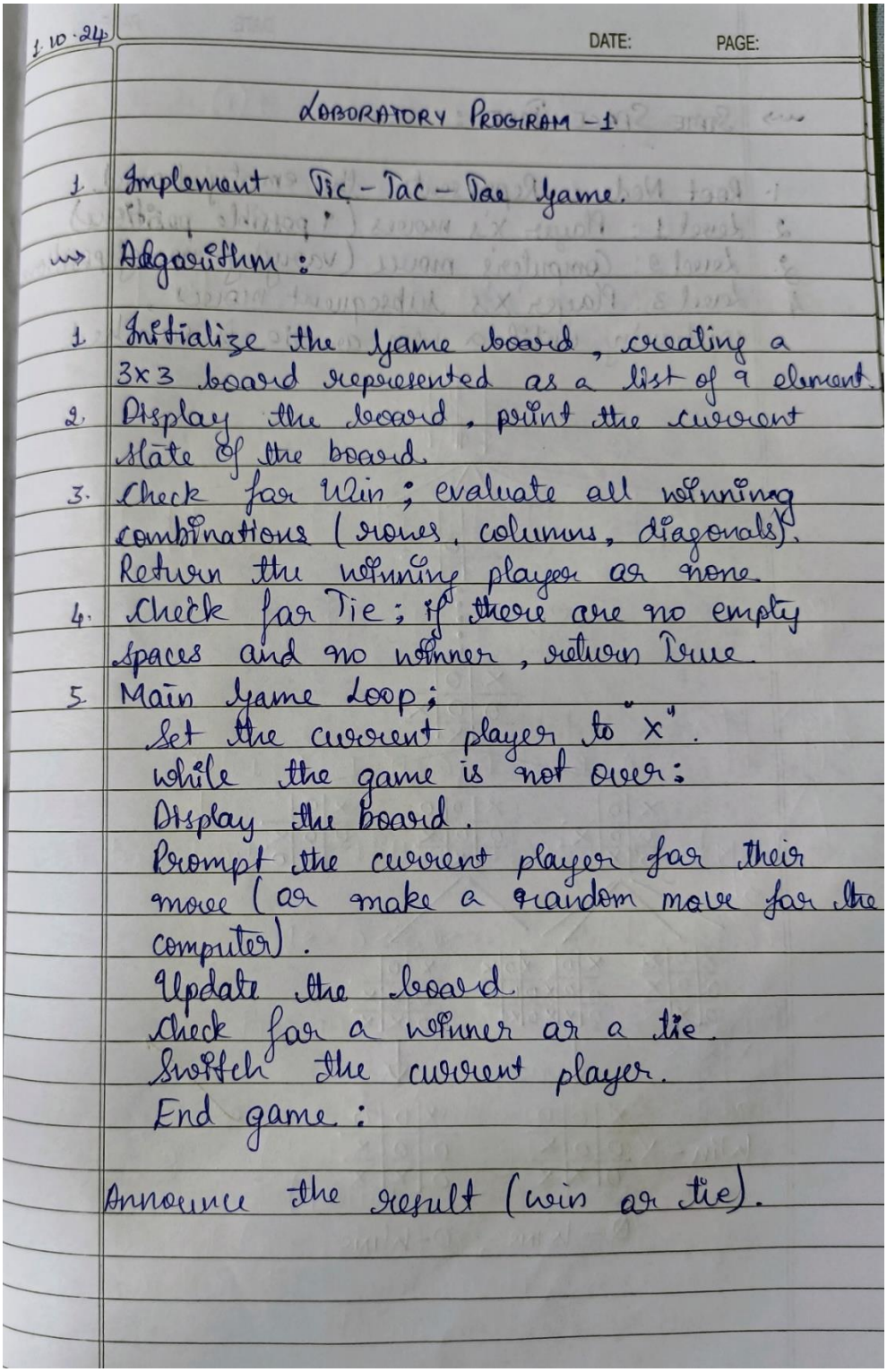
LABORATORY PROGRAM – 1

IMPLEMENT TIC –TAC –TOE GAME

PSEUDOCODE OR ALGORITHM



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LABORATORY PROGRAM - 1

1. Implement Tic - Tac - Toe game.

→ Algorithm:

1. Initialize the game board, creating a 3x3 board represented as a list of 9 element.
2. Display the board, print the current state of the board.
3. Check for Win; evaluate all winning combinations (rows, columns, diagonals). Return the winning player or none.
4. Check for Tie; if there are no empty spaces and no winner, return True.
5. Main game loop;
   Set the current player to "X".
   while the game is not over:
   Display the board.
   Prompt the current player for their move (or make a random move for the computer).
   Update the board.
   Check for a winner or a tie.
   Switch the current player.
   End game:

Announce the result (win or tie).

STATE SPACE TREE

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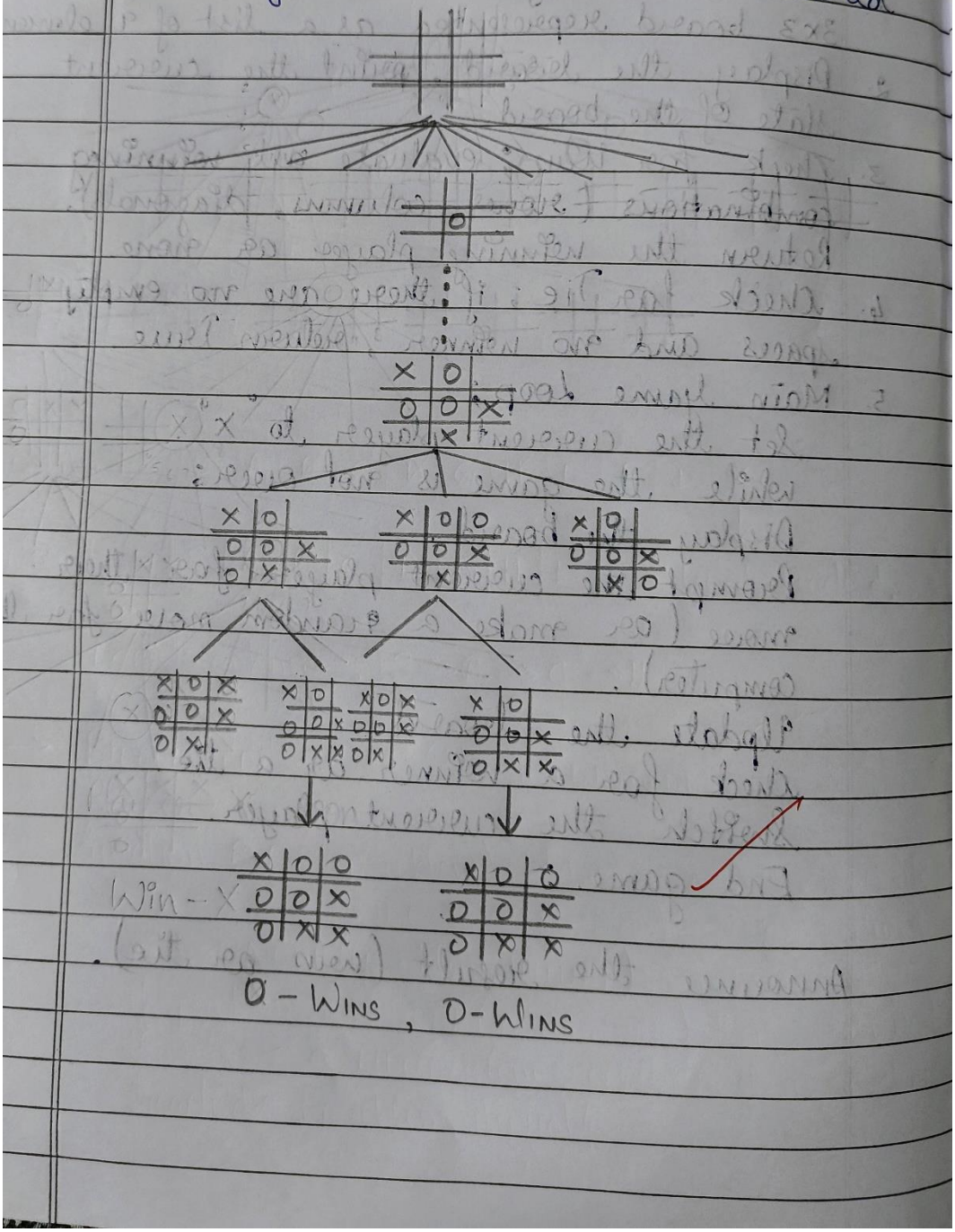
⇒ STATE SPACE TREE::

1. Root Node : Represents the empty board.
2. Level 1 : Player X's moves (9 possible positions)
3. Level 2: Computer's moves (varying no. of positions)
4. Level 3 : Player X's subsequent moves, continuing until a win or tie is reached



CODE

```
import random

board = ["-", "-", "-",
         "-", "-", "-",
         "-", "-", "-"]

def p_board(player):
    print(board[0] + "|" + board[1] + "|" + board[2])
    print(board[3] + "|" + board[4] + "|" + board[5])
    print(board[6] + "|" + board[7] + "|" + board[8])

def check_win():

  for i in range(0, 7, 3):
    if board[i] == board[i + 1] == board[i + 2] and
board[i] != '-':
      return board[i]

  for i in range(3):
    if board[i] == board[i + 3] == board[i + 6] and
board[i] != '-':
      return board[i]

  if board[0] == board[4] == board[8] and board[0] !=
'-':
    return board[0]
  if board[2] == board[4] == board[6] and board[2] !=
'-':
    return board[2]

  return None

def check_tie():
  if '-' not in board:
    return True
  return False

def play_game():
  current_player = "X"
  game_over = False

  while not game_over:
    p_board(current_player)

    if current_player == "X":
      print("It's your turn (X).")
      try:
        position = int(input("Choose a position from 1-9:
")) - 1
        if position < 0 or position > 8 or board[position]
!= '-':
          print("Invalid move. Try again.")
          continue
      except ValueError:
        print("Invalid input. Please enter a number
between 1 and 9.")
        continue
    else:
      print("Computer's turn (O).")
      available_moves = [i for i, spot in
enumerate(board) if spot == '-']
      position = random.choice(available_moves)

    board[position] = current_player
    winner = check_win()

    if winner:
      p_board(current_player)
      print(winner + " won!")
      game_over = True
    elif check_tie():
      p_board(current_player)
      print("It's a tie!")
      game_over = True
    else:
      current_player = "O" if current_player == "X" else
"X"

play_game()
```

OUTPUT

```
-|-|-
-|-|-
-|-|-
It's your turn (X).
Choose a position from 1-9: 5
-|-|-
-|X|-
-|-|-
Computer's turn (O).
-|O|-
-|X|-
-|-|-
It's your turn (X).
Choose a position from 1-9: 7
-|O|-
-|X|-
X|-|-
Computer's turn (O).
-|O|O
-|X|-
X|-|-
It's your turn (X).
Choose a position from 1-9: 1
X|O|O
-|X|-
X|-|-
Computer's turn (O).
X|O|O
-|X|O
X|-|-
It's your turn (X).
Choose a position from 1-9: 4
X|O|O
X|X|O
X|-|-
X won!
```

LABORATORY PROGRAM – 2

SOLVE 8 PUZZLE PROBLEMS

PSEUDOCODE OR ALGORITHM

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LABORATORY PROGRAM :- 2(B)

