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
(Autonomous Institution under VTU)
BENGALURU-560019
Sep-2024 to Jan-2025

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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 **Shashidhar B M (1BM22CS257),** who is 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.

Prof. Sonika Sharma D Assistant Professor Department of CSE, BMSCE	Dr. Joythi S Nayak Professor & HOD Department of CSE, BMSCE

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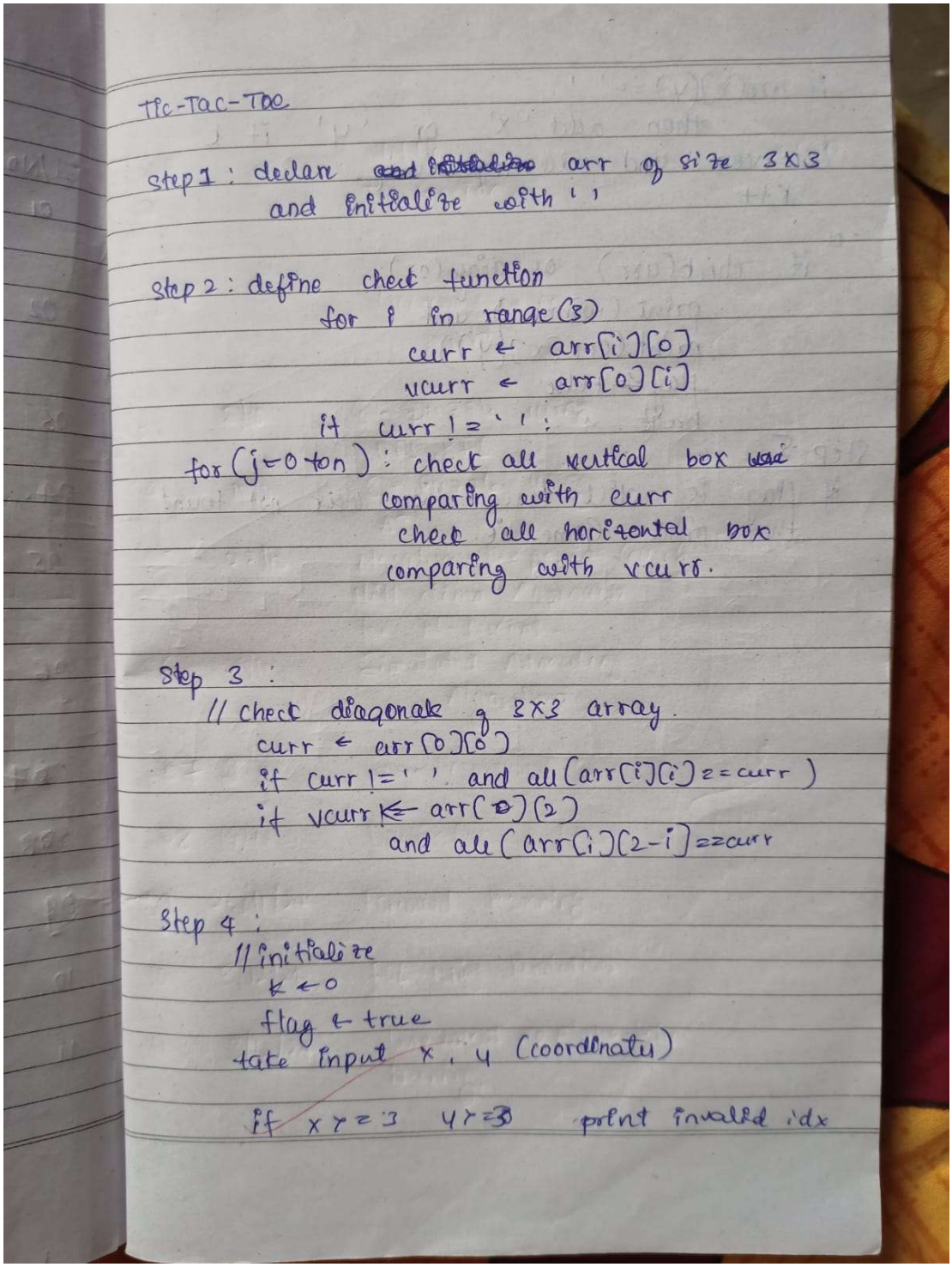
Github Link:

https://github.com/ShashidharM0118/AI_LAB

Program 1

Implement Tic –Tac –Toe Game

Algorithm:



if arr[x][y] == ' '
then add 'x' or '4' if r
is even and odd respectively.
r++

if check(arr) or diag(or);
print (winner found
print (arr[x][4])
flag ⇐ False.
break.

Step 5.
if flag is still true then user not found
then print Game tie

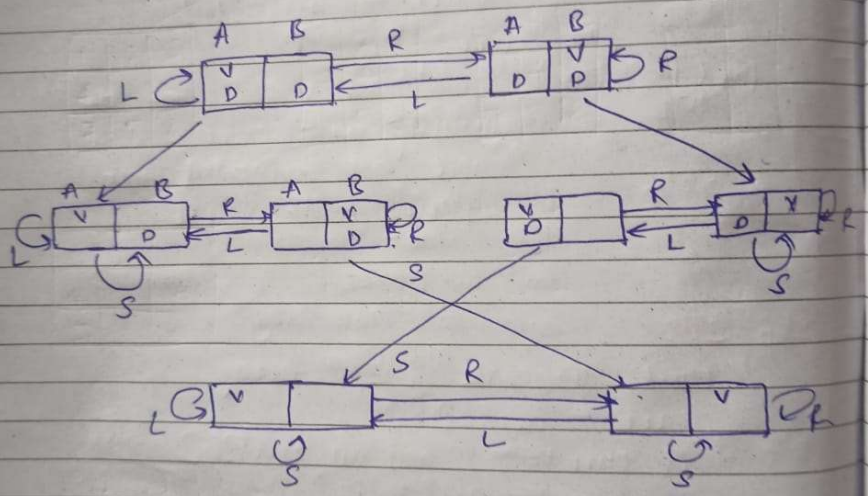
LAB - 2.

Implement vaccum world cleaner. 1/10/23.

function Reflex-vaccum-agent ([location, status])
returns an action.

if status = Dirty then return suck.
else if location = A then return Right
else if location = B then return Left.

State space diagram of vaccum world.



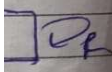
Algorithm:

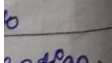
* Add a loop which iterates 4 times to explore all possibilities, take initial location, status of A and B as user input.
* Run on another loop which runs until the status of any room is dirty
* Inside the nested loop from the initial

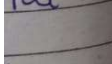
1/10/24.

location, if the current location is clean then it will move left or right

* If the current location is dirt it will suck. and update status = 0
* cost is tracked wherever we get the dirt, ~~Finally~~ inner loop runs till we reach goal state (status of all status ≥ 0)
* print the steps at every stage, goal state and the cost.







Code:

```
def print_board(board):
    print("\n")
    for row in board:
        print("|".join(row))
        print("-" * 5)
    print("\n")


def check_winner(board, player):
    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 board[0][0] == player and board[1][1] == player and board[2][2] == player:
        return True
    if board[0][2] == player and board[1][1] == player and board[2][0] == player:
        return True
    return False


def is_board_full(board):
    return all([cell != ' ' for row in board for cell in row])
```

```
def player_move(board, player):
    while True:
        try:
            move = int(input(f"Player {player}, enter your move (1-9): ")) - 1
            if move < 0 or move >= 9:
                raise ValueError
            row, col = divmod(move, 3)
            if board[row][col] == ' ':
                board[row][col] = player
                break
            else:
                print("This spot is already taken. Try again.")
        except ValueError:
            print("Invalid input. Enter a number between 1 and 9.")


def play_game():
    board = [[' ' for _ in range(3)] for _ in range(3)]
    current_player = 'X'
    game_over = False
    print("Welcome to Tic Tac Toe!")
    print("Player X goes first.")
    print("Enter a number between 1-9 to make your move (1 is top-left and 9 is bottom-right).")
    print_board(board)
    while not game_over:
```

```
        player_move(board, current_player)
        print_board(board)
        if check_winner(board, current_player):
            print(f"Player {current_player} wins!")
            game_over = True
        elif is_board_full(board):
            print("It's a tie!")
            game_over = True
        else
    current_player = 'O' if current_player == 'X' else 'X'
if __name__ == "__main__":
    play_game()
```

```
Player X, enter your move (1-9):
Invalid input. Enter a number between 1 and 9.
Player X, enter your move (1-9): 6

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

Player O, enter your move (1-9): 7

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

Player X, enter your move (1-9): 8

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

It's a tie!
```

```
Player X, enter your move (1-9): 4

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

Player O, enter your move (1-9): 5

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

Player X, enter your move (1-9): 7

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

Player X wins!
```

Implement Vaccum Cleaner Agent

```
count = 0
def rec(state, loc):
    global count
    if state['A'] == 0 and state['B'] == 0:
        print("Turning vacuum off")
        return

    if state[loc] == 1:
        state[loc] = 0
        count += 1
        print(f"Cleaned {loc}.")
        next_loc = 'B' if loc == 'A' else 'A'
        state[loc] = int(input(f"Is {loc} clean now? (0 if clean, 1 if dirty): "))
        if(state[next_loc]!=1):
          state[next_loc]=int(input(f"Is {next_loc} dirty? (0 if clean, 1 if dirty): "))
    if(state[loc]==1):
      rec(state,loc)
    else:
      next_loc = 'B' if loc == 'A' else 'A'
      dire="left" if loc=="B" else "right"
      print(loc,"is clean")
      print(f"Moving vacuum {dire}")
      if state[next_loc] == 1:
```

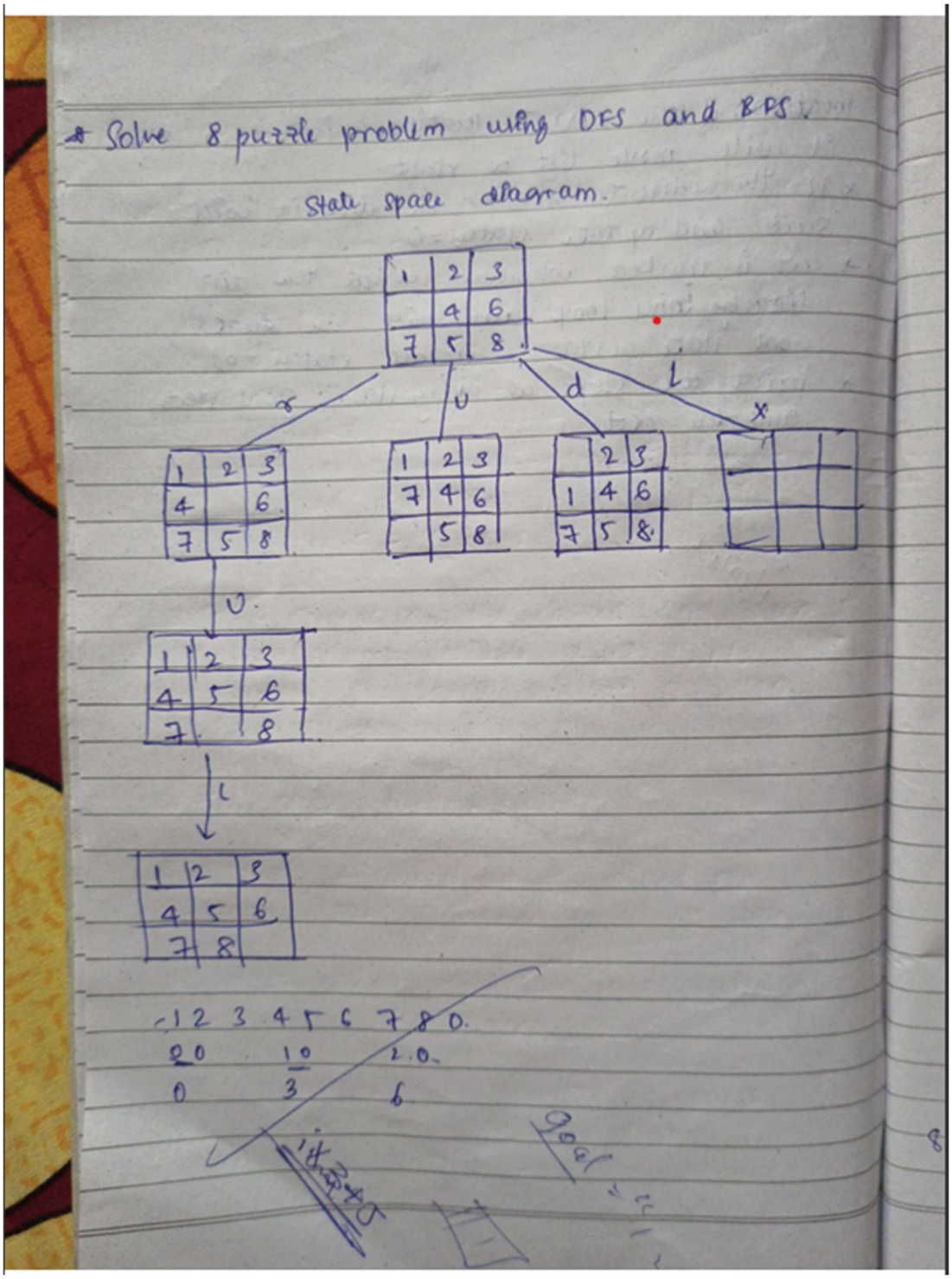
```
        rec(state, next_loc)


state = {}
state['A'] = int(input("Enter state of A (0 for clean, 1 for dirty): "))
state['B'] = int(input("Enter state of B (0 for clean, 1 for dirty): "))
loc = input("Enter location (A or B): ")
rec(state, loc)
print("Cost:",count)
print(state)
```

```
Enter state of A (0 for clean, 1 for dirty): 0
Enter state of B (0 for clean, 1 for dirty): 0
Enter location (A or B): A
Turning vacuum off
Cost: 0
{'A': 0, 'B': 0}
```

