_board

lowest_conflicts = conflicts

Step 3: Check if best neighbor is an improvement

if lowest_conflicts >= current_conflicts:

return board

Step 4: Update to best neighbor

board = best_neighbor

current_conflicts = lowest_conflicts.

function random_board(n):

board = array of size n.

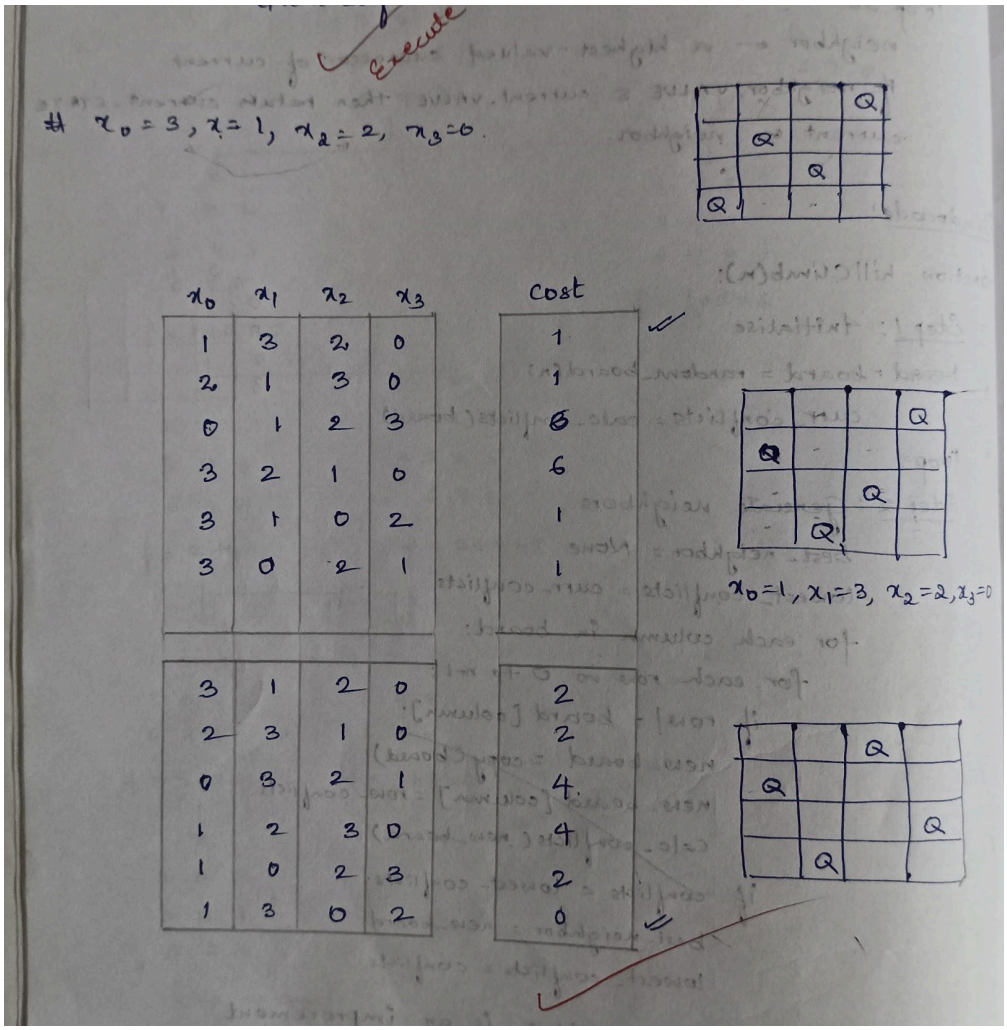
for each column: board[column] = random row.

Code:

```
import random

def calculate_conflicts(board):
    conflicts = 0
    n = len(board)
    for i in range(n):
        for j in range(i + 1, n):
            if board[i] == board[j] or abs(board[i] - board[j]) == abs(i - j):
                conflicts += 1
    return conflicts

def hill_climbing(n):
    cost = 0
    while True:
        current_board = list(range(n))
        random.shuffle(current_board)
        current_conflicts = calculate_conflicts(current_board)

        while True:
            found_better = False
            for i in range(n):
                for j in range(n):
                    if j != current_board[i]:
                        neighbor_board = list(current_board)
                        neighbor_board[i] = j
                        neighbor_conflicts = calculate_conflicts(neighbor_board)
                        if neighbor_conflicts < current_conflicts:
                            print("Current Board:")
                            print_board(current_board)
                            print(f"Current Conflicts: {current_conflicts}")
                            print("Neighbor Board:")
                            print_board(neighbor_board)
                            print(f"Neighbor Conflicts: {neighbor_conflicts}")
                            current_board = neighbor_board
                            current_conflicts = neighbor_conflicts
                            cost += 1
                            found_better = True
                            break
                if found_better:
                    break

            if not found_better:
                break

        if current_conflicts == 0:
```