1. Pseudocode for 8 puzzle problem:

```
function FIND-ZERO(state) returns (row, col)
    for i from 0 to 2 do
        for j from 0 to 2 do
            if state[i][j] == 0 then
                return (i, j)

function MOVE (state, direction) return new_state
    new_state ← copy of state
    (i,j) ← FIND-ZERO(state)
    if direction == "up" and i>0 then
        swap new_state[i][j] with new_state[i-1][j]
    else if direction == "down" and i<2 then
        swap new_state[i][j] with new_state[i+1][j]
    else if direction == "left" and j>0 then
        swap new_state[i][j] with new_state[i][j-1]
    else if direction == "right" and j<2 then
        swap new_state[i][j] with new_state[i][j+1]
return new_state

function IS-GOAL(state) returns boolean
    return state == goal_state

function PRINT-STATE(state)
    for each row in state do
        print row
```

```
function DFS(initial_state) returns path or failure
    stack ← [(initial_state, [])]
    visited ← empty set
    while not IS-EMPTY(stack) do
        (state, path) ← POP(stack)
        PRINT-STATE(state)

        if IS-GOAL(state) then
            return path

        visited.add(str(state))
        for direction in ["up", "down", "left", "right"] do
            new_state ← MOVE(state, direction)
            if new_state is not null and str(new_state) not
            in visited then
                PUSH(stack, (new_state, path + [direction]))
    return failure

function GET-INITIAL-STATE() returns initial_state
    print("Enter the initial state of the 8-puzzle
    (0 for empty space):")
    initial_state ← empty list
    for i from 0 to 2 do
        row ← input row as list of integers
        initial_state.append(row)
    return initial_state

main
    initial_state ← GET-INITIAL-STATE()
    PRINT-STATE(initial_state)
    start_time ← current time
    print("Solving using DFS:")
```

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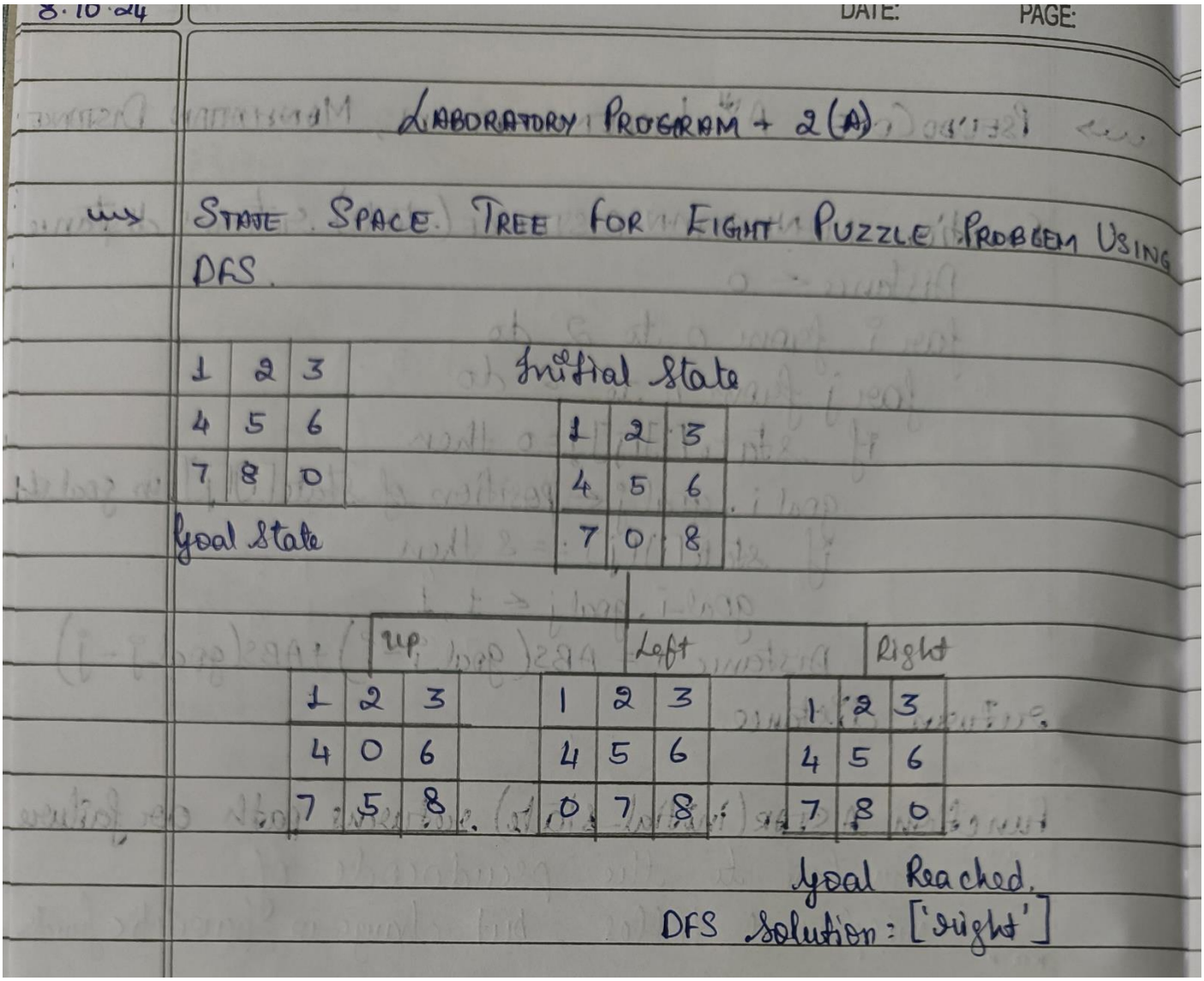
```
dfs_solution ← DFS(initial_state)
end_time ← current time
if dfs_solution is not null then
    print("DFS Solution:", dfs_solution)
else
    print("No solution found")
print("Time taken by DFS:", end_time - start_time)
```

STATE SPACE TREE



CODE

```
from collections import deque
import time

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

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

def move(state, direction):
    new_state = [row[:] for row in state]
    zero_pos = find_zero(state)
    i, j = zero_pos

    if direction == "up" and i > 0:
        new_state[i][j], new_state[i-1][j] = new_state[i-
1][j], new_state[i][j]
    elif direction == "down" and i < 2:
        new_state[i][j], new_state[i+1][j] =
new_state[i+1][j], new_state[i][j]
    elif direction == "left" and j > 0:
        new_state[i][j], new_state[i][j-1] = new_state[i][j-
1], new_state[i][j]
    elif direction == "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 is_goal(state):
    return state == goal_state

def print_state(state):
    for row in state:
        print(row)
    print("\n")

def dfs(initial_state):
    stack = [(initial_state, [])]
    visited = set()

    while stack:
        state, path = stack.pop()
        print("Exploring state in DFS:")
        print_state(state)

        if is_goal(state):
            return path

        visited.add(str(state))
        for direction in ["up", "down", "left", "right"]:
            new_state = move(state, direction)
            if new_state and str(new_state) not in visited:
                stack.append((new_state, path + [direction]))

    return None

def get_initial_state():
    print("Enter the initial state of the 8-puzzle (0 for
empty space):")
    initial_state = []
    for i in range(3):
        row = list(map(int, input(f"Enter row {i+1}
(space-separated): ").strip().split()))
        if len(row) != 3:
            raise ValueError("Each row must contain
exactly 3 numbers.")
        initial_state.append(row)
    return initial_state

if __name__ == "__main__":
    initial_state = get_initial_state()

    print("Initial State:")
    print_state(initial_state)

    start_time_dfs = time.time()
    print("Solving using DFS:")
    dfs_solution = dfs(initial_state)
    end_time_dfs = time.time()
    if dfs_solution:
        print("DFS Solution:", dfs_solution)
    else:
        print("No solution found with DFS.")
    print(f"Time taken by DFS: {end_time_dfs -
start_time_dfs:.6f} seconds")
```

OUTPUT

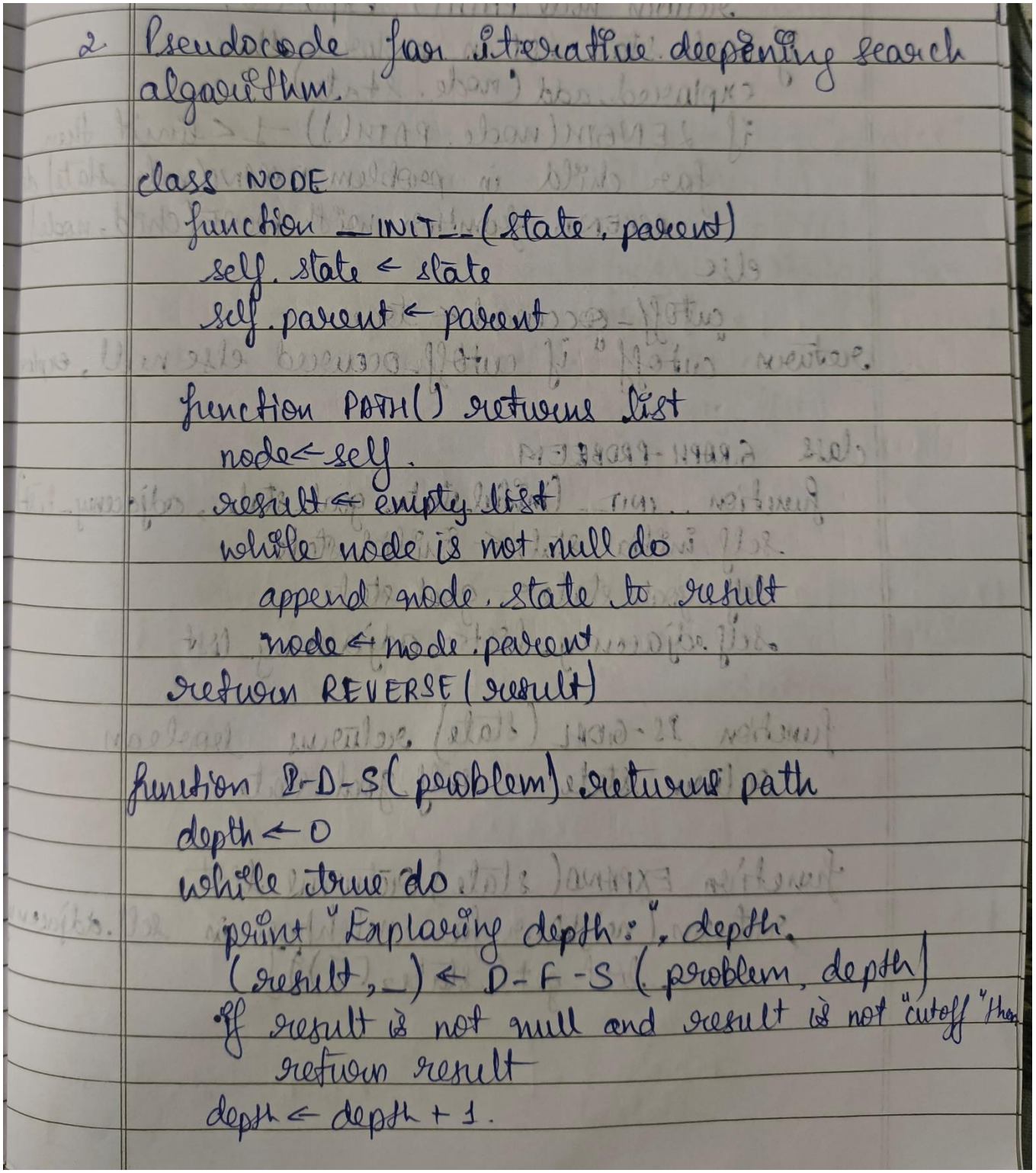
```
Enter the initial state of the 8-puzzle (0 for empty space):
Enter row 1 (space-separated): 1 2 3
Enter row 2 (space-separated): 4  6 5
Enter row 3 (space-separated): 8 7 0
Initial State:
[1, 2, 3]
[4, 6, 5]
[8, 7, 0]


Solving using DFS:
Exploring state in DFS:
[1, 2, 3]
[4, 6, 5]
[8, 7, 0]


Exploring state in DFS:
[1, 2, 3]
[4, 6, 5]
[8, 0, 7]


Exploring state in DFS:
[1, 2, 3]
[4, 6, 5]
[0, 8, 7]


Exploring state in DFS:
[1, 2, 3]
[0, 6, 5]
[4, 8, 7]
```

```
 Exploring state in DFS:
 [1, 2, 3]
 [4, 8, 5]
 [7, 0, 6]


 Exploring state in DFS:
 [1, 2, 3]
 [4, 8, 5]
 [7, 6, 0]


 Exploring state in DFS:
 [1, 2, 3]
 [4, 0, 5]
 [7, 8, 6]


 Exploring state in DFS:
 [1, 2, 3]
 [4, 5, 0]
 [7, 8, 6]


 Exploring state in DFS:
 [1, 2, 3]
 [4, 5, 6]
 [7, 8, 0]


 DFS Solution: ['left', 'left', 'up', 'right', 'right', 'down', 'left', 'le
 Time taken by DFS: 0.183756 seconds
```

