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

B.M.S. College of Engineering,
Bull Temple Road, Bangalore 560019
(Affiliated To Visvesvaraya Technological University, Belgaum)
Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Artificial Intelligence (23CS5PCAIN)" carried out by **Rani Aishwarya H S (1BM22CS217),** 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.

Radhika A D Assistant Professor Department of CSE, BMSCE	Dr. Kavitha Sooda Professor & HOD Department of CSE, BMSCE

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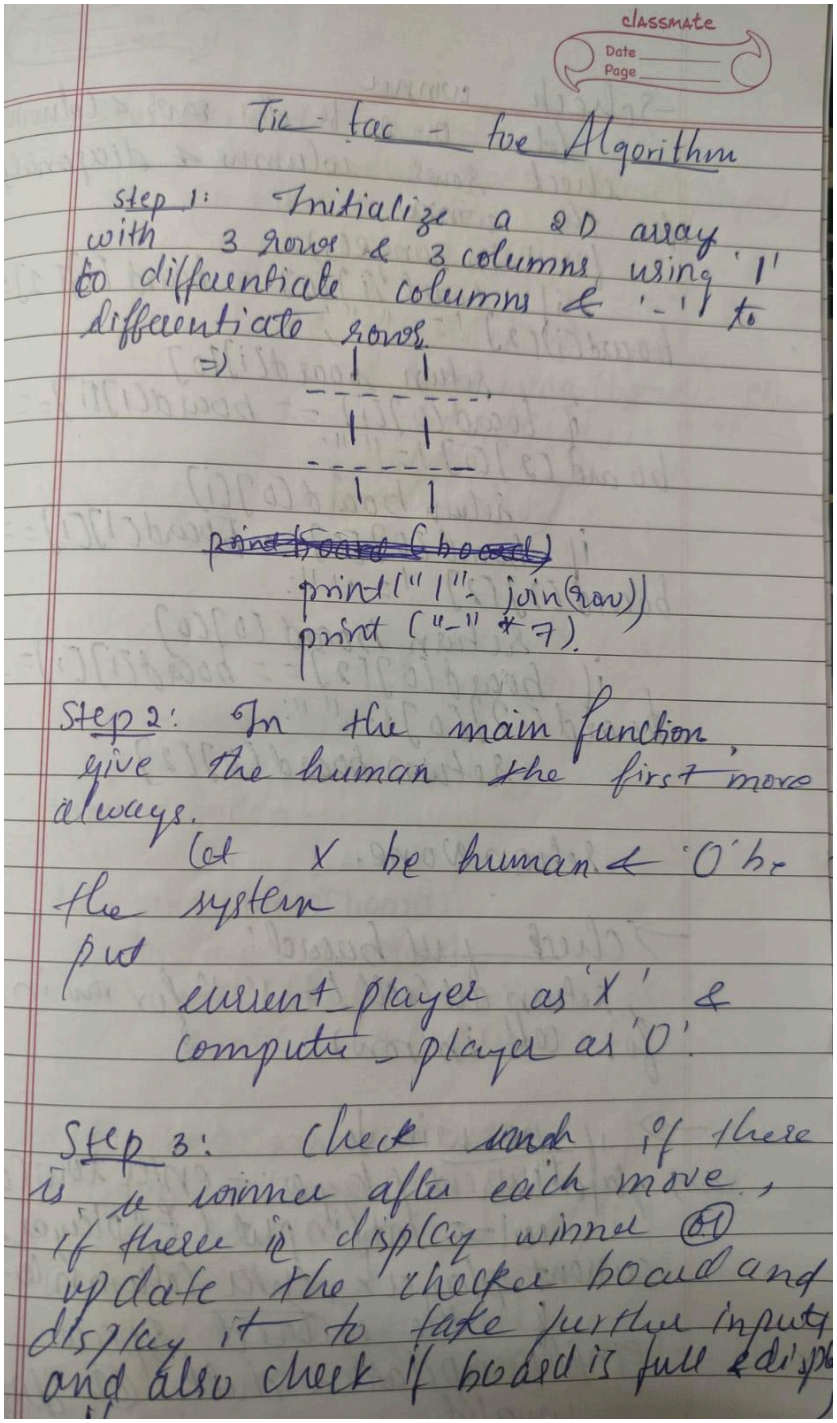
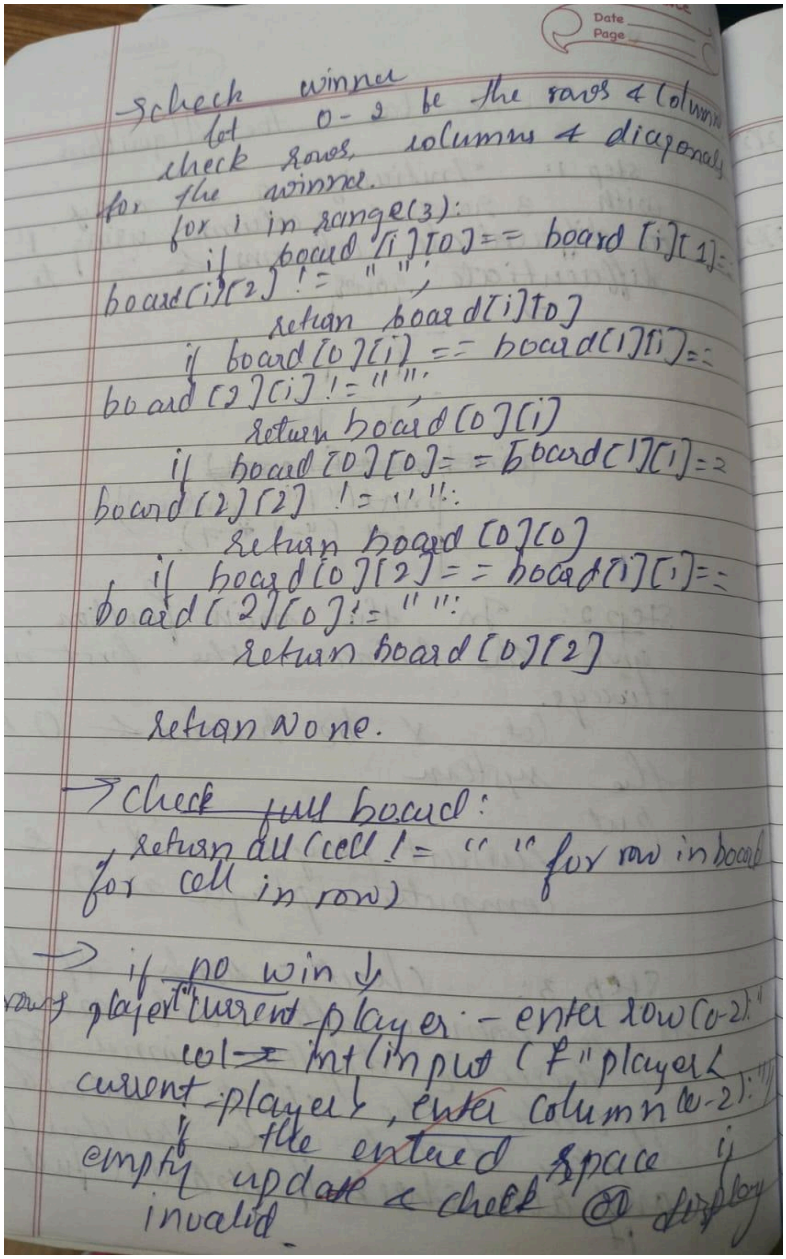
Github Link:
https://github.com/likitha-zzie/AI-LAB

Program 1
Implement Tic –Tac –Toe Game

Algorithm:



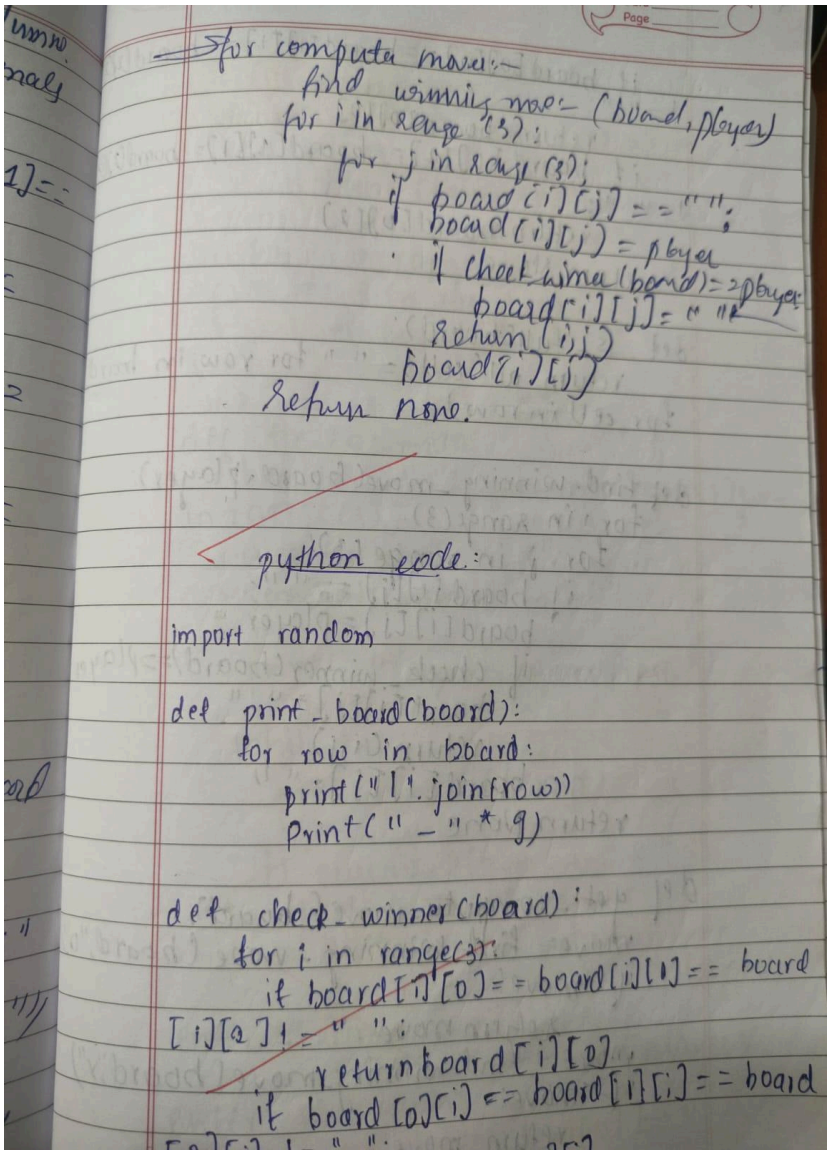


-> check winner
    let 0-2 be the rows & columns
check rows, columns & diagonals
for the winner.
    for i in range(3):
        if board[i][0] == board[i][1] ==
board[i][2] != " ":
            return board[i][0]
        if board[0][i] == board[1][i] ==
board[2][i] != " ":
            return board[0][i]
        if board[0][0] == board[1][1] ==
board[2][2] != " ":
            return board[0][0]
        if board[0][2] == board[1][1] ==
board[2][0] != " ":
            return board[0][2]

    return none.

-> check full board:
    return all(cell != " " for row in board
for cell in row)

-> if no win ↓
player current_player - enter row(0-2):"
    col = int(input("player
current_player, enter column(0-2):"))
    if the entered space is
empty update & check @ display
invalid.



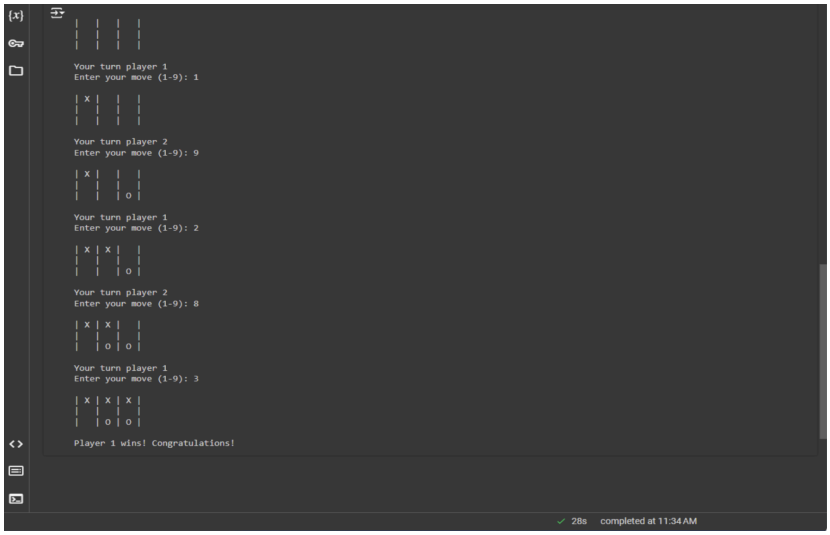
Code:

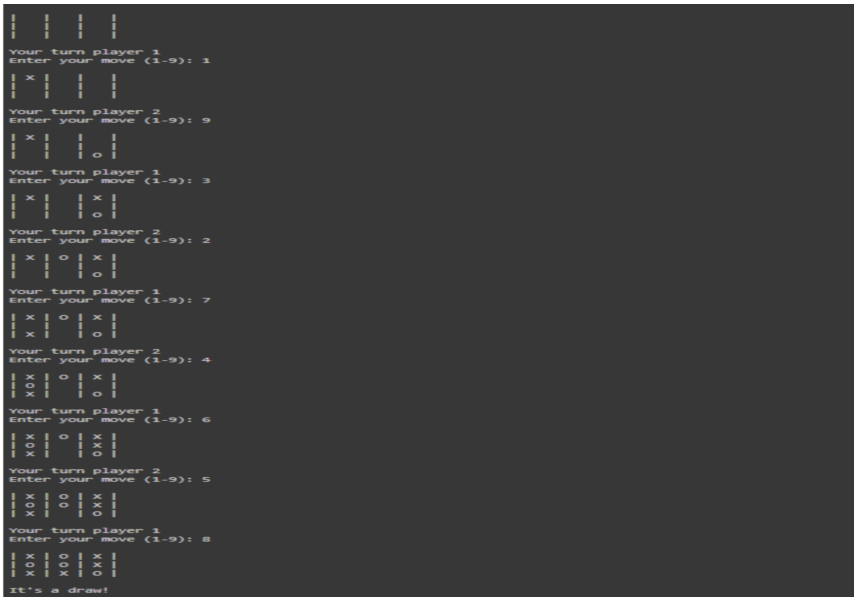
```
# Initialize the board
board = [' ' for _ in range(9)]

# Function to draw the board
def draw_board():
    row1 = '| {} | {} | {} |'.format(board[0], board[1], board[2])
    row2 = '| {} | {} | {} |'.format(board[3], board[4], board[5])
    row3 = '| {} | {} | {} |'.format(board[6], board[7], board[8])
    print()
    print(row1)
    print(row2)
    print(row3)
    print()
```

```
# Function for player's move
def player_move(icon):
    if icon == 'X':
        number = 1
    elif icon == 'O':
        number = 2
    print("Your turn, player {}".format(number))
    choice = int(input("Enter your move (1-9): ").strip())
    if board[choice - 1] == ' ':
        board[choice - 1] = icon
    else:
        print()
        print("That space is taken!")

# Function to check for victory
def is_victory(icon):
    if (board[0] == icon and board[1] == icon and board[2] == icon) or \
       (board[3] == icon and board[4] == icon and board[5] == icon) or \
       (board[6] == icon and board[7] == icon and board[8] == icon) or \
       (board[0] == icon and board[3] == icon and board[6] == icon) or \
       (board[1] == icon and board[4] == icon and board[7] == icon) or \
       (board[2] == icon and board[5] == icon and board[8] == icon) or \
       (board[0] == icon and board[4] == icon and board[8] == icon) or \
       (board[2] == icon and board[4] == icon and board[6] == icon):
        return True
    else:
        return False

# Function to check for a draw
def is_draw():
    if ' ' not in board:
        return True
    else:
        return False

# Function to play the game
def play_game():
    draw_board()
    while True:
        player_move('X')
        draw_board()
        if is_victory('X'):
            print("Player 1 wins! Congratulations!")
            break
        elif is_draw():
            print("It's a draw!")
```

```
            break

        player_move('O')
        draw_board()
        if is_victory('O'):
            print("Player 2 wins! Congratulations!")
            break
        elif is_draw():
            print("It's a draw!")
            break

# Start the game
play_game()
```