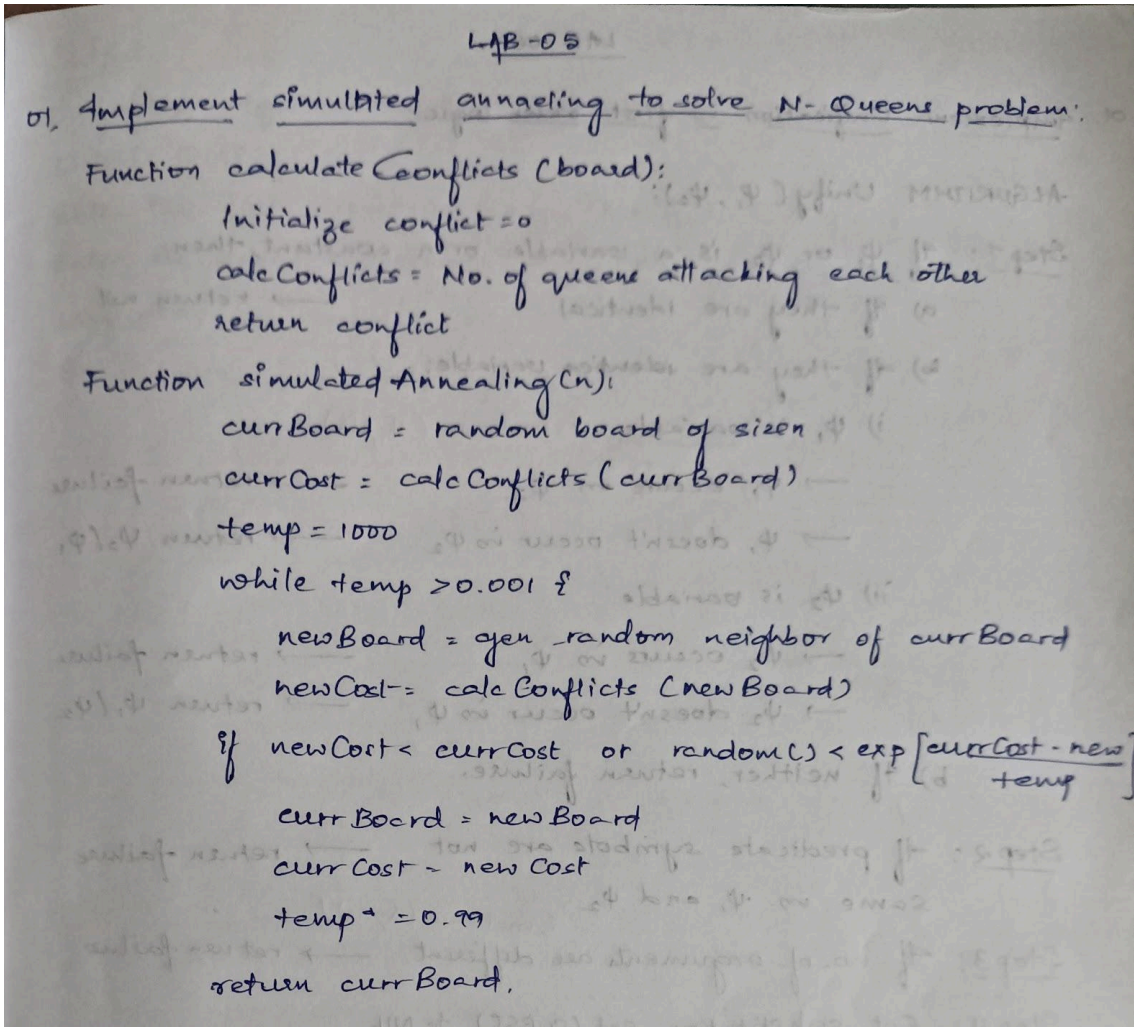
```
        return current_board, current_conflicts, cost

def print_board(board):
    n = len(board)
    for i in range(n):
        row = ['.'] * n
        row[board[i]] = 'Q'
        print(' '.join(row))
    print()

print("Output: 1BM22CS290")
n = 4
solution, conflicts, cost = hill_climbing(n)
print("Final Board Configuration:")
print_board(solution)
print("Number of Cost:", cost)
```

Output:



5. Implement Simulated Annealing to Solve 8-Queens problem.

Algorithm:



LAB-05

01. Implement simulated annealing to solve N-Queens problem.

Function calculateConflicts(board):
    Initialize conflict = 0
    calcConflicts = No. of queens attacking each other
    return conflict

Function simulatedAnnealing(n):
    currBoard = random board of size n
    currCost = calcConflicts(currBoard)
    temp = 1000
    while temp > 0.001 {
        newBoard = gen_random neighbor of currBoard
        newCost = calcConflicts(newBoard)
        if newCost < currCost or random() < exp[(currCost - new)/temp]
        currBoard = newBoard
        currCost = newCost
        temp * = 0.99
    return currBoard.

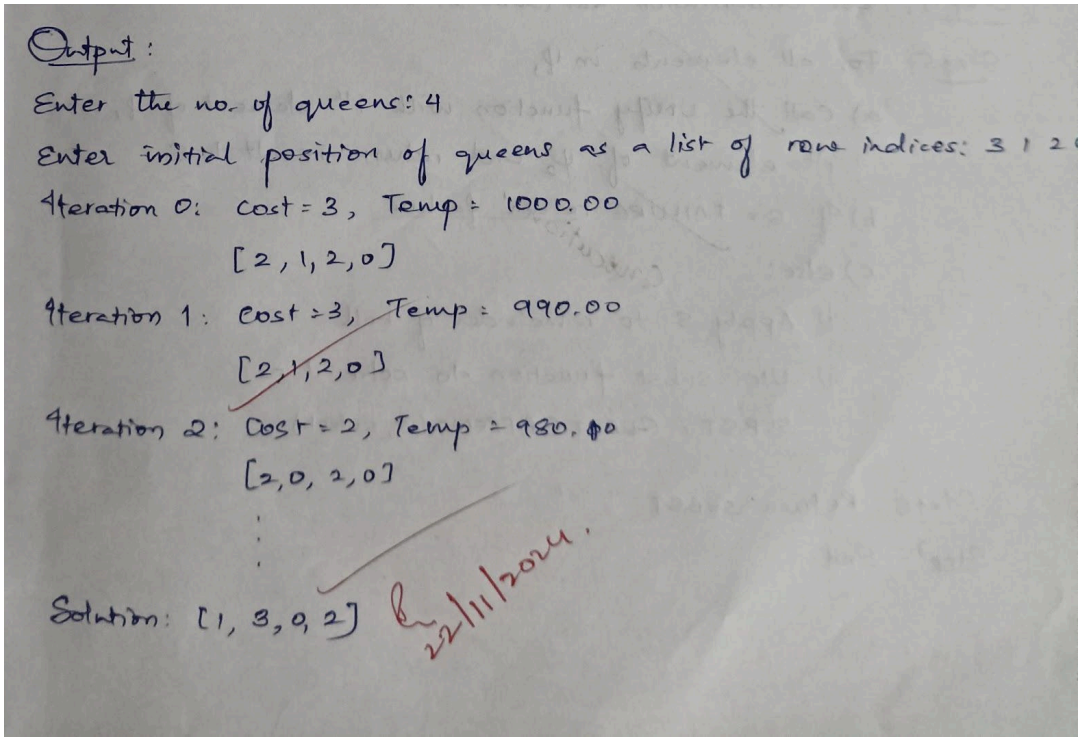
Code:

```
import random
import math

def count_conflicts(state):
    conflicts = 0
    n = len(state)
    for i in range(n):
        for j in range(i + 1, n):
            if state[i] == state[j]:
                conflicts += 1
            if abs(state[i] - state[j]) == abs(i - j):
                conflicts += 1
```

```
    return conflicts

def generate_neighbors(state):
    neighbors = []
    n = len(state)
    for i in range(n):
        for j in range(i + 1, n):
            neighbor = state[:]
            neighbor[i], neighbor[j] = neighbor[j], neighbor[i]
            neighbors.append(neighbor)
    return neighbors

def acceptance_probability(old_cost, new_cost, temperature):
    if new_cost < old_cost:
        return 1.0
    return math.exp((old_cost - new_cost) / temperature)

def simulated_annealing(n, initial_state, initial_temp, cooling_rate, max_iterations):
    state = initial_state
    current_cost = count_conflicts(state)
    temperature = initial_temp

    for iteration in range(max_iterations):
        neighbors = generate_neighbors(state)
        random_neighbor = random.choice(neighbors)
        new_cost = count_conflicts(random_neighbor)

        if acceptance_probability(current_cost, new_cost, temperature) > random.random():
            state = random_neighbor
            current_cost = new_cost

        temperature *= cooling_rate

        if current_cost == 0:
            return state
    return None

def get_user_input(n):
    while True:
        try:
            print("Output: 1BM22CS290")
              user_input = input(f"Enter the column positions for the queens (space-separated integers
between 0 and {n-1}): ")
            initial_state = list(map(int, user_input.split()))
            for row in range(n):
              board = ['Q' if col == initial_state[row] else '.' for col in range(n)]
```