LABORATORY PROGRAM – 3

IMPLEMENT ITERATIVE DEEPENING SEARCH ALGORITHM

PSEUDOCODE OR ALGORITHM



2. Pseudocode for iterative deepening search algorithm.

```
class NODE
    function __INIT__(state, parent)
        self.state ← state
        self.parent ← parent

    function PATH() returns list
        node ← self.
        result ← empty list
        while node is not null do
            append node.state to result
            node ← node.parent
        return REVERSE(result)

function I-D-S(problem) returns path
    depth ← 0
    while true do
        print "Exploring depth:", depth.
        (result, _) ← D-F-S(problem, depth)
        if result is not null and result is not "cutoff" then
            return result
        depth ← depth + 1.
```

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```
function D-F-S(problem, limit) returns path or cutoff
    frontier ← [NODE(problem.initial_state)]
    explored ← empty_set
    cutoff_occurred ← false
    while frontier is not empty do
        node ← POP(frontier)
        if problem.IS-GOAL(node.state) then
            return node.PATH(), explored.
        if node.state not in explored then
            explored.add(node.state)
            if LENGTH(node.PATH()) - 1 < limit then
                for child in problem.EXPAND(node.state) do
                    APPEND frontier with NODE(child, node)
            else
                cutoff_occurred ← true
    return "cutoff" if cutoff_occurred else null, explored

class GRAPH-PROBLEM
    function __INIT__(initial_state, goal_state, adjacency_list)
        self.initial_state ← initial_state
        self.goal_state ← goal_state
        self.adjacency_list ← adjacency_list

    function IS-GOAL(state) returns boolean
        return state == self.goal_state

    function EXPAND(state) returns list,
        return [neighbor for neighbor in self.adjacency
            _list.get(state, [])].
```

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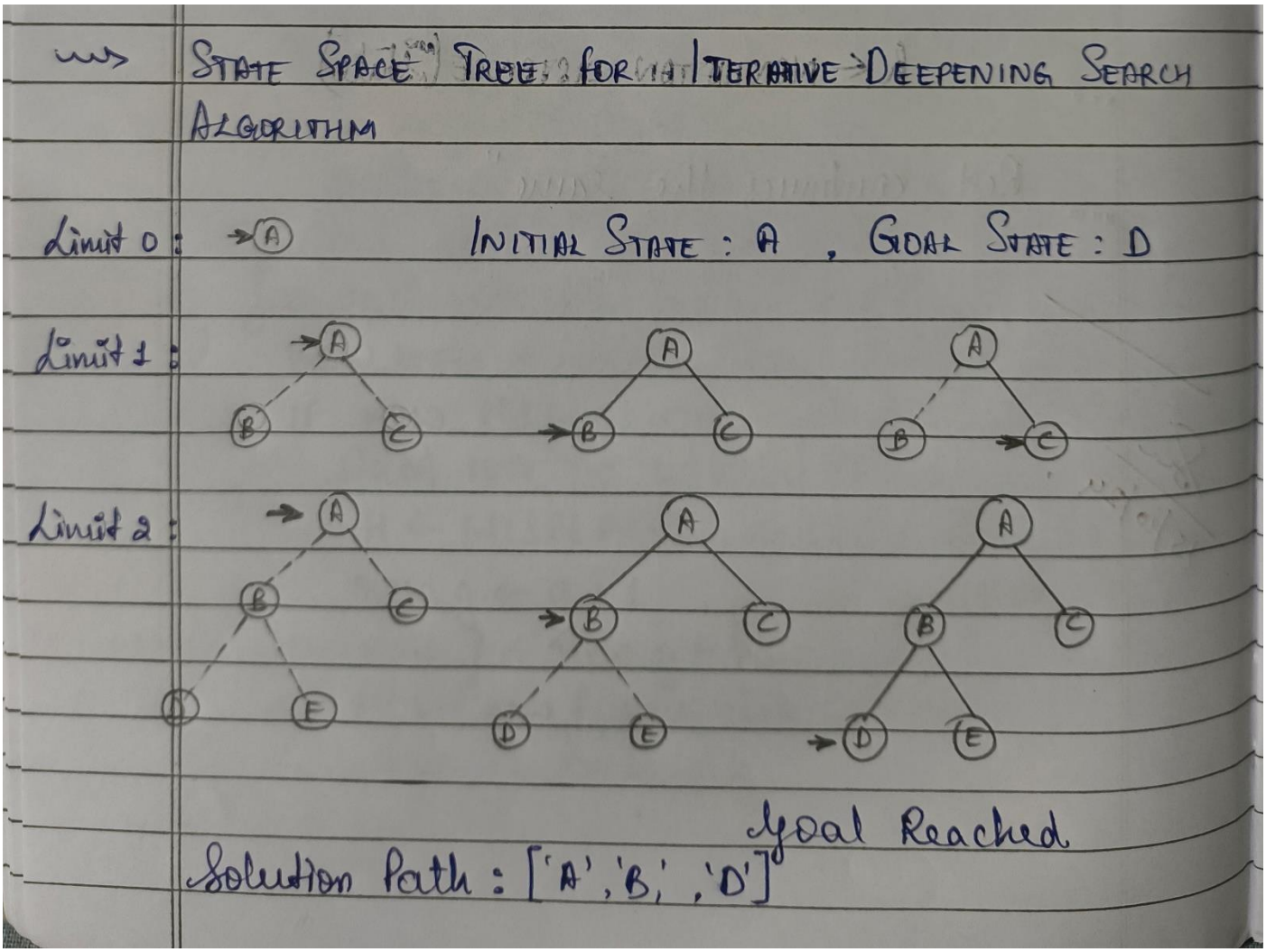
```
function GET-GRAPH-FROM-INPUT() returns GRAPH-PROBLEM
    adjacency_list ← empty_dictionary
    initial_state ← INPUT("Enter the initial state:").strip()
    goal_state ← INPUT("Enter the goal state:").strip()
    print "Enter the AD list for graph."
    print "Type 'done' when finished."
    while true do
        node ← INPUT("Enter node:").strip()
        if node.lower() == "done" then
            break
        neighbors_input ← INPUT("Enter N of "+node+"
        separated by spaces:").strip()
        neighbors ← neighbors_input.split()
        adjacency_list[node] ← [neighbor.strip() for
            neighbor in neighbors]
    return GRAPH-PROBLEM(initial_state, goal_state,
                         adjacency_list)

main
    problem ← GET-GRAPH-FROM-INPUT()
    solution ← I-D-S(problem)
    if solution is not null then
        print "Solution Path:", solution
    else
        print "No solution found."
```

STATE SPACE TREE



CODE

```
class Node:
    def __init__(self, state, parent=None):
        self.state = state
        self.parent = parent

    def path(self):
        node, result = self, []
        while node:
            result.append(node.state)
            node = node.parent
        return result[::-1]

def iterative_deepening_search(problem):
    depth = 0
    while True:
        print(f"Exploring depth: {depth}")
        result, _ = depth_limited_search(problem, depth)
        if result is not None and result != 'cutoff':
            return result
        depth += 1

def depth_limited_search(problem, limit):
    frontier = [Node(problem.initial_state)]
    explored = set()
    cutoff_occurred = False

    while frontier:
        node = frontier.pop()

        if problem.is_goal(node.state):
            return node.path(), explored

        if node.state not in explored:
            explored.add(node.state)
            if len(node.path()) - 1 < limit:
                for child in problem.expand(node.state):
                    frontier.append(Node(child, node))
            else:
                cutoff_occurred = True

    return 'cutoff' if cutoff_occurred else None, explored

class GraphProblem:
    def __init__(self, initial_state, goal_state,
adjacency_list):
        self.initial_state = initial_state
        self.goal_state = goal_state
        self.adjacency_list = adjacency_list

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

    def expand(self, state):
        return [neighbor for neighbor in
self.adjacency_list.get(state, [])]

def get_graph_from_input():
    adjacency_list = {}
    initial_state = input("Enter the initial state: ").strip()
    goal_state = input("Enter the goal state: ").strip()

    print("Enter the adjacency list for the graph
(neighbors of each node).")
    print("Type 'done' when finished.")

    while True:
        node = input("Enter node (or 'done' to finish):
").strip()
        if node.lower() == 'done':
            break
        neighbors_input = input(f"Enter neighbors of
{node} separated by spaces: ").strip()
        neighbors = neighbors_input.split()
        adjacency_list[node] = [neighbor.strip() for
neighbor in neighbors]

    return GraphProblem(initial_state, goal_state,
adjacency_list)

if __name__ == "__main__":
    problem = get_graph_from_input()
    solution = iterative_deepening_search(problem)

    if solution:
        print("Solution Path:", solution)
    else:
        print("No solution found.")
```

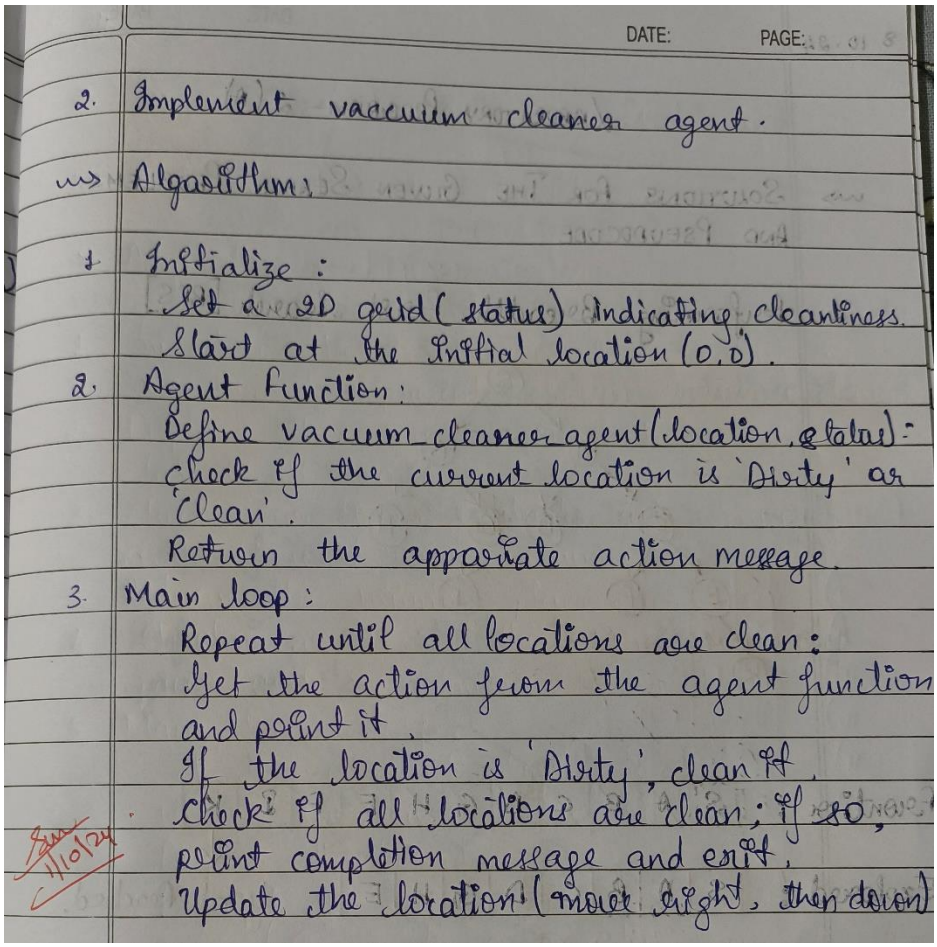
OUTPUT