Program 2

Implement 8 puzzle problems using Depth First Search (DFS)



Algorithm

* declare a string with a goal state: "123456780" and take the input of the other string as the current state
* where idx of string is.
  idx = i * 3 + j
* define solve function with parameter board, curr, pos.
  Solve (board, curr_pos)
  where curr_pos represents the current empty position.
* Now if the board is not in the visited set and call recursive call solve (board, pos)
* For new board
  define moves = [[1,0], [-1,0], [0,1], [0,-1]]
  here for every curr_pos
  define new_pos adding each element of the moves.
* swap new_pos and currpos in the board to get new_board configuration.
* If new_board == goalstate then return true and solution exit.
* If after traversing all moves in loop if we get the same configurations as visited then solution doesn't exist

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Program :

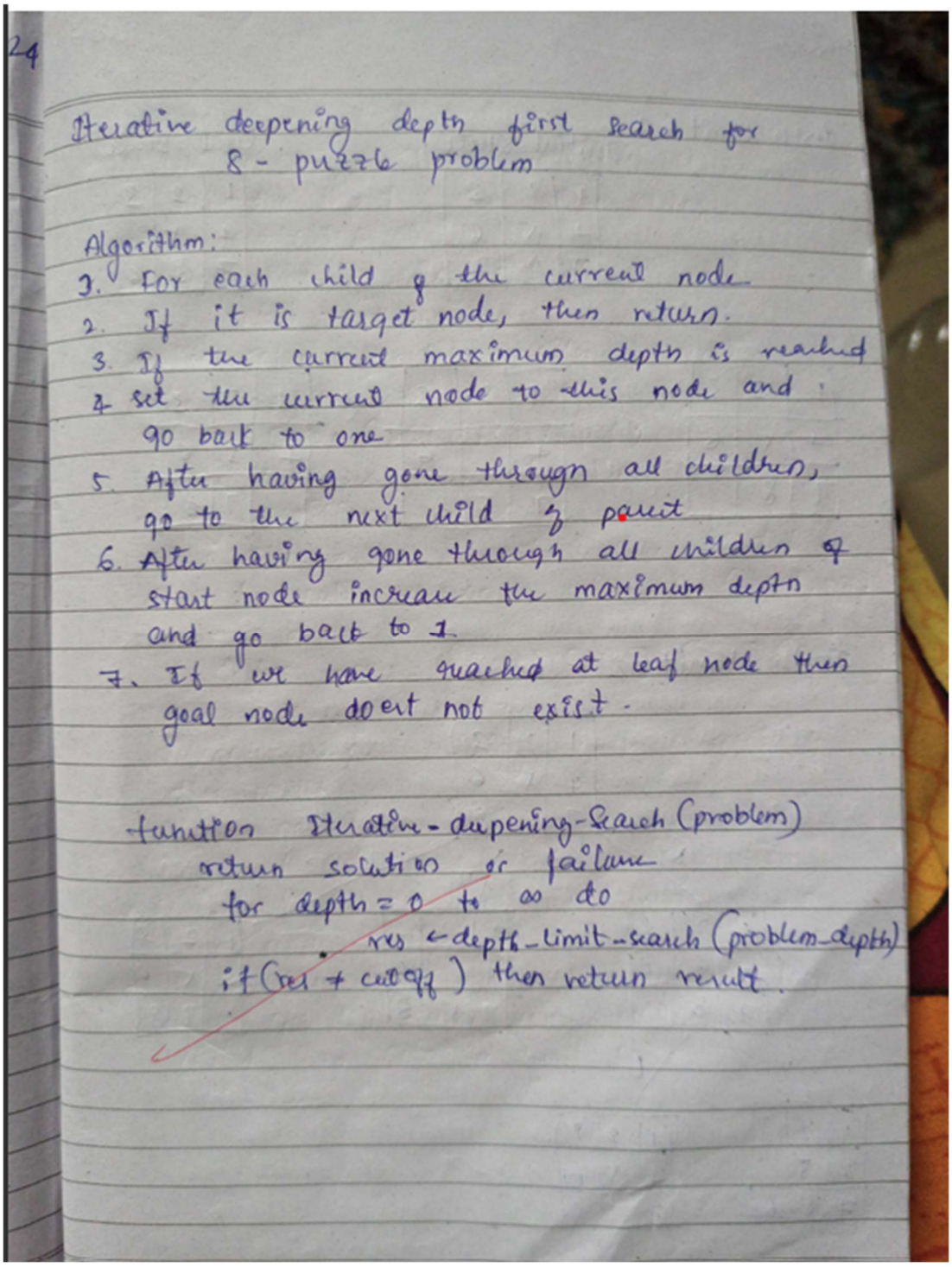
```
goal_state = [[1, 2, 3],
              [4, 5, 6],
              [7, 8, 0]]


def is_goal(state):
    return state == goal_state
def find_blank(state):
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
                return i, j
def swap(state, i1, j1, i2, j2):
    new_state = [row[:] for row in state]
    new_state[i1][j1], new_state[i2][j2] = new_state[i2][j2], new_state[i1][j1]
    return new_state
def get_neighbors(state):
    neighbors = []
    i, j = find_blank(state)
    if i > 0:
        neighbors.append(swap(state, i, j, i - 1, j))
    if i < 2:
        neighbors.append(swap(state, i, j, i + 1, j))
    if j > 0:
```

```
        neighbors.append(swap(state, i, j, i, j - 1))
    if j < 2:
        neighbors.append(swap(state, i, j, i, j + 1))
     return neighbors
def dfs(state, visited, path):
    state_tuple = tuple(tuple(row) for row in state)
    if state_tuple in visited:
        return None
    visited.add(state_tuple)
    if is_goal(state):
        return path
    for neighbor in get_neighbors(state):
        result = dfs(neighbor, visited, path + [neighbor])
        if result is not None:
            return result

    return None

initial_state = [[1, 2, 3],
                 [4, 0, 6],
                 [7, 5, 8]]

visited = set()
solution = dfs(initial_state, visited, [])
```

```
if solution:
    print("Solution found in", len(solution), "steps:")
    for step in solution:
        for row in step:
            print(row)
        print()
else:
    print("No solution found.")
```

```
Solution found in 2 steps:
[1, 2, 3]
[4, 5, 6]
[7, 0, 8]

[1, 2, 3]
[4, 5, 6]
[7, 8, 0]
```

Implement Iterative deepening search algorithm



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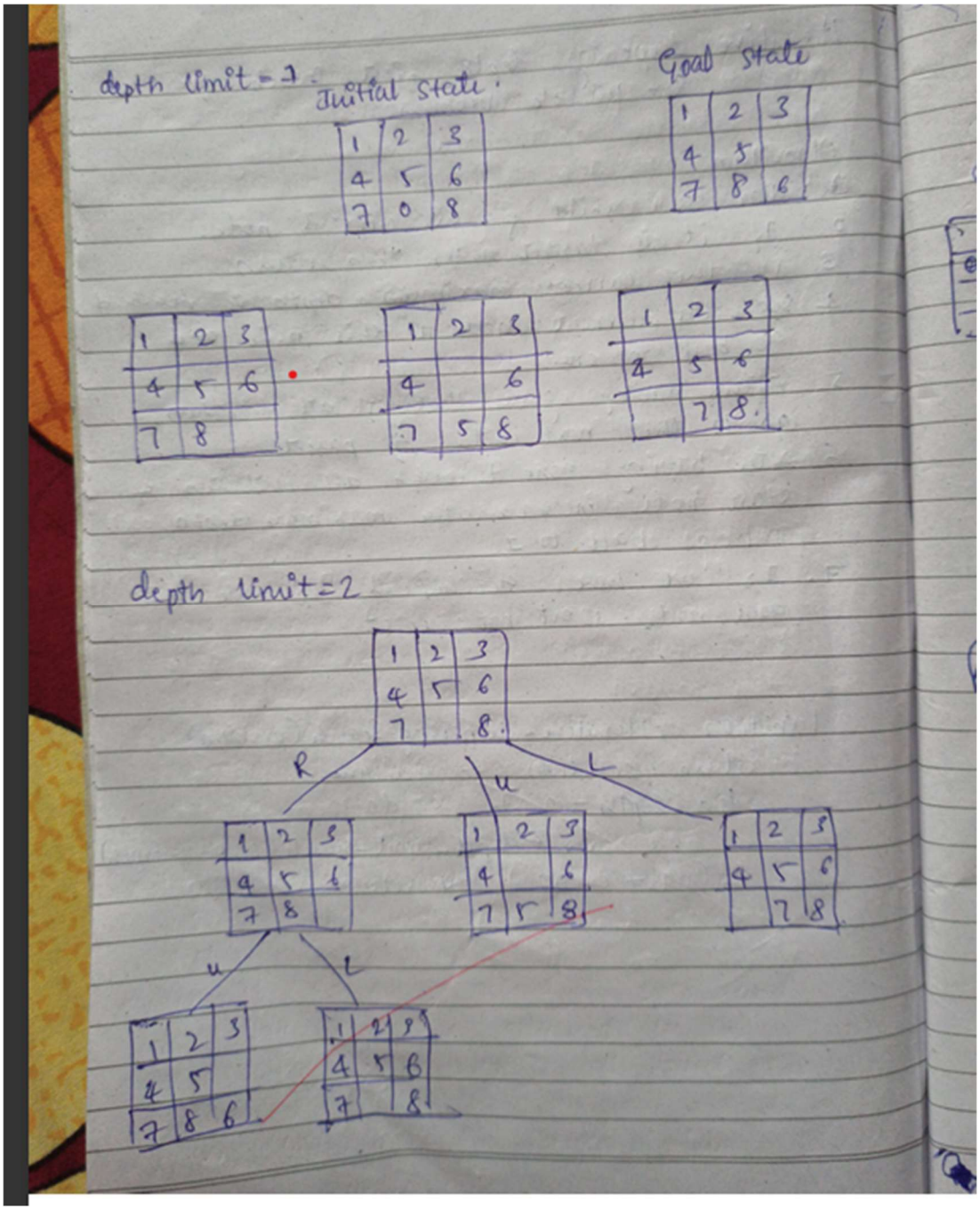
Iterative deepening depth first search for 8-puzzle problem

Algorithm:

1. For each child of the current node
2. If it is target node, then return.
3. If the current maximum depth is reached
4. set the current node to this node and go back to one
5. After having gone through all children, go to the next child of parent
6. After having gone through all children of start node increase the maximum depth and go back to 1.
7. If we have reached at leaf node then goal node does not exist.

function Iterative-deepening-Search (problem)
return solution or failure
for depth = 0 to ∞ do
res ← depth-limit-search (problem, depth)
if (res ≠ cutoff) then return result.



program

```
class PuzzleState:
    def __init__(self, board, moves=0):
        self.board = board
        self.blank_index = board.index(0)  # Find the index of the blank space (0)
```

```
        self.moves = moves

    def get_possible_moves(self):
        possible_moves = []
        row, col = divmod(self.blank_index, 3)

        # Define possible movements: up, down, left, right
        directions = [(-1, 0), (1, 0), (0, -1), (0, 1)]  # (row_change, col_change)

        for dr, dc in directions:
            new_row, new_col = row + dr, col + dc
            if 0 <= new_row < 3 and 0 <= new_col < 3:
                new_blank_index = new_row * 3 + new_col
                new_board = self.board[:]
                # Swap the blank with the adjacent tile
                new_board[self.blank_index], new_board[new_blank_index] =
new_board[new_blank_index], new_board[self.blank_index]
                possible_moves.append(PuzzleState(new_board, self.moves + 1))

        return possible_moves

    def is_goal(self, goal_state):
        return self.board == goal_state

def depth_limited_search(state, depth, goal_state):
```

```
    if state.is_goal(goal_state):
        return state
    if depth == 0:
        return None

    for next_state in state.get_possible_moves():
        result = depth_limited_search(next_state, depth - 1, goal_state)
        if result is not None:
            return result

    return None

def iterative_deepening_search(initial_state, goal_state):
    depth = 0
    while True:
        result = depth_limited_search(initial_state, depth, goal_state)
        if result is not None:
            return result
        depth += 1

# Example Usage
if __name__ == "__main__":
    initial_board = [2, 8, 3, 1, 6, 4, 7, 0, 5]  # Initial state
    goal_state = [2, 0, 3, 1, 8, 4, 7, 6, 5]  # Final state
```

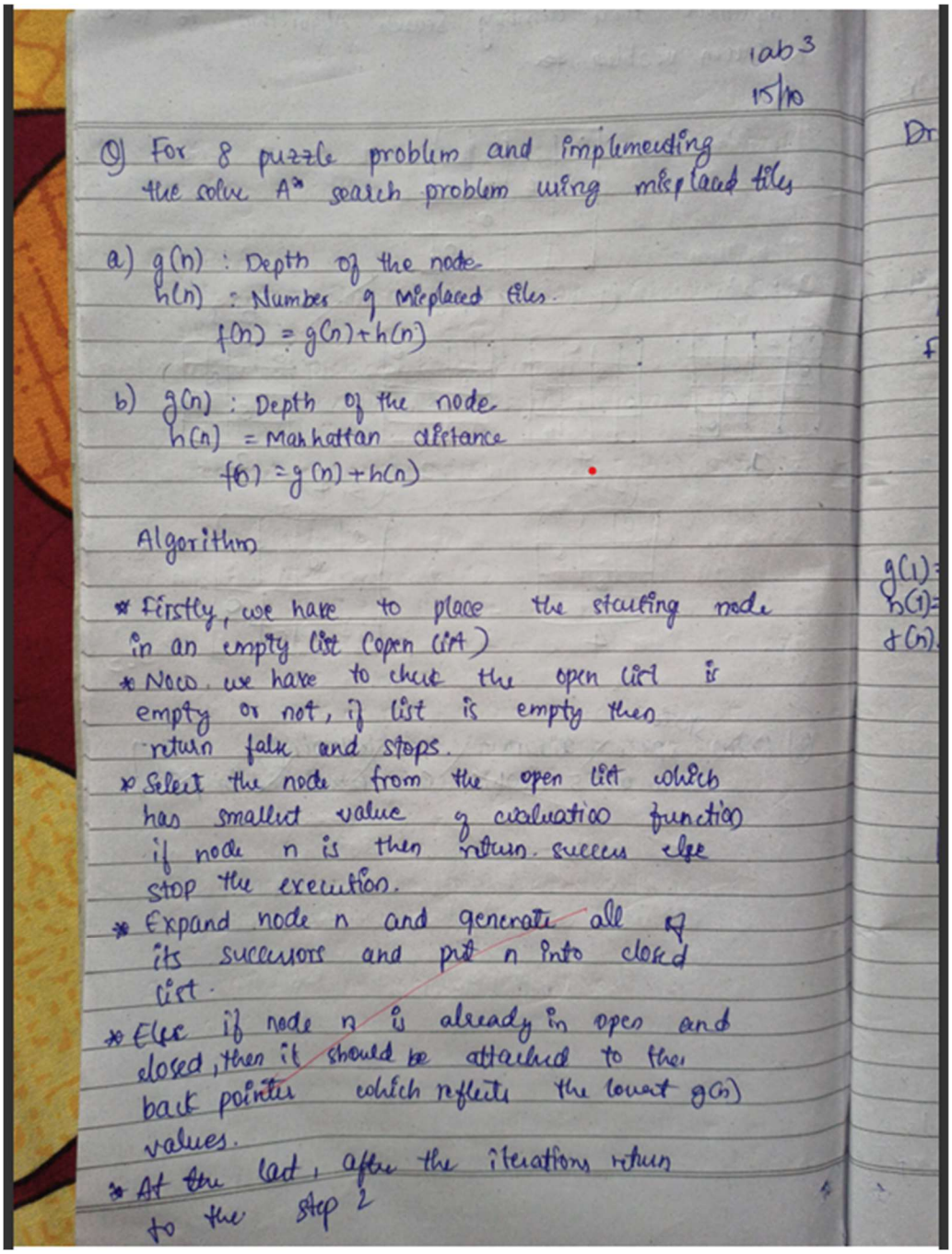
```
initial_state = PuzzleState(initial_board)

solution = iterative_deepening_search(initial_state, goal_state)

if solution:
    print("Solution found!")
    print("Moves:", solution.moves)
    print("Final Board State:", solution.board)
else:
    print("No solution found.")
```

```
Solution found!
Moves: 2
Final Board State: [2, 0, 3, 1, 8, 4, 7, 6, 5]
```

Program 3

Implement A* Search Algorithm

Misplaced Tiles:



lab 3
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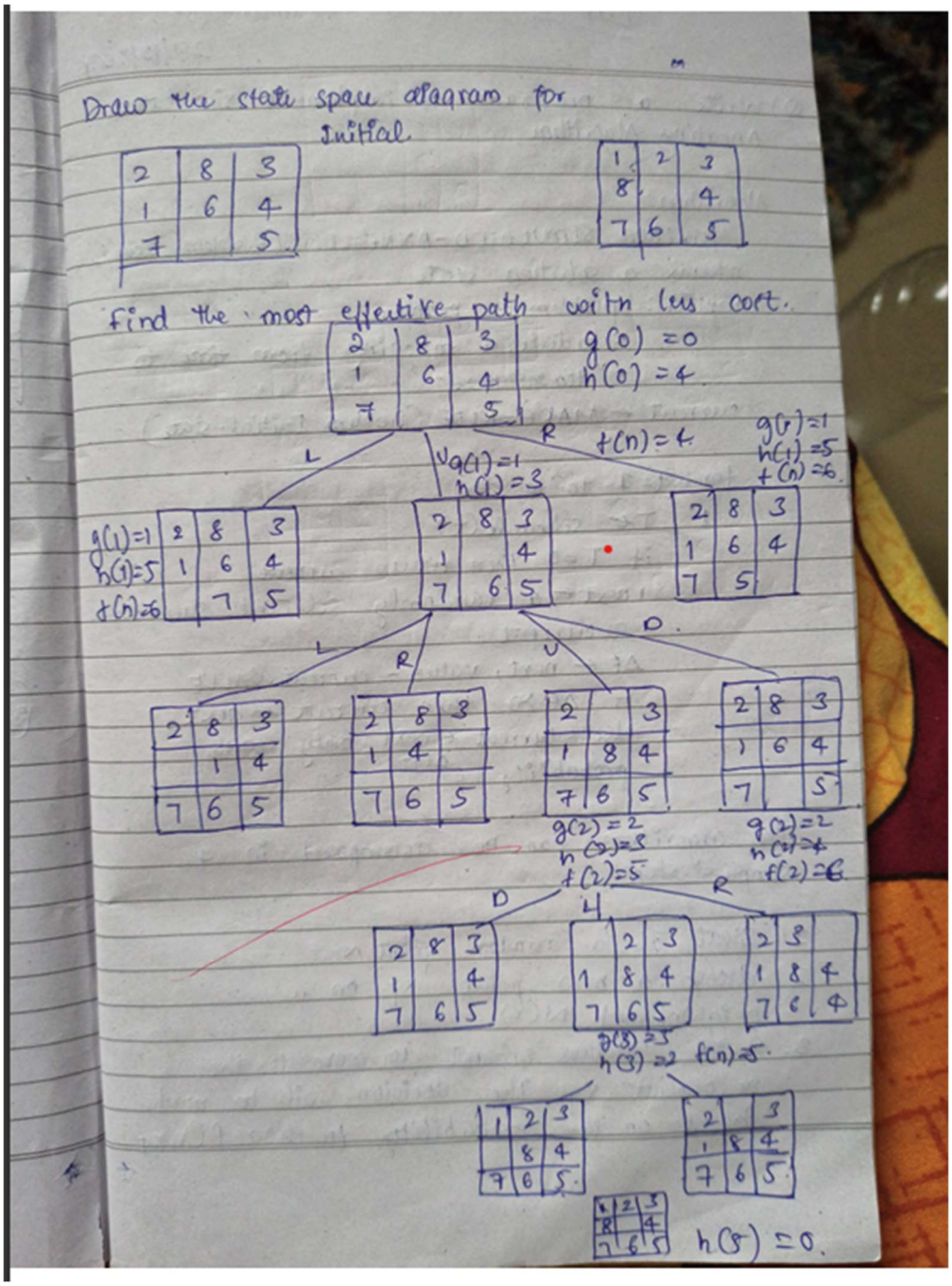
Q) For 8 puzzle problem and implementing the solve A* search problem using misplaced tiles

a) g(n) : Depth of the node
h(n) : Number of misplaced tiles.
f(n) = g(n) + h(n)

b) g(n) : Depth of the node
h(n) = Manhattan distance
f(n) = g(n) + h(n)

Algorithm

* Firstly, we have to place the starting node in an empty list (open list)
* Now we have to check the open list is empty or not, if list is empty then return false and stops.
* Select the node from the open list which has smallest value of evaluation function if node n is then return success else stop the execution.
* Expand node n and generate all of its successors and put n into closed list.
* Else if node n is already in open and closed, then it should be attached to the back pointer which reflects the lowest g(n) values.
* At the last, after the iterations return to the step 2


Draw the state space diagram for
Initial
Find the most effective path with less cost.
g(0) = 0
h(0) = 4
f(n) = 4
g(1) = 1
h(1) = 3
g(2) = 2
h(2) = 5
f(2) = 5
h(3) = 0.

Program:

```
import heapq
def manhattan_distance(state, goal):
    distance = 0
    for i in range(3):
        for j in range(3):
            tile = state[i][j]
            if tile != 0:
                for r in range(3):
                    for c in range(3):
                        if goal[r][c] == tile:
                            target_row, target_col = r, c
                            break
                distance += abs(target_row - i) + abs(target_col - j)
    return distance


def findmin(open_list, goal):
    minv = float('inf')
    best_state = None
    for state in open_list:
        h = manhattan_distance(state['state'], goal)
        f = state['g'] + h
        if f < minv:
            minv = f
```

```
            best_state = state
    open_list.remove(best_state)
    return best_state


def operation(state):
    next_states = []
    blank_pos = find_blank_position(state['state'])
    for move in ['up', 'down', 'left', 'right']:
        new_state = apply_move(state['state'], blank_pos, move)
        if new_state:
            next_states.append({
                'state': new_state,
                'parent': state,
                'move': move,
                'g': state['g'] + 1
            })
    return next_states


def find_blank_position(state):
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
                return i, j
    return None
```

```
def apply_move(state, blank_pos, move):
    i, j = blank_pos
    new_state = [row[:] for row in state]
    if move == 'up' and i > 0:
        new_state[i][j], new_state[i - 1][j] = new_state[i - 1][j], new_state[i][j]
    elif move == 'down' and i < 2:
        new_state[i][j], new_state[i + 1][j] = new_state[i + 1][j], new_state[i][j]
    elif move == 'left' and j > 0:
        new_state[i][j], new_state[i][j - 1] = new_state[i][j - 1], new_state[i][j]
    elif move == 'right' and j < 2:
        new_state[i][j], new_state[i][j + 1] = new_state[i][j + 1], new_state[i][j]
    else:
        return None
    return new_state

def print_state(state):
    for row in state:
        print(' '.join(map(str, row)))
initial_state = [[2, 8, 3], [1, 6, 4], [7, 0, 5]]
goal_state = [[1, 2, 3], [8, 0, 4], [7, 6, 5]]

open_list = [{'state': initial_state, 'parent': None, 'move': None, 'g': 0}]
visited_states = []
```

```
while open_list:
    best_state = findmin(open_list, goal_state)

    h = manhattan_distance(best_state['state'], goal_state)
    f = best_state['g'] + h

    print(f"g(n) = {best_state['g']}, h(n) = {h}, f(n) = {f}")
    print_state(best_state['state'])
    print()

    if h == 0:
        print("Goal state reached!")
        break

    visited_states.append(best_state['state'])
    next_states = operation(best_state)

    for state in next_states:
        if state['state'] not in visited_states:
            open_list.append(state)

if h == 0:
    moves = []
```

```
    goal_state_reached = best_state
    while goal_state_reached['move'] is not None:
        moves.append(goal_state_reached['move'])
        goal_state_reached = goal_state_reached['parent']
    moves.reverse()
    print("\nMoves to reach the goal state:", moves)
else:
    print("No solution found.")
```

OUTPUT :

```
g(n) = 0, h(n) = 5, f(n) = 5
2 8 3
1 6 4
7 0 5

g(n) = 1, h(n) = 4, f(n) = 5
2 8 3
1 0 4
7 6 5

g(n) = 2, h(n) = 3, f(n) = 5
2 0 3
1 8 4
7 6 5

g(n) = 3, h(n) = 2, f(n) = 5
0 2 3
1 8 4
7 6 5

g(n) = 4, h(n) = 1, f(n) = 5
1 2 3
0 8 4
7 6 5

g(n) = 5, h(n) = 0, f(n) = 5
1 2 3
8 0 4
7 6 5

Goal state reached!

Moves to reach the goal state: ['up', 'up', 'left', 'down', 'right']
```

Misplaced Tiles:

```
import heapq


def find_blank_tile(state):
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
                return i, j
    return None


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


def generate_moves(state):
    moves = []
    x, y = find_blank_tile(state)
    directions = [(-1, 0), (1, 0), (0, -1), (0, 1)]


    for dx, dy in directions:
```