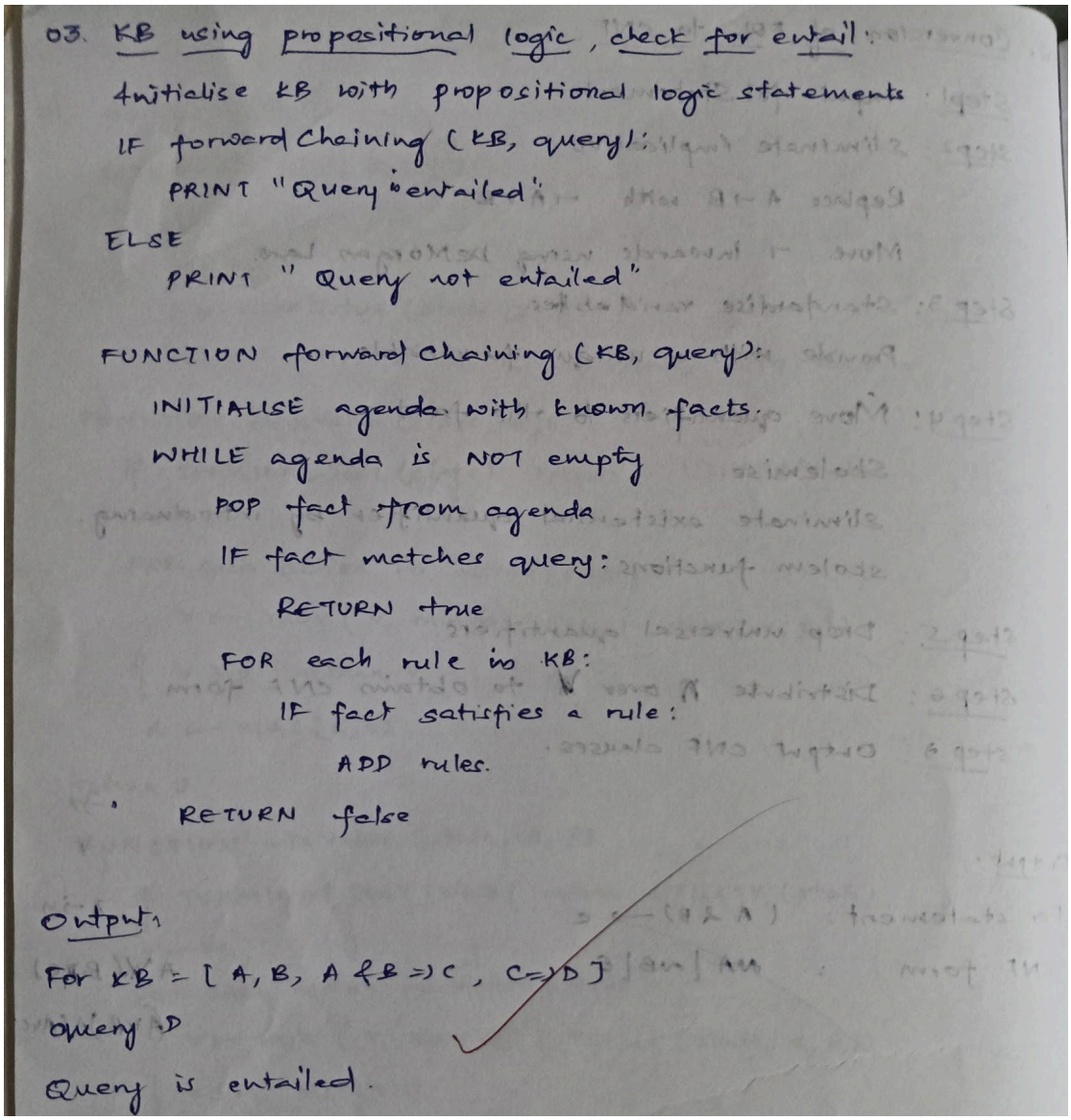
```
            print(' '.join(board))
        if len(initial_state) != n or any(x < 0 or x >= n for x in initial_state):
            print(f"Invalid input. Please enter exactly {n} integers between 0 and {n-1}.")
            continue
        return initial_state
    except ValueError:
        print(f"Invalid input. Please enter a list of {n} integers.")

n = 8
initial_state = get_user_input(n)

initial_temp = 1000
cooling_rate = 0.99
max_iterations = 10000

solution = simulated_annealing(n, initial_state, initial_temp, cooling_rate, max_iterations)
if solution:
    print("Solution found!")
    for row in range(n):
        board = ['Q' if col == solution[row] else '.' for col in range(n)]
        print(' '.join(board))
else:
    print("No solution found within the given iterations.")
```

Output:



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

Algorithm:



03. KB using propositional logic, check for entail:

Initialise KB with propositional logic statements

IF forwardChaining(KB, query):

PRINT "Query entailed"

ELSE

PRINT "Query not entailed"

FUNCTION forwardChaining(KB, query):

INITIALISE agenda with known facts.

WHILE agenda is NOT empty

POP fact from agenda

IF fact matches query:

RETURN true

FOR each rule in KB:

IF fact satisfies a rule:

ADD rules.

RETURN false

Output:

For KB = [A, B, A & B => C, C => D]

query :D

Query is entailed.