```
Enter the initial state: A
Enter the goal state: G
Enter the adjacency list for the graph (neighbors of each node).
Type 'done' when finished.
Enter node (or 'done' to finish): A
Enter neighbors of A separated by spaces: B C
Enter node (or 'done' to finish): B
Enter neighbors of B separated by spaces: D E
Enter node (or 'done' to finish): D
Enter neighbors of D separated by spaces: H I
Enter node (or 'done' to finish): C
Enter neighbors of C separated by spaces: F G
Enter node (or 'done' to finish): F
Enter neighbors of F separated by spaces: K
Enter node (or 'done' to finish): done
Exploring depth: 0
Exploring depth: 1
Exploring depth: 2
Solution Path: ['A', 'C', 'G']
```

LABORATORY PROGRAM – 4

IMPLEMENT VACUUM CLEANER AGENT

PSEUDOCODE OR ALGORITHM



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2. Implement vaccuum cleaner agent.

=> Algorithm:

1. Initialize:
   Set a 2D grid (status) indicating cleanliness.
   Start at the initial location (0,0).
2. Agent Function:
   Define vacuum_cleaner_agent(location, status):
   Check if the current location is 'Dirty' or 'Clean'.
   Return the appropriate action message.
3. Main loop:
   Repeat until all locations are clean:
   Get the action from the agent function and print it.
   If the location is 'Dirty', clean it.
   Check if all locations are clean; if so, print completion message and exit.
   Update the location (move right, then down)

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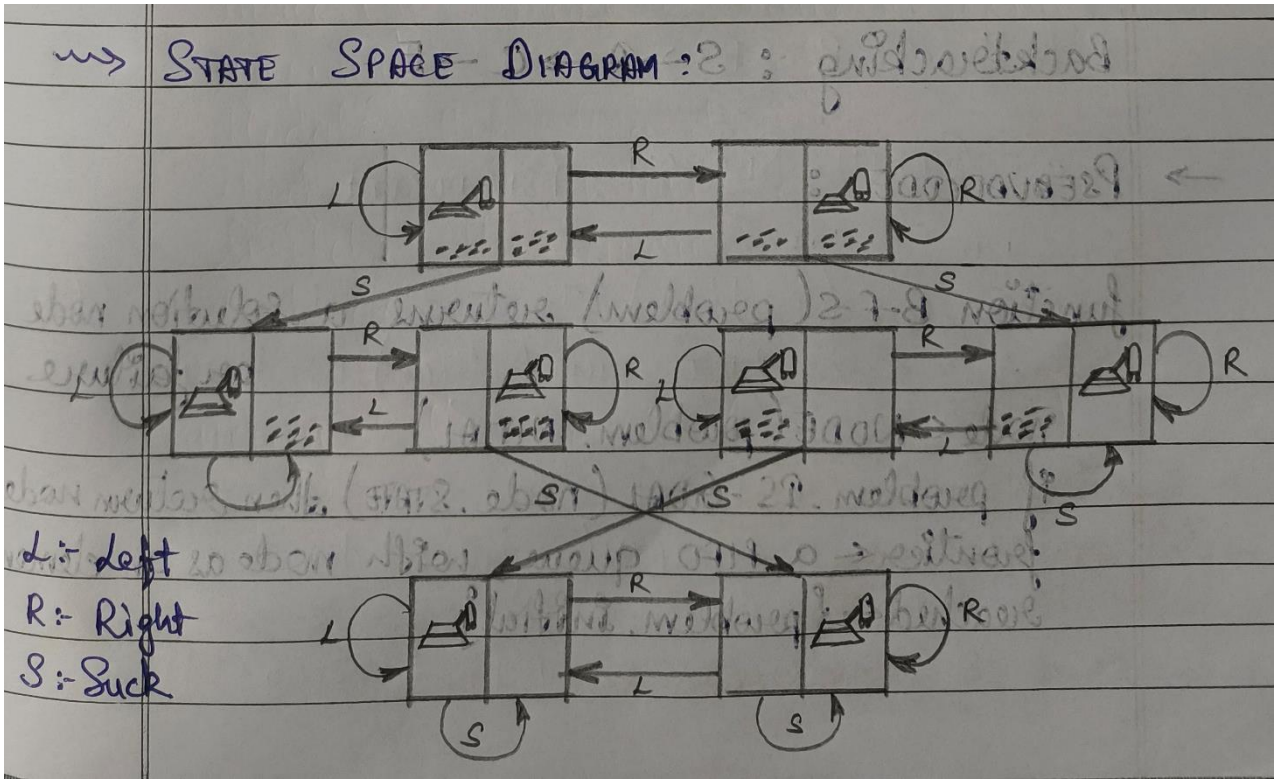
STATE SPACE TREE



CODE

```
def vacuum_world():
    goal_state = {'A': '0', 'B': '0'}
    cost = 0
    location_input = input("Enter the initial location of the vacuum cleaner (A or B): ")
    status_input = input(f"Enter the status of room {location_input} (0 for Clean, 1 for Dirty): ")
    status_input_complement = input(f"Enter the status of the other room ({'B' if location_input == 'A' else 'A'}) (0 for Clean, 1 for Dirty): ")

    # Set the initial state based on user input
    initial_state = {
        'A': status_input if location_input == 'A' else status_input_complement,
        'B': status_input_complement if location_input == 'A' else status_input
    }

    print("\nInitial Location Condition:", initial_state)

    if location_input == 'A':
        print("\nVacuum cleaner is placed in room A.")

        if status_input == '1':
            print("Room A is Dirty. Cleaning room A...")
            goal_state['A'] = '0'
            cost += 1
            print("Cost for cleaning room A:", cost)

            if status_input_complement == '1':
                print("\nRoom B is also Dirty. Moving to room B...")
                cost += 1
                print("Cost for moving to room B:", cost)
                print("Cleaning room B...")
                goal_state['B'] = '0'
                cost += 1
                print("Cost for cleaning room B:", cost)
            else:
                print("\nRoom B is already Clean. No further action needed.")

        else:
            print("Room A is already Clean.")

            if status_input_complement == '1':
                print("\nRoom B is Dirty. Moving to room B...")
                cost += 1
                print("Cost for moving to room B:", cost)
                print("Cleaning room B...")
                goal_state['B'] = '0'
                cost += 1
                print("Cost for cleaning room B:", cost)
            else:
                print("\nRoom B is already Clean. No further action needed.")

    else:
        print("\nVacuum cleaner is placed in room B.")

        if status_input == '1':
            print("Room B is Dirty. Cleaning room B...")
            goal_state['B'] = '0'
            cost += 1
            print("Cost for cleaning room B:", cost)

            if status_input_complement == '1':
                print("\nRoom A is also Dirty. Moving to room A...")
                cost += 1
                print("Cost for moving to room A:", cost)
                print("Cleaning room A...")
                goal_state['A'] = '0'
                cost += 1
                print("Cost for cleaning room A:", cost)
            else:
                print("\nRoom A is already Clean. No further action needed.")

        else:
            print("Room B is already Clean.")

            if status_input_complement == '1':
                print("\nRoom A is Dirty. Moving to room A...")
                cost += 1
                print("Cost for moving to room A:", cost)
                print("Cleaning room A...")
                goal_state['A'] = '0'
                cost += 1
                print("Cost for cleaning room A:", cost)
            else:
                print("\nRoom A is already Clean. No further action needed.")

    print("\nGOAL STATE:", goal_state)
    print("Total cost for cleaning:", cost)

vacuum_world()
```

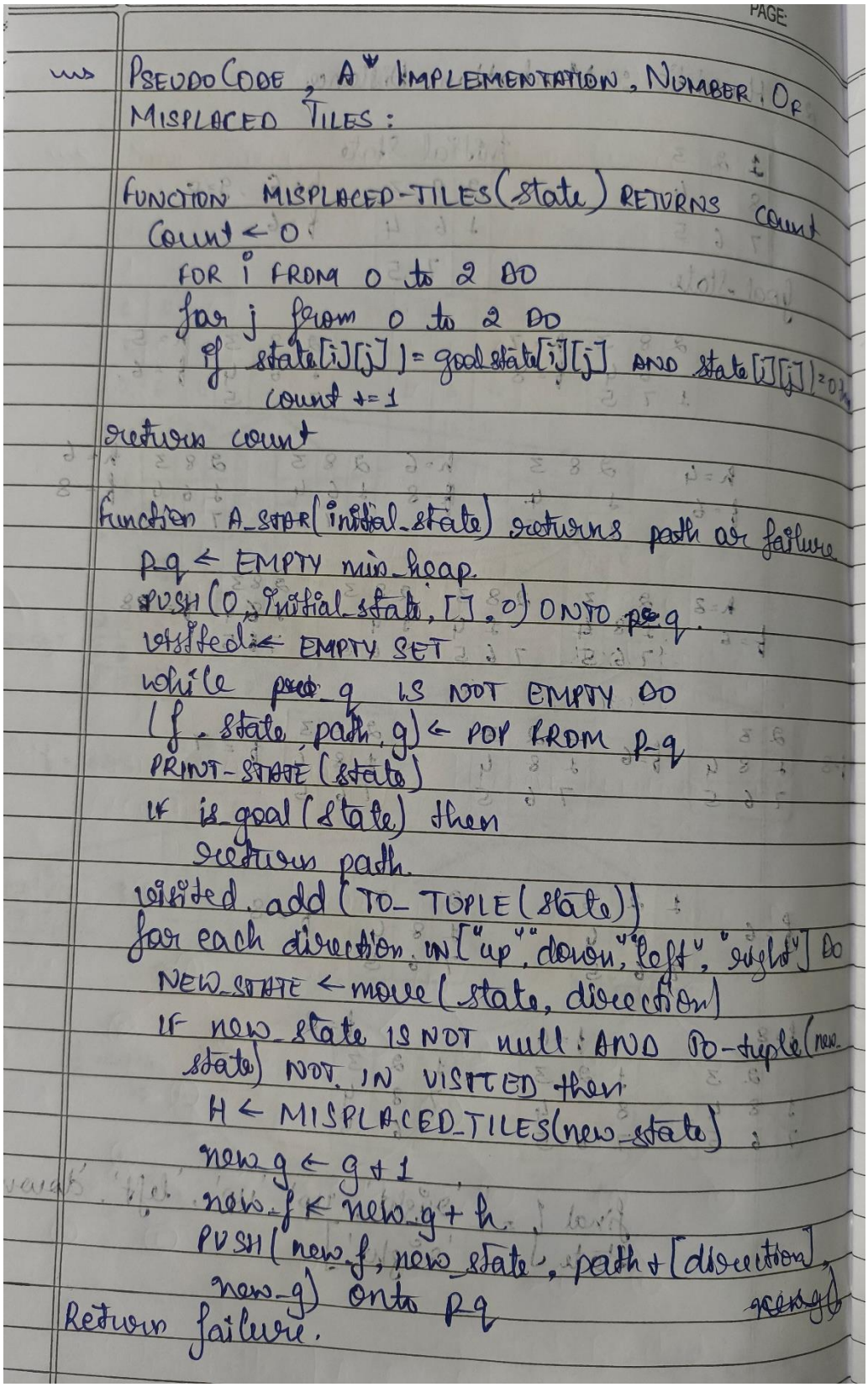
OUTPUT

```
Enter the initial location of the vacuum cleaner (A or B): A
Enter the status of room A (0 for Clean, 1 for Dirty): 1
Enter the status of the other room (B) (0 for Clean, 1 for Dirty): 1