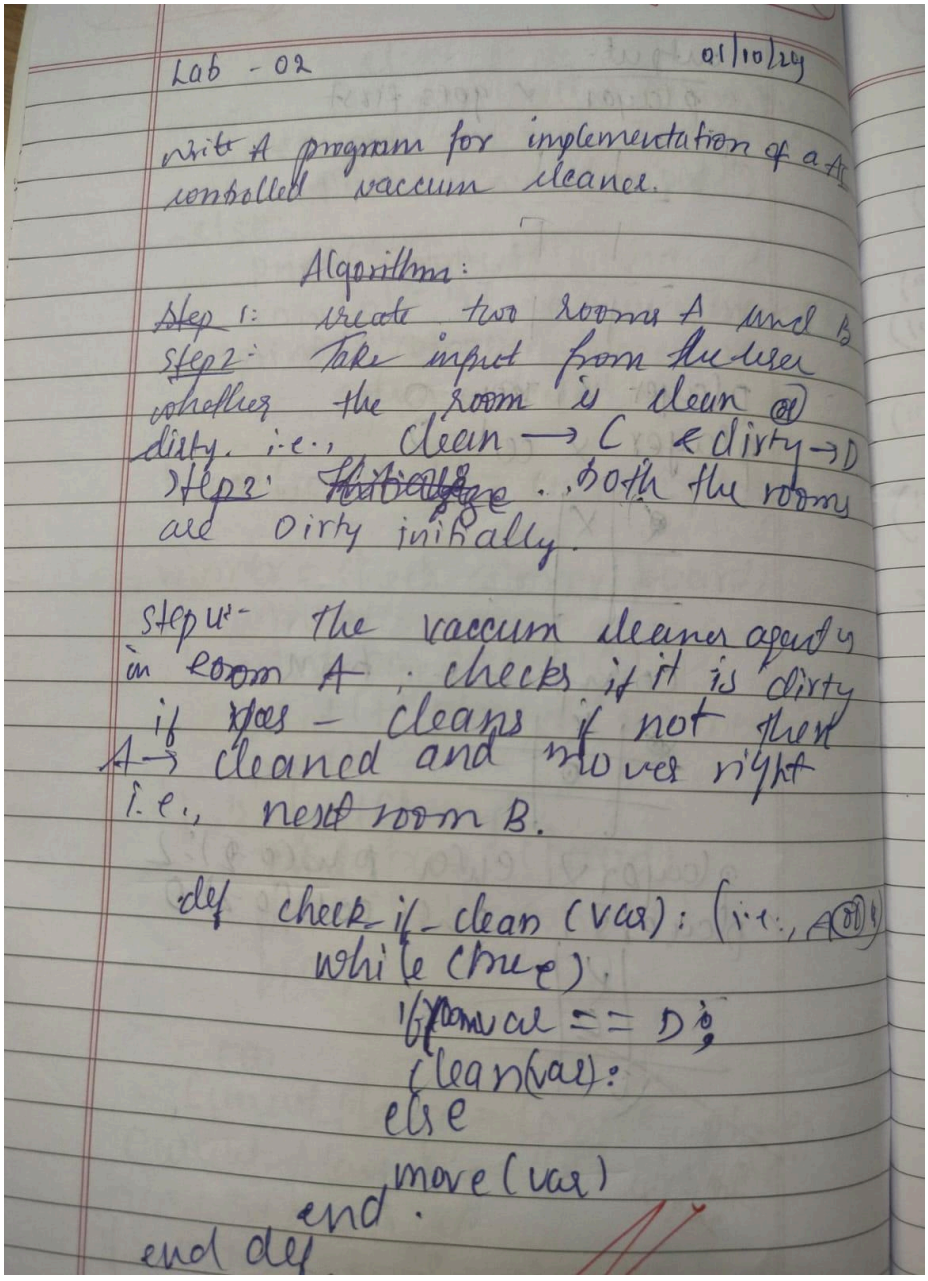
Output:





Program 2

Implement vacuum cleaner agent



Lab - 02 01/10/24

write A program for implementation of a AI controlled vaccum cleaner.

Algorithm:

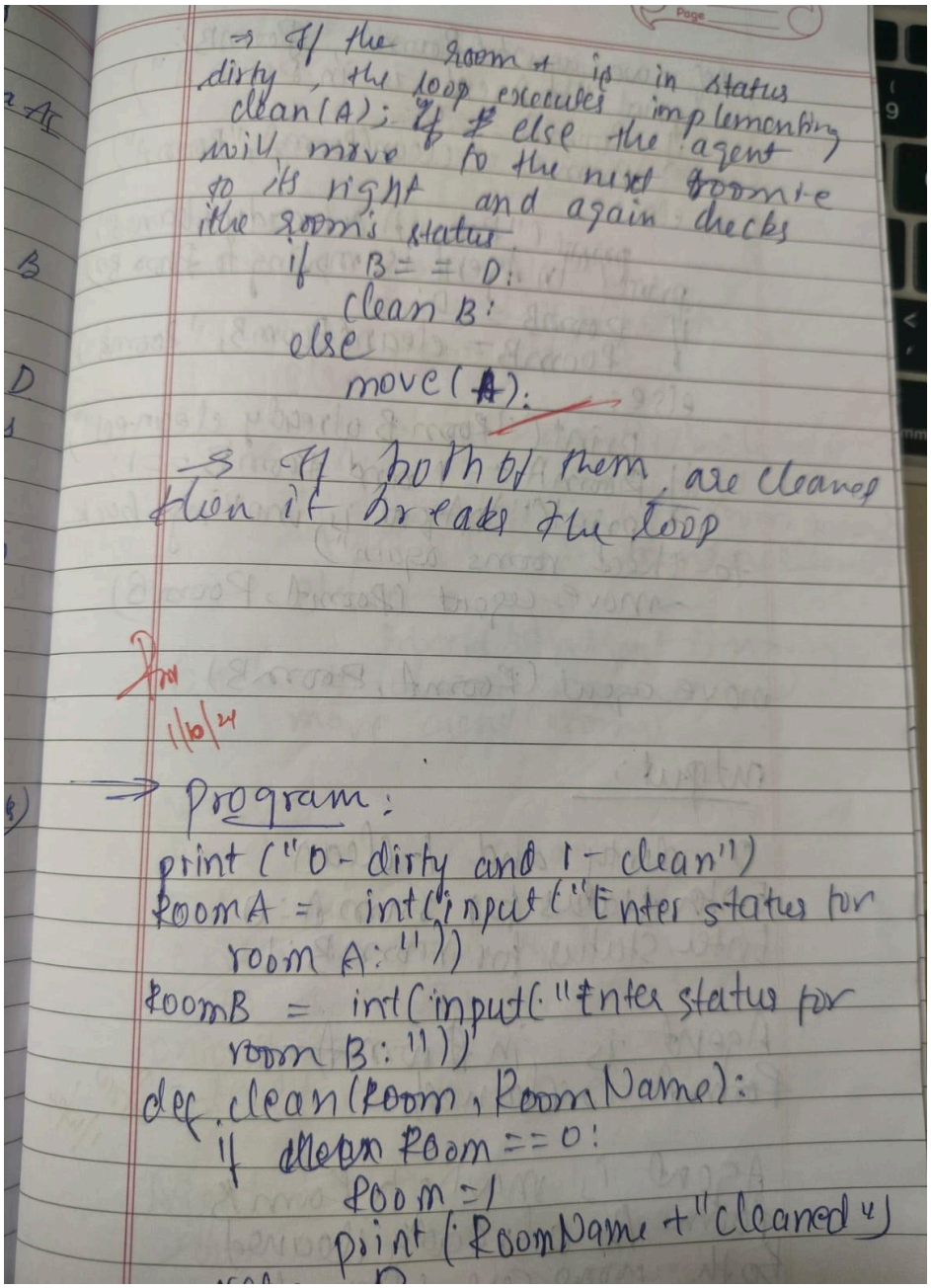
Step 1: Create two rooms A and B

Step 2: Take input from the user whether the room is clean or dirty. i.e., clean → C & dirty → D

Step 3: Both the rooms are dirty initially.

Step 4: The vaccum cleaner agent is in room A, checks if it is dirty if yes - cleans if not then A → cleaned and moves right i.e., next room B.

```
def check_if_clean(var): (i.e., A or B)
    while(true):
        if var == D:
            clean(var):
        else
            move(var)
    end.
end def
```



Code:

```
# Reflex function for vacuum cleaner
def reflex(loc, status, cost):
    s = status  # Track the current status of the location
    if status == 1:  # If the location is dirty
        cost += 1
        print(f"SUCK at {loc}")
        s = 0  # The location is now clean
```

```
    if loc == "A":
        print("Move RIGHT to B")
        loc = "B"  # Move to B
    elif loc == "B":
        print("Move LEFT to A")
        loc = "A"  # Move to A
    return cost, loc, s  # Return updated cost, location, and status

# Function to check goal state
def goal(a_status, b_status):
    if a_status == 0 and b_status == 0:
        print("Goal reached")
    else:
        print("Goal not reached")

# Input for the starting location and statuses
loc = input("Enter the starting location of the vacuum (A or B): ").strip()
cost = 0
a_status = int(input("Enter the status of location A (0 for clean, 1 for dirty): "))
b_status = int(input("Enter the status of location B (0 for clean, 1 for dirty): "))

# Simulate cleaning process
if loc == "A":
    cost, loc, a_status = reflex("A", a_status, cost)
    cost, loc, b_status = reflex("B", b_status, cost)
elif loc == "B":
    cost, loc, b_status = reflex("B", b_status, cost)
    cost, loc, a_status = reflex("A", a_status, cost)

# Output the total cost and goal status
print(f"Total cost: {cost}")
goal(a_status, b_status)
```

Output:

```
Enter the starting location of the vacuum (A or B): A
Enter the status of location A (0 for clean, 1 for dirty): 0
Enter the status of location B (0 for clean, 1 for dirty): 0
Move RIGHT to B
Move LEFT to A
Total cost: 0
Goal reached
```

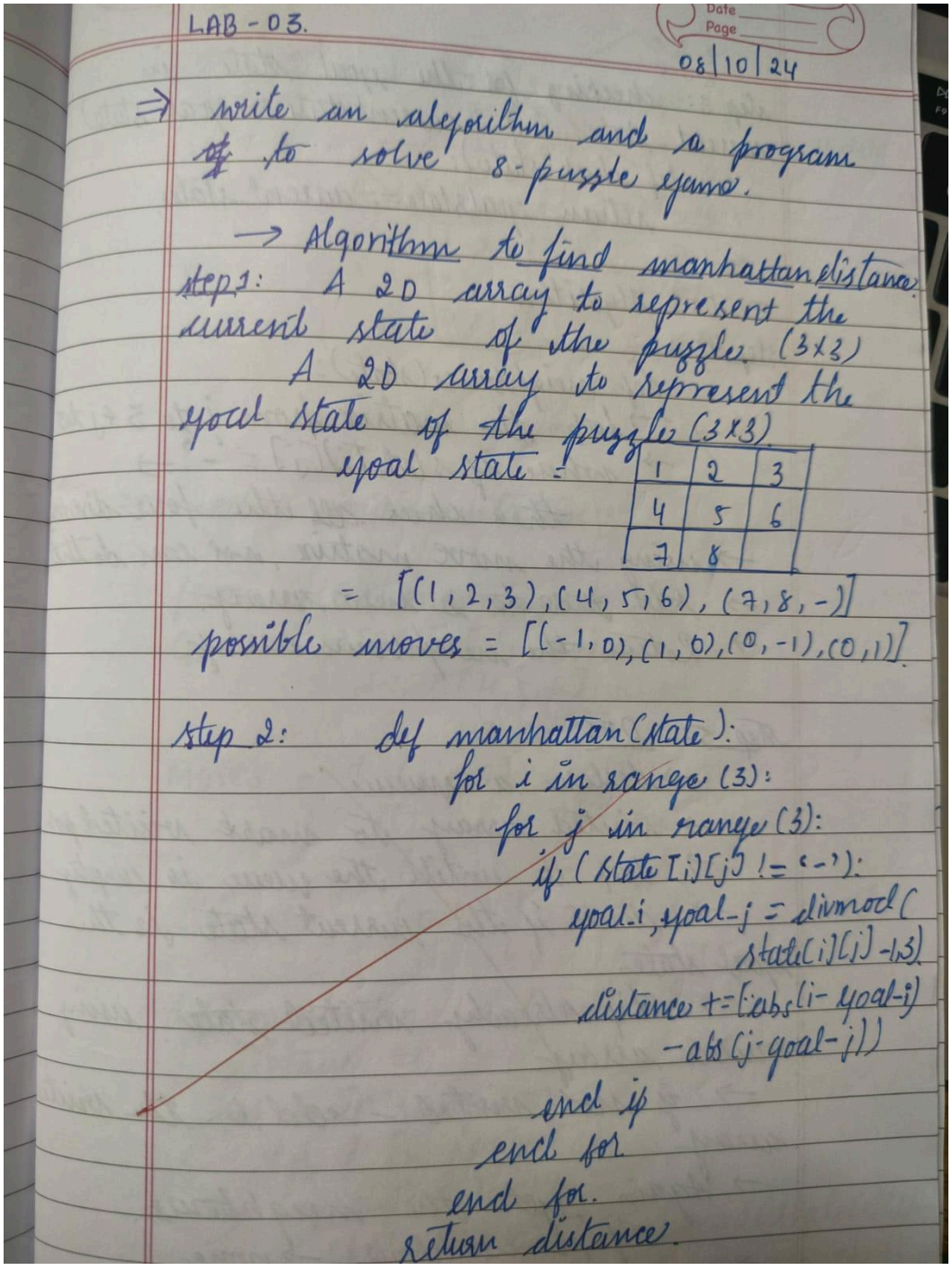
```
Enter the starting location of the vacuum (A or B): B
Enter the status of location A (0 for clean, 1 for dirty): 1
Enter the status of location B (0 for clean, 1 for dirty): 1
SUCK at A
Move RIGHT to B
SUCK at B
Move LEFT to A
Total cost: 2
Goal reached
```

```
Enter the starting location of the vacuum (A or B): A
Enter the status of location A (0 for clean, 1 for dirty): 1
Enter the status of location B (0 for clean, 1 for dirty): 0
SUCK at A
Move RIGHT to B
Move LEFT to A
Total cost: 1
Goal reached
```

```
Enter the starting location of the vacuum (A or B): A
Enter the status of location A (0 for clean, 1 for dirty): 0
Enter the status of location B (0 for clean, 1 for dirty): 1
Move RIGHT to B
SUCK at B
Move LEFT to A
Total cost: 1
Goal reached
```

Program 3

Implement 8 puzzle problems using DFS and BFS:



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⇒ write an algorithm and a program to solve 8-puzzle game.

→ Algorithm to find manhattan distance:

step 1: A 2D array to represent the current state of the puzzle. (3x3)
A 2D array to represent the goal state of the puzzle (3x3).

goal state =

1	2	3
4	5	6
7	8	

= [(1,2,3),(4,5,6),(7,8,-)]

possible moves = [(-1,0),(1,0),(0,-1),(0,1)]

step 2:

```
def manhattan(state):
    for i in range(3):
        for j in range(3):
            if(state[i][j] != '-'):
                goal_i, goal_j = divmod(
                        state[i][j]-1,3)
                distance += [abs(i-goal_i)
                    -abs(j-goal_j))
            end if
        end for
    end for.
return distance.
```

step 3: checking for the goal state in current state (if current state == goal state)

```
def check(state):
    return goalstate == current_state
```

⇒ DFS Algorithm

step 4:

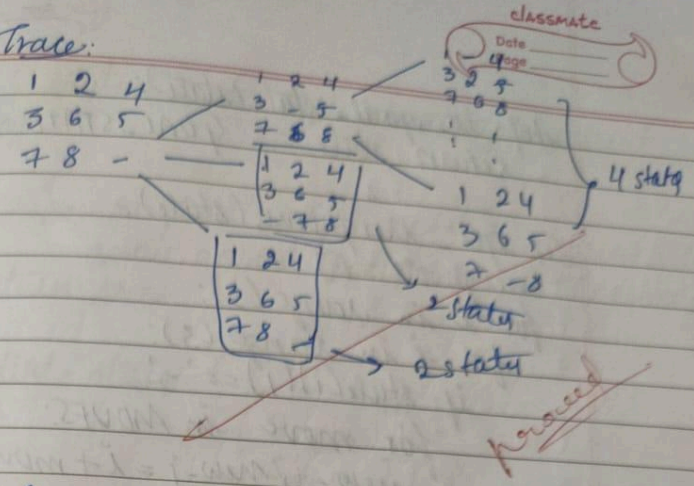
```
def neighbours(state):
```

→ loop the matrix from i to 3 & j to
→ where if state[i][j] = '-' →
then check all the four dire
→ using the move matrix, we can do th
→ add those to a new array.
→ Return the neighbours array.

Step 5: DFS.

→ declare a queue
→ visited array to mark visited
→ loop it until the queue is empty
→ check if the current state is the goal state.
→ skip already visited state using visited array.
→ if not visited - add to the visited array
→ Again get the neighbours.
if no neighbours → none.
→ end.