Code:

```
from sympy.logic.boolalg import Or, And, Not
from sympy.abc import A, B, C, D, E, F
from sympy import simplify_logic

def is_entailment(kb, query):
```

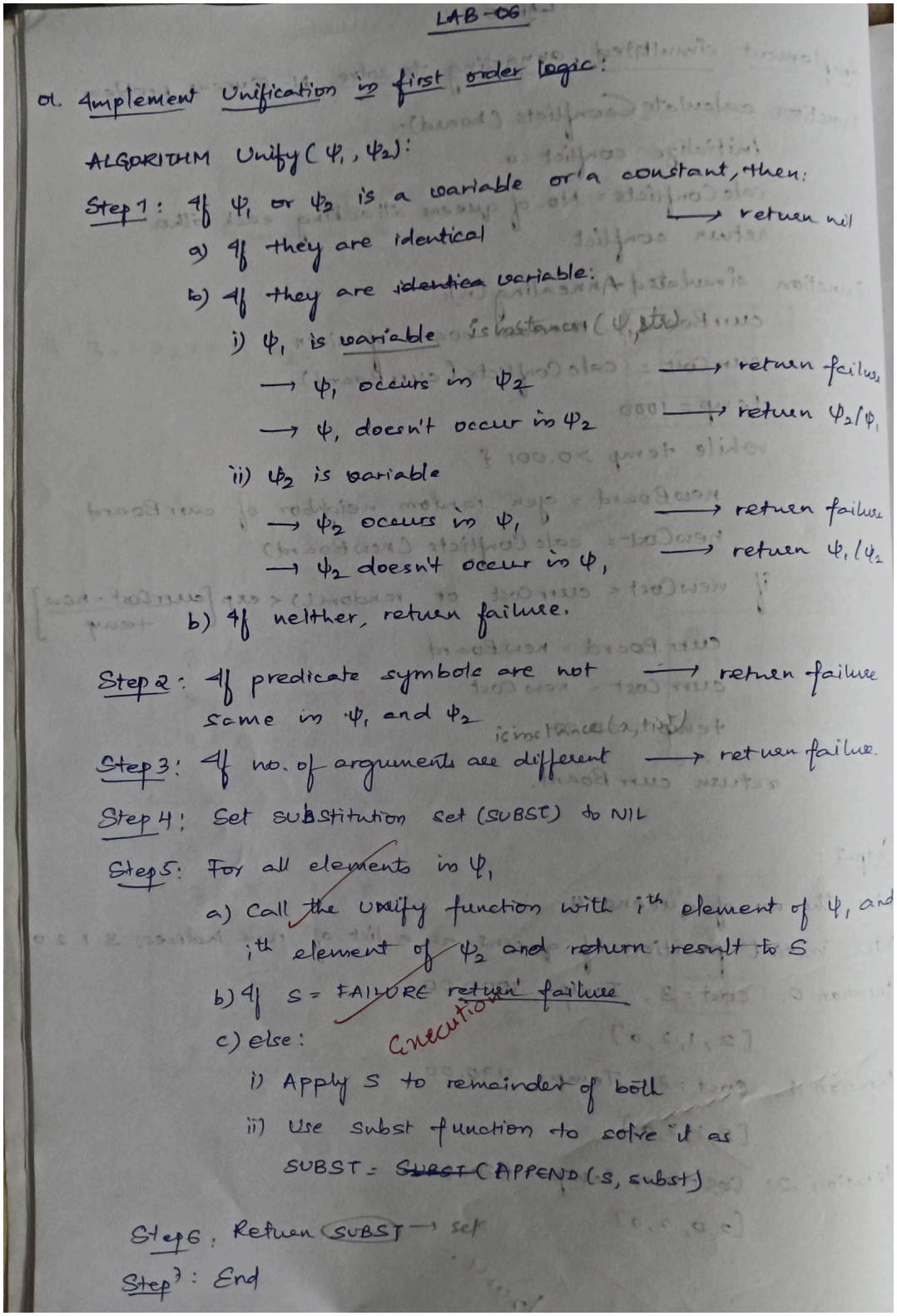
```
    # Negate the query
    negated_query = Not(query)

    # Add negated query to the knowledge base
    kb_with_negated_query = And(*kb, negated_query)

    # Simplify the combined KB to CNF
    simplified_kb = simplify_logic(kb_with_negated_query, form="cnf")

    # If the simplified KB evaluates to False, the query is entailed
    return simplified_kb == False


# Define a larger Knowledge Base
kb = [
    Or(A, B),        # A ∨ B
    Or(Not(A), C),   # ¬A ∨ C
    Or(Not(B), D),   # ¬B ∨ D
    Or(Not(D), E),   # ¬D ∨ E
    Or(Not(E), F),   # ¬E ∨ F
    F                # F
]
# Query to check
query = Or(C, F)  # C ∨ F

# Check entailment
result = is_entailment(kb, query)
print(f"Is the query '{query}' entailed by the knowledge base? {'Yes' if result else 'No'}")
```

Output:

Is the query 'C | F' entailed by the knowledge base? Yes

7. Implement unification in first order logic.

Algorithm:



LAB-06

Q. Implement Unification in first order logic:

ALGORITHM Unify(ψ_1, ψ_2):

Step 1: If ψ_1 or ψ_2 is a variable or a constant, then:
- a) If they are identical → return nil
- b) If they are identical variable:
  - i) ψ_1 is variable
    - → ψ_1 occurs in ψ_2 → return failure
    - → ψ_1 doesn't occur in ψ_2 → return ψ_2/ψ_1
  - ii) ψ_2 is variable
    - → ψ_2 occurs in ψ_1 → return failure
    - → ψ_2 doesn't occur in ψ_1 → return ψ_1/ψ_2
- b) If neither, return failure.

Step 2: If predicate symbol are not same in ψ_1 and ψ_2 → return failure

Step 3: If no. of arguments are different → return failure.

Step 4: Set substitution set (SUBST) to NIL

Step 5: For all elements in ψ_1
- a) Call the Unify function with i^{th} element of ψ_1 and i^{th} element of ψ_2 and return result to S
- b) If S = FAILURE return failure
- c) else:
  - i) Apply S to remainder of both
  - ii) Use subst function to solve it as SUBST = APPEND(S, subst)

Step 6: Return SUBST → set

Step 7: End

Code:

```
import re

def occurs_check(var, x):
    if var == x:
        return True
    elif isinstance(x, list):
        return any(occurs_check(var, xi) for xi in x)
    return False

def unify_var(var, x, subst):
    if var in subst:
        return unify(subst[var], x, subst)
    elif isinstance(x, (list, tuple)) and tuple(x) in subst:
        return unify(var, subst[tuple(x)], subst)
    elif occurs_check(var, x):
        return "FAILURE"
    else:
        subst[var] = tuple(x) if isinstance(x, list) else x
        return subst

def unify(x, y, subst=None):
    if subst is None:
        subst = {}
    if x == y:
        return subst
    elif isinstance(x, str) and x.islower():
        return unify_var(x, y, subst)
    elif isinstance(y, str) and y.islower():
        return unify_var(y, x, subst)
    elif isinstance(x, list) and isinstance(y, list):
        if len(x) != len(y):
            return "FAILURE"
        if x[0] != y[0]:
            return "FAILURE"
        for xi, yi in zip(x[1:], y[1:]):
            subst = unify(xi, yi, subst)
            if subst == "FAILURE":
                return "FAILURE"
        return subst
    else:
        return "FAILURE"

def unify_and_check(expr1, expr2):
    result = unify(expr1, expr2)
    if result == "FAILURE":
```