Initial Location Condition: {'A': '1', 'B': '1'}

Vacuum cleaner is placed in room A.
Room A is Dirty. Cleaning room A...
Cost for cleaning room A: 1

Room B is also Dirty. Moving to room B...
Cost for moving to room B: 2
Cleaning room B...
Cost for cleaning room B: 3

GOAL STATE: {'A': '0', 'B': '0'}
Total cost for cleaning: 3
```

LABORATORY PROGRAM – 5(A)

IMPLEMENT A* SEARCH ALGORITHM

PSEUDOCODE OR ALGORITHM



PSEUDO CODE A* IMPLEMENTATION, NUMBER OF MISPLACED TILES:

```
FUNCTION MISPLACED-TILES(state) RETURNS count
  count ← 0
    FOR i FROM 0 to 2 DO
    for j from 0 to 2 DO
      if state[i][j] = goal_state[i][j] AND state[i][j] ≠ 0
          count += 1
  return count

function A_STAR(initial_state) returns path or failure
  pq ← EMPTY min_heap
  PUSH (0, initial_state, [], 0) ONTO pq
  visited ← EMPTY SET
  while pq IS NOT EMPTY DO
  f, state, path, g) ← POP FROM pq
  PRINT-STATE (state)
  IF is_goal(state) then
     return path
  visited.add(TO_TUPLE(state))
  for each direction in ["up", "down", "left", "right"] DO
    NEW_STATE ← move(state, direction)
    IF new_state IS NOT null AND to-tuple(new_
      state) NOT IN VISITED then
      H ← MISPLACED_TILES(new_state)
      new_g ← g + 1
      new_f ← new_g + h
      PUSH(new_f, new_state, path + [direction],
        new_g) onto pq
Return failure.
```

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PSEUDOCODE, A* IMPLEMENTATION, MANHATTAN DISTANCE

```
Function MANHATTAN-DISTANCE(state) returns distance
    Distance ← 0
    for i from 0 to 2 do
        for j from 0 to 2 do
            if state[i][j] != 0 then
                goal_i, goal_j ← position of state[i][j] in goal state
                if state[i][j] == 8 then
                    goal_i, goal_j ← 1, 1
                Distance += ABS(goal_i - i) + ABS(goal_j - j)
    return distance
```

Function A_STAR(initial_state) returns path or failure

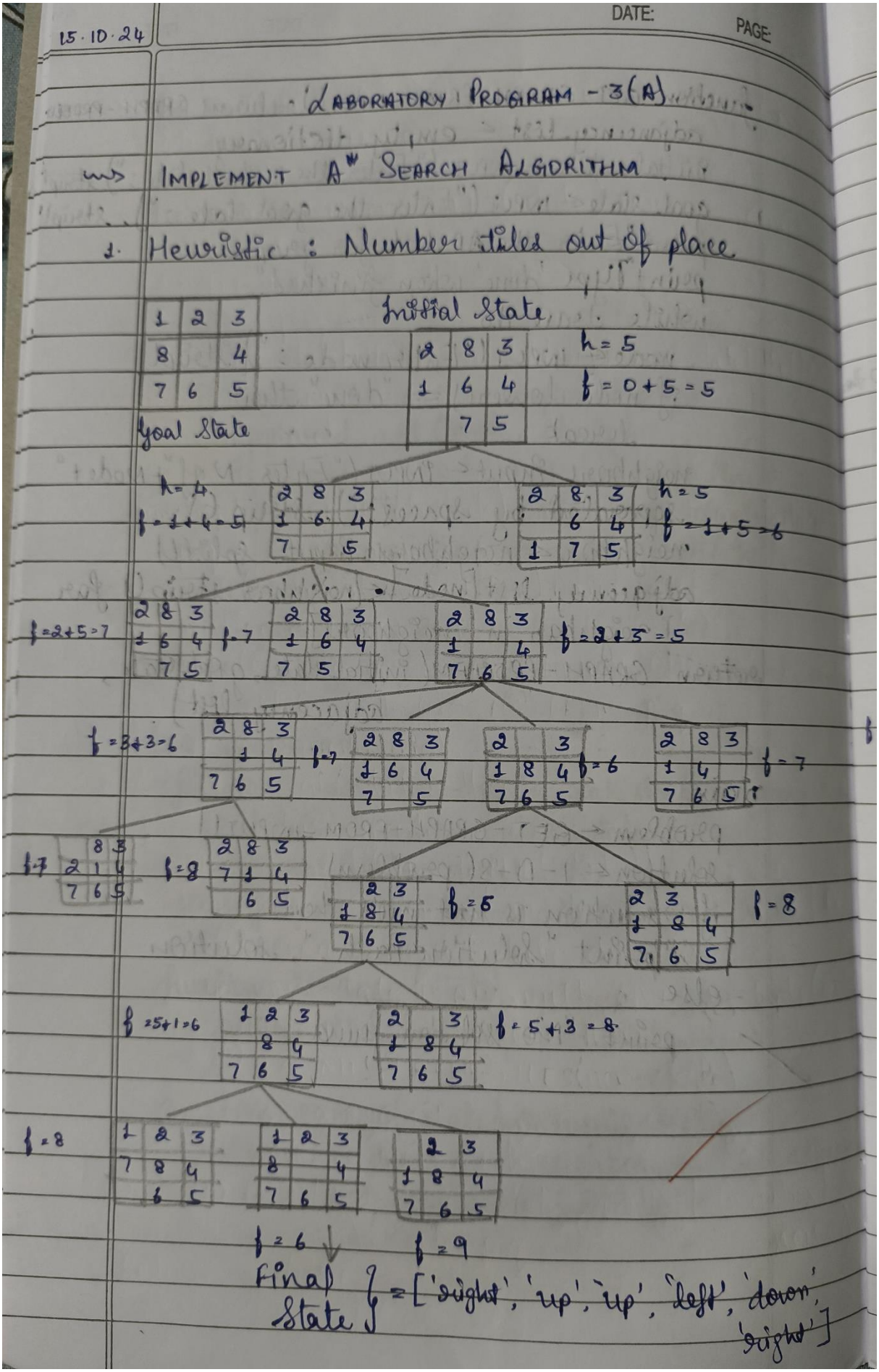
Similar to the pseudocode of misplaced_tiles, but change in heuristic function

h ← MANHATTAN-DISTANCE(state)

Rest continues the same

15/10/24

STATE SPACE TREE



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2. Heuristic : Manhattan Distance

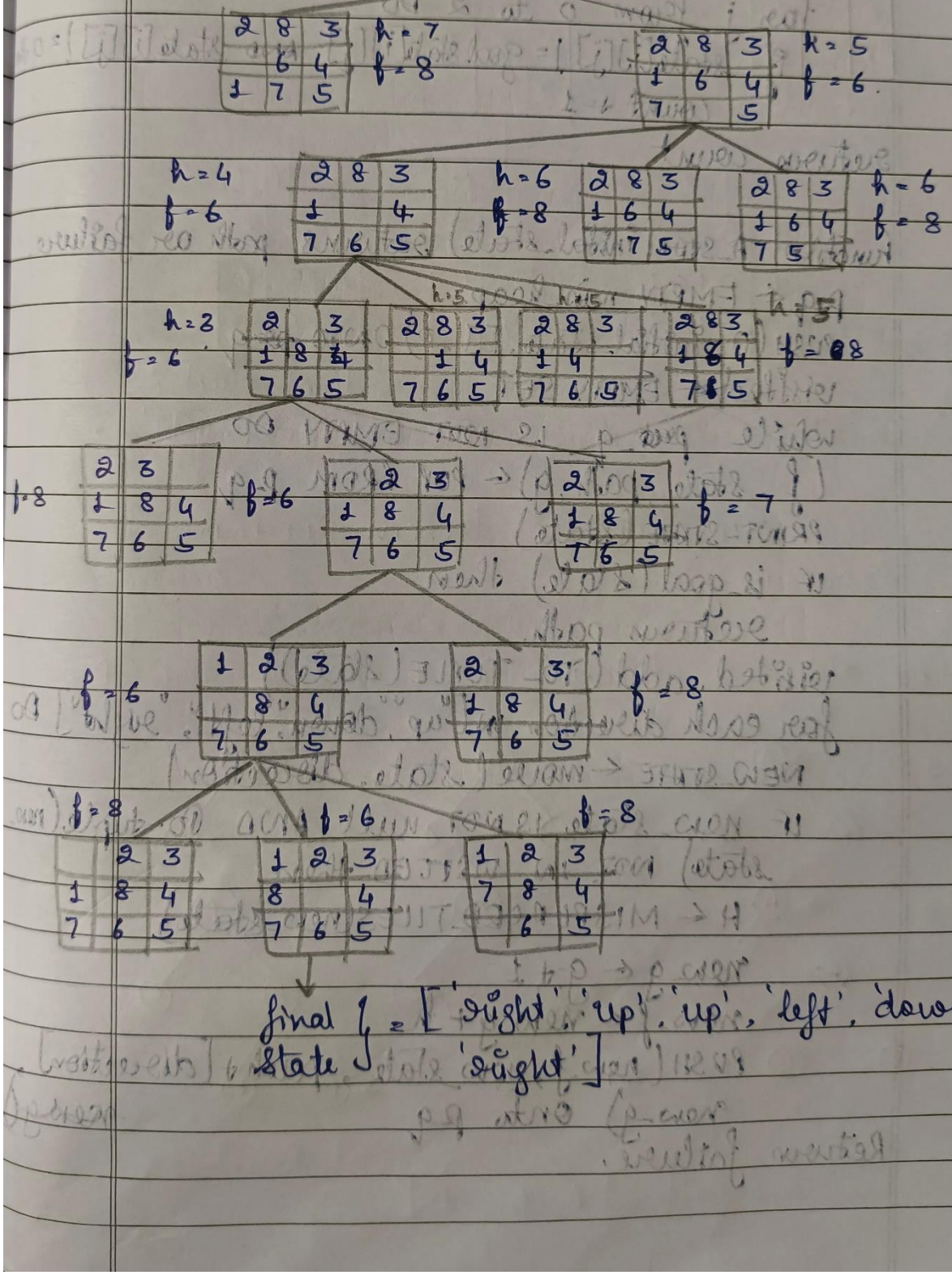
Goal State

1	2	3
8		4
7	6	5

Initial State

2	8	3
1	6	4
	7	5

h=6, g=0, f=6



Final State = ['right', 'up', 'up', 'left', 'down', 'right']

CODE - G(N): DEPTH OF THE NODE, H(N): NUMBER OF MISPLACED TILES

```
import heapq

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

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

def move(state, direction):
    new_state = [row[:] for row in state]
    i, j = find_zero(state)
    if direction == "up" and i > 0:
        new_state[i][j], new_state[i-1][j] = new_state[i-
1][j], new_state[i][j]
    elif direction == "down" and i < 2:
        new_state[i][j], new_state[i+1][j] =
new_state[i+1][j], new_state[i][j]
    elif direction == "left" and j > 0:
        new_state[i][j], new_state[i][j-1] = new_state[i][j-
1], new_state[i][j]
    elif direction == "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 is_goal(state):
    return state == goal_state

def misplaced_tiles(state):
    return sum(1 for i in range(3) for j in range(3)
               if state[i][j] != goal_state[i][j] and state[i][j]
!= 0)

def a_star(initial_state):
    priority_queue = []
    heapq.heappush(priority_queue, (0, initial_state, [],
0))
    visited = set()

    while priority_queue:
        f, state, path, g = heapq.heappop(priority_queue)
        print("Exploring state in A*:")
        print_state(state)

        if is_goal(state):
            return path

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

        for direction in ["up", "down", "left", "right"]:
            new_state = move(state, direction)
            if new_state and tuple(map(tuple, new_state))
not in visited:
                h = misplaced_tiles(new_state)
                new_g = g + 1
                new_f = new_g + h
                heapq.heappush(priority_queue, (new_f,
new_state, path + [direction], new_g))

    return None

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

def get_initial_state():
    print("Enter the initial state of the 8-puzzle (0 for
empty space):")
    initial_state = []
    for i in range(3):
        row = list(map(int, input(f"Enter row {i+1}
(space-separated): ").strip().split()))
        if len(row) != 3:
            raise ValueError("Each row must contain
exactly 3 numbers.")
        initial_state.append(row)
    return initial_state

if __name__ == "__main__":
    initial_state = get_initial_state()
    print("Initial State:")
    print_state(initial_state)
    print("Solving using A* search:")
    a_star_solution = a_star(initial_state)

    if a_star_solution:
        print("A* Solution:", a_star_solution)
    else:
        print("No solution found with A*.")
```

OUTPUT - G(N): DEPTH OF THE NODE, H(N): NUMBER OF MISPLACED TILES

```
Enter the initial state of the 8-puzzle (0 for empty space):
Enter row 1 (space-separated): 2 8 3
Enter row 2 (space-separated): 1 6 4
Enter row 3 (space-separated): 0 7 5
Initial State:
[2, 8, 3]
[1, 6, 4]
[0, 7, 5]

Solving using A* search:
Exploring state in A*:
[2, 8, 3]
[1, 6, 4]
[0, 7, 5]

Exploring state in A*:
[2, 8, 3]
[1, 6, 4]
[7, 0, 5]

Exploring state in A*:
[2, 8, 3]
[1, 0, 4]
[7, 6, 5]

Exploring state in A*:
[2, 0, 3]
[1, 8, 4]
[7, 6, 5]

Exploring state in A*:
[0, 2, 3]
[1, 8, 4]
[7, 6, 5]

Exploring state in A*:
[1, 2, 3]
[0, 8, 4]
[7, 6, 5]

Exploring state in A*:
[1, 2, 3]
[8, 0, 4]
[7, 6, 5]

A* Solution: ['right', 'up', 'up', 'left', 'down', 'right']
```

CODE - G(N): DEPTH OF THE NODE, H(N): MANHATTAN DISTANCE

```
import heapq

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

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

def move(state, direction):
    new_state = [row[:] for row in state]
    i, j = find_zero(state)
    if direction == "up" and i > 0:
        new_state[i][j], new_state[i-1][j] = new_state[i-
1][j], new_state[i][j]
    elif direction == "down" and i < 2:
        new_state[i][j], new_state[i+1][j] =
new_state[i+1][j], new_state[i][j]
    elif direction == "left" and j > 0:
        new_state[i][j], new_state[i][j-1] = new_state[i][j-
1], new_state[i][j]
    elif direction == "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 is_goal(state):
    return state == goal_state

def manhattan_distance(state):
    distance = 0
    for i in range(3):
        for j in range(3):
            if state[i][j] != 0:
                goal_i, goal_j = divmod(state[i][j] - 1, 3)
                if state[i][j] == 8:
                    goal_i, goal_j = 1, 1
                distance += abs(goal_i - i) + abs(goal_j - j)
    return distance

def a_star(initial_state):
    priority_queue = []
    heapq.heappush(priority_queue, (0, initial_state, [],
0))
    visited = set()

    while priority_queue:
        f, state, path, g = heapq.heappop(priority_queue)
        print("Exploring state in A*:")
        print_state(state)

        if is_goal(state):
            return path

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

        for direction in ["up", "down", "left", "right"]:
            new_state = move(state, direction)
            if new_state and tuple(map(tuple, new_state))
not in visited:
                h = manhattan_distance(new_state)
                new_g = g + 1
                new_f = new_g + h
                heapq.heappush(priority_queue, (new_f,
new_state, path + [direction], new_g))

    return None

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

def get_initial_state():
    print("Enter the initial state of the 8-puzzle (0 for
empty space):")
    initial_state = []
    for i in range(3):
        row = list(map(int, input(f"Enter row {i+1}
(space-separated): ").strip().split()))
        if len(row) != 3:
            raise ValueError("Each row must contain
exactly 3 numbers.")
        initial_state.append(row)
    return initial_state

if __name__ == "__main__":
    initial_state = get_initial_state()
    print("Initial State:")
    print_state(initial_state)
    print("Solving using A* search:")
    a_star_solution = a_star(initial_state)

    if a_star_solution:
        print("A* Solution:", a_star_solution)
    else:
        print("No solution found with A*.")
```

OUTPUT - G(N): DEPTH OF THE NODE, H(N): MANHATTAN DISTANCE

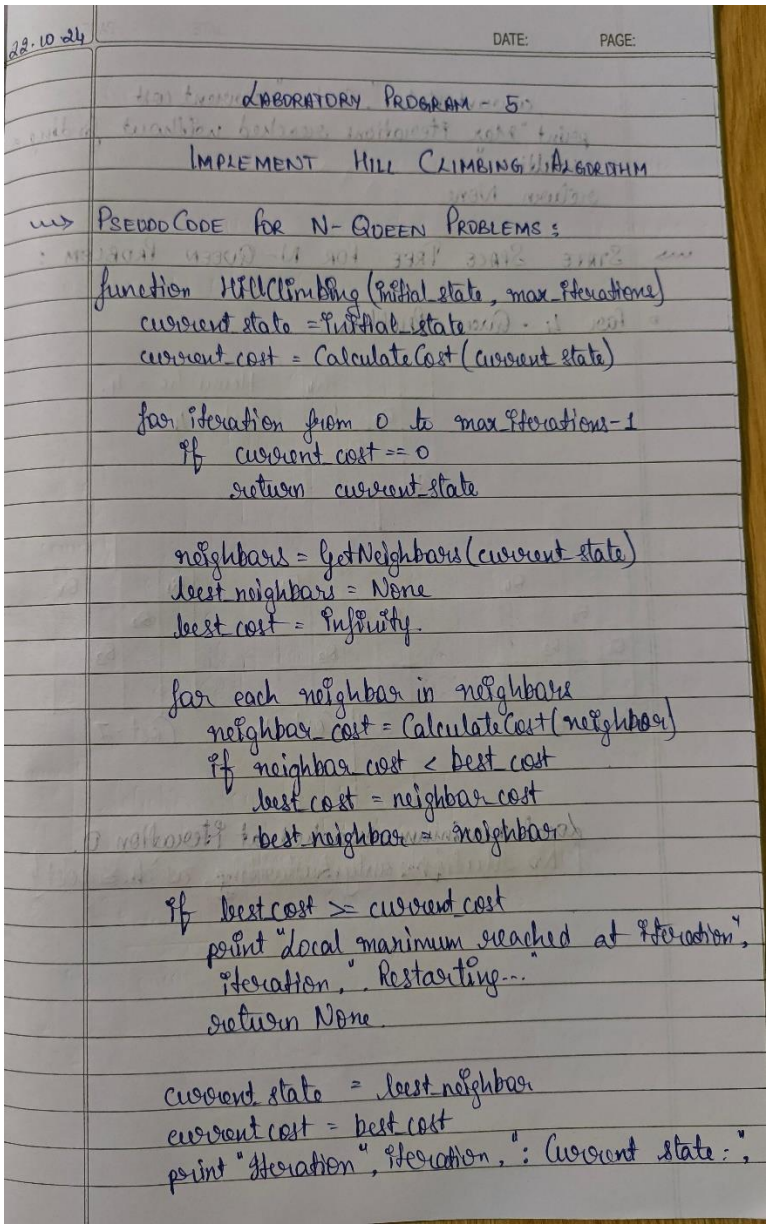
```
Enter the initial state of the 8-puzzle (0 for empty space):
Enter row 1 (space-separated): 2 8 3
Enter row 2 (space-separated): 1 6 4
Enter row 3 (space-separated): 0 7 5
Initial State:
[2, 8, 3]
[1, 6, 4]
[0, 7, 5]

Solving using A* search:
Exploring state in A*:
[2, 8, 3]
[1, 6, 4]
[0, 7, 5]

Exploring state in A*:
[2, 8, 3]
[1, 6, 4]
[7, 0, 5]

Exploring state in A*:
[2, 8, 3]
[1, 6, 4]
[7, 5, 0]

Exploring state in A*:
[2, 8, 3]
[0, 6, 4]
[1, 7, 5]

Exploring state in A*:
[2, 8, 3]
[1, 0, 4]
[7, 6, 5]
```

```
Exploring state in A*:
[2, 8, 3]
[1, 5, 6]
[7, 4, 0]

Exploring state in A*:
[0, 8, 3]
[2, 6, 4]
[1, 7, 5]

Exploring state in A*:
[1, 2, 3]
[7, 8, 4]
[0, 6, 5]

Exploring state in A*:
[1, 2, 3]
[7, 8, 6]
[0, 5, 4]

Exploring state in A*:
[1, 2, 3]
[8, 0, 4]
[7, 6, 5]

A* Solution: ['right', 'up', 'up', 'left', 'down', 'right']
```

LABORATORY PROGRAM – 5(B)

IMPLEMENT HILL CLIMBING ALGORITHM

PSEUDOCODE OR ALGORITHM



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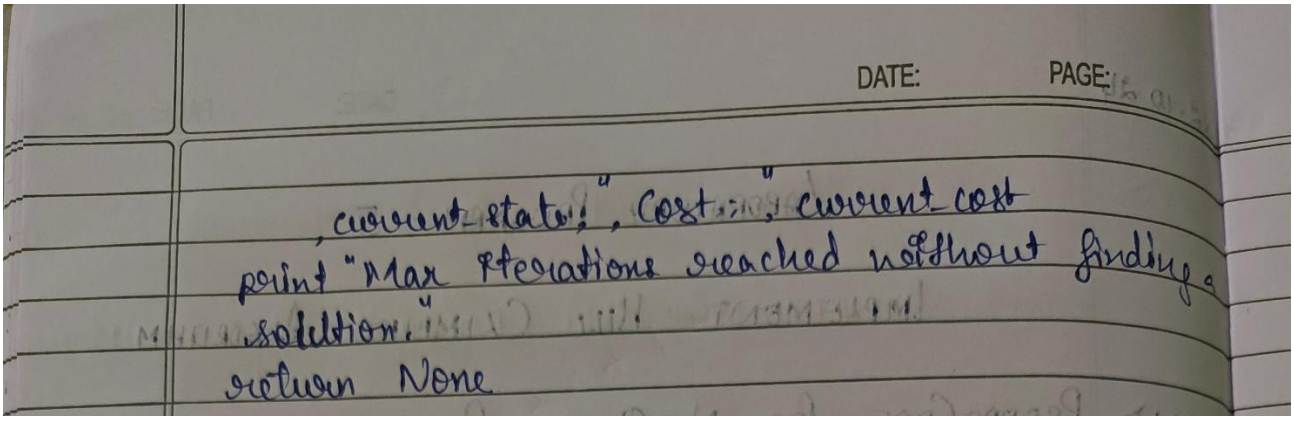
LABORATORY PROGRAM - 5

IMPLEMENT HILL CLIMBING ALGORITHM

=> PSEUDO CODE FOR N-QUEEN PROBLEMS:

```
function HillClimbing(initial_state, max_iterations)
    current state = initial_state
    current_cost = CalculateCost(current state)

    for iteration from 0 to max_iterations-1
        if current_cost == 0
            return current_state

        neighbors = GetNeighbors(current_state)
        best_neighbors = None
        best_cost = Infinity.

        for each neighbor in neighbors
            neighbor_cost = CalculateCost(neighbor)
            if neighbor_cost < best_cost
                best_cost = neighbor_cost
                best_neighbor = neighbor

        if best_cost >= current_cost
            print "Local maximum reached at iteration",
            "iteration", ". Restarting..."
            return None.

        current_state = best_neighbor
        current_cost = best_cost
        print "Iteration", iteration, ": Current state:",
```



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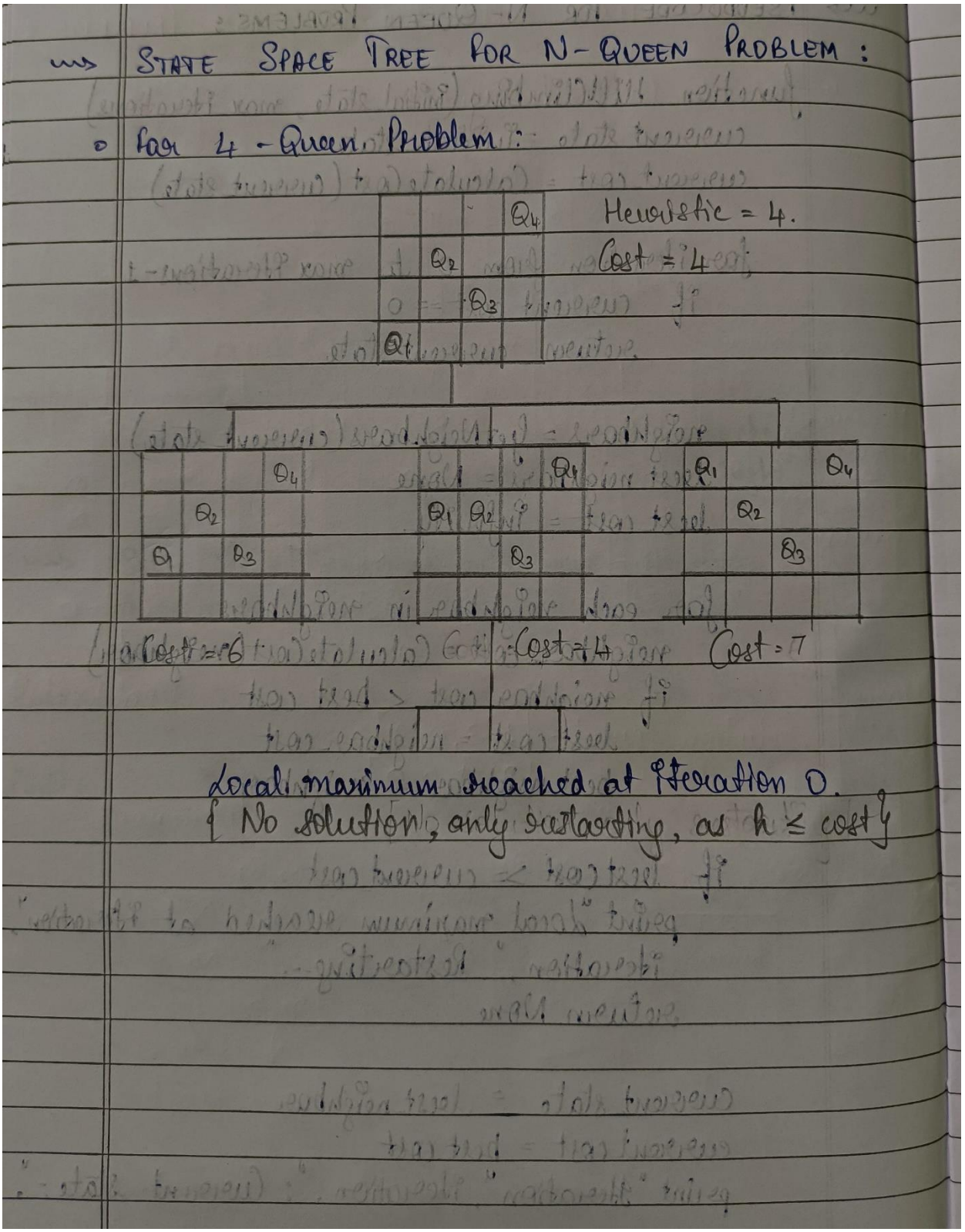
```
, current_state, ", Cost:", current_cost
print "Max iterations reached without finding a
solution."
return None
```

STATE SPACE TREE

⇝ STATE SPACE TREE FOR N-QUEEN PROBLEM :

- For 4-Queen Problem :



Local maximum reached at Iteration 0.
{ No solution, only restarting, as h ≤ cost }

CODE

```
import random

def calculate_cost(state):
    """Calculate the number of conflicts in the current state."""
    cost = 0
    n = len(state)
    for i in range(n):
        for j in range(i + 1, n):
            if state[i] == state[j] or abs(state[i] - state[j]) == abs(i - j):
                cost += 1
    return cost

def get_neighbors(state):
    """Generate all possible neighbors by moving each queen in its column."""
    neighbors = []
    n = len(state)
    for col in range(n):
        for row in range(n):
            if state[col] != row:  # Move the queen in column `col` to a different row
                new_state = list(state)
                new_state[col] = row
                neighbors.append(new_state)
    return neighbors

def hill_climbing(initial_state, max_iterations=1000):
    """Perform hill climbing search to solve the N-Queens problem."""
    current_state = initial_state
    current_cost = calculate_cost(current_state)

    for iteration in range(max_iterations):
        if current_cost == 0:
            return current_state

        neighbors = get_neighbors(current_state)
        neighbor_costs = [(neighbor, calculate_cost(neighbor)) for neighbor in neighbors]
        next_state, next_cost = min(neighbor_costs, key=lambda x: x[1])

        if next_cost >= current_cost:
            print(f"Local maximum reached at iteration {iteration}. Restarting...")
            return None
        current_state, current_cost = next_state, next_cost
        print(f"Iteration {iteration}: Current state: {current_state}, Cost: {current_cost}")

    print(f"Max iterations reached without finding a solution.")
    return None

try:
    n = int(input("Enter the number of queens (N): "))
    if n <= 0:
        raise ValueError("N must be a positive integer.")

    initial_state = list(map(int, input(f"Enter the initial state as a list of {n} integers (rows for each column): ").split()))
    if len(initial_state) != n or any(not (0 <= row < n) for row in initial_state):
        raise ValueError(f"Invalid initial state. Please provide {n} integers between 0 and {n-1}.")
except ValueError as e:
    print(e)
    n = 4
    initial_state = [random.randint(0, n - 1) for _ in range(n)]
    print(f"Using random initial state: {initial_state}")

solution = None

while solution is None:
    solution = hill_climbing(initial_state)

print(f"Solution found: {solution}")
```

OUTPUT

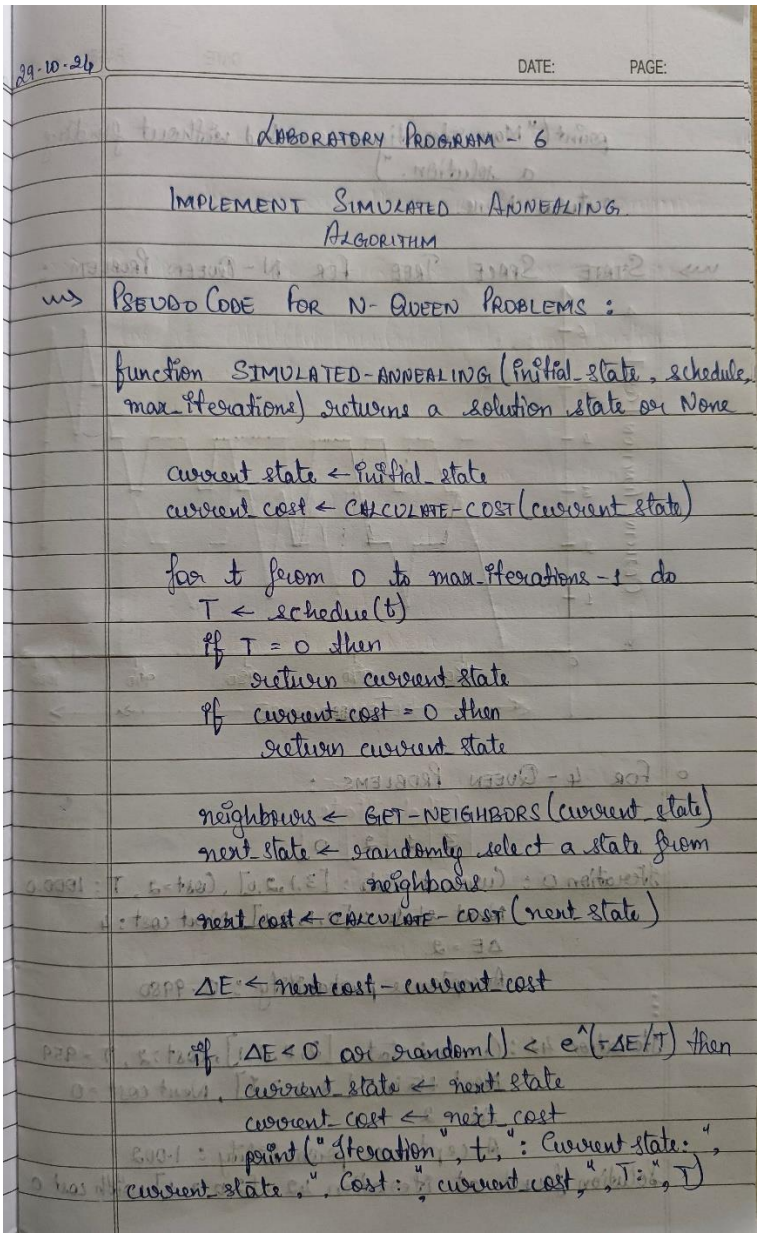
```
Enter the number of queens (N): 4
Enter the initial state as a list of 4 integers (rows for each column): 3 1 2 0
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
Local maximum reached at iteration 0. Restarting...
```

```
Enter the number of queens (N): 4
Enter the initial state as a list of 4 integers (rows for each column): 0 0 0 0
Iteration 0: Current state: [0, 3, 0, 0], Cost: 3
Iteration 1: Current state: [1, 3, 0, 0], Cost: 1
Iteration 2: Current state: [1, 3, 0, 2], Cost: 0
Solution found: [1, 3, 0, 2]
```

LABORATORY PROGRAM – 6

IMPLEMENT SIMULATED ANNEALING ALGORITHM

PSEUDOCODE OR ALGORITHM



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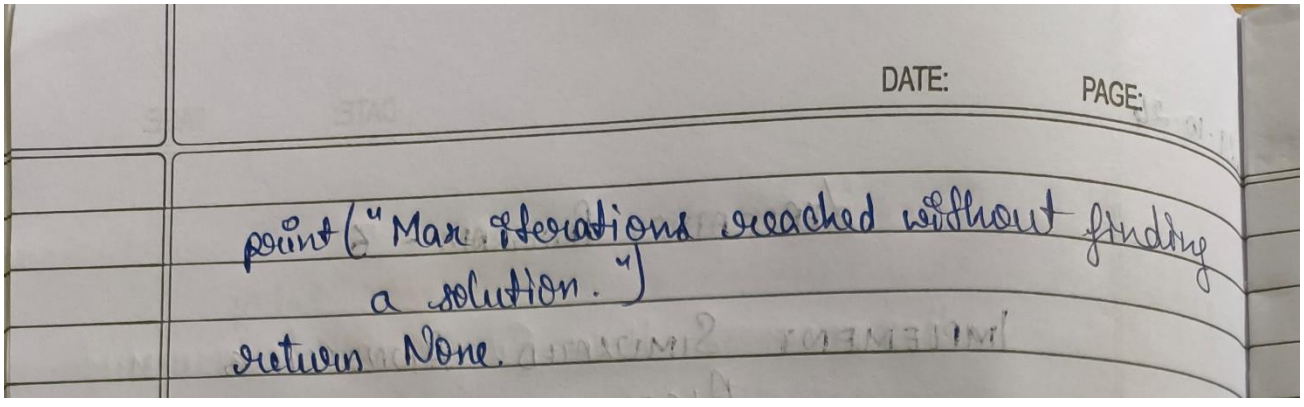
LABORATORY PROGRAM - 6

IMPLEMENT SIMULATED ANNEALING ALGORITHM

=> PSEUDO CODE FOR N-QUEEN PROBLEMS :

```
function SIMULATED-ANNEALING (initial_state, schedule, max_iterations) returns a solution state or None

    current state ← initial_state
    current_cost ← CALCULATE-COST(current_state)

    for t from 0 to max_iterations - 1 do
        T ← schedule(t)
        if T = 0 then
            return current state
        if current_cost = 0 then
            return current state

        neighbours ← GET-NEIGHBORS(current_state)
        next_state ← randomly select a state from
                     neighbors
        next_cost ← CALCULATE-COST(next_state)

        ΔE ← next_cost - current_cost

        if ΔE < 0 or random() < e^(-ΔE/T) then
            current_state ← next_state
            current_cost ← next_cost
            print("Iteration ", t, ": Current state: ",
current_state, ". Cost: ", current_cost, ", T: ", T)
```



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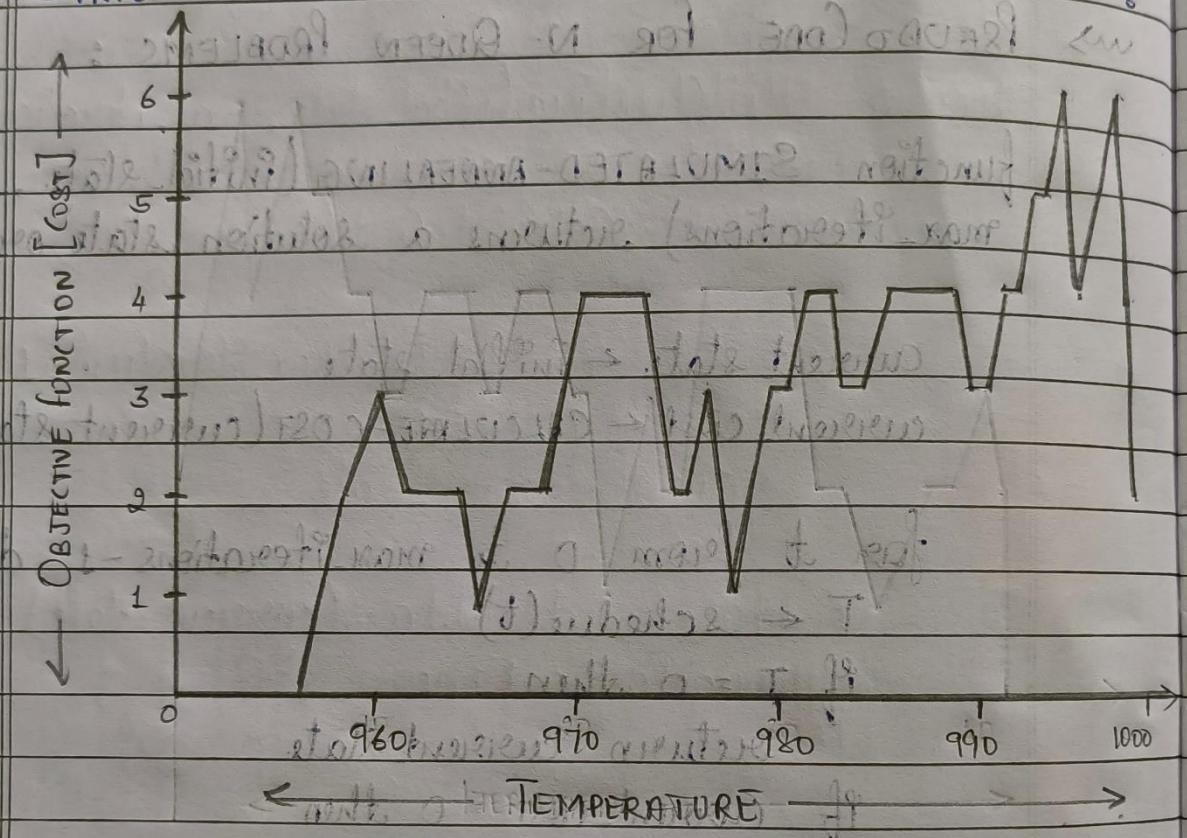
```
    print("Max iterations reached without finding
        a solution.")
    return None.
```

STATE SPACE TREE

STATE SPACE TREE FOR N-QUEEN PROBLEM :



- FOR 4-QUEEN PROBLEMS :

Initial State

3	1	2	0

Iteration 0 : Current state : [3,1,2,0], Cost=2, T : 1000.0
Next state : [0,1,2,0], Next cost : 4
$\Delta E = 2$
Acceptance probability : 0.9980
⋮
Iteration 41 : Current state : [2,0,2,1], Cost : 2, T = 959
Next state : [2,0,3,1], Next cost = 0
$\Delta E = 2$
Acceptance probability : 1.002
Solution found at iteration 42 : [2,0,3,1] with cost 0

CODE

```
import random
import math
import matplotlib.pyplot as plt

def calculate_cost(state):
    cost = 0
    n = len(state)
    for i in range(n):
        for j in range(i + 1, n):
            if state[i] == state[j] or abs(state[i] - state[j]) ==
abs(i - j):
                cost += 1
    return cost

def get_neighbors(state):
    neighbors = []
    n = len(state)
    for col in range(n):
        for row in range(n):
            if state[col] != row:
                new_state = list(state)
                new_state[col] = row
                neighbors.append(new_state)
    return neighbors

def simulated_annealing_with_tracking(initial_state,
schedule, max_iterations=1000):
    current_state = initial_state
    current_cost = calculate_cost(current_state)
    costs = []
    temperatures = []

    for t in range(max_iterations):
        T = schedule(t)
        if T == 0:
            break

        if current_cost == 0:
            costs.append(current_cost)
            temperatures.append(T)
            print(f"Solution found at iteration {t}:
{current_state} with cost {current_cost}")
            break

        neighbors = get_neighbors(current_state)
        next_state = random.choice(neighbors)
        next_cost = calculate_cost(next_state)

        ΔE = next_cost - current_cost
        acceptance_probability = math.exp(-ΔE / T) if T >
0 else 0
        accept = ΔE < 0 or random.random() <
acceptance_probability

        print(f"Iteration {t}:")
        print(f"  Current state: {current_state}, Cost:
{current_cost}, Temperature (T): {T}")
        print(f"  Next state: {next_state}, Next cost:
{next_cost}")
        print(f"  ΔE = {ΔE}")
        print(f"  Acceptance probability:
{acceptance_probability}")
        print(f"  Acceptance condition met: {accept}")

        costs.append(current_cost)
        temperatures.append(T)

        if accept:
            current_state, current_cost = next_state,
next_cost

    costs.append(current_cost)
    temperatures.append(T)
    return costs, temperatures

def linear_schedule(t, initial_temp=1000,
final_temp=1, max_iter=1000):
    return max(final_temp, initial_temp - (initial_temp -
final_temp) * (t / max_iter))

try:
    n = int(input("Enter the number of queens (N): "))
    if n <= 0:
        raise ValueError("N must be a positive integer.")

    initial_state = list(map(int, input(f"Enter the initial
state as a list of {n} integers (rows for each column):
").split()))
    if len(initial_state) != n or any(not (0 <= row < n)
for row in initial_state):
        raise ValueError(f"Invalid initial state. Please
provide {n} integers between 0 and {n-1}.")
except ValueError as e:
    print(e)
    n = 4
    initial_state = [random.randint(0, n - 1) for _ in
range(n)]
    print(f"Using random initial state: {initial_state}")

costs, temperatures =
simulated_annealing_with_tracking(initial_state,
linear_schedule)

plt.figure(figsize=(14, 6))

plt.subplot(1, 2, 1)
plt.plot(costs, label="Objective Function (Cost)")
plt.xlabel("Iterations")
plt.ylabel("Objective Function (Cost)")
plt.title("Objective Function (Cost) over Iterations")
plt.legend()
```

```
plt.subplot(1, 2, 2)
plt.plot(temperatures, costs, label="Objective Function (Cost)")
plt.xlabel("Temperature")
plt.ylabel("Objective Function (Cost)")
plt.title("Objective Function (Cost) over Temperature")
plt.legend()
plt.tight_layout()
plt.show()

if costs[-1] == 0:
    print(f"Solution found: {initial_state}")
else:
    print("Max iterations reached without finding a solution.")
```

OUTPUT

```
Enter the number of queens (N): 4
Enter the initial state as a list of 4 integers (rows for each column): 3 1 2 0
Iteration 0:
  Current state: [3, 1, 2, 0], Cost: 2, Temperature (T): 1000.0
  Next state: [3, 1, 0, 0], Next cost: 3
  ΔE = 1
  Acceptance probability: 0.999000499833375
  Acceptance condition met: True
Iteration 1:
  Current state: [3, 1, 0, 0], Cost: 3, Temperature (T): 999.001
  Next state: [3, 1, 3, 0], Next cost: 2
  ΔE = -1
  Acceptance probability: 1.001001501166707
  Acceptance condition met: True
Iteration 2:
  Current state: [3, 1, 3, 0], Cost: 2, Temperature (T): 998.002
  Next state: [3, 3, 3, 0], Next cost: 4
  ΔE = 2
  Acceptance probability: 0.9979980026753383
  Acceptance condition met: True
Iteration 3:
  Current state: [3, 3, 3, 0], Cost: 4, Temperature (T): 997.003
  Next state: [3, 2, 3, 0], Next cost: 5
  ΔE = 1
  Acceptance probability: 0.998997496833386
  Acceptance condition met: True
```

```
Iteration 16:
  Current state: [3, 2, 3, 1], Cost: 3, Temperature (T): 984.016
  Next state: [2, 2, 3, 1], Next cost: 2
  ΔE = -1
  Acceptance probability: 1.0010167601888467
  Acceptance condition met: True
Iteration 17:
  Current state: [2, 2, 3, 1], Cost: 2, Temperature (T): 983.017
  Next state: [2, 0, 3, 1], Next cost: 0
  ΔE = -2
  Acceptance probability: 1.0020366239173017
  Acceptance condition met: True
Solution found at iteration 18: [2, 0, 3, 1] with cost 0
Solution found for the initial state: [3, 1, 2, 0]
```