Trace:



⇒ code implementation:

```
from collections import deque
GOAL_STATE = [ [1, 2, 3],
               [4, 5, 6],
               [7, 8, '-'] ]
MOVES = [ (-1, 0),  # Up
          (1, 0),   # down
          (0, -1),  # Left
          (0, 1) ]  # Right.

def manhattan_distance(state):
    distance = 0
    for i in range(3):
        for j in range(3):
            if state[i][j] != '-':
                goal_i, goal_j = divmod(state[i][j] -
                                        -1, 3)
                distance += abs(i - goal_i) + abs(j - goal
```

Code:
BFS:

```
from collections import deque

# Goal state for the 8-puzzle
goal_state = [[1, 2, 3],
              [4, 5, 6],
              [7, 8, 0]]

# Possible moves
moves = {'up': (-1, 0), 'down': (1, 0), 'left': (0, -1), 'right': (0, 1)}

# Function to find the position of the blank (0)
def find_blank(state):
    for i in range(len(state)):
        for j in range(len(state[i])):
            if state[i][j] == 0:
                return i, j

# Function to check if a state is the goal state
def is_goal(state):
    return state == goal_state

# Function to generate neighbors by moving the blank tile
def get_neighbors(state):
    neighbors = []
    blank_row, blank_col = find_blank(state)
    for move, (dr, dc) in moves.items():
        new_row, new_col = blank_row + dr, blank_col + dc
        if 0 <= new_row < 3 and 0 <= new_col < 3:
            # Create a new state by swapping tiles
            new_state = [row[:] for row in state]
            new_state[blank_row][blank_col], new_state[new_row][new_col] =
new_state[new_row][new_col], new_state[blank_row][blank_col]
            neighbors.append((new_state, move))
    return neighbors

# Function to print the puzzle state
def print_puzzle(state):
    for row in state:
        print(row)
    print()

# BFS algorithm to solve the puzzle
def bfs(start_state):
    queue = deque([(start_state, [])])  # Queue stores (current state, path to reach it)
```

```
    visited = set()  # To avoid revisiting states
    visited.add(tuple(tuple(row) for row in start_state))  # Convert state to a tuple for
hashing

    while queue:
        current_state, path = queue.popleft()

        # Check if the goal is reached
        if is_goal(current_state):
            return current_state, path

        # Explore neighbors
        for neighbor, move in get_neighbors(current_state):
            state_tuple = tuple(tuple(row) for row in neighbor)
            if state_tuple not in visited:
                visited.add(state_tuple)
                queue.append((neighbor, path + [move]))

    return None, None

# Function to get user input for the initial state
def get_user_input():
    print("Enter the initial state of the 8-puzzle (row by row):")
    state = []
    for i in range(3):
        while True:
            try:
                row = list(map(int, input(f"Enter row {i+1} (3 integers, space-separated):
").split()))
                if len(row) != 3 or any(x not in range(9) for x in row):
                    raise ValueError
                state.append(row)
                break
            except ValueError:
                print("Invalid input. Please enter 3 integers between 0 and 8.")
    return state

# Function to demonstrate the solution step by step
def demonstrate_solution(start_state, solution_path):
    current_state = start_state
    print("Initial state:")
    print_puzzle(current_state)
    for move in solution_path:
        print(f"Move: {move}")
        for neighbor, move_name in get_neighbors(current_state):
            if move_name == move:
                current_state = neighbor
```

```
            print_puzzle(current_state)
            break

# Main function
if __name__ == "__main__":
    start_state = get_user_input()
    final_state, solution_path = bfs(start_state)
    if solution_path:
        print("Solution found. Steps are demonstrated below:")
        demonstrate_solution(start_state, solution_path)
    else:
        print("No solution found.")
```

Output:

```
Enter the initial state of the 8-puzzle (row by row):
Enter row 1 (3 integers, space-separated): 1 2 3
Enter row 2 (3 integers, space-separated): 0 4 6
Enter row 3 (3 integers, space-separated): 7 5 8
Solution found. Steps are demonstrated below:
Initial state:
[1, 2, 3]
[0, 4, 6]
[7, 5, 8]

Move: right
[1, 2, 3]
[4, 0, 6]
[7, 5, 8]

Move: down
[1, 2, 3]
[4, 5, 6]
[7, 0, 8]

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

```
Enter the initial state of the 8-puzzle (row by row):
Enter row 1 (3 integers, space-separated): 1 3 2
Enter row 2 (3 integers, space-separated): 4 6 0
Enter row 3 (3 integers, space-separated): 7 5 8
No solution found.
```

DFS:

```
from copy import deepcopy

# Directions for moving the blank space (0): up, down, left, right
DIRECTIONS = [(-1, 0), (1, 0), (0, -1), (0, 1)]

class PuzzleState:
    def __init__(self, board, parent=None, move=""):
        self.board = board
        self.parent = parent
        self.move = move

    # Find the position of the blank (0)
    def get_blank_position(self):
        for i in range(3):
            for j in range(3):
                if self.board[i][j] == 0:
                    return i, j

    # Generate successor states by moving the blank space
    def generate_successors(self):
        successors = []
        x, y = self.get_blank_position()
        for dx, dy in DIRECTIONS:
            new_x, new_y = x + dx, y + dy
            if 0 <= new_x < 3 and 0 <= new_y < 3:
                new_board = deepcopy(self.board)
                new_board[x][y], new_board[new_x][new_y] = new_board[new_x][new_y],
new_board[x][y]
                successors.append(PuzzleState(new_board, parent=self))
        return successors

    # Check if the current state matches the goal state
    def is_goal(self, goal_state):
        return self.board == goal_state

    # String representation of the puzzle state
    def __str__(self):
        return "\n".join([" ".join(map(str, row)) for row in self.board])

# Depth-limited search (DLS)
def depth_limited_search(current_state, goal_state, depth):
    if depth == 0 and current_state.is_goal(goal_state):
        return current_state
```

```
    if depth > 0:
        for successor in current_state.generate_successors():
            found = depth_limited_search(successor, goal_state, depth - 1)
            if found:
                return found
    return None

# Iterative deepening search (IDS)
def iterative_deepening_search(start_state, goal_state):
    depth = 0
    while True:
        print(f"\nSearching at depth level: {depth}")
        result = depth_limited_search(start_state, goal_state, depth)
        if result:
            return result
        depth += 1

# Get user input for start and goal states
def get_user_input():
    print("Enter the start state (use 0 for the blank):")
    start_state = []
    for _ in range(3):
        row = list(map(int, input().split()))
        start_state.append(row)
    print("Enter the goal state (use 0 for the blank):")
    goal_state = []
    for _ in range(3):
        row = list(map(int, input().split()))
        goal_state.append(row)
    return start_state, goal_state

# Main function
def main():
    start_board, goal_board = get_user_input()
    start_state = PuzzleState(start_board)
    goal_state = goal_board
    result = iterative_deepening_search(start_state, goal_state)
    if result:
        print("\nGoal reached!")
        path = []
        while result:
            path.append(result)
            result = result.parent
        path.reverse()
        for state in path:
            print(state, "\n")
    else:
```

```
        print("Goal state not found.")

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

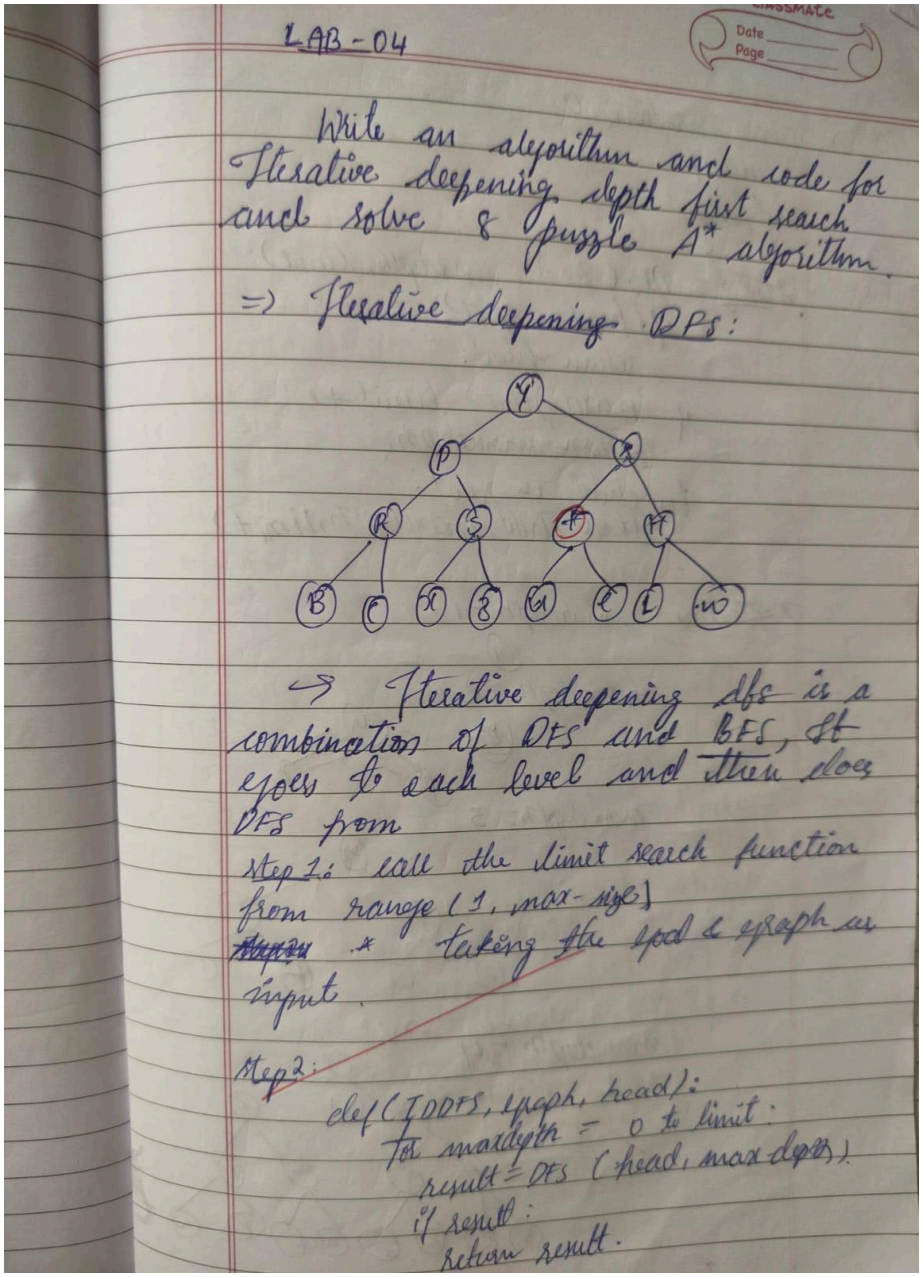
Output:

```
Enter the start state (use 0 for the blank):
2 8 3
1 6 4
7 0 5
Enter the goal state (use 0 for the blank):
1 2 3
8 0 4
7 6 5

Searching at depth level: 0

Searching at depth level: 1

Searching at depth level: 2

Searching at depth level: 3

Searching at depth level: 4

Searching at depth level: 5

Goal reached!
2 8 3
1 6 4
7 0 5

2 8 3
1 0 4
7 6 5

2 0 3
1 8 4
7 6 5

0 2 3
1 8 4
7 6 5

1 2 3
0 8 4
7 6 5

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

Program 4

Implement A* search algorithm

Algorithm:



LAB - 04

Write an algorithm and code for Iterative deepening depth first search and solve 8 puzzle A* algorithm.

=> Iterative deepening DFS:

=> Iterative deepening dfs is a combination of DFS and BFS, it goes to each level and then does DFS from

Step 1: call the limit search function from range (1, max-size)

* taking the goal & graph as input.

Step 2:

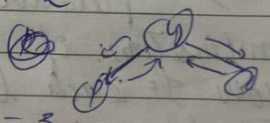
```
def (IDDFS, graph, head):
    for maxdepth = 0 to limit:
    result = DFS (head, max depth)
    if result:
        return result.
```

return 0
end if
end for

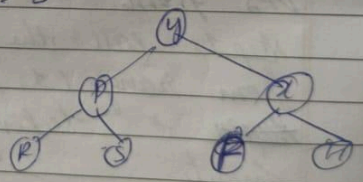
step 3: DFS(head, maxdepth, limit):
if (head == goal):
return head:
if maxdepth == limit+1
return maxdepth
for child in root:
DFS(child, maxdepth, limit)

⇒ Iterations: maxdepth = 1

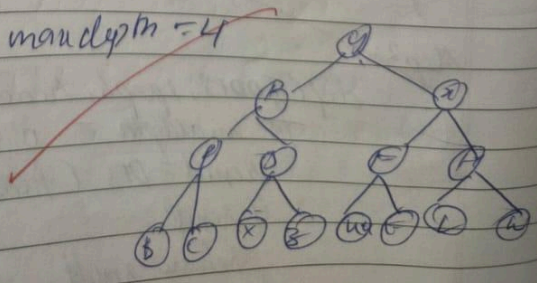
maxdepth = 2



maxdepth = 3



maxdepth = 4



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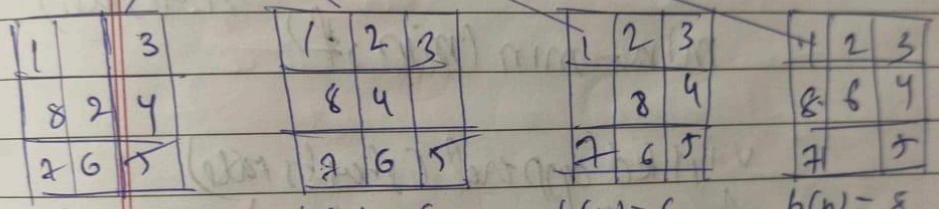
Algorithm for 8 puzzle using A*.

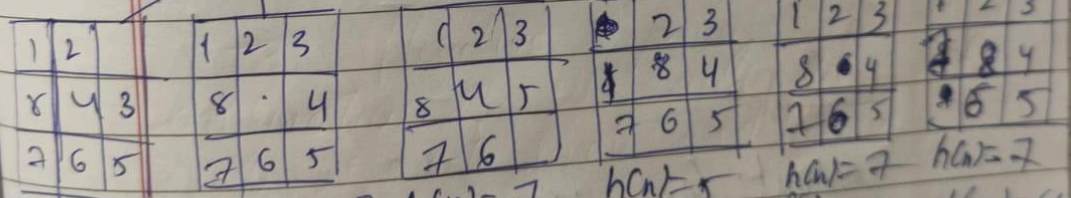
Initial state

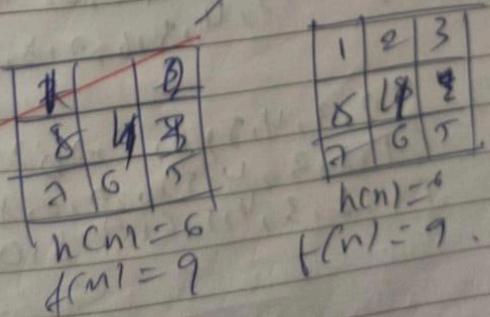
1	2	3
8		4
7	6	5

goal state

2	8	1
	4	3
7	6	5







Code:
Misplaced Tiles:

```
import heapq

# Define the goal state as a tuple of tuples
GOAL_STATE = ((1, 2, 3),
              (8, 0, 4),
              (7, 6, 5))

# Heuristic: Count the number of misplaced tiles
def misplaced_tile(state):
    misplaced = 0
    for i in range(3):
        for j in range(3):
            if state[i][j] != 0 and state[i][j] != GOAL_STATE[i][j]:
                misplaced += 1
    return misplaced

# Find the position of the blank tile (0)
def find_blank(state):
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
                return i, j

# Generate neighbors by moving the blank tile
def generate_neighbors(state):
    neighbors = []
    x, y = find_blank(state)
    directions = [(0, 1), (0, -1), (1, 0), (-1, 0)]  # Right, Left, Down, Up
    for dx, dy in directions:
        nx, ny = x + dx, y + dy
        if 0 <= nx < 3 and 0 <= ny < 3:
            # Create a new state by swapping tiles
            new_state = [list(row) for row in state]
            new_state[x][y], new_state[nx][ny] = new_state[nx][ny], new_state[x][y]
            neighbors.append(tuple(tuple(row) for row in new_state))
    return neighbors

# Reconstruct the path from the start state to the goal state
def reconstruct_path(came_from, current):
    path = [current]
    while current in came_from:
        current = came_from[current]
        path.append(current)
```