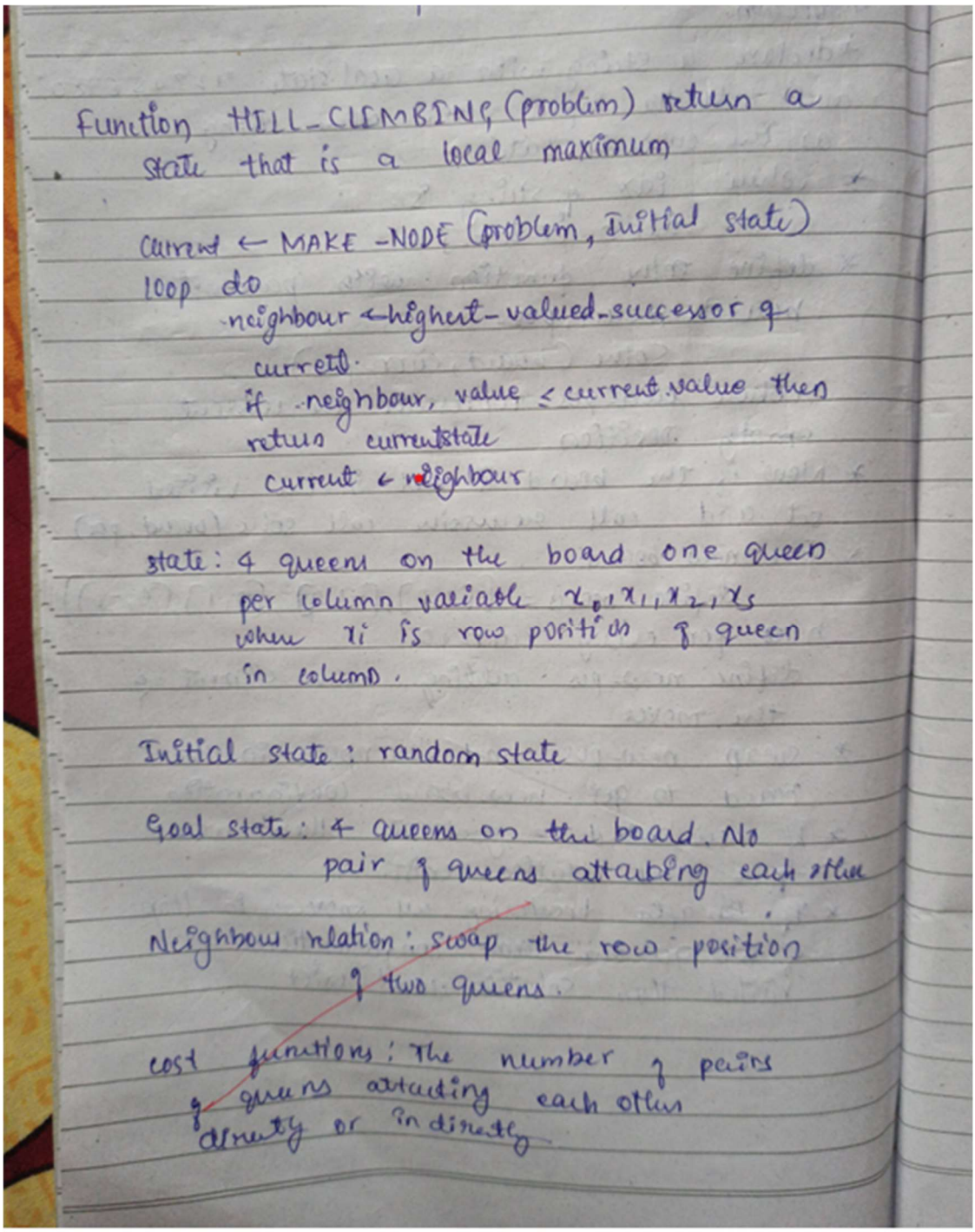
```
        new_x, new_y = x + dx, y + dy
        if 0 <= new_x < 3 and 0 <= new_y < 3:
            new_state = [row[:] for row in state]

            new_state[x][y], new_state[new_x][new_y] = new_state[new_x][new_y], new_state[x][y]
            moves.append(new_state)
    return moves

def print_state(state):
    for row in state:
        print(row)
    print()

def a_star_8_puzzle(start, goal):

    open_list = []

    heapq.heappush(open_list, (count_misplaced_tiles(start, goal), 0, start, None))

    visited = set()

    while open_list:

        f_n, g_n, current_state, previous_state = heapq.heappop(open_list)
```

```
        print(f"g(n) = {g_n}, h(n) = {f_n - g_n}, f(n) = {f_n}")
        print_state(current_state)

        if current_state == goal:
            print("Goal state reached!")
            return

        visited.add(tuple(map(tuple, current_state)))

        for move in generate_moves(current_state):
            move_tuple = tuple(map(tuple, move))
            if move_tuple not in visited:

                g_move = g_n + 1
                h_move = count_misplaced_tiles(move, goal)
                f_move = g_move + h_move
                heapq.heappush(open_list, (f_move, g_move, move, current_state))

start_state = [[2, 8, 3], [1, 6, 4], [7, 0, 5]]
goal_state = [[1, 2, 3], [8, 0, 4], [7, 6, 5]]

a_star_8_puzzle(start_state, goal_state)
```

```
g(n) = 0, h(n) = 4, f(n) = 4
[2, 8, 3]
[1, 6, 4]
[7, 0, 5]

g(n) = 1, h(n) = 3, f(n) = 4
[2, 8, 3]
[1, 0, 4]
[7, 6, 5]

g(n) = 2, h(n) = 3, f(n) = 5
[2, 0, 3]
[1, 8, 4]
[7, 6, 5]

g(n) = 2, h(n) = 3, f(n) = 5
[2, 8, 3]
[0, 1, 4]
[7, 6, 5]

g(n) = 3, h(n) = 2, f(n) = 5
[0, 2, 3]
[1, 8, 4]
[7, 6, 5]

g(n) = 4, h(n) = 1, f(n) = 5
[1, 2, 3]
[0, 8, 4]
[7, 6, 5]

g(n) = 5, h(n) = 0, f(n) = 5
[1, 2, 3]
[8, 0, 4]
[7, 6, 5]

Goal state reached!
```

Program 4

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



Function HILL-CLIMBING (problem) return a state that is a local maximum

Current ← MAKE-NODE (problem, Initial state)
loop do
neighbour ← highest-valued-successor of current.
if neighbour, value ≤ current value then return current state
current ← neighbour

state: 4 queens on the board one queen per column variable x_0, x_1, x_2, x_3 where x_i is row position of queen in column.

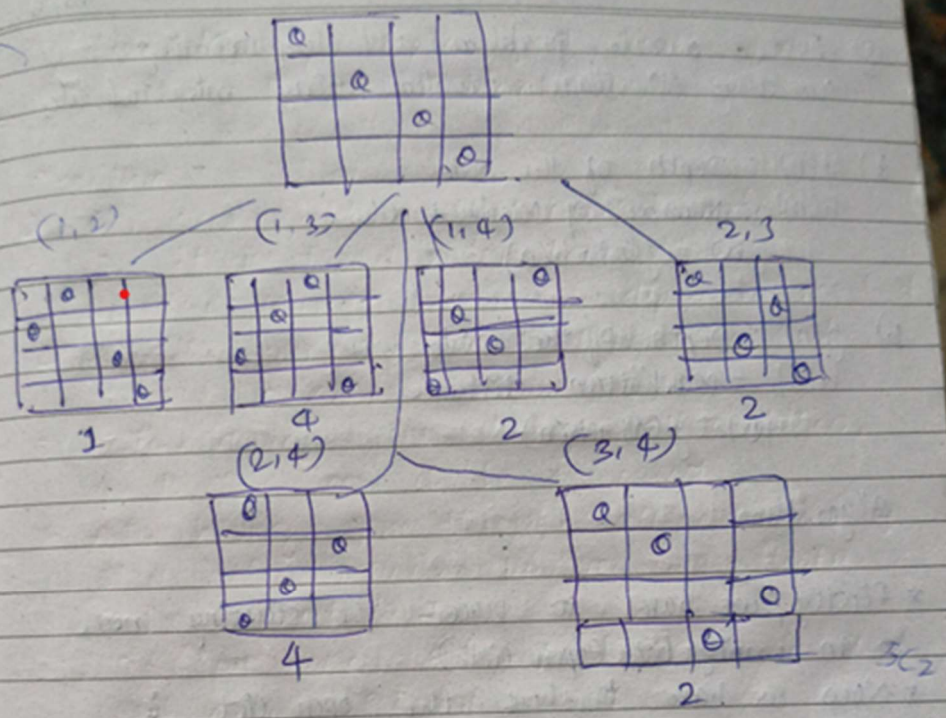
Initial state: random state

Goal state: 4 queens on the board. No pair of queens attacking each other.

Neighbour relation: Swap the row position of two queens.

cost functions: The number of pairs of queens attacking each other directly or indirectly

Implement Hill climbing Search Algorithm to solve N-Queen problem.



Q) Draw state space diagram for following write all 5 which are mentioned in ppt.

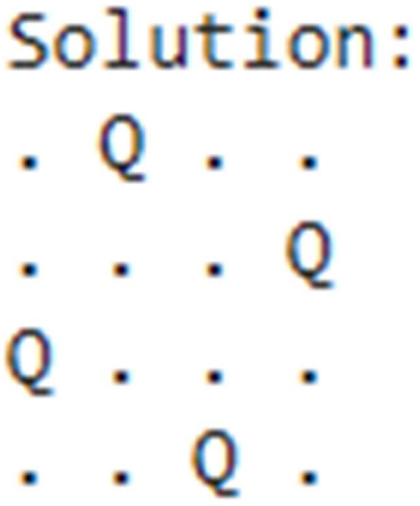
PROGRAM :

```
import random

class NQueens:
    def __init__(self, n):
        self.n = n
        self.board = self.init_board()
    def init_board(self):
        # Randomly place one queen in each column
        return [random.randint(0, self.n - 1) for _ in range(self.n)]


    def fitness(self, board):
        # Count the number of pairs of queens attacking each other
        conflicts = 0
        for col in range(self.n):
            for other_col in range(col + 1, self.n):
                if board[col] == board[other_col] or abs(board[col] - board[other_col]) == abs(col -
other_col):
                    conflicts += 1
        return conflicts
    def get_neighbors(self, board):
        neighbors = []
        for col in range(self.n):
            for row in range(self.n):
                if row != board[col]:  # Move queen to a different row in the same column
                    new_board = board[:]
```

```
                new_board[col] = row
                neighbors.append(new_board)
        return neighbors
    def hill_climbing(self):
        current_board = self.board
        current_fitness = self.fitness(current_board)

        while current_fitness > 0:
            neighbors = self.get_neighbors(current_board)
            next_board = None
            next_fitness = current_fitness
            for neighbor in neighbors:
                neighbor_fitness = self.fitness(neighbor)
                if neighbor_fitness < next_fitness:
                    next_fitness = neighbor_fitness
                    next_board = neighbor
            if next_board is None:
                # Stuck at local maximum, can either return or restart
                print("Stuck at local maximum. Restarting...")
                self.board = self.init_board()
                current_board = self.board
                current_fitness = self.fitness(current_board)
            else:
                current_board = next_board
```

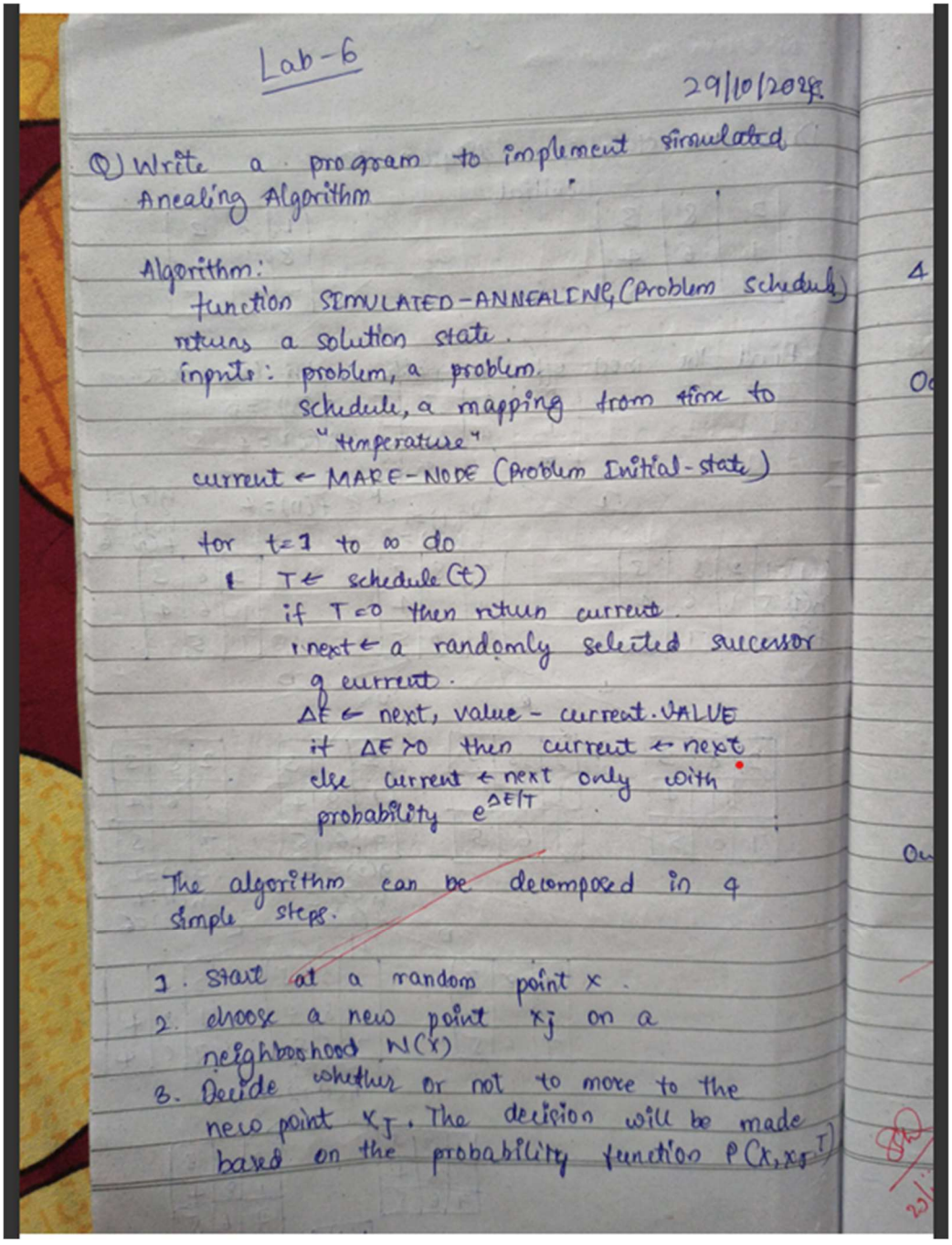
```
            current_fitness = next_fitness
        return current_board
# Example usage
if __name__ == "__main__":
    n = 4  # Size of the board (N)
    n_queens_solver = NQueens(n)
    solution = n_queens_solver.hill_climbing()

    print("Solution:")
    for row in solution:
        line = ['Q' if i == row else '.' for i in range(n)]
        print(' '.join(line))
```

OUTPUT



Program 5

Simulated Annealing to Solve 8-Queens problem.



Lab-6

29/10/2024

Q) Write a program to implement simulated Annealing Algorithm

Algorithm:

function SIMULATED-ANNEALING(Problem schedule) returns a solution state.

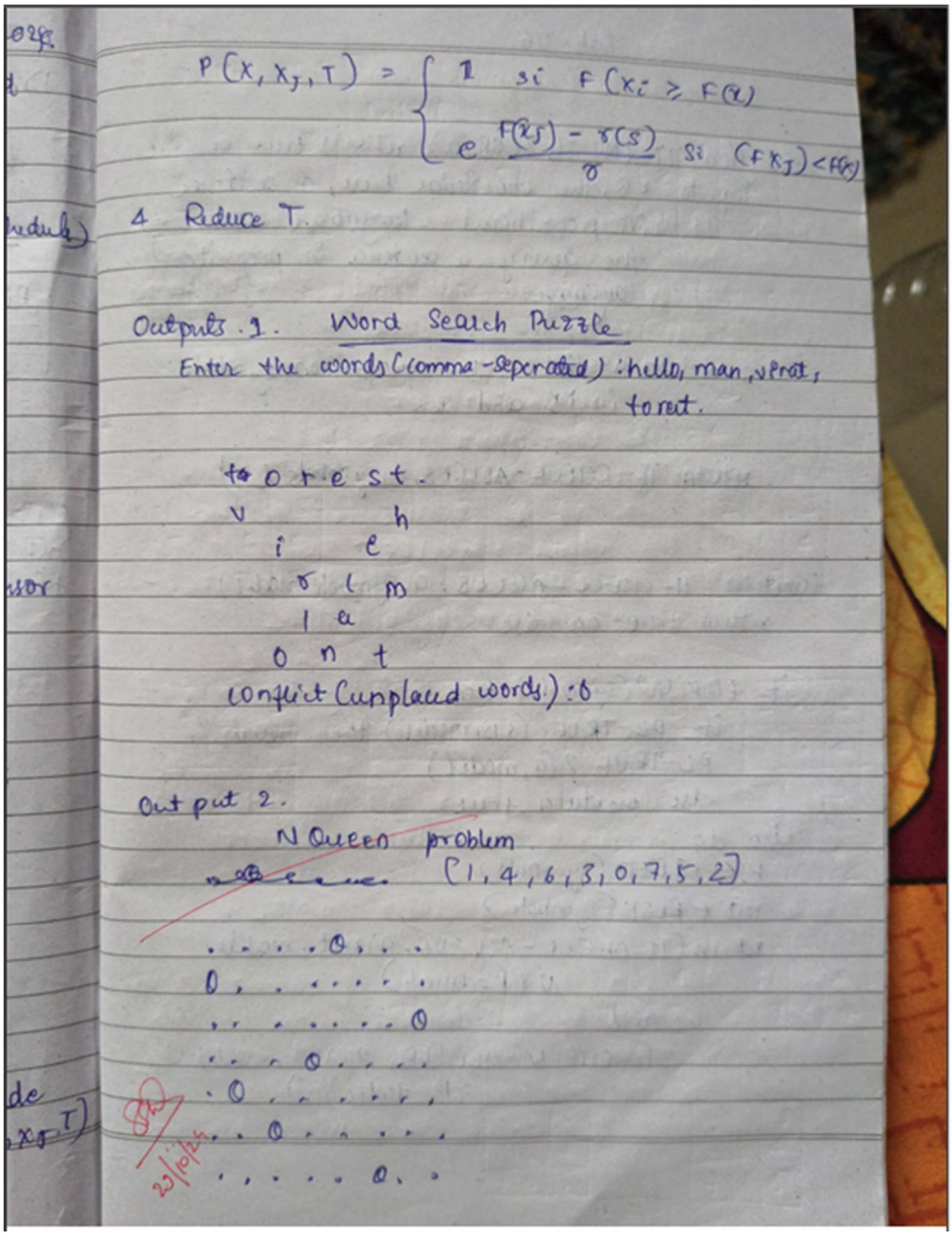
inputs: problem, a problem.
schedule, a mapping from time to "temperature"

current ← MAKE-NODE (Problem Initial-state)

for t=1 to ∞ do
T ← schedule (t)
if T=0 then return current.
next ← a randomly selected successor of current.
ΔE ← next, value - current.VALUE
if ΔE > 0 then current ← next
else current ← next only with probability $e^{\Delta E/T}$

The algorithm can be decomposed in 4 simple steps.

1. Start at a random point x.
2. choose a new point x_j on a neighborhood N(x)
3. Decide whether or not to move to the new point x_j. The decision will be made based on the probability function P(x, x_j, T)



PROGRAM :

import random

import math

def print_board(state):

```
    size = len(state)
    for i in range(size):
        row = ['.'] * size
        row[state[i]] = 'Q'
        print(' '.join(row))
    print()

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

def random_state(size):
    return [random.randint(0, size - 1) for _ in range(size)]

def neighbor(state):
    new_state = state[:]
    idx = random.randint(0, len(state) - 1)
    new_state[idx] = random.randint(0, len(state) - 1)
    return new_state
```

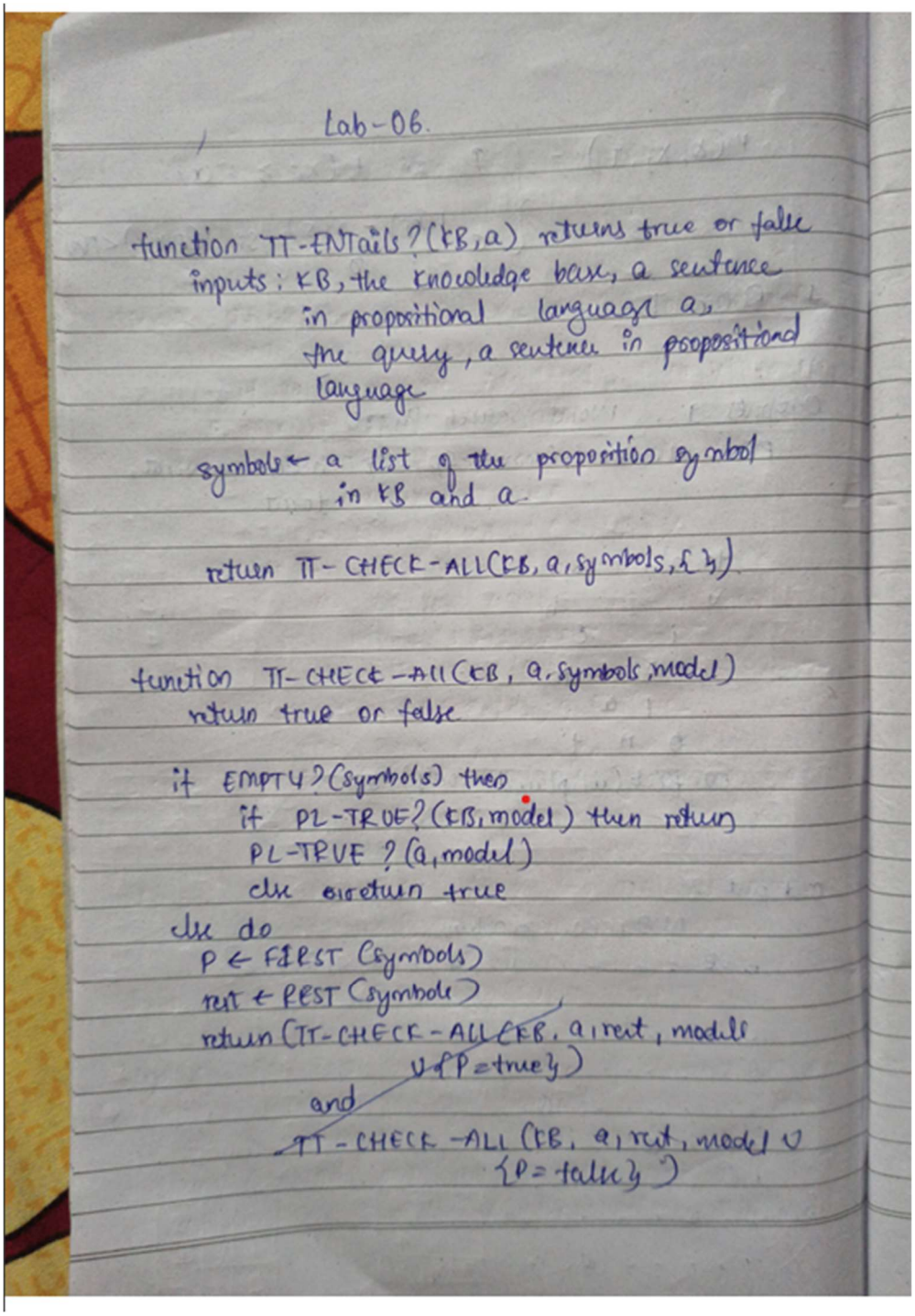
```
def simulated_annealing(size, initial_temp, cooling_rate):
    current_state = random_state(size)
    current_conflicts = calculate_conflicts(current_state)
    temperature = initial_temp

    while temperature > 1:
        new_state = neighbor(current_state)
        new_conflicts = calculate_conflicts(new_state)

        # If new state is better, accept it
        if new_conflicts < current_conflicts:
            current_state, current_conflicts = new_state, new_conflicts
        else:
            # Accept with a probability based on temperature
            acceptance_probability = math.exp((current_conflicts - new_conflicts) / temperature)
            if random.random() < acceptance_probability:
                current_state, current_conflicts = new_state, new_conflicts

        temperature *= cooling_rate

    return current_state

def main():
```

```
    size = 8
    initial_temp = 1000
    cooling_rate = 0.995

    solution = simulated_annealing(size, initial_temp, cooling_rate)
    print("Solution found:")
    print_board(solution)
    print("Conflicts:", calculate_conflicts(solution))

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

```
Solution found:
. . . . . . Q .
. . Q . . . . .
. . . . . . . Q
Q . . . . . . .
. . . . Q . . .
. . . Q . . . .
. . . . Q . . .
. . . . . Q . .

Conflicts: 6
```

Program 6

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



Lab-06.

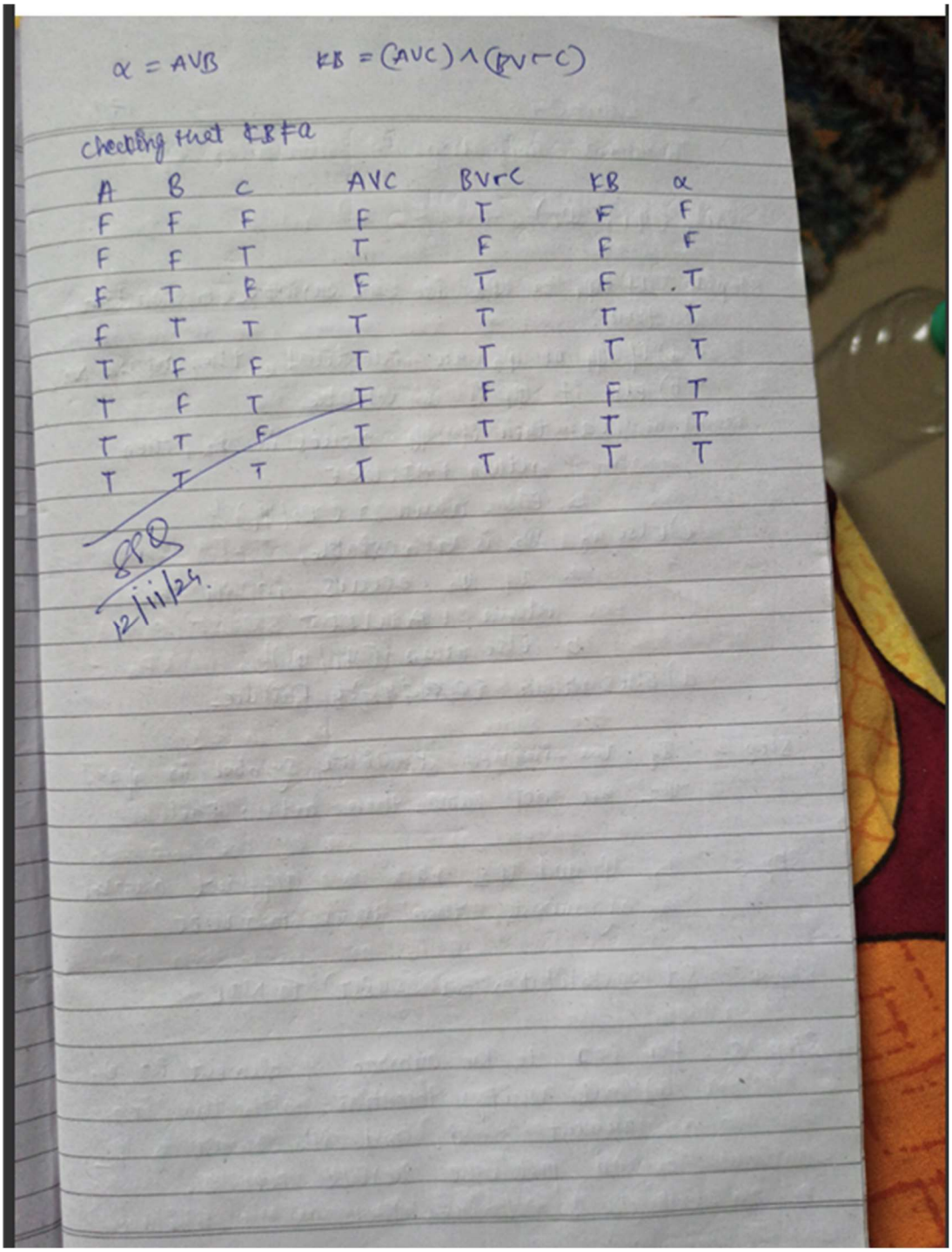
function TT-ENTails?(KB, α) returns true or false
inputs: KB, the knowledge base, a sentence in propositional language α,
the query, a sentence in propositional language

symbols ← a list of the proposition symbol in KB and α

return TT-CHECK-ALL(KB, α, symbols, {})

function TT-CHECK-ALL(KB, α, symbols, model)
return true or false

if EMPTY?(symbols) then
if PL-TRUE?(KB, model) then return PL-TRUE?(α, model)
else return true
else do
P ← FIRST(symbols)
rest ← REST(symbols)
return (TT-CHECK-ALL(KB, α, rest, model ∪ {P = true}) and TT-CHECK-ALL(KB, α, rest, model ∪ {P = false}))



PROGRAM :

```
def truth_table_entailment():
    print(f"{'A':<7}{'B':<7}{'C':<7}{'A or C':<12}{'B or not C':<15}{'KB':<8}{'alpha':<10}")
```

```
print("-" * 65)
all_entail = True
for A in [False, True]:
    for B in [False, True]:
        for C in [False, True]:
            # Calculate individual components
            A_or_C = A or C                 # A or C
            B_or_not_C = B or (not C)       # B or not C
            KB = A_or_C and B_or_not_C      # KB = (A or C) and (B or not C)
            alpha = A or B                  # alpha = A or B

            # Determine if KB entails alpha for this row
            kb_entails_alpha = (not KB) or alpha  # True if KB implies alpha

            # If in any row KB does not entail alpha, set flag to False
            if not kb_entails_alpha:
                all_entail = False

            # Print the results for this row
            print(f"{str(A):<7}{str(B):<7}{str(C):<7}{str(A_or_C):<12}{str(B_or_not_C):<15}{str(KB)
:<8}{str(alpha):<10}")

    # Final result based on all rows
    if all_entail:
        print("\nKB entails alpha for all cases.")
```

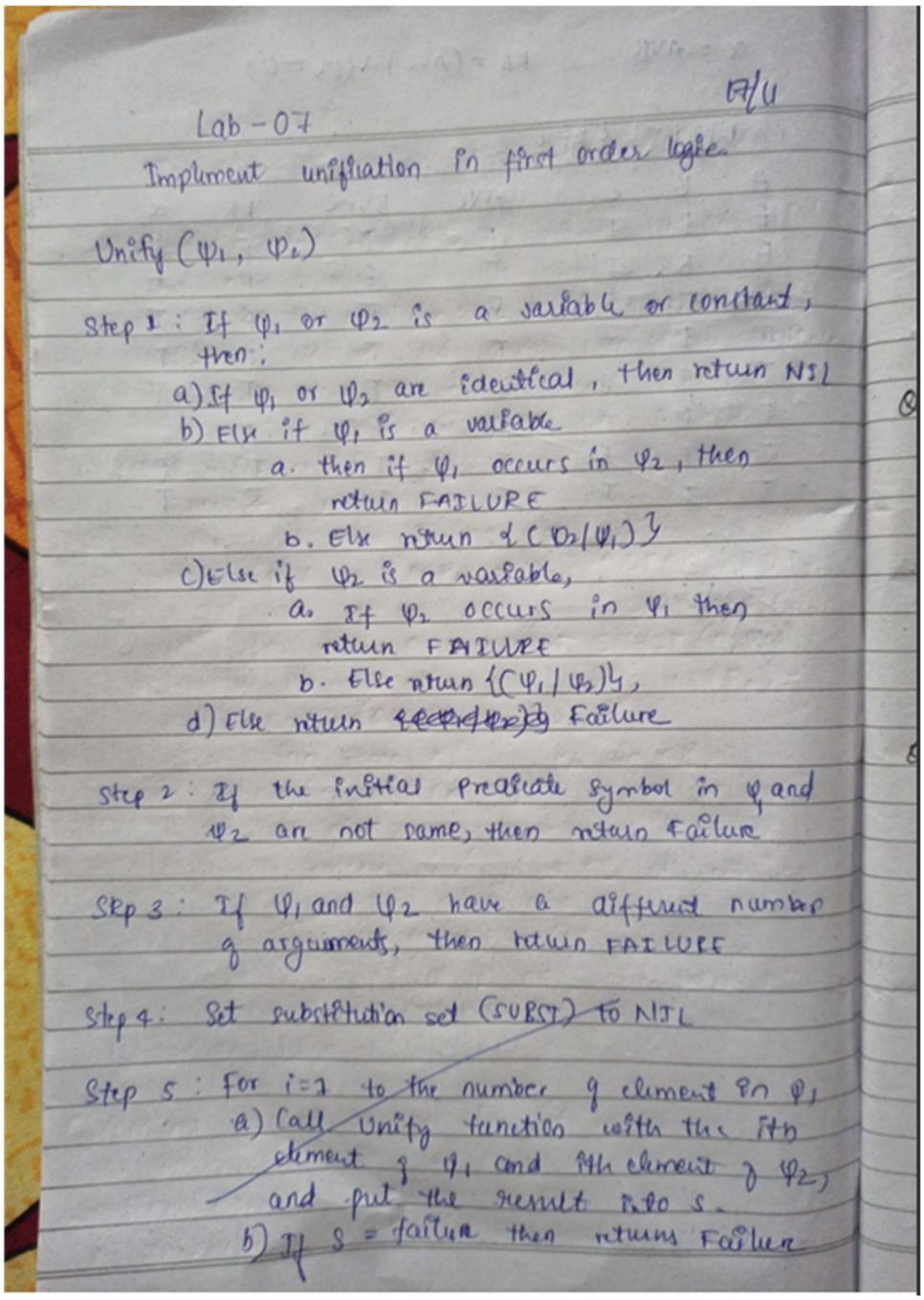
```
    else:
        print("\nKB does not entail alpha for all cases.")


# Run the function to display the truth table and final result
truth_table_entailment()
```

OUTPUT :

```
A      B      C      A or C      B or not C     KB      alpha
---------------------------------------------------------------
False  False  False  False       True           False   False
False  False  True   True        False          False   False
False  True   False  False       True           False   True
False  True   True   True        True           True    True
True   False  False  True        True           True    True
True   False  True   True        False          False   True
True   True   False  True        True           True    True
True   True   True   True        True           True    True

KB entails alpha for all cases.
```

Program 7

Implement unification in first order logic.



Lab - 07

Implement unification in first order logic

Unify (ψ_1, ψ_2)

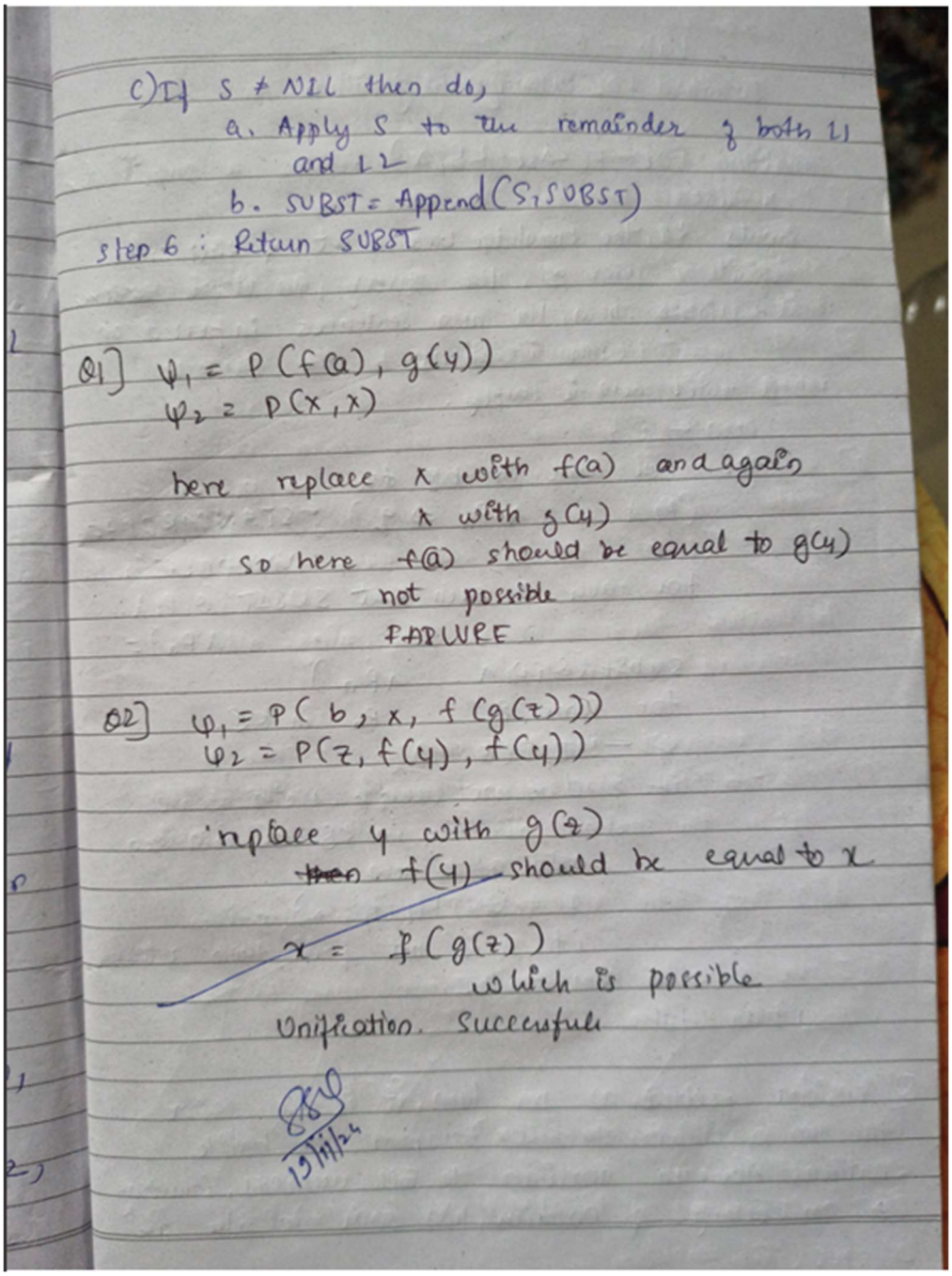
Step 1 : If ψ_1 or ψ_2 is a variable or constant, then:
a) If ψ_1 or ψ_2 are identical, then return NIL
b) Else if ψ_1 is a variable
a. then if ψ_1 occurs in ψ_2, then return FAILURE
b. Else return {(ψ_2/ψ_1)}
c) Else if ψ_2 is a variable,
a. If ψ_2 occurs in ψ_1 then return FAILURE
b. Else return {(ψ_1/ψ_2)},
d) Else return ~~{(psi1/psi2)}~~ Failure

Step 2 : If the initial predicate symbol in ψ_1 and ψ_2 are not same, then return Failure

Step 3 : If ψ_1 and ψ_2 have a different number of arguments, then return FAILURE

Step 4 : Set substitution set (SUBST) to NIL

Step 5 : For i=1 to the number of element in ψ_1
a) Call Unify function with the ith element of ψ_1 and ith element of ψ_2, and put the result into S.
b) If S = failure then returns Failure



PROGRAM :

```
def unify(expr1, expr2, substitution=None):
    """
    Perform unification on two expressions in first-order logic.
```

```
Args:
    expr1: The first expression (can be a variable, constant, or list representing a function).
    expr2: The second expression.
    substitution: The current substitution (dictionary).

Returns:
    A dictionary representing the most general unifier (MGU), or None if unification fails.
"""
if substitution is None:
    substitution = {}

# Debug: Print inputs and current substitution
print(f"Unifying {expr1} and {expr2} with substitution {substitution}")

# Apply existing substitutions to both expressions
expr1 = apply_substitution(expr1, substitution)
expr2 = apply_substitution(expr2, substitution)

# Debug: Print expressions after applying substitution
print(f"After substitution: {expr1} and {expr2}")

# Case 1: If expressions are identical, no substitution is needed
if expr1 == expr2:
```

```
    return substitution

# Case 2: If expr1 is a variable
if is_variable(expr1):
    return unify_variable(expr1, expr2, substitution)

# Case 3: If expr2 is a variable
if is_variable(expr2):
    return unify_variable(expr2, expr1, substitution)

# Case 4: If both are compound expressions (e.g., functions or predicates)
if is_compound(expr1) and is_compound(expr2):
    if expr1[0] != expr2[0] or len(expr1) != len(expr2):
        print(f"Failure: Predicate names or arity mismatch {expr1[0]} != {expr2[0]}")
        return None  # Function names or arity mismatch
    for arg1, arg2 in zip(expr1[1:], expr2[1:]):
        substitution = unify(arg1, arg2, substitution)
        if substitution is None:
            print(f"Failure: Could not unify arguments {arg1} and {arg2}")
            return None
    return substitution

# Case 5: Otherwise, unification fails
print(f"Failure: Could not unify {expr1} and {expr2}")
```

```
    return None

def unify_variable(var, expr, substitution):
    """
    Handles the unification of a variable with an expression.

    Args:
        var: The variable.
        expr: The expression to unify with.
        substitution: The current substitution.

    Returns:
        The updated substitution, or None if unification fails.
    """
    if var in substitution:
        # Apply substitution recursively
        return unify(substitution[var], expr, substitution)
    elif occurs_check(var, expr):
        # Occurs check fails if the variable appears in the term it's being unified with
        print(f"Occurs check failed: {var} in {expr}")
        return None
    else:
        substitution[var] = expr
        print(f"Substitution added: {var} -> {expr}")
```

```
        return substitution

def occurs_check(var, expr):
    """
    Checks if a variable occurs in an expression (to prevent cyclic substitutions).

    Args:
        var: The variable to check.
        expr: The expression to check against.

    Returns:
        True if the variable occurs in the expression, otherwise False.
    """
    if var == expr:
        return True
    elif is_compound(expr):
        return any(occurs_check(var, arg) for arg in expr[1:])
    return False

def is_variable(expr):
    """Checks if the expression is a variable."""
    return isinstance(expr, str) and expr[0].islower()

def is_compound(expr):
```

```
    """Checks if the expression is compound (e.g., function or predicate)."""
    return isinstance(expr, list) and len(expr) > 0

def apply_substitution(expr, substitution):
    """
    Applies a substitution to an expression.

    Args:
        expr: The expression to apply the substitution to.
        substitution: The current substitution.

    Returns:
        The updated expression with substitutions applied.
    """
    if is_variable(expr) and expr in substitution:
        return apply_substitution(substitution[expr], substitution)
    elif is_compound(expr):
        return [apply_substitution(arg, substitution) for arg in expr]
    return expr

# Example Usage:
expr1 = ['P', 'X', 'Y']
expr2 = ['P', 'a', 'Z']
result = unify(expr1, expr2)
```

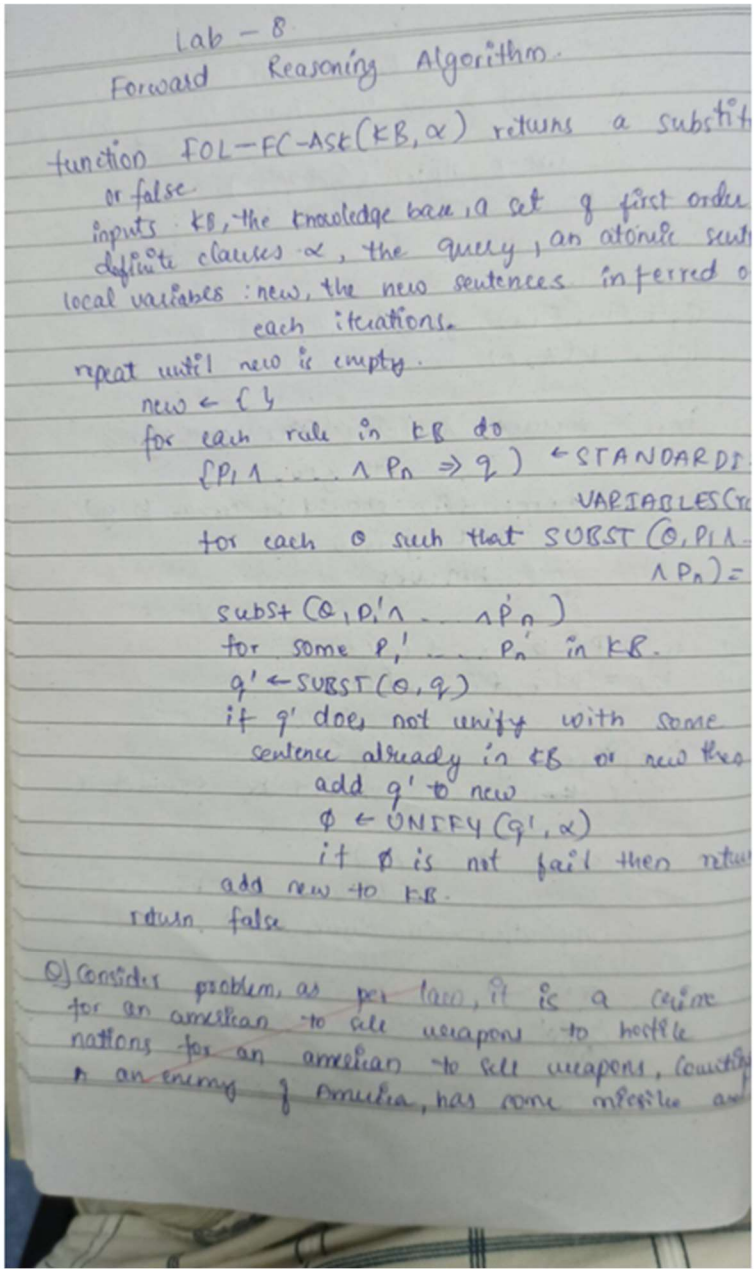
print("Unification Result:", result)

OUTPUT :

```
Unifying ['P', 'X', 'Y'] and ['P', 'a', 'Z'] with substitution {}
After substitution: ['P', 'X', 'Y'] and ['P', 'a', 'Z']
Unifying X and a with substitution {}
After substitution: X and a
Substitution added: a -> X
Unifying Y and Z with substitution {'a': 'X'}
After substitution: Y and Z
Failure: Could not unify Y and Z
Failure: Could not unify arguments Y and Z
Unification Result: None
```

Program 8

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



Lab – 8

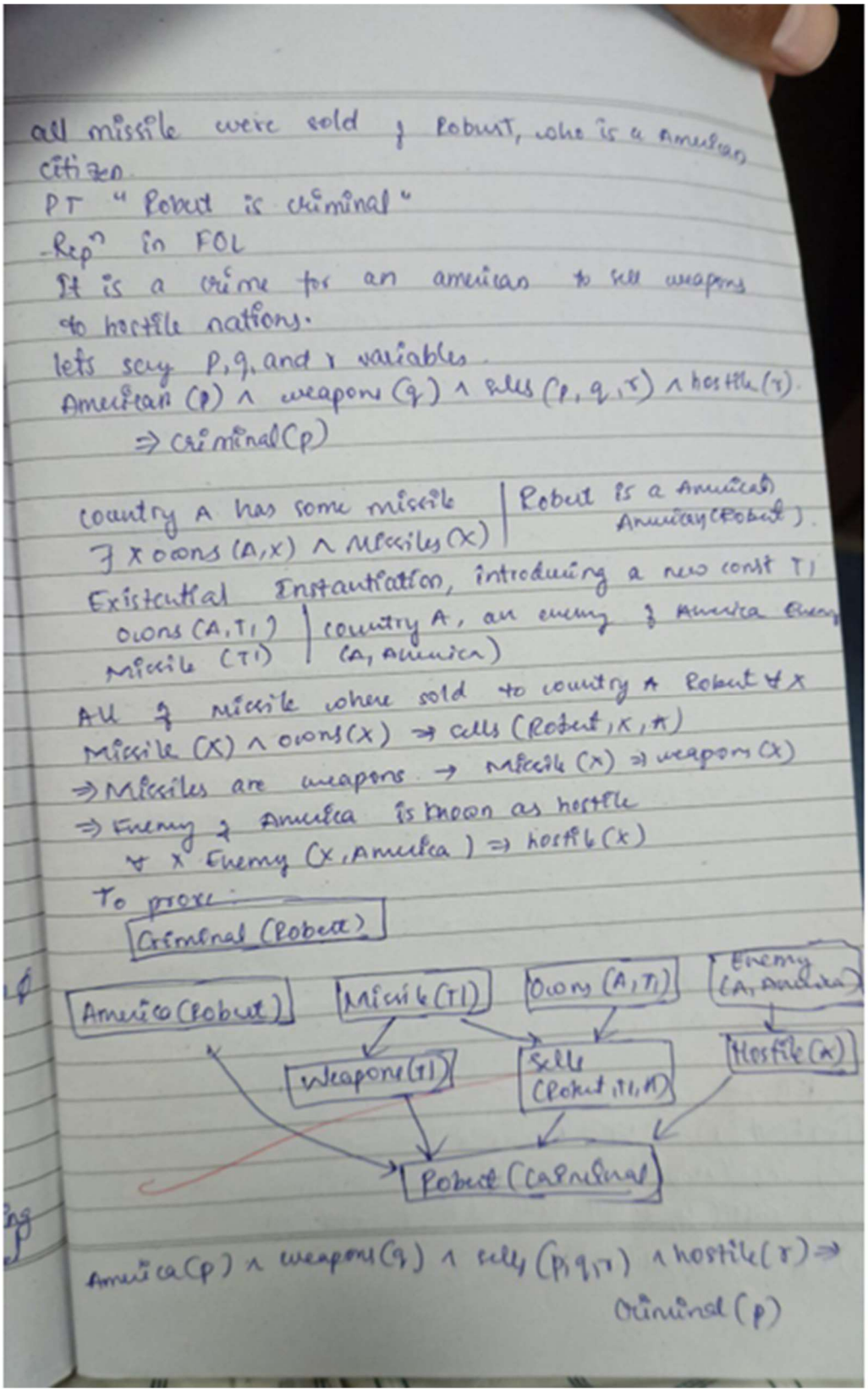
Forward Reasoning Algorithm.

function FOL-FC-ASK(KB, α) returns a substit
or false

inputs: KB, the knowledge base, a set of first order
definite clauses α, the query, an atomic sent
local variables: new, the new sentences inferred o
each iterations.

repeat until new is empty.
new ← { }
for each rule in KB do
(P1 ∧ ... ∧ Pn ⇒ q) ← STANDARDI
VARIABLES(r
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 the
add q' to new
φ ← UNIFY(q', α)
if φ is not fail then retu
add new to KB.
return false

Q) Consider problem, as per law, it is a crime
for an american to sell weapons to hostile
nations for an american to sell weapons, Country
A an enemy of America, has some missiles and



class ForwardReasoning:

PROGRAM :

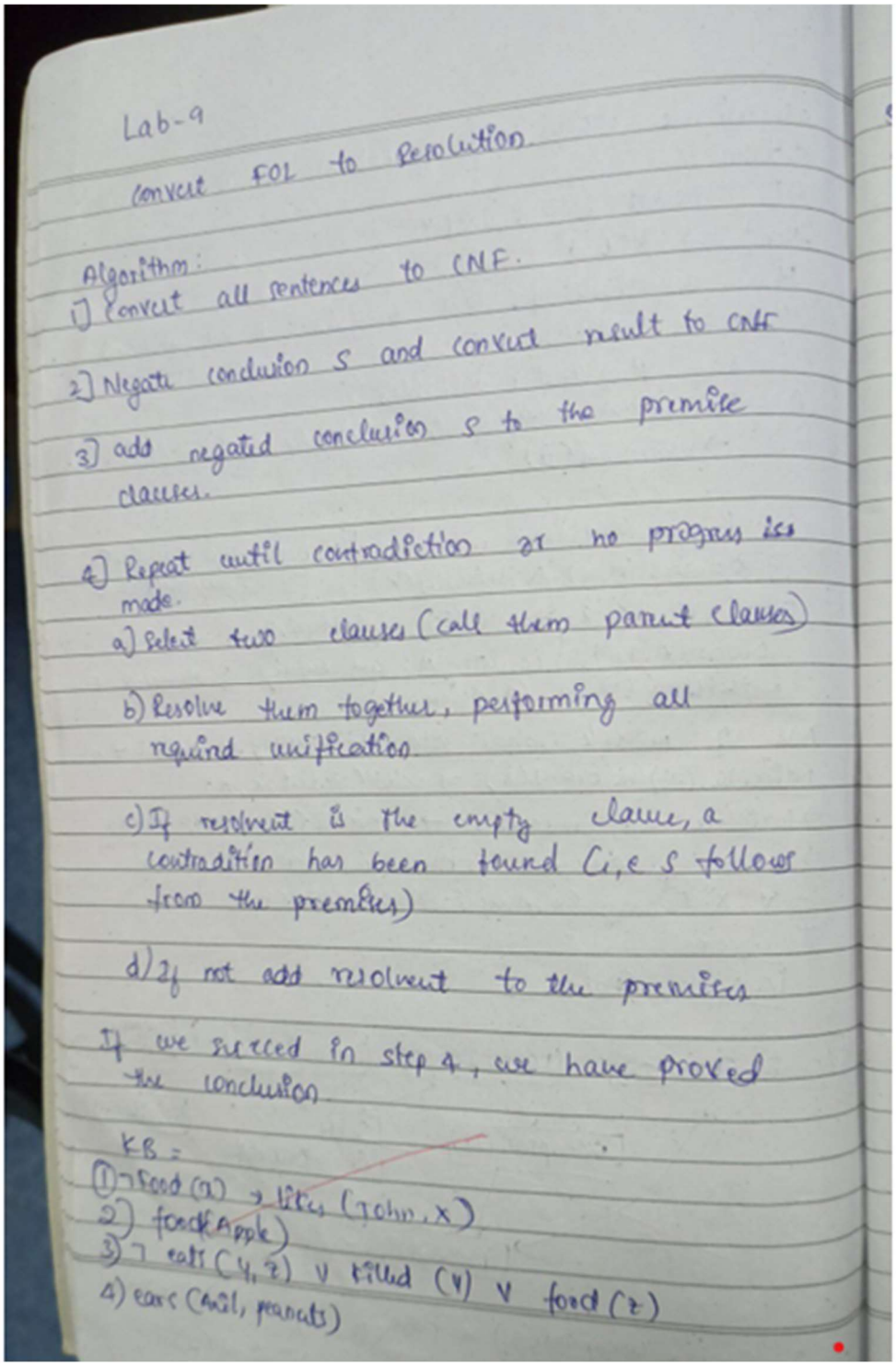
```
    def __init__(self, rules, facts):
        self.rules = rules  # List of rules (condition -> result)
        self.facts = set(facts)  # Known facts

    def infer(self):
        applied_rules = True

        while applied_rules:
            applied_rules = False
            for rule in self.rules:
                condition, result = rule
                if condition.issubset(self.facts) and result not in self.facts:
                    self.facts.add(result)
                    applied_rules = True
                    print(f"Applied rule: {condition} -> {result}")
        return self.facts


# Define rules as (condition, result) where condition is a set
rules = [
    ({"A"}, "B"),
    ({"B"}, "C"),
    ({"C", "D"}, "E"),
    ({"E"}, "F")
]

# Define initial facts
facts = {"A", "D"}

# Initialize and run forward reasoning
reasoner = ForwardReasoning(rules, facts)
final_facts = reasoner.infer()

print("\nFinal facts:")
print(final_facts)
```

OUTPUT :

```
Applied rule: {'A'} -> B
Applied rule: {'B'} -> C
Applied rule: {'C', 'D'} -> E
Applied rule: {'E'} -> F

Final facts:
{'C', 'E', 'B', 'F', 'A', 'D'}
```

Program 9

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



Lab-9

Convert FOL to Resolution

Algorithm:

1] Convert all sentences to CNF.

2] Negate conclusion S and convert result to CNF

3] add negated conclusion S to the premise clauses.

4] Repeat until contradiction or no progress is made.

a] Select two clauses (call them parent clauses)

b] Resolve them together, performing all required unification

c] If resolvent is the empty clause, a contradiction has been found (i.e S follows from the premises)

d] If not add resolvent to the premises

If we succeed in step 4, we have proved the conclusion

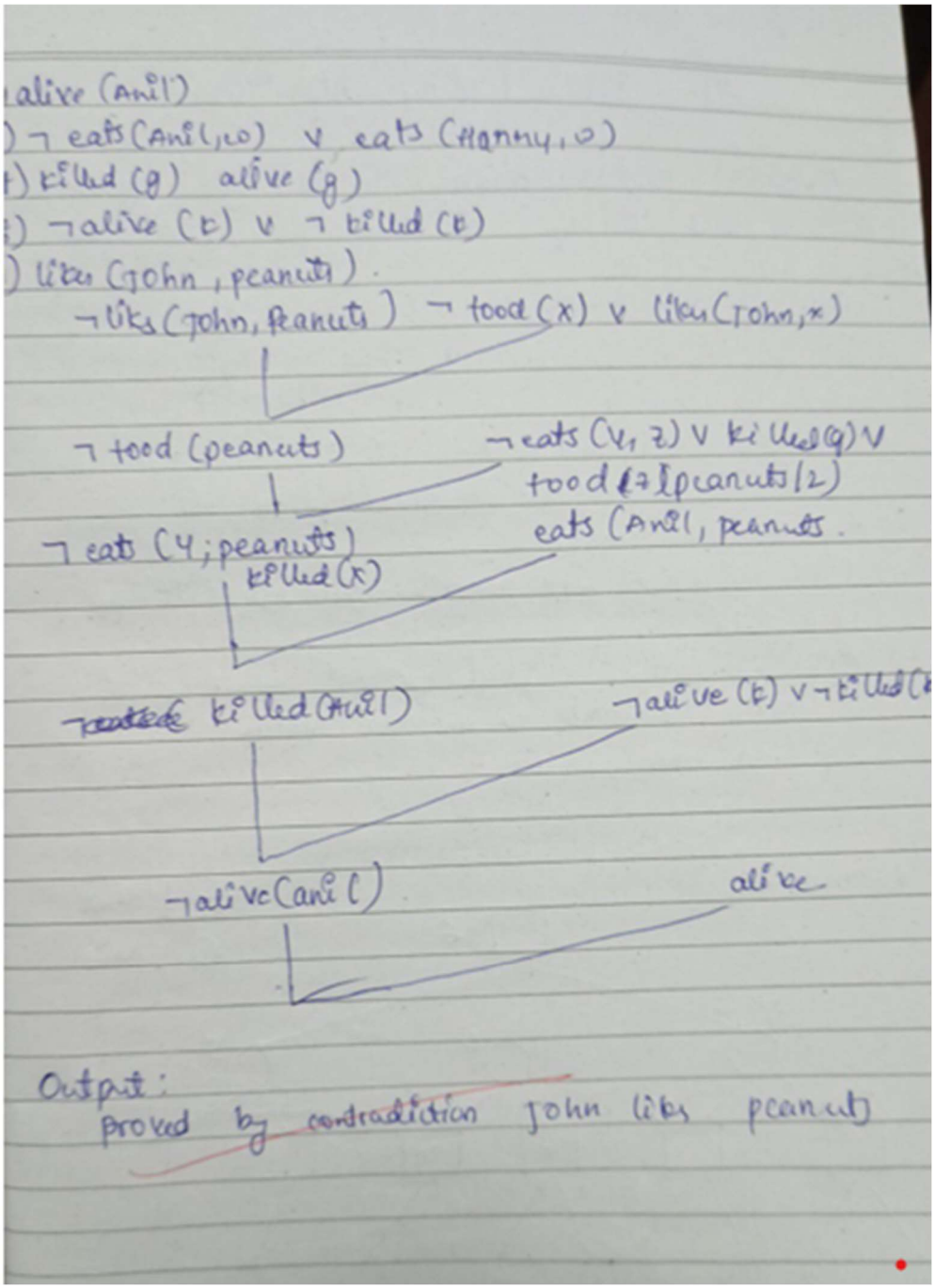
KB =

1) ¬food(x) → likes(John, x)

2) food(Apple)

3) ¬eats(y, z) ∨ killed(y) ∨ food(z)

4) eats(Anil, peanuts)

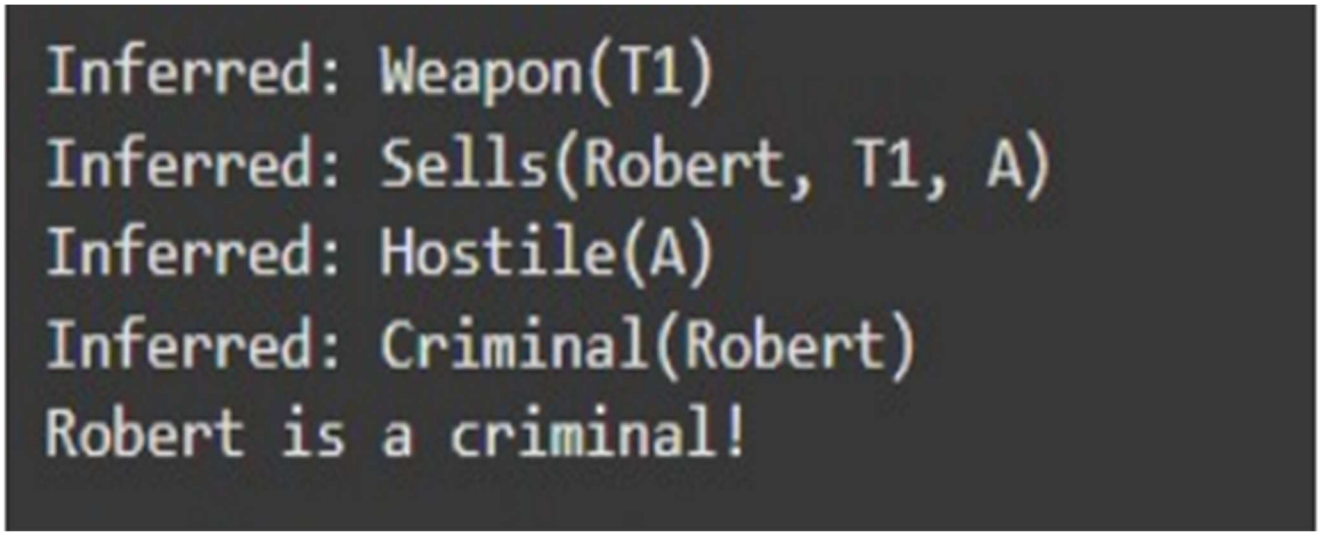


PROGRAM :

```
# Define the knowledge base (KB) as a set of facts
KB = set()
# Premises based on the provided FOL problem
KB.add('American(Robert)')
KB.add('Enemy(America, A)')
KB.add('Missile(T1)')
```

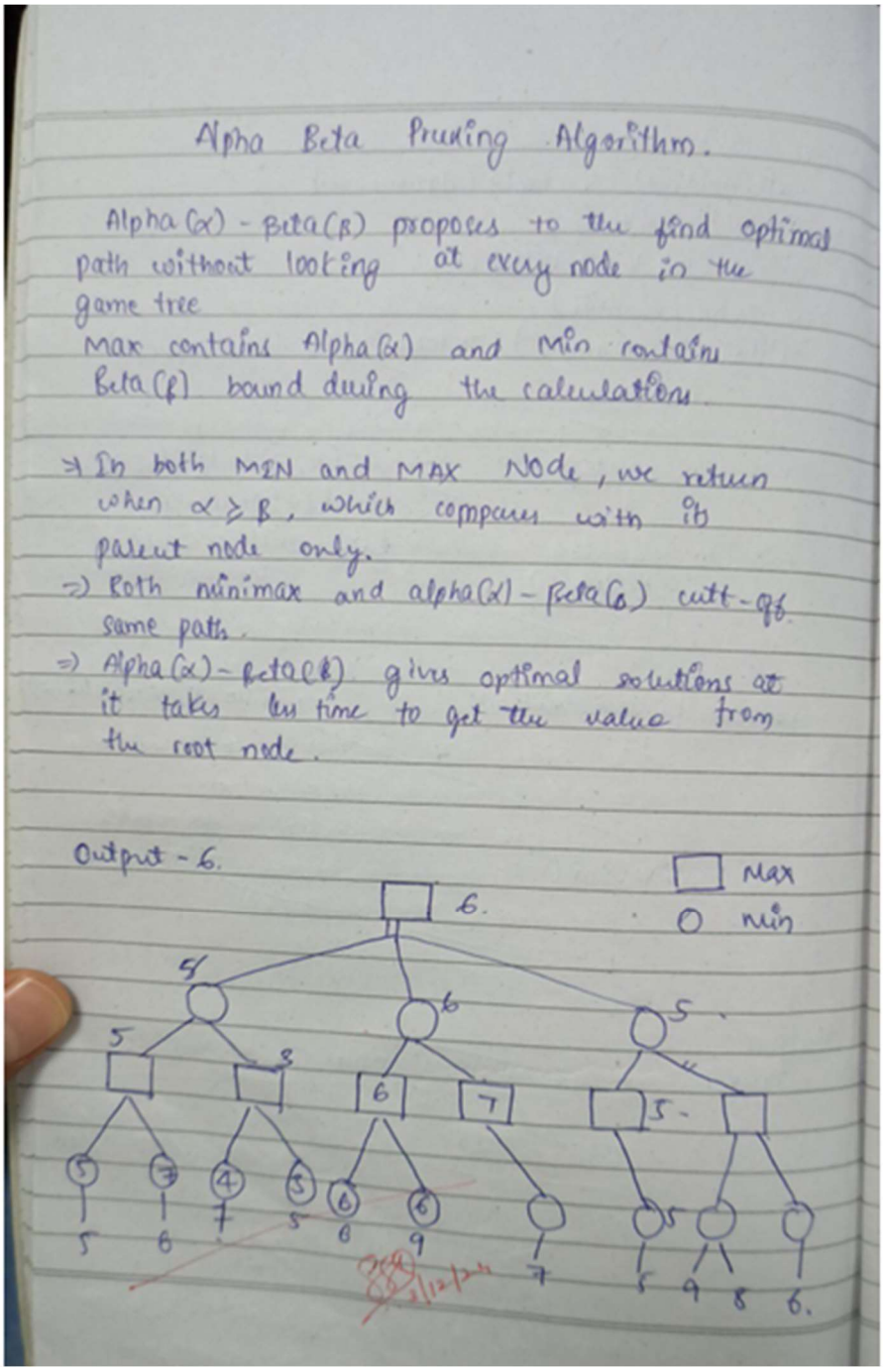
```
KB.add('Owns(A, T1)')
# Define inference rules
def modus_ponens(fact1, fact2, conclusion):
""" Apply modus ponens inference rule: if fact1 and fact2 are true, then conclude conclusion
"""
if fact1 in KB and fact2 in KB:
KB.add(conclusion)
print(f"Inferred: {conclusion}")
def forward_chaining():
""" Perform forward chaining to infer new facts until no more inferences can be made """
# 1. Apply: Missile(x) → Weapon(x)
if 'Missile(T1)' in KB:
KB.add('Weapon(T1)')
print(f"Inferred: Weapon(T1)")
1
# 2. Apply: Sells(Robert, T1, A) from Owns(A, T1) and Weapon(T1)
if 'Owns(A, T1)' in KB and 'Weapon(T1)' in KB:
KB.add('Sells(Robert, T1, A)')
print(f"Inferred: Sells(Robert, T1, A)")
# 3. Apply: Hostile(A) from Enemy(A, America)
if 'Enemy(America, A)' in KB:
KB.add('Hostile(A)')
print(f"Inferred: Hostile(A)")
# 4. Now, check if the goal is reached (i.e., if 'Criminal(Robert)' can be inferred)
if 'American(Robert)' in KB and 'Weapon(T1)' in KB and 'Sells(Robert, T1, A)' in KB and
'Hostile(A)' in KB:
KB.add('Criminal(Robert)')
print("Inferred: Criminal(Robert)")
# Check if we've reached our goal
if 'Criminal(Robert)' in KB:
print("Robert is a criminal!")
else:
print("No more inferences can be made.")
# Run forward chaining to attempt to derive the conclusion
forward_chaining()
```

OUTPUT :


Inferred: Weapon(T1)
Inferred: Sells(Robert, T1, A)
Inferred: Hostile(A)
Inferred: Criminal(Robert)
Robert is a criminal!

Program 10

Implement Alpha-Beta Pruning.



PROGRAM :

```
# Alpha-Beta Pruning Implementation
def alpha_beta_pruning(node, alpha, beta, maximizing_player):
# Base case: If it's a leaf node, return its value (simulating evaluation of the node)
if type(node) is int:
return node
# If not a leaf node, explore the children
if maximizing_player:
max_eval = -float('inf')
for child in node: # Iterate over children of the maximizer node
eval = alpha_beta_pruning(child, alpha, beta, False)
max_eval = max(max_eval, eval)
alpha = max(alpha, eval) # Maximize alpha
if beta <= alpha: # Prune the branch
break
return max_eval
else:
min_eval = float('inf')
for child in node: # Iterate over children of the minimizer node
eval = alpha_beta_pruning(child, alpha, beta, True)
min_eval = min(min_eval, eval)
beta = min(beta, eval) # Minimize beta
if beta <= alpha: # Prune the branch
1
break
return min_eval
# Function to build the tree from a list of numbers
def build_tree(numbers):
# We need to build a tree with alternating levels of maximizers and minimizers
# Start from the leaf nodes and work up
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]) # Combine two nodes
else:
```

```
next_level.append(current_level[i]) # Odd number of elements, just carry forward
current_level = next_level
return current_level[0] # Return the root node, which is a maximizer
# Main function to run alpha-beta pruning
def main():
# Input: User provides a list of numbers
numbers = list(map(int, input("Enter numbers for the game tree (space-separated): ").split()))
2
# Build the tree with the given numbers
tree = build_tree(numbers)
# Parameters: Tree, initial alpha, beta, and the root node is a maximizing player
alpha = -float('inf')
beta = float('inf')
maximizing_player = True # The root node is a maximizing player
# Perform alpha-beta pruning and get the final result
result = alpha_beta_pruning(tree, alpha, beta, maximizing_player)
print("Final Result of Alpha-Beta Pruning:", result)
if __name__ == "__main__":
main()
```

OUTPUT :