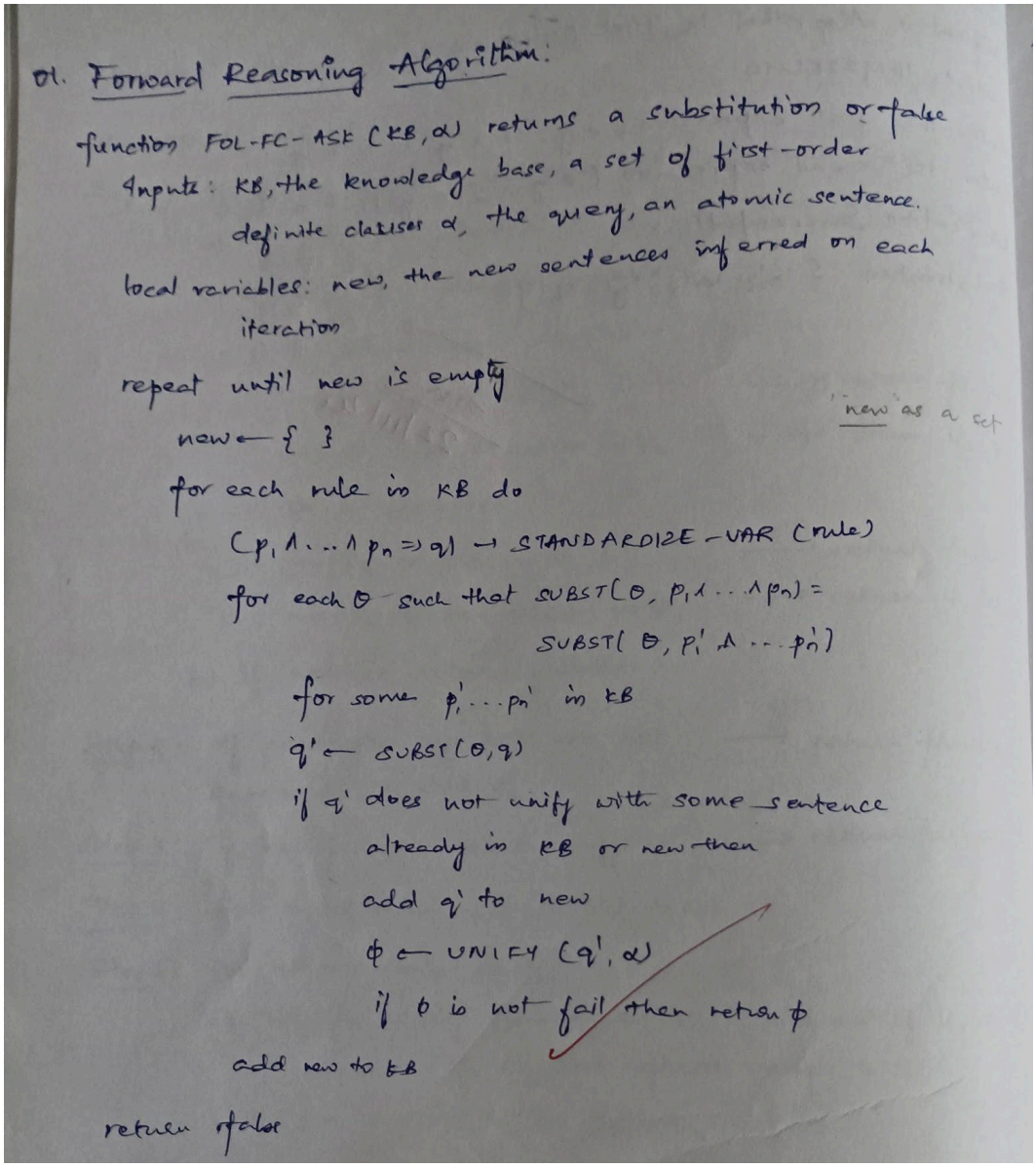
```
        return False, None
    return True, result

def display_result(expr1, expr2, is_unified, subst):
    print("Expression 1:", expr1)
    print("Expression 2:", expr2)
    if not is_unified:
        print("Result: Unification Failed")
    else:
        print("Result: Unification Successful")
        print("Substitutions:", {k: list(v) if isinstance(v, tuple) else v for k, v in subst.items()})

def parse_input(input_str):
    input_str = input_str.replace(" ", "")
    def parse_term(term):
        if '(' in term:
            match = re.match(r'([a-zA-Z0-9_]+)(.*)', term)
            if match:
                predicate = match.group(1)
                arguments_str = match.group(2)
                arguments = [parse_term(arg.strip()) for arg in arguments_str.split(',')]
                return [predicate] + arguments
        return term
    return parse_term(input_str)

def main():
    while True:
        print("Output: 1BM22CS290")
        expr1_input = input("Enter the first expression (e.g., p(x, f(y))): ")
        expr2_input = input("Enter the second expression (e.g., p(a, f(z))): ")
        expr1 = parse_input(expr1_input)
        expr2 = parse_input(expr2_input)
        is_unified, result = unify_and_check(expr1, expr2)
        display_result(expr1, expr2, is_unified, result)
            another_test = input("Do you want to test another pair of expressions? (yes/no): ").strip().lower()
        if another_test != 'yes':
            break

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

Output:

```
Output: 1BM22CS290
Enter the first expression (e.g., p(x, f(y))): p(x,y,z)
Enter the second expression (e.g., p(a, f(z))): p(a,b)
Expression 1: ['p', '(x', 'y', 'z)']
Expression 2: ['p', '(a', 'b)']
Result: Unification Failed
Do you want to test another pair of expressions? (yes/no): yes
Output: 1BM22CS290
Enter the first expression (e.g., p(x, f(y))): p(a,b)
Enter the second expression (e.g., p(a, f(z))): p(q,r)
Expression 1: ['p', '(a', 'b)']
Expression 2: ['p', '(q', 'r)']
Result: Unification Successful
Substitutions: {'(a': '(q', 'b)': 'r)'}
Do you want to test another pair of expressions? (yes/no): no
```

8. Create a knowledge base consisting of first order logic statements and prove the given query using forward reasoning.

Algorithm:



01. Forward Reasoning Algorithm:

function FOL-FC-ASK (KB, α) returns a substitution or false
inputs: KB, the knowledge base, a set of first-order definite clauses
α, the query, an atomic sentence
local variables: new, the new sentences inferred on each iteration
repeat until new is empty
new ← { }
new as a set
for each rule in KB do
(p1 ∧ ... ∧ pn ⇒ q) → STANDARDIZE-VAR (rule)
for each θ such that SUBST(θ, p1 ∧ ... ∧ pn) = SUBST(θ, p1' ∧ ... ∧ pn')
for some p1' ... pn' in KB
q' ← SUBST(θ, q)
if q' does not unify with some sentence already in KB or new then
add q' to new
φ ← UNIFY (q', α)
if φ is not fail then return φ
add new to KB
return false

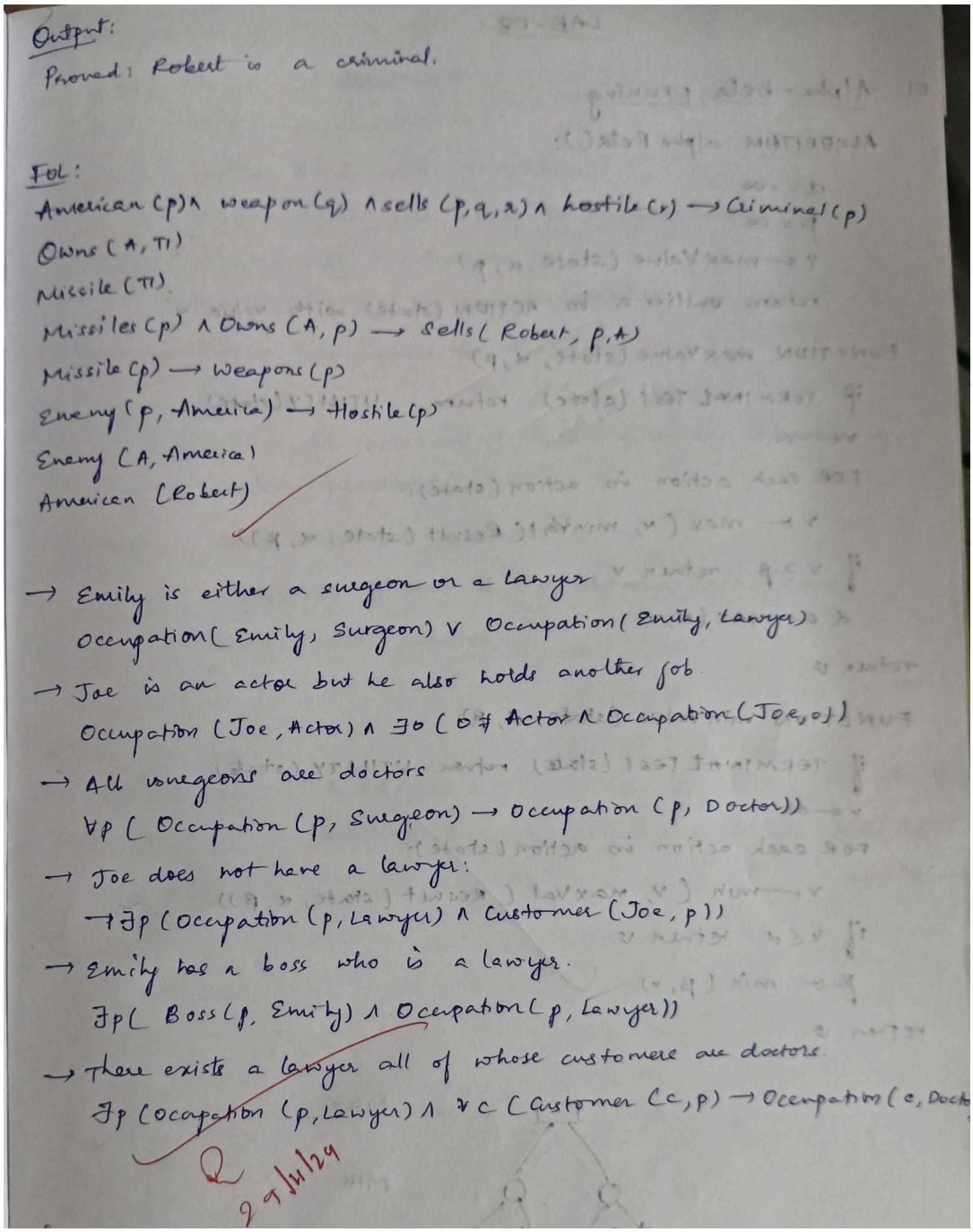
Code:

```
# Define initial facts and rules
facts = {"InAmerica(West)", "SoldWeapons(West, Nono)", "Enemy(Nono, America)"}
rules = [
    {
        "conditions": ["InAmerica(x)", "SoldWeapons(x, y)", "Enemy(y, America)"],
        "conclusion": "Criminal(x)",
    },
```

```
    {
        "conditions": ["Enemy(y, America)"],
        "conclusion": "Dangerous(y)",
    },
]

# Forward chaining function
def forward_chaining(facts, rules):
    derived_facts = set(facts)  # Initialize derived facts
    while True:
        new_fact_found = False

        for rule in rules:
            # Substitute variables and check if conditions are met
            for fact in derived_facts:
                if "x" in rule["conditions"][0]:
                    # Substitute variables (x, y) with specific instances
                    for condition in rule["conditions"]:
                        if "x" in condition or "y" in condition:
                            x = "West"  # Hardcoded substitution for simplicity
                            y = "Nono"
                            conditions = [
                                cond.replace("x", x).replace("y", y)
                                for cond in rule["conditions"]
                            ]
                            conclusion = (
                                rule["conclusion"].replace("x", x).replace("y", y)
                            )

                            # Check if all conditions are satisfied
                                    if all(cond in derived_facts for cond in conditions) and conclusion not in
derived_facts:
                                derived_facts.add(conclusion)
                                print(f"New fact derived: {conclusion}")
                                new_fact_found = True

        # Exit loop if no new fact is found
        if not new_fact_found:
            break

    return derived_facts

# Run forward chaining
final_facts = forward_chaining(facts, rules)
print("Output: 1BM22CS290")
print("\nFinal derived facts:")
```

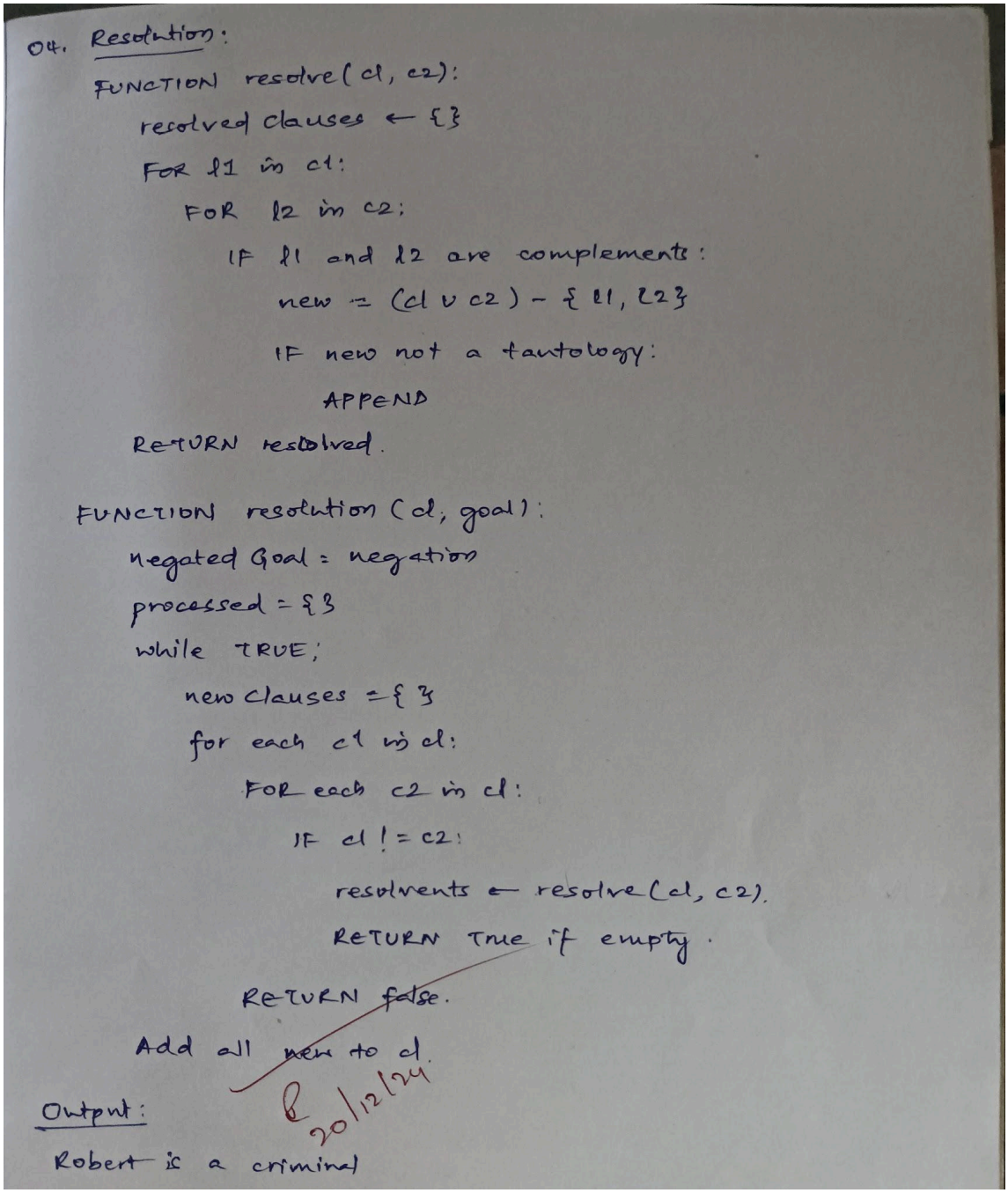
```
for fact in final_facts:
    print(fact)
```

Output:



9. Create a knowledge base consisting of first order logic statements and prove the given query using Resolution.

Algorithm:



04. Resolution:

```
FUNCTION resolve(c1, c2):
    resolved clauses ← {}
    FOR l1 in c1:
        FOR l2 in c2:
            IF l1 and l2 are complements:
                new = (c1 ∪ c2) - {l1, l2}
                IF new not a tautology:
                    APPEND
    RETURN resolved.

FUNCTION resolution(cl, goal):
    negated Goal = negation
    processed = {}
    while TRUE;
        new clauses = {}
        for each c1 in cl:
            FOR each c2 in cl:
                IF c1 != c2:
                    resolvents ← resolve(c1, c2).
                    RETURN True if empty.
        RETURN false.
    Add all new to cl.
```

Output:

Robert is a criminal

20/12/24

Code:

```
# Define the knowledge base (KB)
KB = {
```

```
    "food(Apple)": True,
    "food(vegetables)": True,
    "eats(Anil, Peanuts)": True,
    "alive(Anil)": True,
    "likes(John, X)": "food(X)",  # Rule: John likes all food
    "food(X)": "eats(Y, X) and not killed(Y)",  # Rule: Anything eaten and not killed is food
    "eats(Harry, X)": "eats(Anil, X)",  # Rule: Harry eats what Anil eats
    "alive(X)": "not killed(X)",  # Rule: Alive implies not killed
    "not killed(X)": "alive(X)",  # Rule: Not killed implies alive
}

# Function to evaluate if a predicate is true based on the KB
def resolve(predicate):
    # If it's a direct fact in KB
    if predicate in KB and isinstance(KB[predicate], bool):
        return KB[predicate]

    # If it's a derived rule
    if predicate in KB:
        rule = KB[predicate]
        if " and " in rule:  # Handle conjunction
            sub_preds = rule.split(" and ")
            return all(resolve(sub.strip()) for sub in sub_preds)
        elif " or " in rule:  # Handle disjunction
            sub_preds = rule.split(" or ")
            return any(resolve(sub.strip()) for sub in sub_preds)
        elif "not " in rule:  # Handle negation
            sub_pred = rule[4:]  # Remove "not "
            return not resolve(sub_pred.strip())
        else:  # Handle single predicate
            return resolve(rule.strip())

    # If the predicate is a specific query (e.g., likes(John, Peanuts))
    if "(" in predicate:
        func, args = predicate.split("(")
        args = args.strip(")").split(", ")
        if func == "food" and args[0] == "Peanuts":
            return resolve("eats(Anil, Peanuts)") and not resolve("killed(Anil)")
        if func == "likes" and args[0] == "John" and args[1] == "Peanuts":
            return resolve("food(Peanuts)")

    # Default to False if no rule or fact applies
    return False

# Query to prove: John likes Peanuts
query = "likes(John, Peanuts)"
```

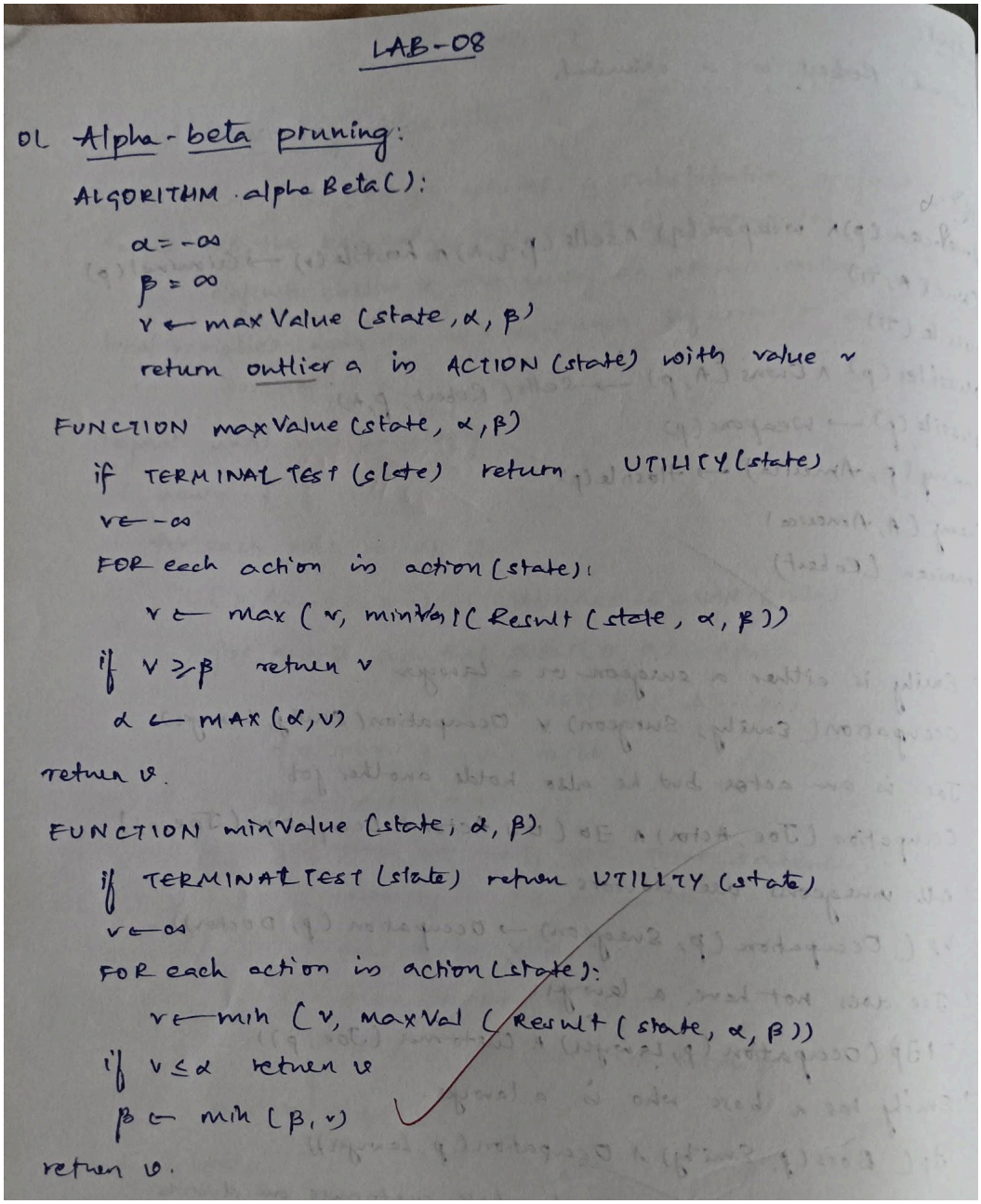
```
result = resolve(query)

# Print the result
print("Output: 1BM22CS290")
print(f"Does John like peanuts? {'Yes' if result else 'No'}")
```

Output:

```
Output: 1BM22CS290
Does John like peanuts? Yes
```

10. Implement Alpha-Beta Pruning.

Algorithm:



LAB-08

01 Alpha-beta pruning:

ALGORITHM alphaBeta():

α = -∞
β = ∞
v ← maxValue (state, α, β)
return outlier a in ACTION (state) with value v

FUNCTION maxValue (state, α, β)
if TERMINAL TEST (state) return UTILITY (state)
v ← -∞
FOR each action in action (state):
v ← max (v, minVal (Result (state, α, β))
if v ≥ β return v
α ← MAX (α, v)
return v.

FUNCTION minValue (state, α, β)
if TERMINAL Test (state) return UTILITY (state)
v ← ∞
FOR each action in action (state):
v ← min (v, maxVal (Result (state, α, β))
if v ≤ α return v
β ← min (β, v)
return v.

Code:

```
def alpha_beta_pruning(node, alpha, beta, maximizing_player):
    if type(node) is int:
        return node

    if maximizing_player:
```

```
        max_eval = -float('inf')
        for child in node:
            eval = alpha_beta_pruning(child, alpha, beta, False)
            max_eval = max(max_eval, eval)
            alpha = max(alpha, eval)
            if beta <= alpha:
                break
        return max_eval
    else:
        min_eval = float('inf')
        for child in node:
            eval = alpha_beta_pruning(child, alpha, beta, True)
            min_eval = min(min_eval, eval)
            beta = min(beta, eval)
            if beta <= alpha:
                break
        return min_eval

def build_tree(numbers):
    current_level = [[n] for n in numbers]

    while len(current_level) > 1:
        next_level = []
        for i in range(0, len(current_level), 2):
            if i + 1 < len(current_level):
                next_level.append(current_level[i] + current_level[i + 1])
            else:
                next_level.append(current_level[i])
        current_level = next_level

    return current_level[0]

def main():
    print("Output: 1BM22CS290")
    numbers = list(map(int, input("Enter numbers for the game tree (space-separated): ").split()))
    tree = build_tree(numbers)

    alpha = -float('inf')
    beta = float('inf')
    maximizing_player = True

    result = alpha_beta_pruning(tree, alpha, beta, maximizing_player)
    print("Final Result of Alpha-Beta Pruning:", result)

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

Output:

```
Output: 1BM22CS290
Enter numbers for the game tree (space-separated): 10 9 14 18 5 4 50 3
Final Result of Alpha-Beta Pruning: 50
```