```
    path.reverse()
    return path

# A* search algorithm
def a_star(start):
    open_list = []
    heapq.heappush(open_list, (0 + misplaced_tile(start), 0, start))  # (f(n), g(n), state)
    g_score = {start: 0}  # Cost from start to the current state
    came_from = {}
    visited = set()

    while open_list:
        _, g, current = heapq.heappop(open_list)

        # Check if we have reached the goal
        if current == GOAL_STATE:
            path = reconstruct_path(came_from, current)
            return path, g

        visited.add(current)

        # Explore neighbors
        for neighbor in generate_neighbors(current):
            if neighbor in visited:
                continue

            tentative_g = g_score[current] + 1  # Each move has a cost of 1

            # If this path is better, update scores and add to the queue
            if tentative_g < g_score.get(neighbor, float('inf')):
                came_from[neighbor] = current
                g_score[neighbor] = tentative_g
                f_score = tentative_g + misplaced_tile(neighbor)  # f(n) = g(n) + h(n)
                heapq.heappush(open_list, (f_score, tentative_g, neighbor))

    return None, None  # No solution found

# Print a given puzzle state
def print_state(state):
    for row in state:
        print(row)
    print()

# Main function
if __name__ == "__main__":
    start_state = ((2, 8, 3),
                   (1, 6, 4),
```

```
            (7, 0, 5))

print("Initial State:")
print_state(start_state)
print("Goal State:")
print_state(GOAL_STATE)

solution, cost = a_star(start_state)
if solution:
    print(f"Solution found with cost: {cost}")
    print("Steps:")
    for step in solution:
        print_state(step)
else:
    print("No solution found.")
```

Output:

```
Initial State:
(2, 8, 3)
(1, 6, 4)
(7, 0, 5)

Goal State:
(1, 2, 3)
(8, 0, 4)
(7, 6, 5)

Solution found with cost: 5
Steps:
(2, 8, 3)
(1, 6, 4)
(7, 0, 5)

(2, 8, 3)
(1, 0, 4)
(7, 6, 5)

(2, 0, 3)
(1, 8, 4)
(7, 6, 5)

(0, 2, 3)
(1, 8, 4)
(7, 6, 5)

(1, 2, 3)
(0, 8, 4)
(7, 6, 5)

(1, 2, 3)
(8, 0, 4)
(7, 6, 5)
```

Manhattan:

```
import heapq

# Define the goal state as a tuple of tuples
GOAL_STATE = ((1, 2, 3),
              (8, 0, 4),
              (7, 6, 5))

# Heuristic: Calculate the Manhattan distance for each tile
def manhattan_distance(state):
    distance = 0
    for i in range(3):
        for j in range(3):
            value = state[i][j]
            if value != 0:
                goal_x, goal_y = divmod(value - 1, 3)  # Find the goal position of the current tile
                distance += abs(goal_x - i) + abs(goal_y - j)
    return distance

# Find the position of the blank tile (0)
def find_blank(state):
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
                return i, j

# Generate neighbors by moving the blank tile
def generate_neighbors(state):
    neighbors = []
    x, y = find_blank(state)
    directions = [(0, 1), (0, -1), (1, 0), (-1, 0)]  # Right, Left, Down, Up
    for dx, dy in directions:
        nx, ny = x + dx, y + dy
        if 0 <= nx < 3 and 0 <= ny < 3:
            # Create a new state by swapping tiles
            new_state = [list(row) for row in state]
            new_state[x][y], new_state[nx][ny] = new_state[nx][ny], new_state[x][y]
            neighbors.append(tuple(tuple(row) for row in new_state))
    return neighbors

# Reconstruct the path from the start state to the goal state
def reconstruct_path(came_from, current):
    path = [current]
    while current in came_from:
        current = came_from[current]
```

```
        path.append(current)
    path.reverse()
    return path

# A* search algorithm
def a_star(start):
    open_list = []
    heapq.heappush(open_list, (manhattan_distance(start), 0, start))  # (f(n), g(n), state)
    g_score = {start: 0}  # Cost from start to the current state
    came_from = {}
    visited = set()

    while open_list:
        f, g, current = heapq.heappop(open_list)

        # Check if we have reached the goal
        if current == GOAL_STATE:
            path = reconstruct_path(came_from, current)
            return path, g

        visited.add(current)

        # Explore neighbors
        for neighbor in generate_neighbors(current):
            if neighbor in visited:
                continue

            tentative_g = g_score[current] + 1  # Each move has a cost of 1

            # If this path is better, update scores and add to the queue
            if tentative_g < g_score.get(neighbor, float('inf')):
                came_from[neighbor] = current
                g_score[neighbor] = tentative_g
                f_score = tentative_g + manhattan_distance(neighbor)  # f(n) = g(n) + h(n)
                heapq.heappush(open_list, (f_score, tentative_g, neighbor))

    return None, None  # No solution found

# Print a given puzzle state
def print_state(state):
    for row in state:
        print(row)
    print()

# Main function
if __name__ == "__main__":
    start_state = ((2, 8, 3),
```

```
            (1, 6, 4),
            (7, 0, 5))

    print("Initial State:")
    print_state(start_state)
    print("Goal State:")
    print_state(GOAL_STATE)

    solution, cost = a_star(start_state)
    if solution:
        print(f"Solution found with cost: {cost}")
        print("Steps:")
        for step in solution:
            print_state(step)
    else:
        print("No solution found.")
```

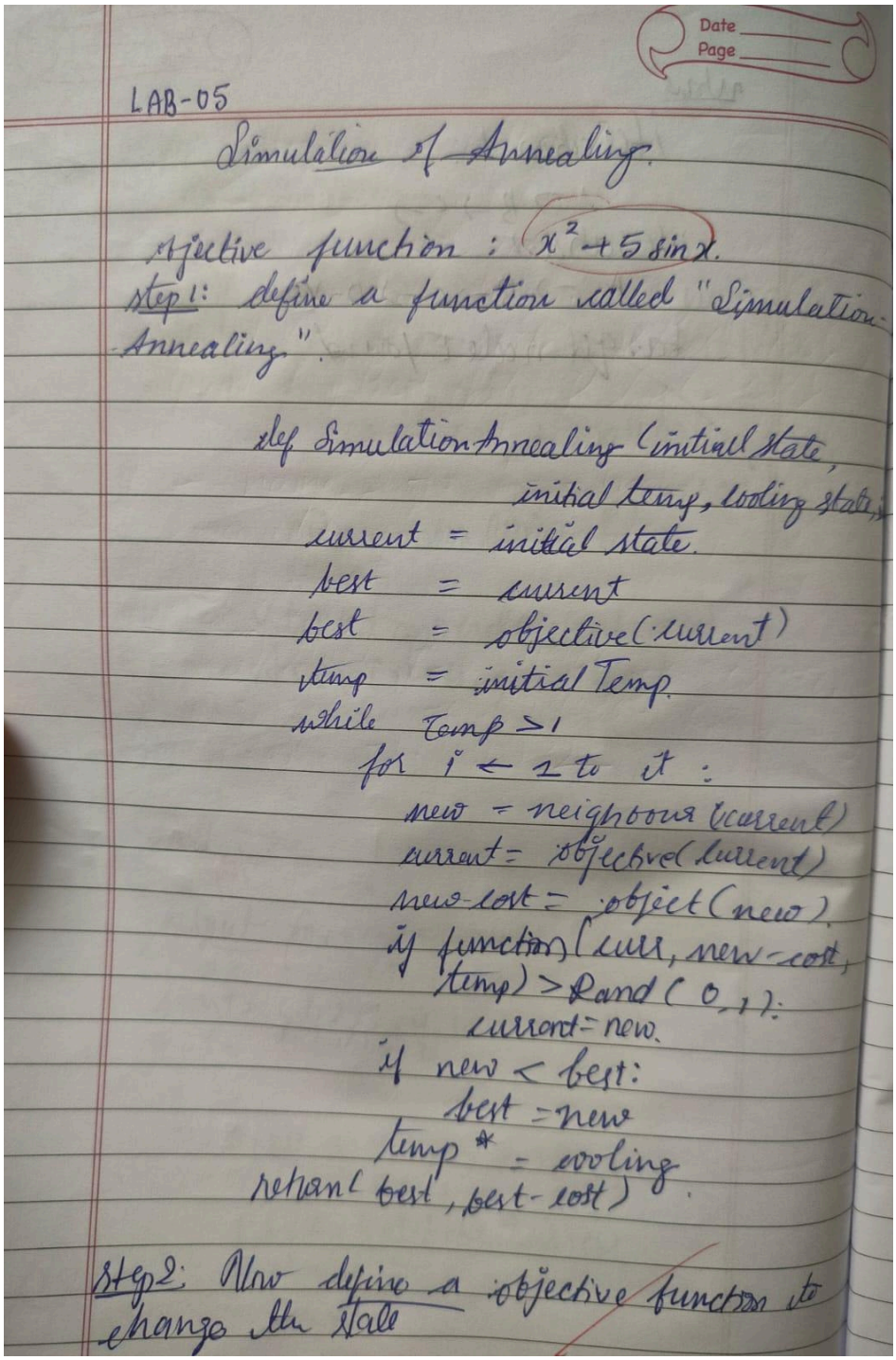
Output:

```
Initial State:
(2, 8, 3)
(1, 6, 4)
(7, 0, 5)

Goal State:
(1, 2, 3)
(8, 0, 4)
(7, 6, 5)

Solution found with cost: 5
Steps:
(2, 8, 3)
(1, 6, 4)
(7, 0, 5)

(2, 8, 3)
(1, 0, 4)
(7, 6, 5)

(2, 0, 3)
(1, 8, 4)
(7, 6, 5)

(0, 2, 3)
(1, 8, 4)
(7, 6, 5)

(1, 2, 3)
(0, 8, 4)
(7, 6, 5)

(1, 2, 3)
(8, 0, 4)
(7, 6, 5)
```

Program 5

Simulated Annealing to Solve 8-Queens problem

Algorithm:



LAB-05

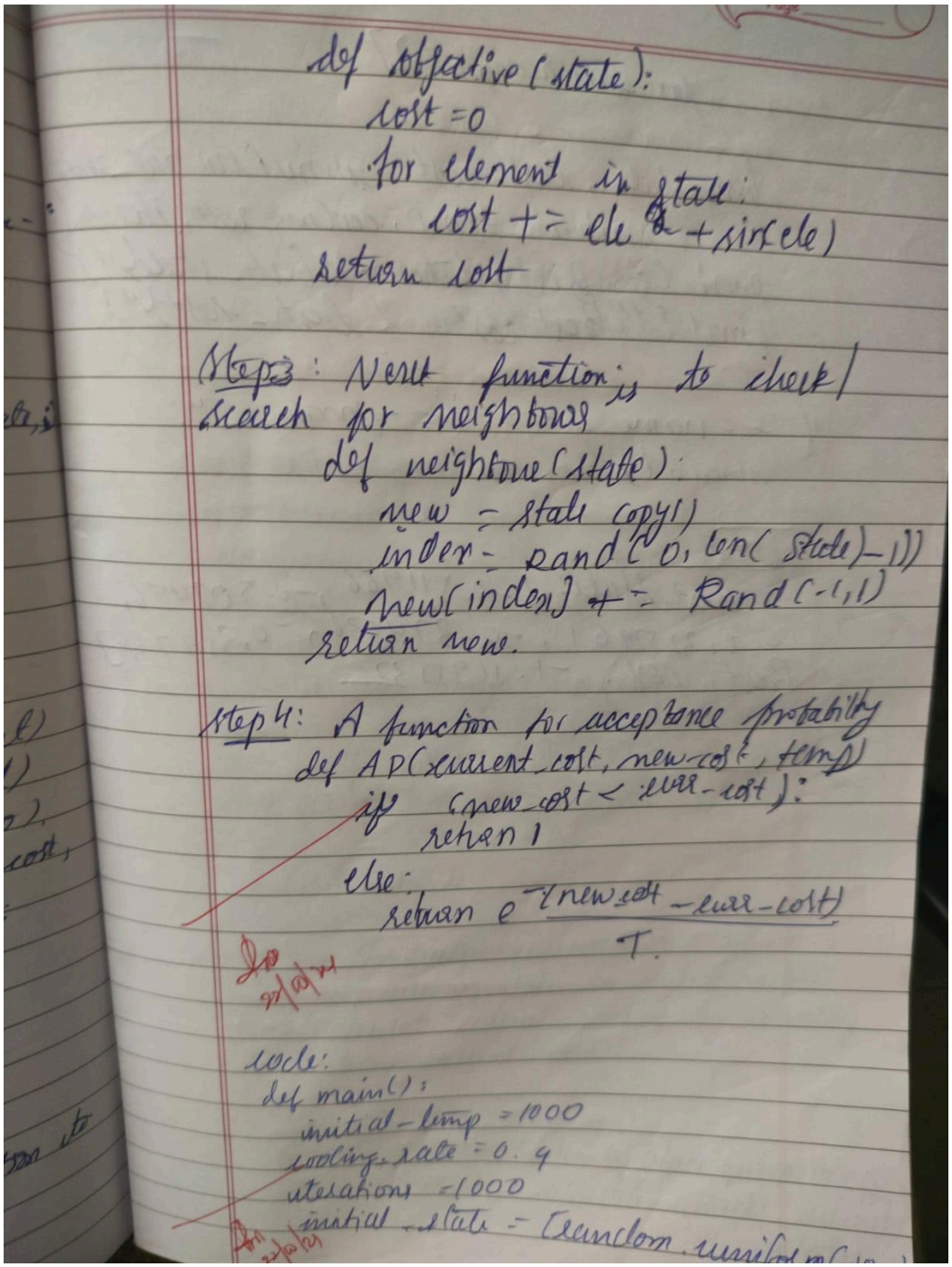
Simulation of Annealing.

objective function : $x^2 + 5\sin x$.

step 1: define a function called "Simulation-Annealing".

```
def SimulationAnnealing (initial state,
                         initial temp, cooling state,
    current = initial state.
    best    = current
    best    = objective(current)
    temp    = initial Temp
    while Temp > 1
        for i ← 1 to it :
            new = neighbour (current)
            current = objective(current)
            new-cost = object(new).
            if function(curr, new-cost,
               temp) > Rand(0,1):
                current = new.
            if new < best:
                best = new
            temp * = cooling
    return(best, best-cost)
```

step 2: Now define a objective function to change the state



Code:

```
import numpy as np
from scipy.optimize import dual_annealing

def queens_max(position):
    # This function calculates the number of pairs of queens that are not attacking each other
```

```
    position = np.round(position).astype(int)
    n = len(position)
    queen_not_attacking = 0

    for i in range(n - 1):
        for j in range(i + 1, n):
            # Check if queens i and j are not attacking each other
            if position[i] != position[j] and abs(position[i] - position[j]) != (j - i):
                queen_not_attacking += 1

    return -queen_not_attacking  # Return negative for maximization

# Bounds for each queen's position (0 to 7 for an 8x8 chessboard)
bounds = [(0, 7) for _ in range(8)]

# Use dual_annealing for simulated annealing optimization
result = dual_annealing(queens_max, bounds)

# Display the results
best_position = np.round(result.x).astype(int)
best_objective = -result.fun

print('The best position found is:', best_position)
print('The number of queens that are not attacking each other is:', best_objective)
```

Output:

```
The best position found is: [3 5 7 2 0 6 4 1]
The number of queens that are not attacking each other is: 28
```

Example: SUDOKU PROBLEM

```
import numpy as np
import random
import math

def is_valid(puzzle, row, col, num):
    """Check if a number can be placed at a specific position."""
    if num in puzzle[row] or num in puzzle[:, col]:
        return False
    box_x, box_y = row // 3 * 3, col // 3 * 3
    if num in puzzle[box_x:box_x + 3, box_y:box_y + 3]:
        return False
    return True
```

```
def initial_fill(puzzle):
    """Fill the empty cells in the puzzle with valid random values."""
    filled = puzzle.copy()
    for row in range(9):
        for col in range(9):
            if filled[row][col] == 0:
                possible_values = [num for num in range(1, 10) if is_valid(filled, row, col, num)]
                if possible_values:
                    filled[row][col] = random.choice(possible_values)
    return filled

def objective(puzzle):
    """Calculate the number of conflicts in the Sudoku puzzle."""
    conflicts = 0
    # Row conflicts
    for row in range(9):
        conflicts += 9 - len(set(puzzle[row]))
    # Column conflicts
    for col in range(9):
        conflicts += 9 - len(set(puzzle[:, col]))
    # Box conflicts
    for box_x in range(0, 9, 3):
        for box_y in range(0, 9, 3):
            box = puzzle[box_x:box_x+3, box_y:box_y+3].flatten()
            conflicts += 9 - len(set(box))
    return conflicts

def simulated_annealing(puzzle, max_iter=100000, start_temp=1.0, end_temp=0.01, alpha=0.99):
    """Solve the Sudoku puzzle using simulated annealing."""
    current_state = initial_fill(puzzle)
    current_score = objective(current_state)
    temp = start_temp

    for iteration in range(max_iter):
        if current_score == 0:  # Solution found
            break
        # Randomly pick an empty cell
        row, col = random.randint(0, 8), random.randint(0, 8)
        while puzzle[row][col] != 0:
            row, col = random.randint(0, 8), random.randint(0, 8)

        # Create a new state with a random value in the chosen cell
        new_state = current_state.copy()
        new_value = random.randint(1, 9)
        if is_valid(new_state, row, col, new_value):
            new_state[row][col] = new_value
```

```
        new_score = objective(new_state)
        delta_score = new_score - current_score

        # Accept new state based on simulated annealing criteria
        if delta_score < 0 or random.uniform(0, 1) < math.exp(-delta_score / temp):
            current_state, current_score = new_state, new_score

        # Decrease temperature
        temp *= alpha
        if temp < end_temp:
            break

    return current_state

# Example usage:
puzzle = np.array([
    [5, 3, 0, 0, 7, 0, 0, 0, 0],
    [6, 0, 0, 1, 9, 5, 0, 0, 0],
    [0, 9, 8, 0, 0, 0, 0, 6, 0],
    [8, 0, 0, 0, 6, 0, 0, 0, 3],
    [4, 0, 0, 8, 0, 3, 0, 0, 1],
    [7, 0, 0, 0, 2, 0, 0, 0, 6],
    [0, 6, 0, 0, 0, 0, 2, 8, 0],
    [0, 0, 0, 4, 1, 9, 0, 0, 5],
    [0, 0, 0, 0, 8, 0, 0, 7, 9]
])

solved_puzzle = simulated_annealing(puzzle)
print("Solved Sudoku:\n", solved_puzzle)
```

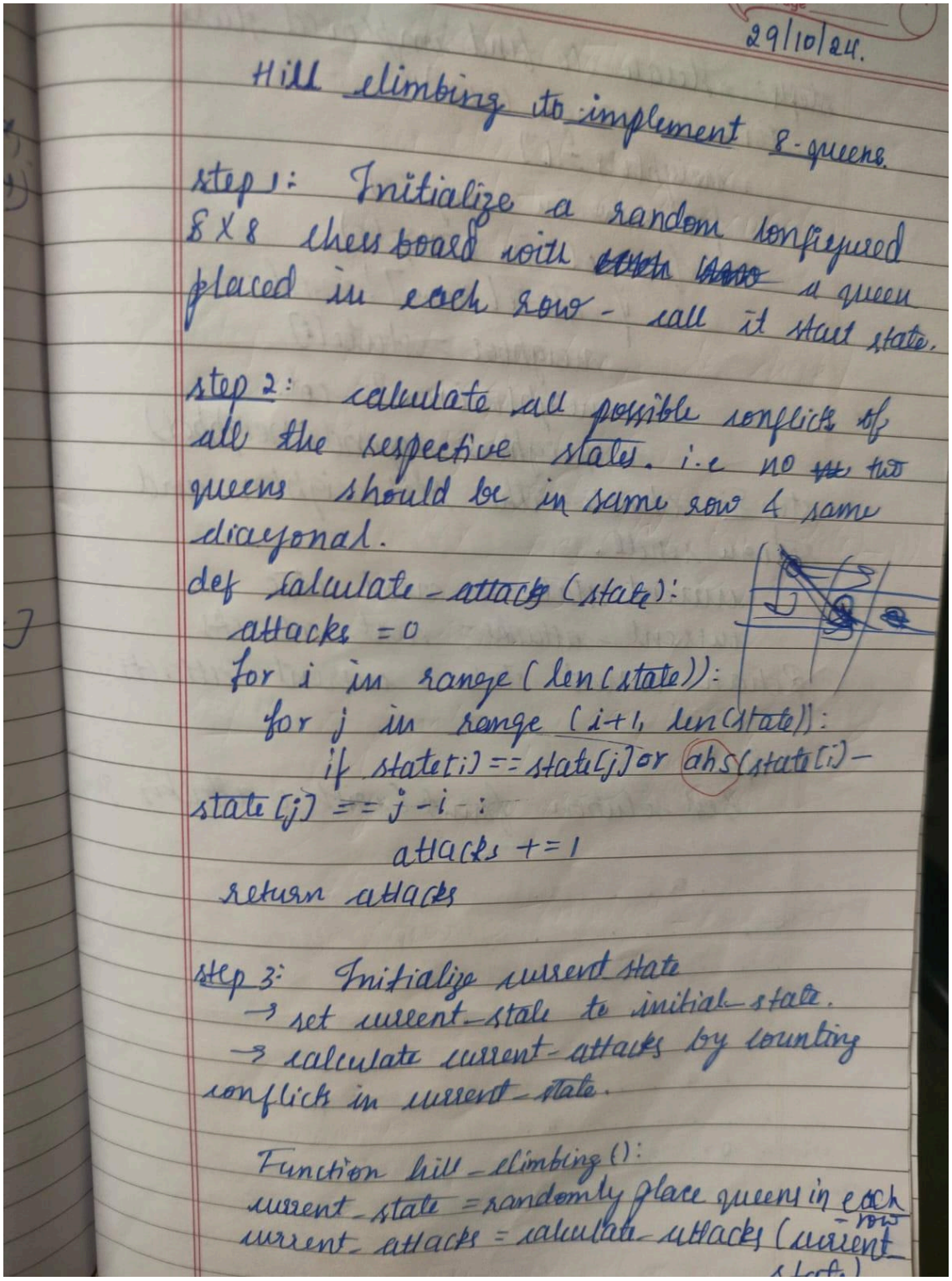
Output:

```
Solved Sudoku:
 [[5 3 4 2 7 6 9 1 0]
 [6 2 7 1 9 5 4 3 8]
 [1 9 8 3 4 0 5 6 2]
 [8 1 2 7 6 4 0 9 3]
 [4 0 9 8 5 3 7 2 1]
 [7 0 3 9 2 1 8 5 6]
 [3 6 5 0 0 7 2 8 4]
 [2 8 0 4 1 9 3 0 5]
 [0 4 1 5 8 2 6 7 9]]
```

Program 6

Implement Hill Climbing search algorithm to solve N-Queens problem

Algorithm:



29/10/24.

Hill climbing to implement 8-queens.

step 1: Initialize a random configured 8 X 8 chess board with ~~each~~ ~~three~~ a queen placed in each row - call it start state.

step 2: calculate all possible conflicts of all the respective states. i.e no ~~two~~ two queens should be in same row & same diagonal.

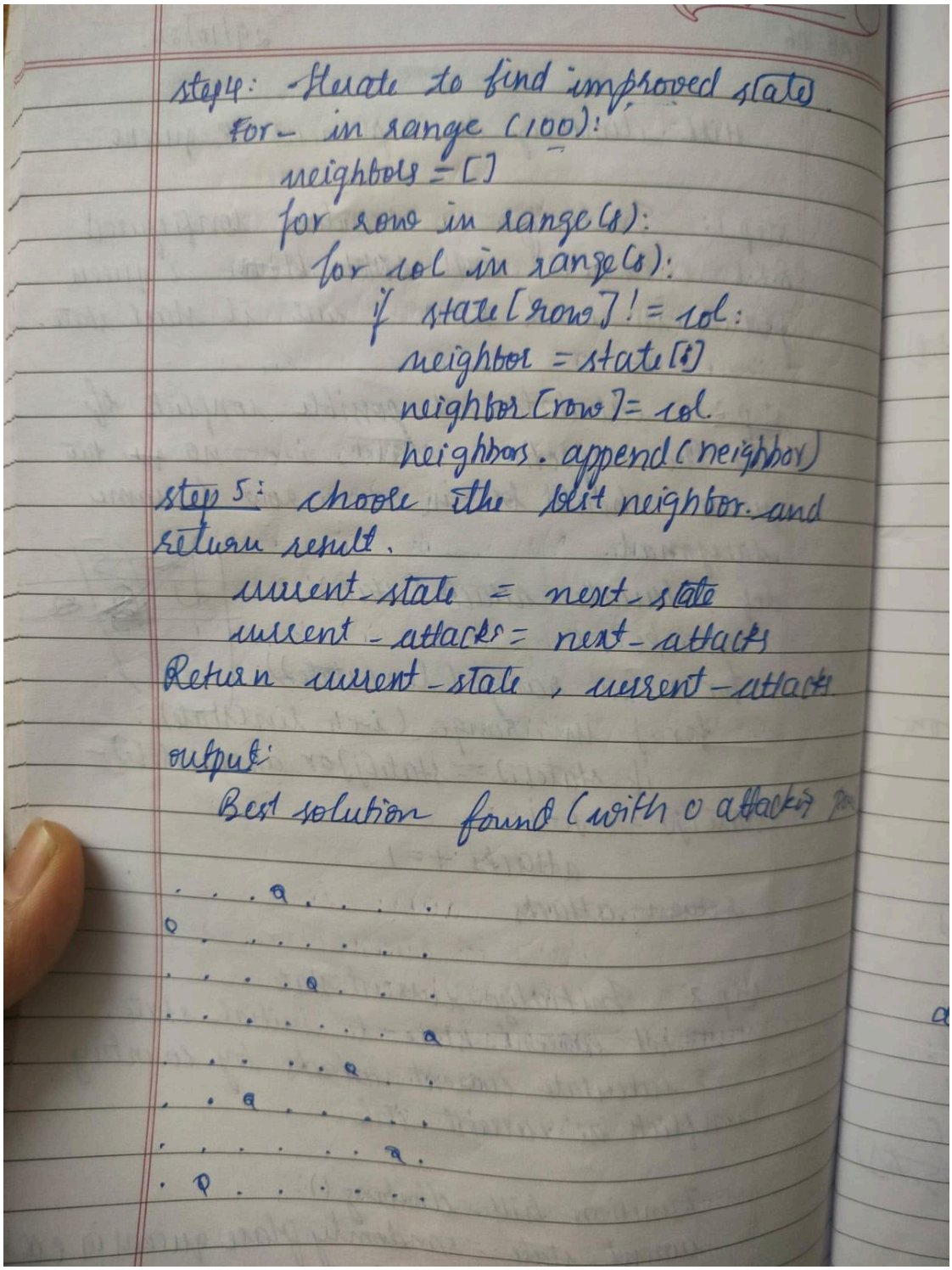
```
def calculate_attacks (state):
    attacks = 0
    for i in range (len(state)):
        for j in range (i+1, len(state)):
            if state[i] == state[j] or abs(state[i]-
state[j] == j-i :
                attacks += 1
    return attacks
```

step 3: Initialize current state

→ set current_state to initial_state.

→ calculate current_attacks by counting conflicts in current_state.

```
Function hill_climbing():
current_state = randomly place queens in each row
current_attacks = calculate_attacks (current_
                                    state)
```



Code:

```
import random

def get_attacking_pairs(state):
    """Calculates the number of attacking pairs of queens."""
```

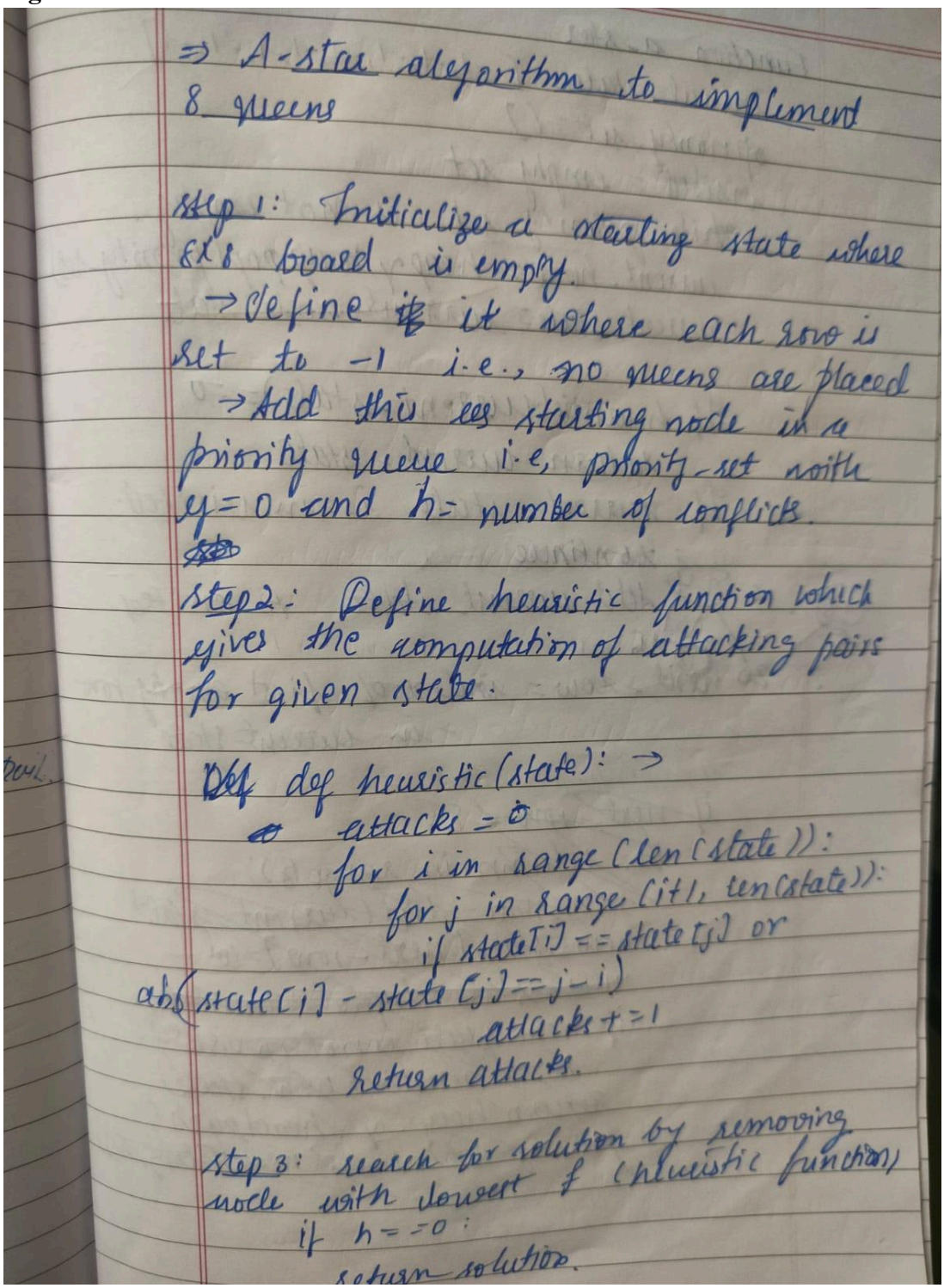
```
    attacks = 0
    n = len(state)
    for i in range(n):
        for j in range(i + 1, n):
            # Check if queens are in the same column or diagonals
            if state[i] == state[j] or abs(state[i] - state[j]) == abs(i - j):
                attacks += 1
    return attacks

def generate_successors(state):
    """Generates all possible successors by moving each queen to every other column in
its row."""
    n = len(state)
    successors = []
    for row in range(n):
        for col in range(n):
            if col != state[row]:  # Only generate new states with different columns
                new_state = state[:]
                new_state[row] = col
                successors.append(new_state)
    return successors

def hill_climbing(n):
    """Hill climbing algorithm for N-Queens problem."""
    # Start with a random state
    current = [random.randint(0, n - 1) for _ in range(n)]
    steps = 0

    while True:
        current_attacks = get_attacking_pairs(current)
        successors = generate_successors(current)

        # Find the neighbor with the minimum attacks
        neighbor = min(successors, key=get_attacking_pairs)
        neighbor_attacks = get_attacking_pairs(neighbor)
        steps += 1

        print(f"Step {steps}: Current State: {current}, Attacks: {current_attacks}")

        # If no better neighbor is found, return the current state
        if neighbor_attacks >= current_attacks:
            return current, current_attacks

        # Move to the better neighbor
        current = neighbor

def print_board(state):
```

```
    """Prints the board with queens placed."""
    n = len(state)
    board = [["." for _ in range(n)] for _ in range(n)]
    for row in range(n):
        board[row][state[row]] = "Q"
    for row in board:
        print(" ".join(row))
    print("\n")

# Set the size of the board
n = 8  # Change this value to test with different board sizes

solution, attacks = hill_climbing(n)
print("Final State (Solution):", solution)
print("Number of Attacking Pairs:", attacks)
print_board(solution)
```

Output:

```
Step 1: Current State: [0, 0, 0, 2], Attacks: 4, Cost: 4
Step 2: Current State: [0, 3, 0, 2], Attacks: 1, Cost: 1
Step 3: Current State: [1, 3, 0, 2], Attacks: 0, Cost: 0
Final State (Solution): [1, 3, 0, 2]
Number of Attacking Pairs: 0
. Q . .
. . . Q
Q . . .
. . Q .
```

Implement A-star algorithm to solve N-Queens problem
Algorithm:



⇒ A-star algorithm to implement 8 queens

step 1: Initialize a starting state where 8x8 board is empty.
→ Define it where each row is set to -1 i.e., no queens are placed
→ Add this as starting node in a priority queue i.e, priority set with g=0 and h= number of conflicts.

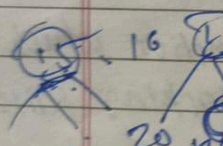
step 2: Define heuristic function which gives the computation of attacking pairs for given state.

```
def heuristic(state): →
    attacks = 0
    for i in range(len(state)):
        for j in range(i+1, len(state)):
            if state[i] == state[j] or
abs(state[i] - state[j]) == j - i)
                attacks += 1
    return attacks.
```

step 3: search for solution by removing node with lowest f (heuristic function)
if h == 0:
return solution.

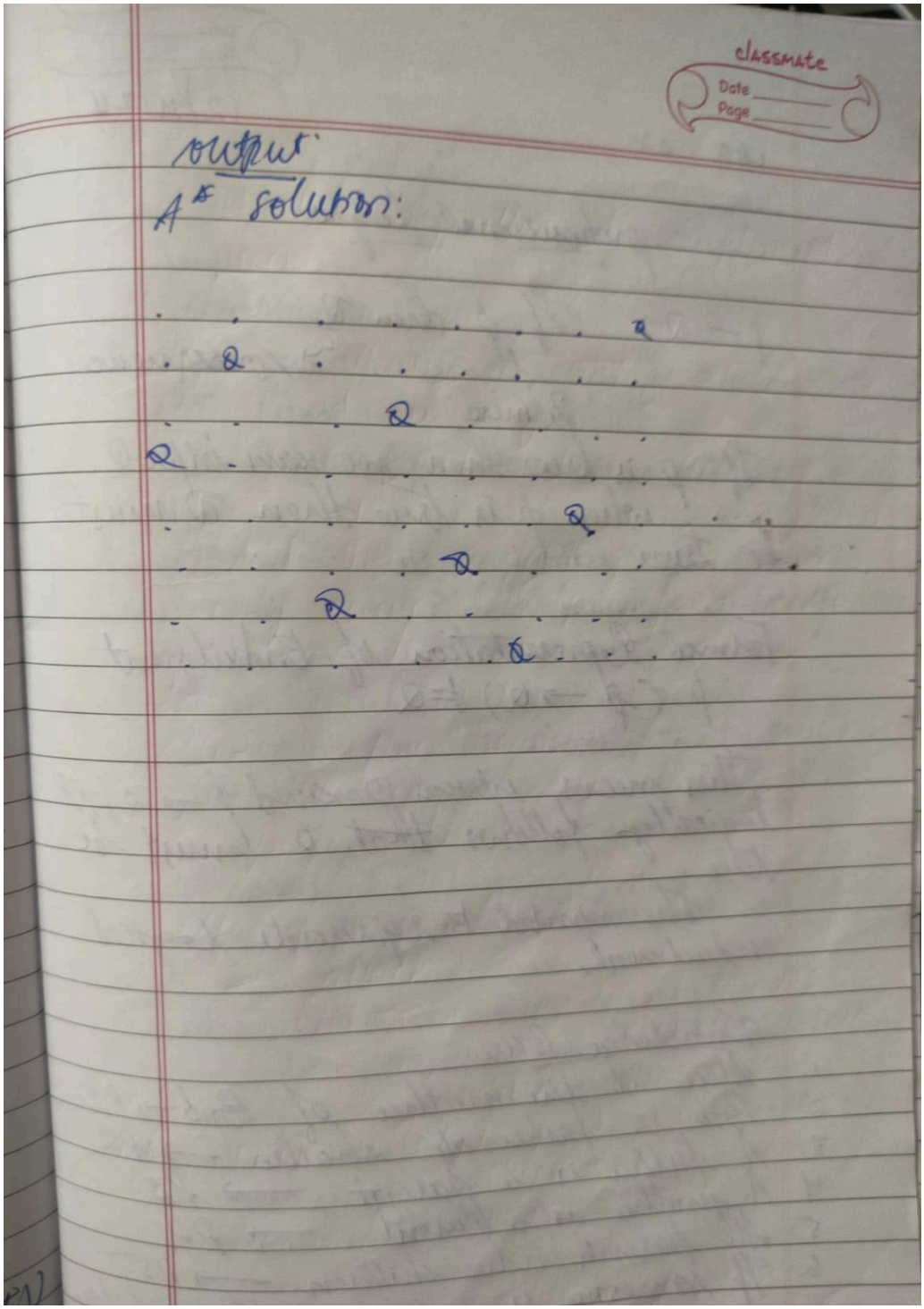
Function a_star
initial_state = [-1,-1,-1,-1,-1,-1,-1,-1]
priority_set = []
visited = empty set
while priority_set is not empty:
current_node = heapq.heappop(priority_set)
current_state = current_node.state

If heuristic(current_state) == 0
return current_state
If current_state is in visited:
continue
Add current_state to visited



next_row = index of first empty row in current state

if next_row < 8:
for column in range(8):
new_state = list(current_state)
new_state[next_row] = col
new_state = tuple(new_state)
if new_state is not in visited:
h = heuristic(new_state)
heapq.heappush(priority_set, (new_state, h))



code:

```
import heapq
```

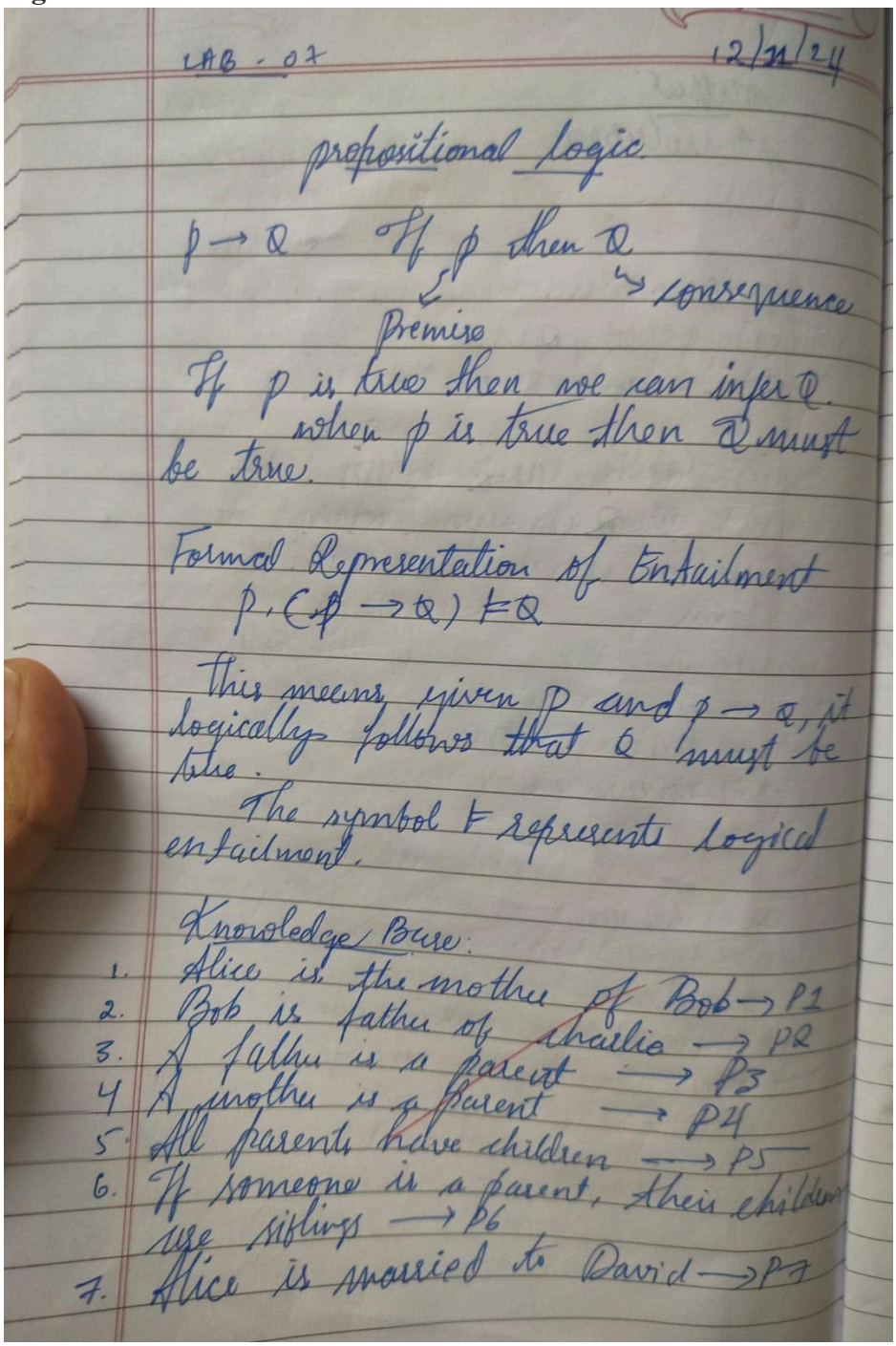
```
# Helper function to calculate the heuristic (number of conflicts)
def heuristic(board):
    conflicts = 0
    for i in range(len(board)):
        for j in range(i + 1, len(board)):
            if board[i] == board[j] or abs(board[i] - board[j]) == j - i:
                conflicts += 1
    return conflicts

# A* Search for 8-queens
def a_star_8_queens():
    n = 8
    open_set = []
    # Initial state: empty board
    heapq.heappush(open_set, (0, []))  # (f, board)

    while open_set:
        f, board = heapq.heappop(open_set)

        # Goal check
        if len(board) == n and heuristic(board) == 0:
            return board

        # Generate successors
        row = len(board)
        for col in range(n):
            new_board = board + [col]
            if heuristic(new_board) == 0:  # No conflicts so far
                g = row + 1
                h = heuristic(new_board)
                heapq.heappush(open_set, (g + h, new_board))


    return None  # No solution found

# Run A* search
solution = a_star_8_queens()
print("Solution board (column positions for each row):", solution)
```

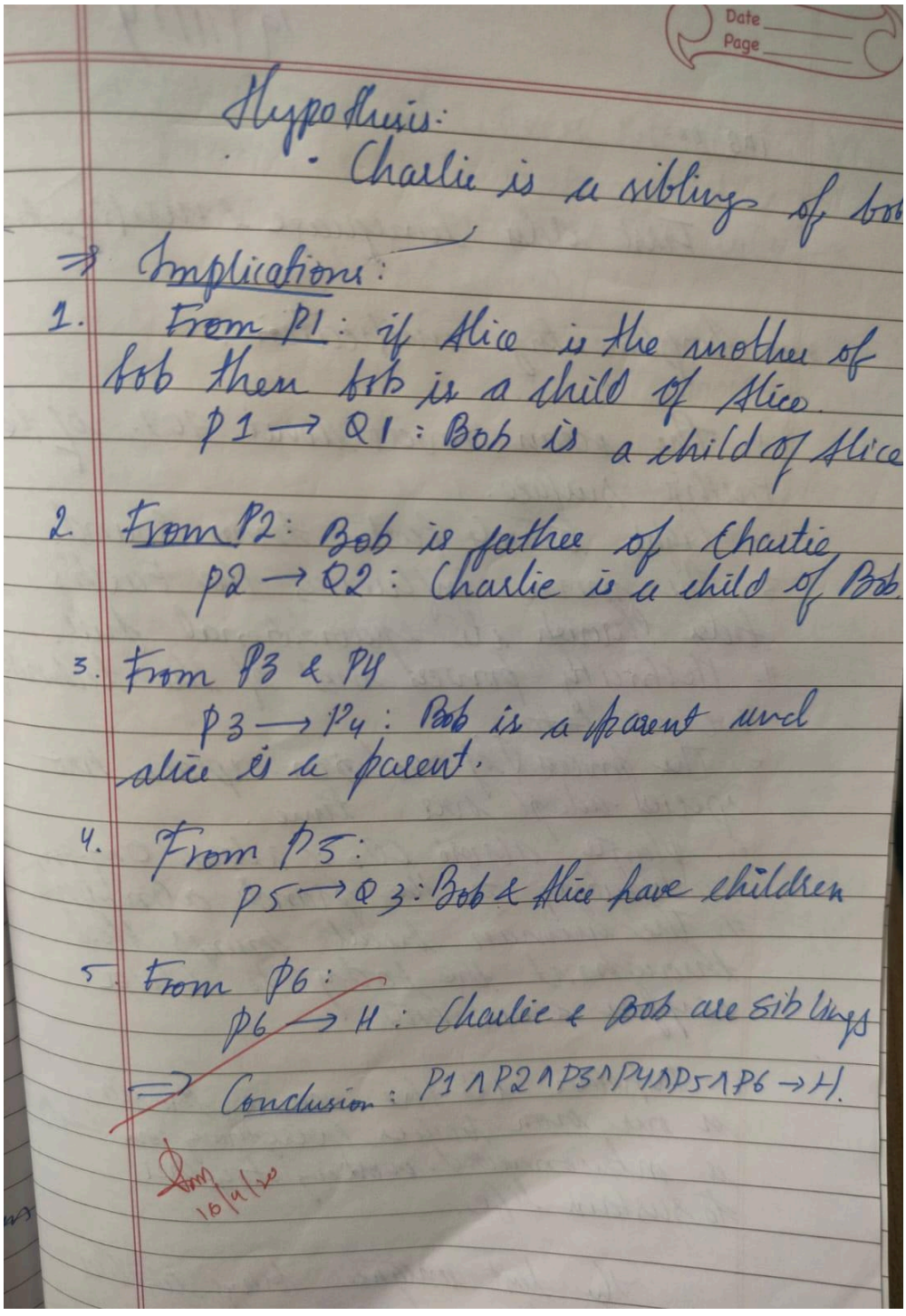
output:

```
Solution board (column positions for each row): [0, 4, 7, 5, 2, 6, 1, 3]
```

Program 7

Implement prepositional logic
Algorithm:



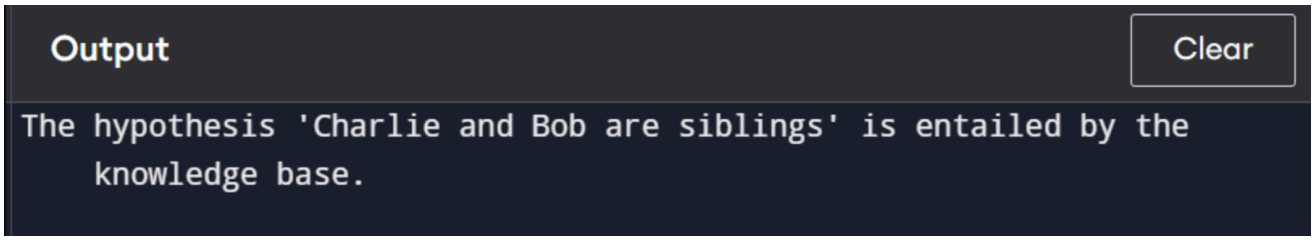


code:

```
class KnowledgeBase:
    def __init__(self):
        self.facts = []
        self.rules = []

    def add_fact(self, fact):
```

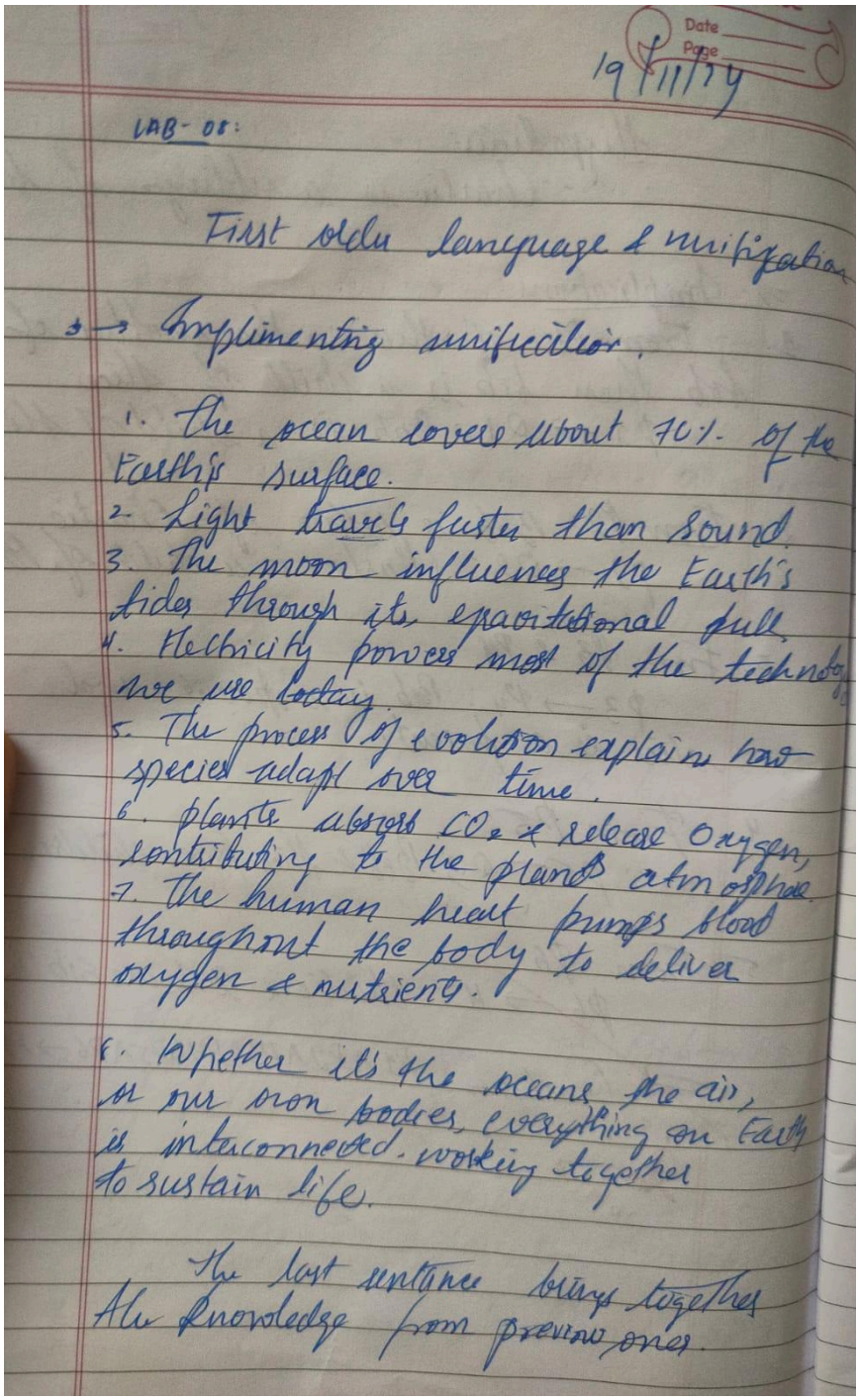
```
        self.facts.append(fact)

    def add_rule(self, premise, conclusion):
        self.rules.append((premise, conclusion))

    def infer(self):
        new_inferences = True

        while new_inferences:
            new_inferences = False

            for premise, conclusion in self.rules:
                if all(fact in self.facts for fact in premise) and conclusion not in self.facts:
                    self.facts.append(conclusion)
                    new_inferences = True

    def entails(self, hypothesis):
        return hypothesis in self.facts

# Example Usage
kb = KnowledgeBase()

# Adding facts
kb.add_fact("Alice is mother of Bob")
kb.add_fact("Bob is father of Charlie")
kb.add_fact("A father is a parent")
kb.add_fact("A mother is a parent")
kb.add_fact("All parents have children")
kb.add_fact("Alice is married to Davis")

# Adding rules
kb.add_rule(["Bob is father of Charlie", "A father is a parent"], "Bob is parent")
kb.add_rule(["Alice is mother of Bob", "A mother is a parent"], "Alice is parent")
kb.add_rule(["Bob is parent", "All parents have children"], "Charlie and Bob are
siblings")

# Perform inference
kb.infer()

# Hypothesis
hypothesis = "Charlie and Bob are siblings"

if kb.entails(hypothesis):
    print(f"The hypothesis '{hypothesis}' is entailed by the knowledge base.")
else:
    print(f"The hypothesis '{hypothesis}' is not entailed by the knowledge base.")
```

output:


Output
Clear
The hypothesis 'Charlie and Bob are siblings' is entailed by the knowledge base.

Program 8
Implement unification in first order logic

Algorithm: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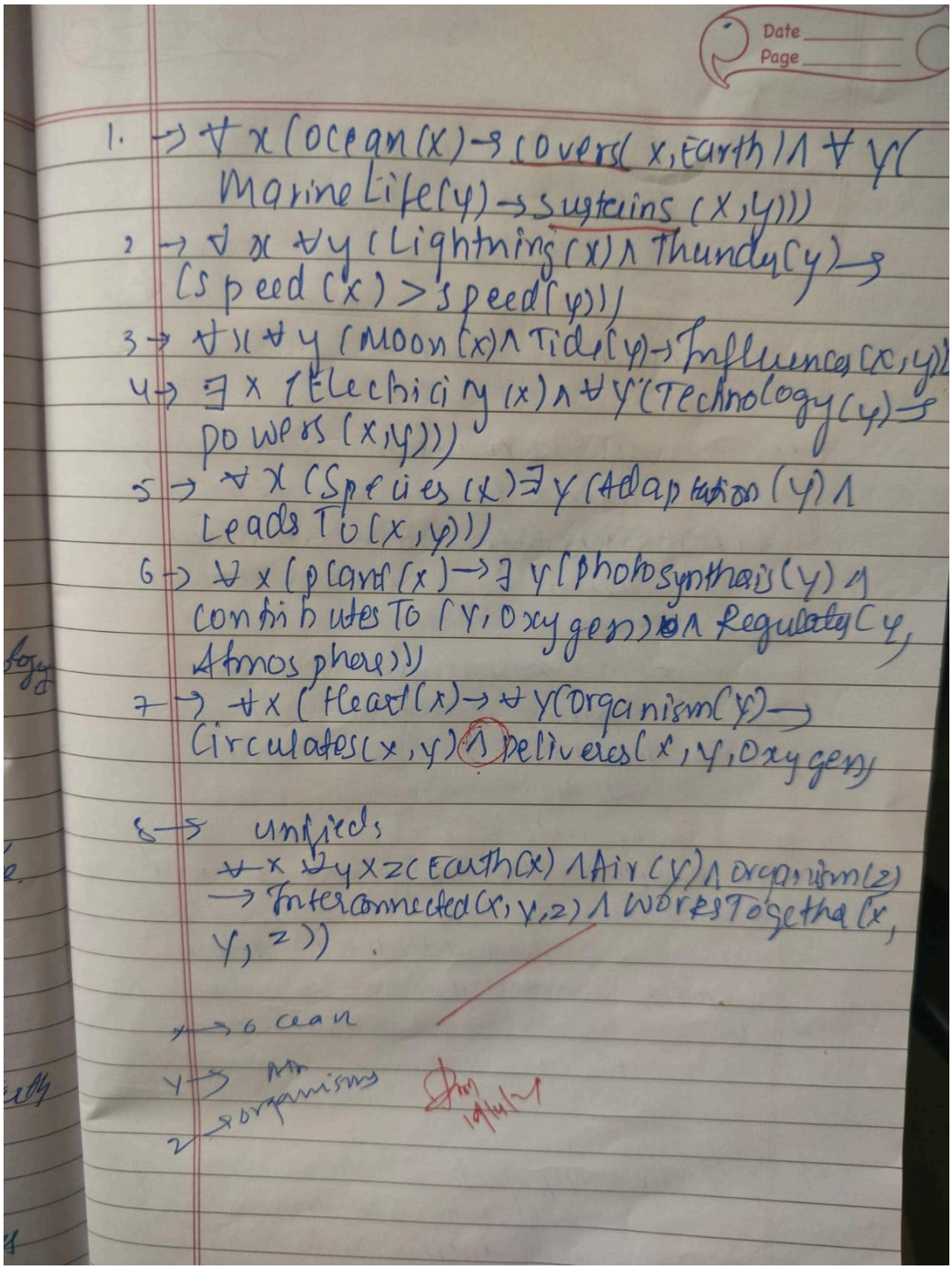
LAB - 08:

First order language & unification

→ Implementing unification.

1. The ocean covers about 70% of the Earth's surface.
2. Light travels faster than sound.
3. The moon influences the Earth's tides through its gravitational pull.
4. Electricity powers most of the technology we use today.
5. The process of evolution explains how species adapt over time.
6. Plants absorb CO_2 & release Oxygen, contributing to the planet's atmosphere.
7. The human heart pumps blood throughout the body to deliver oxygen & nutrients.
8. Together it's the oceans, the air, our own bodies, everything on Earth is interconnected, working together to sustain life.

The last sentence brings together the knowledge from previous ones.



Code:

```
class UnificationError(Exception):
    """Custom exception for unification errors."""
    pass

def occurs_check(var, term, subst):
```

```
    """Check if `var` occurs in `term` (to prevent circular substitutions)."""
    if var == term:
        return True
    elif isinstance(term, (list, tuple)):
        return any(occurs_check(var, t, subst) for t in term)
    elif isinstance(term, str) and term in subst:
        return occurs_check(var, subst[term], subst)
    return False

def is_variable(term):
    """Check if `term` is a variable (starting with `?`)."""
    return isinstance(term, str) and term.startswith('?')

def unify(psi1, psi2, subst=None):
    """Attempt to unify two terms, `psi1` and `psi2`, under the given substitution."""
    if subst is None:
        subst = {}

    if psi1 == psi2:
        return subst
    elif is_variable(psi1):
        if psi1 in subst:
            return unify(subst[psi1], psi2, subst)
        elif occurs_check(psi1, psi2, subst):
            raise UnificationError(f"Occurs check failed: {psi1} in {psi2}")
        else:
            subst[psi1] = psi2
            return subst
    elif is_variable(psi2):
        if psi2 in subst:
            return unify(psi1, subst[psi2], subst)
        elif occurs_check(psi2, psi1, subst):
            raise UnificationError(f"Occurs check failed: {psi2} in {psi1}")
        else:
            subst[psi2] = psi1
            return subst
    elif isinstance(psi1, list) and isinstance(psi2, list):
        if psi1[0] != psi2[0]:
            raise UnificationError(f"Predicate symbols don't match: {psi1[0]} != {psi2[0]}")
        if len(psi1) != len(psi2):
            raise UnificationError(f"Argument lengths don't match: {len(psi1)} != {len(psi2)}")
        for arg1, arg2 in zip(psi1[1:], psi2[1:]):  # Skip the predicate symbol (first element)
            subst = unify(arg1, arg2, subst)
        return subst
    else:
        raise UnificationError(f"Cannot unify {psi1} with {psi2}")
```

```
def get_input():
    """Get input from the user and perform unification."""
    try:
        term1 = eval(input("Enter the first term (e.g., ['P', 'b', 'x', ['f', ['g', 'z']]]): "))
        term2 = eval(input("Enter the second term (e.g., ['P', 'z', ['f', 'y'], ['f', 'y']]): "))
        substitution = unify(term1, term2)
        print("Unification successful!")
        print("Substitution:", substitution)
    except UnificationError as e:
        print("Unification failed:", e)
    except Exception as e:
        print("Invalid input or error:", e)

# Run the unification input prompt
get_input()
```

Output:

```
Enter the first term (e.g., ['P', 'b', 'x', ['f', ['g', 'z']]]): ['P',['f',['a']],['g',['?y']]]
Enter the second term (e.g., ['P', 'z', ['f', 'y'], ['f', 'y']]):  ['P','?x','?x']
Unification failed: Predicate symbols don't match: g != f
```

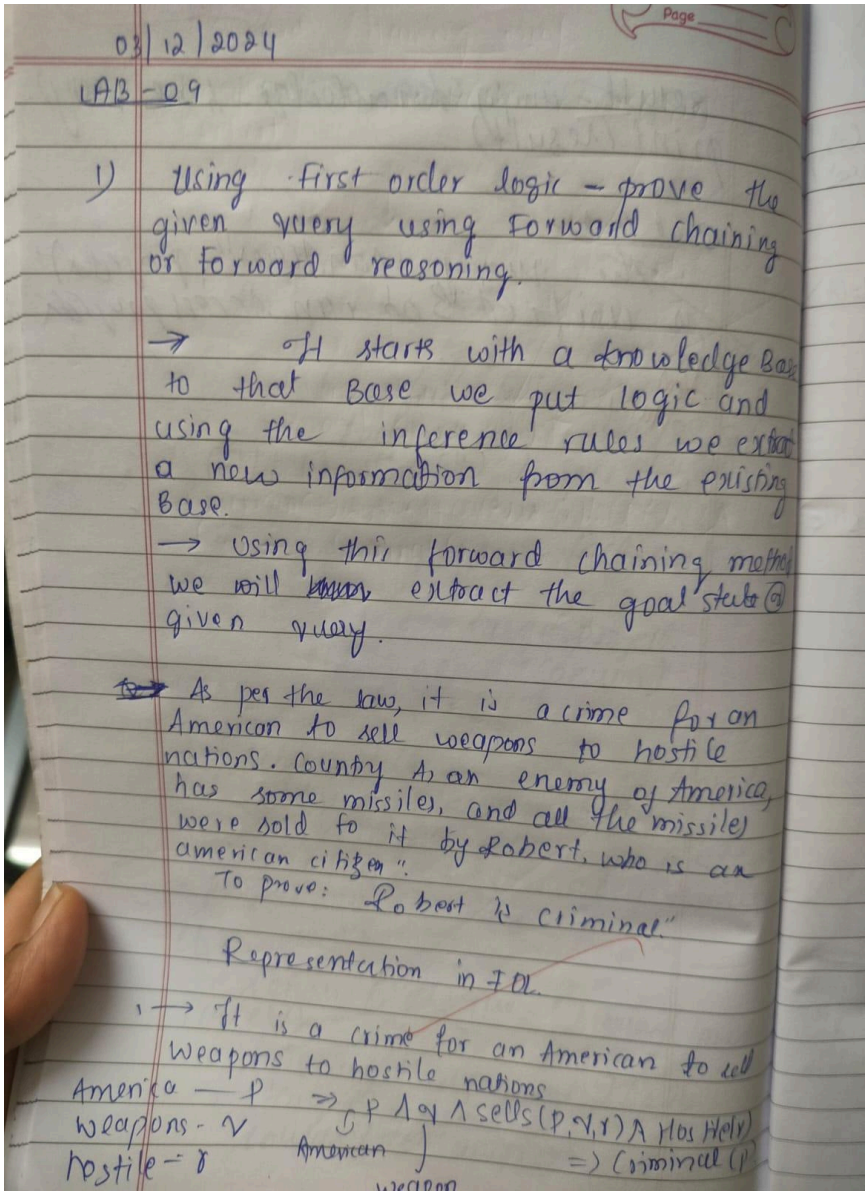
+ Code + Text

```
Enter the first term (e.g., ['P', 'b', 'x', ['f', ['g', 'z']]]): ['P', 'b', '?x', ['f', ['g', '?z']]]
Enter the second term (e.g., ['P', 'z', ['f', 'y'], ['f', 'y']]): ['P', '?z', ['f', '?y'], ['f', '?y']]
Unification successful!
Substitution: {'?z': 'b', '?x': ['f', '?y'], '?y': ['g', '?z']}
```

Program 9

Forward Chaining:

Algorithm:



2 → County A has some missiles.
$\exists x$ Owns (A, x) ∧ Missile(x)

anew constant T1:
Owns (A, T1)
Missile (T1)

3 → All of the missiles were sold to county by Robert.

$\forall x$ Missile(x) ∧ Owns (A, x) ⇒ Sells (Robert, x, A)

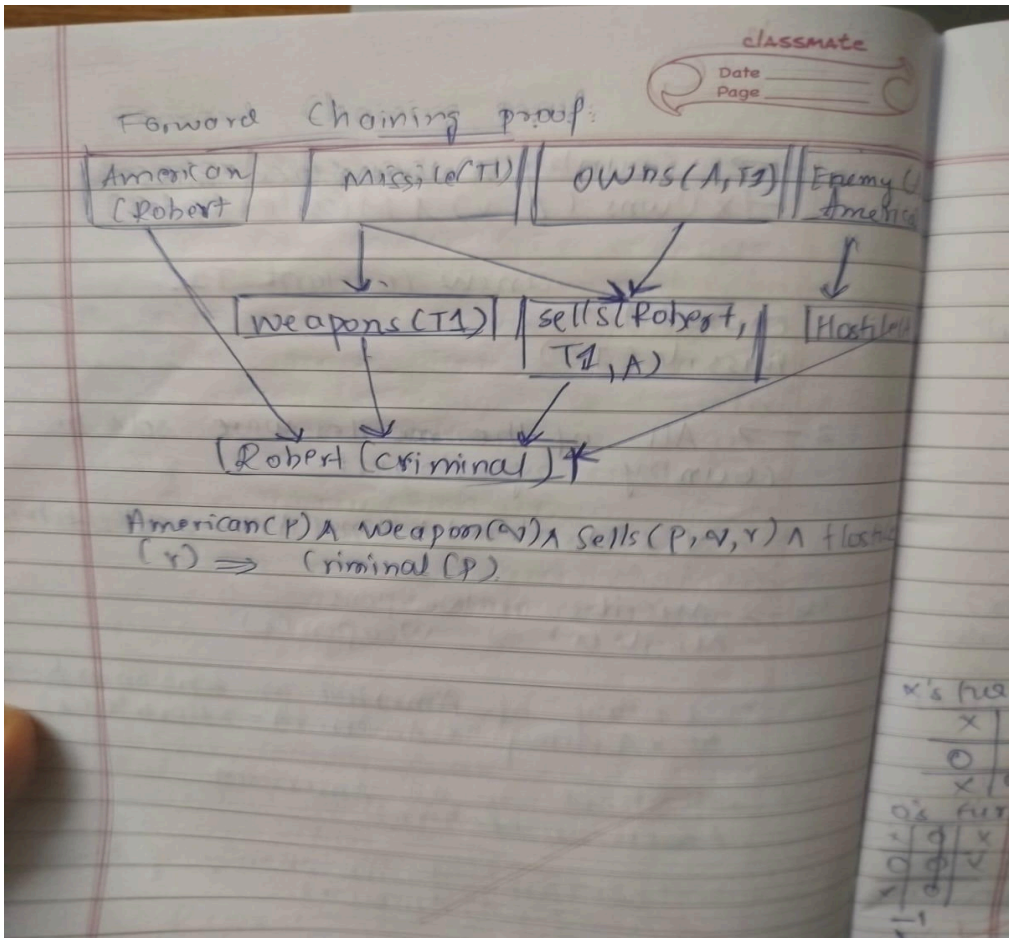
4 → Missiles are weapons.
Missile (x) ⇒ Weapon (x)

5 → Enemy of America is known as hostile
$\forall x$ Enemy (x, America) ⇒ Hostile (x)

6 → Robert is an American
American (Robert)

7 → The county A, an enemy of America
Enemy (A, America).

To prove:
Robert is Criminal
Criminal (Robert).



Code:

```
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 """
```

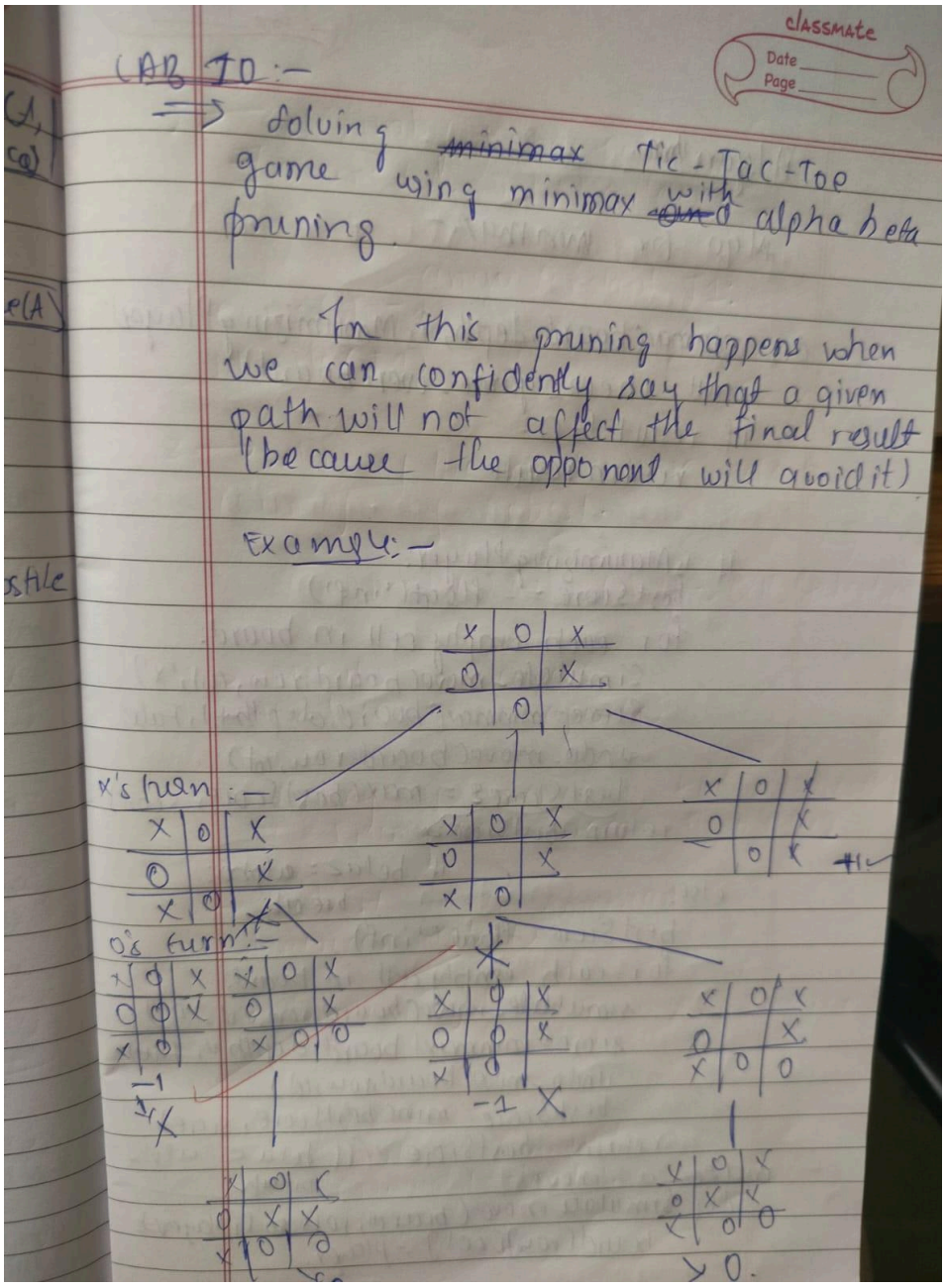
```
    # 1. Apply: Missile(x) → Weapon(x)
    if 'Missile(T1)' in KB:
        KB.add('Weapon(T1)')
        print(f"Inferred: Weapon(T1)")

    # 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:

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

Program 10:
Alpha Beta Pruning(Tic-Tac-Toe):

Algorithm:



Code:

```
import math

def minimax(node, depth, is_maximizing):
    """
```

```
    Implement the Minimax algorithm to solve the decision tree.

    Parameters:
    node (dict): The current node in the decision tree, with the following structure:
    {
        'value': int,
        'left': dict or None,
        'right': dict or None
    }
    depth (int): The current depth in the decision tree.
    is_maximizing (bool): Flag to indicate whether the current player is the maximizing player.

    Returns:
    int: The utility value of the current node.
    """
    # Base case: Leaf node
    if node['left'] is None and node['right'] is None:
        return node['value']

    # Recursive case
    if is_maximizing:
        best_value = -math.inf
        if node['left']:
            best_value = max(best_value, minimax(node['left'], depth + 1, False))
        if node['right']:
            best_value = max(best_value, minimax(node['right'], depth + 1, False))
        return best_value
    else:
        best_value = math.inf
        if node['left']:
            best_value = min(best_value, minimax(node['left'], depth + 1, True))
        if node['right']:
            best_value = min(best_value, minimax(node['right'], depth + 1, True))
        return best_value

# Example usage
decision_tree = {
    'value': 5,
    'left': {
        'value': 6,
        'left': {
            'value': 7,
            'left': {
                'value': 4,
                'left': None,
                'right': None
            },
```

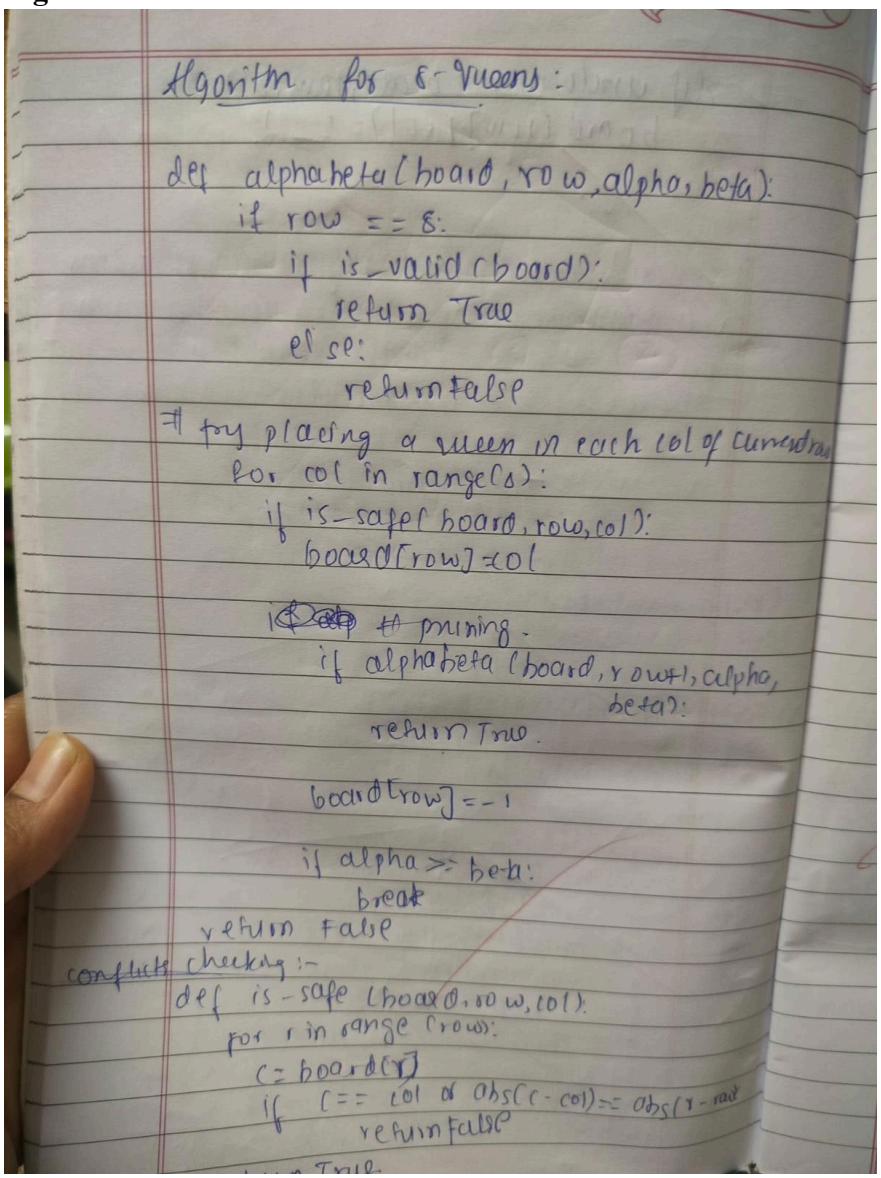
```
            'right': {
                'value': 5,
                'left': None,
                'right': None
            }
        },
        'right': {
            'value': 3,
            'left': {
                'value': 6,
                'left': None,
                'right': None
            },
            'right': {
                'value': 9,
                'left': None,
                'right': None
            }
        }
    },
    'right': {
        'value': 8,
        'left': {
            'value': 7,
            'left': {
                'value': 6,
                'left': None,
                'right': None
            },
            'right': {
                'value': 9,
                'left': None,
                'right': None
            }
        },
        'right': {
            'value': 8,
            'left': {
                'value': 6,
                'left': None,
                'right': None
            },
            'right': None
        }
    }
}
```

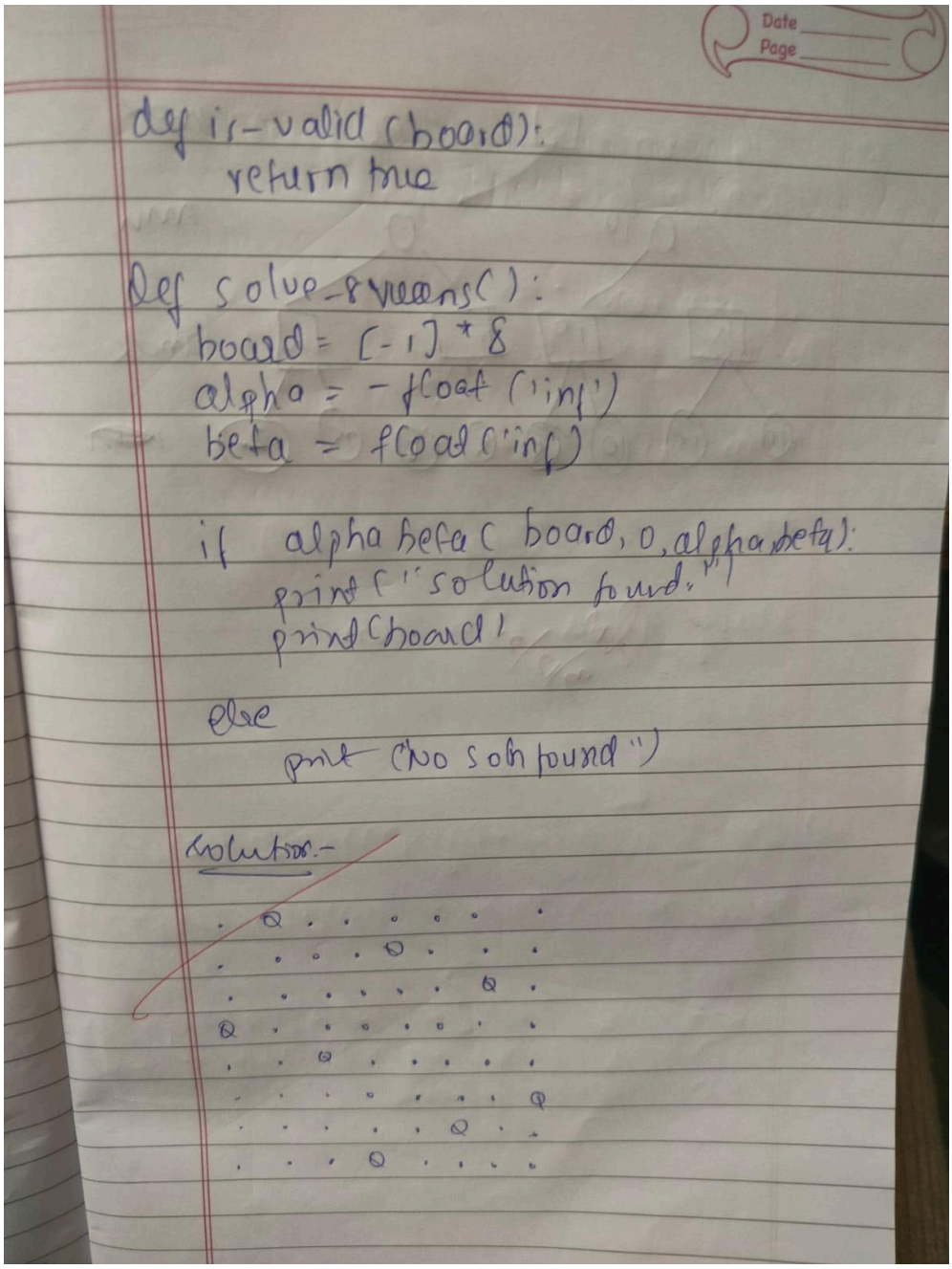
```
# Find the best move for the maximizing player
best_value = minimax(decision_tree, 0, True)
print(f"The best value for the maximizing player is: {best_value}")
```

Output:

```
The best value for the maximizing player is: 6
```

Alpha Beta Pruning(8-queens):
Algorithm:





code:

```
def is_valid(board, row, col):

    for i in range(row):
        if board[i] == col or \
            abs(board[i] - col) == abs(i - row):
            return False
    return True

def alpha_beta(board, row, alpha, beta, isMaximizing):
```

```
    if row == len(board):
        return 1

    if isMaximizing:
        max_score = 0
        for col in range(len(board)):
            if is_valid(board, row, col):
                board[row] = col
                max_score += alpha_beta(board, row + 1, alpha, beta, False)
                board[row] = -1
                alpha = max(alpha, max_score)
                if beta <= alpha:
                    break
        return max_score
    else:
        min_score = float('inf')
        for col in range(len(board)):
            if is_valid(board, row, col):
                board[row] = col
                min_score = min(min_score, alpha_beta(board, row + 1, alpha, beta, True))
                board[row] = -1
                beta = min(beta, min_score)
                if beta <= alpha:
                    break
        return min_score

def solve_8_queens():

    board = [-1] * 8
    alpha = -float('inf')
    beta = float('inf')
    return alpha_beta(board, 0, alpha, beta, True)

solutions = solve_8_queens()
print(f"Number of solutions for the 8 Queens problem: {solutions}")
```

output: