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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

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CERTIFICATE

This is to certify that the Lab work entitled “Artificial Intelligence (23CS5PCAIN)” carried out by **Shreyas K (1BM22CS271),** 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.

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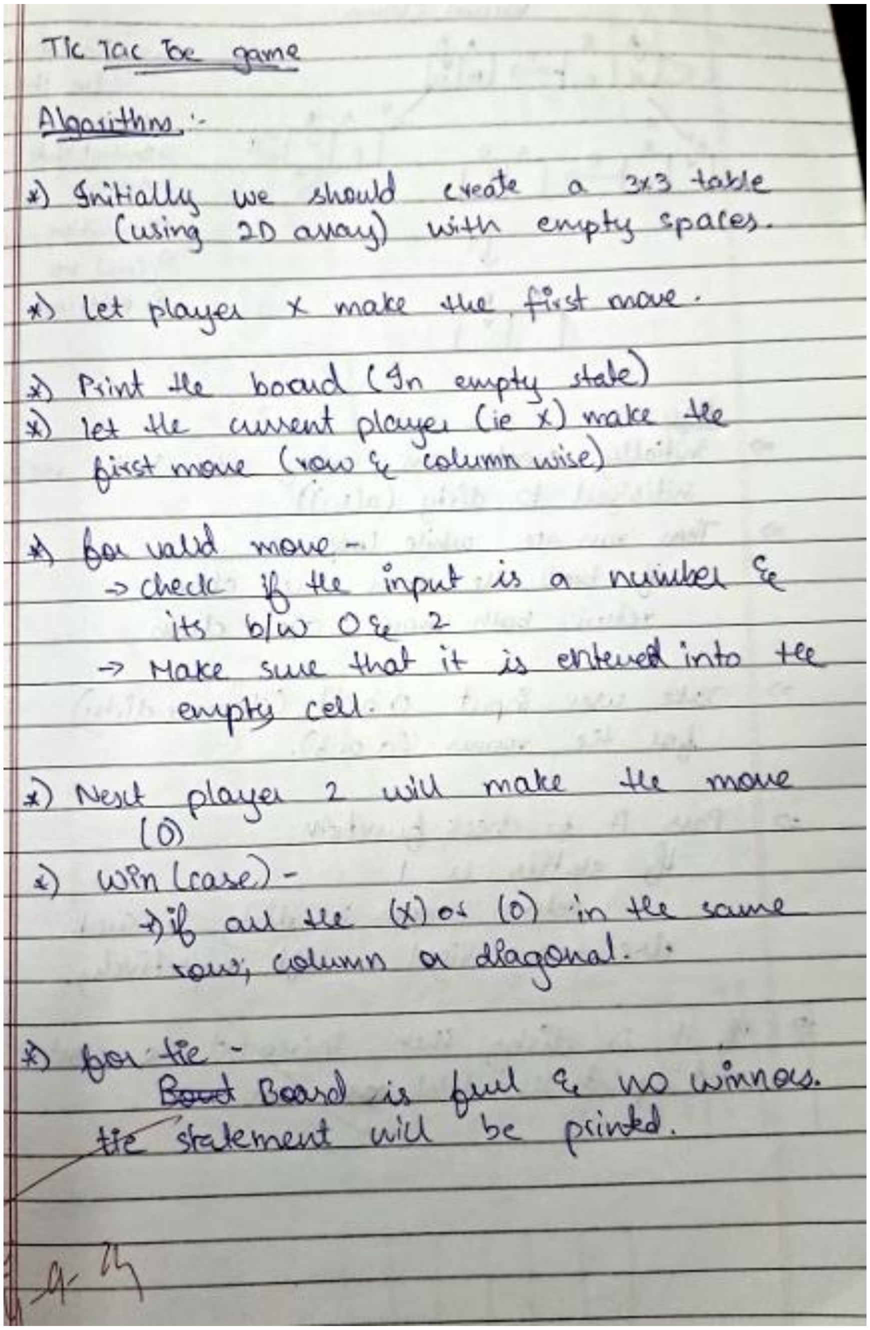
Github Link:
https://github.com/Sakshishetty24/Artificial-Intelligence

Program 1
Implement Tic –Tac –Toe Game
Implement vacuum cleaner agent
Tic-Tac-Toe



Tic Tac Toe game

Algorithm:-

*) Initially we should create a 3x3 table (using 2D array) with empty spaces.

*) Let player x make the first move.

*) Print the board (In empty state)
*) let the current player (ie x) make the first move (row & column wise)

*) for valid move -
-> check if the input is a number & its b/w 0 & 2
-> Make sure that it is entered into the empty cell.

*) Next player 2 (0) will make the move

*) Win (case) -
-> if all the (x) or (0) in the same row, column or diagonal.

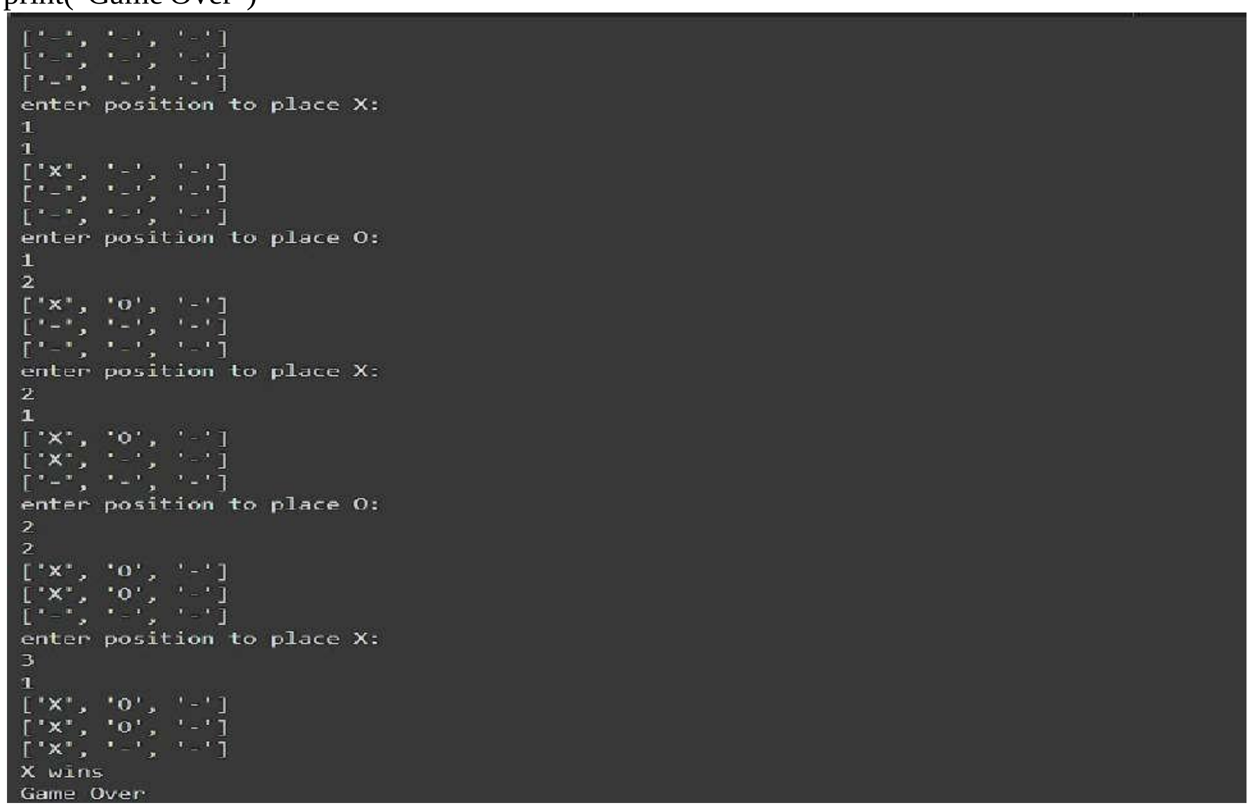
*) for tie -
~~Boot~~ Board is full & no winners. the statement will be printed.

Algorithm:

Code:

```
def check_win(board, r, c):
    if board[r - 1][c - 1] == 'X':
        ch = "O"
    else:
        ch = "X"
    if ch not in board[r - 1] and '-' not in board[r - 1]:
        return True
    elif ch not in (board[0][c - 1], board[1][c - 1], board[2][c - 1]) and '-' not in (board[0][c - 1],
board[1][c - 1], board[2][c - 1]):
        return True
    elif ch not in (board[0][0], board[1][1], board[2][2]) and '-' not in (board[0][0], board[1][1],
board[2][2]):
        return True
    elif ch not in (board[0][2], board[1][1], board[2][0]) and '-' not in (board[0][2], board[1][1],
board[2][0]):
        return True
    return False

def displayb(board):
  print(board[0])
  print(board[1])
  print(board[2])

board=[['-','-','-'],['-','-','-'],['-','-','-']]
displayb(board)
xo=1
flag=0
while '-' in board[0] or '-' in board[1] or '-' in board[2]:

  if xo==1:
    print("enter position to place X:")
    x=int(input())
    y=int(input())
    if(x>3 or y>3):
      print("invalid position")
      continue
    if(board[x-1][y-1]=='-'):
      board[x-1][y-1]='X'
      xo=0
      displayb(board)
    else:
      print("invalid position")
    continue
    if(check_win(board,x,y)):
```

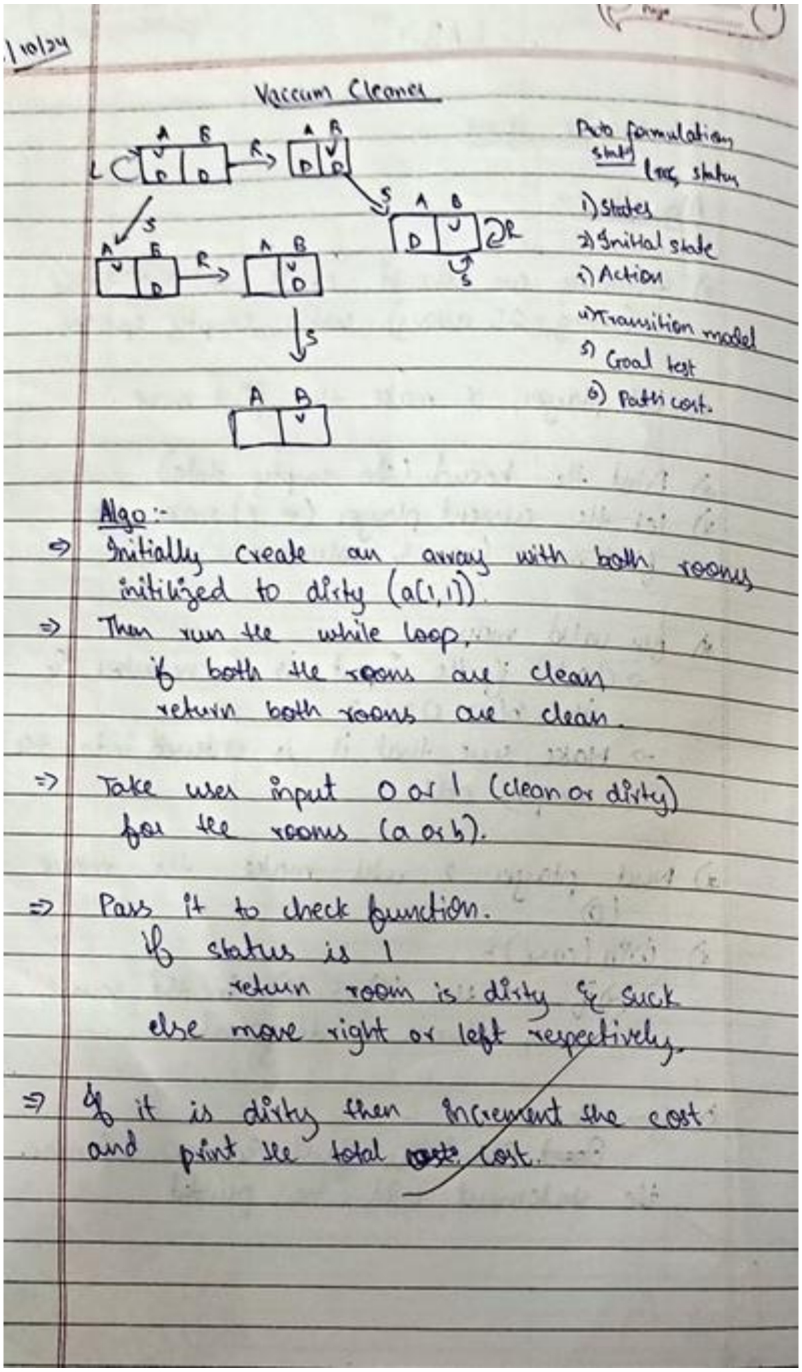
```
        print("X wins")
        flag=1
        break
  else :
    print("enter position to place O:")
    x=int(input())
    y=int(input())
    if(x>3 or y>3):
      print("invalid position")
      continue
    if(board[x-1][y-1]=='-'):
      board[x-1][y-1]='O'
      xo=1
      displayb(board)
    else:
      print("invalid position")
    continue
    if(check_win(board,x,y)):
        print("0 wins")
        flag=1
        break
if flag==0:
  print("Draw")
print("Game Over")
```



```
['-', '-', '-']
['-', '-', '-']
['-', '-', '-']
enter position to place X:
1
1
['X', '-', '-']
['-', '-', '-']
['-', '-', '-']
enter position to place O:
2
2
['X', '-', '-']
['-', 'O', '-']
['-', '-', '-']
enter position to place X:
3
3
['X', '-', '-']
['-', 'O', '-']
['-', '-', 'X']
enter position to place O:
1
2
['X', 'O', '-']
['-', 'O', '-']
['-', '-', 'X']
enter position to place X:
3
2
['X', 'O', '-']
['-', 'O', '-']
['-', 'X', 'X']
enter position to place O:
3
1
['X', 'O', '-']
['-', 'O', '-']
['O', 'X', 'X']
```

```
enter position to place X:
2
1
['X', 'O', '-']
['X', 'O', '-']
['O', 'X', 'X']
enter position to place O:
2
3
['X', 'O', '-']
['X', 'O', 'O']
['O', 'X', 'X']
enter position to place X:
1
3
['X', 'O', 'X']
['X', 'O', 'O']
['O', 'X', 'X']
Draw
Game Over
```

Vacuum Cleaner


1/10/24

Vaccum Cleaner

Prob formulation

1) States
2) Initial state
3) Action
4) Transition model
5) Goal test
6) Path cost.

Algo:-

⇒ Initially create an array with both rooms initilized to dirty (a[1,1]).

⇒ Then run the while loop,
if both the rooms are clean
return both rooms are clean.

⇒ Take user input 0 or 1 (clean or dirty) for the rooms (a or b).

⇒ Pass it to check function.
if status is 1
return room is dirty & suck
else move right or left respectively.

⇒ If it is dirty then increment the cost and print the total ~~cost~~ cost.

Algorithm:

Code:

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

```
    return

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

```
        rec(state,loc)
    else:
        next_loc = 'B' if loc == 'A' else 'A'
        dire="left" if loc=="B" else "right"
        print(loc,"is clean")
        print(f"Moving vacuum {dire}")
        if state[next_loc] == 1:
            rec(state, next_loc)

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

```
Enter state of A (0 for clean, 1 for dirty): 0
Enter state of B (0 for clean, 1 for dirty): 1
Enter location (A or B): A
A is clean
Moving vacuum right
Cleaned B.
Is B clean now? (0 if clean, 1 if dirty): 0
Is A dirty? (0 if clean, 1 if dirty): 0
B is clean
Moving vacuum left
Cost: 1
{'A': 0, 'B': 0}
```

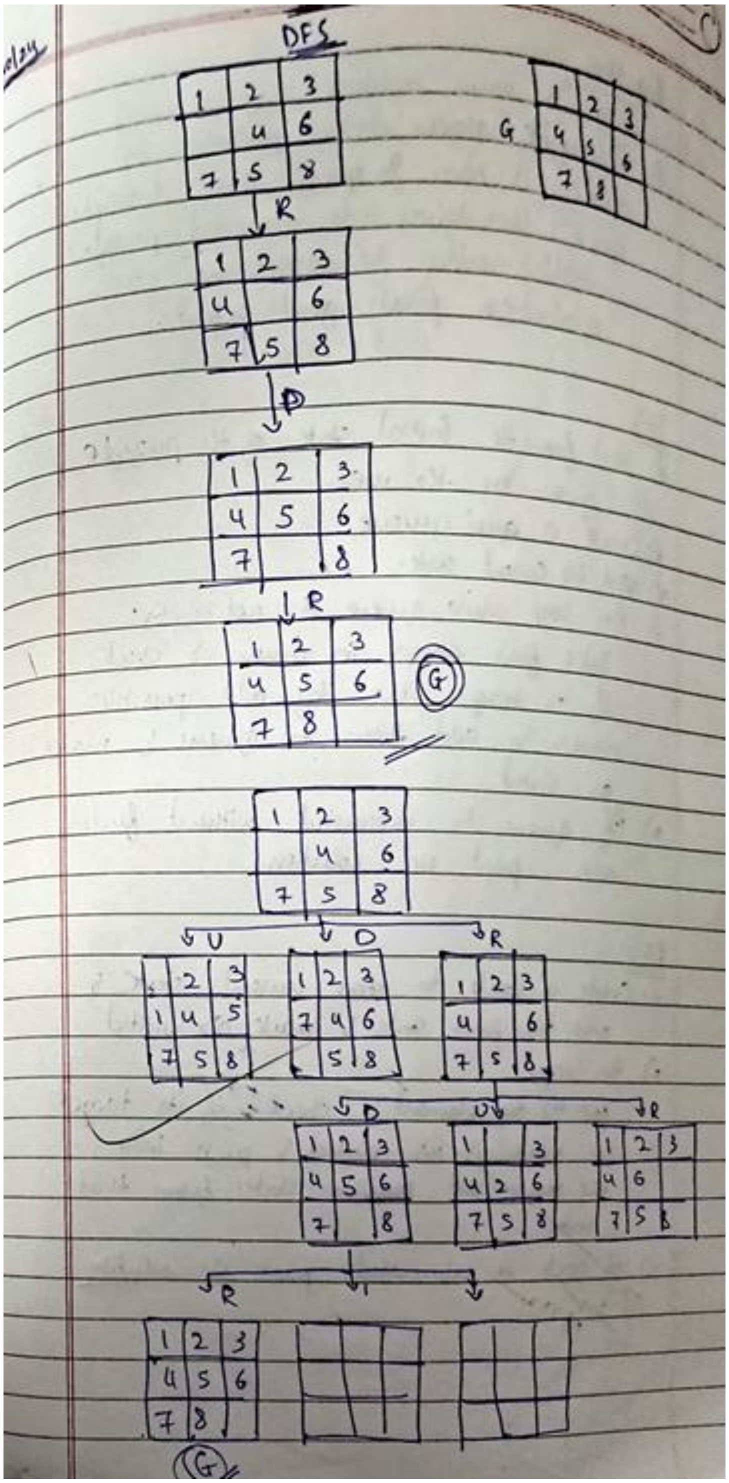
```
Enter state of A (0 for clean, 1 for dirty): 0
Enter state of B (0 for clean, 1 for dirty): 0
Enter location (A or B): A
Turning vacuum off
Cost: 0
{'A': 0, 'B': 0}
```

```
Enter state of A (0 for clean, 1 for dirty): 1
Enter state of B (0 for clean, 1 for dirty): 0
Enter location (A or B): A
Cleaned A.
Is A clean now? (0 if clean, 1 if dirty): 0
Is B dirty? (0 if clean, 1 if dirty): 0
A is clean
Moving vacuum right
Cost: 1
{'A': 0, 'B': 0}
```

```
Enter state of A (0 for clean, 1 for dirty): 1
Enter state of B (0 for clean, 1 for dirty): 1
Enter location (A or B): A
Cleaned A.
Is A clean now? (0 if clean, 1 if dirty): 0
A is clean
Moving vacuum right
Cleaned B.
Is B clean now? (0 if clean, 1 if dirty): 0
Is A dirty? (0 if clean, 1 if dirty): 0
B is clean
Moving vacuum left
Cost: 2
{'A': 0, 'B': 0}
```

Program 2
Implement 8 puzzle problems using Depth First Search (DFS)
Implement Iterative deepening search algorithm

8 puzzle using DFS
Algorithm:



Algorithm.

*) 8 puzzle algo is a problem in which it has 9 space and 1 empty space. User gives a unsorted puzzle initially, using BFS & DFS we can optain the final goal output.

BFS

*) start from the initial state of the puzzle given by the user.
*) Create a ~~que~~ queue
*) Visit the current state.
*) In loop while queue is not empty:
Take first element in queue & check if its target else try all possible moves & add them to queue & make as visited
*) If queue is exhausted without finding soln print No solution.

DFS

*) Create a stack to store current state & add the first state & mark as visited
*) In Loop:
pop the top element & check if its target else mark it as visited & push into the stack all possible states from that state
*) If stack is exhausted print No solution

Code:

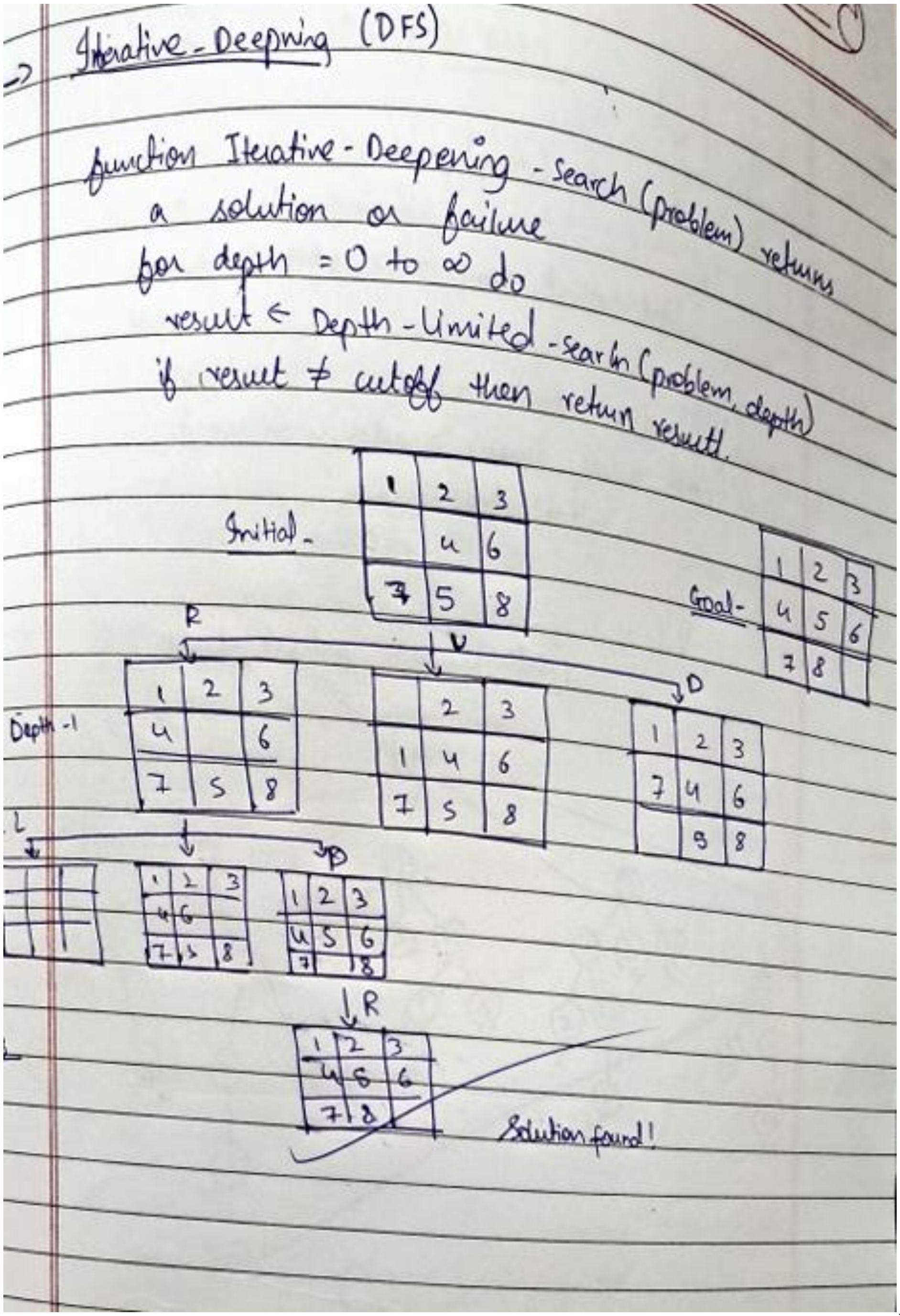
```
def dfs(initial_board, zero_pos):
    stack = [(initial_board, zero_pos, [])]
    visited = set()

    while stack:
        current_board, zero_pos, moves = stack.pop()

        if is_goal(current_board):
```

```
    return moves, len(moves) # Return moves and their count

visited.add(tuple(current_board))

for neighbor_board, neighbor_pos in get_neighbors(current_board, zero_pos):
    if tuple(neighbor_board) not in visited:
        stack.append((neighbor_board, neighbor_pos, moves + [neighbor_board]))
```

```
    return None, 0 # No solution found, return count as 0

# Initial state of the puzzle
initial_board = [1, 2, 3, 0, 4, 6, 7, 5, 8]
zero_position = (1, 0) # Position of the empty tile (0)

# Solve the puzzle using DFS
solution, move_count = dfs(initial_board, zero_position)

if solution:
    print("Solution found with moves ({} moves):".format(move_count))
    for move in solution:
        print_board(move)
        print() # Print an empty line between moves
else:
    print("No solution found.")
```

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

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

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

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

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

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

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

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

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

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

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

Implement Iterative deepening search algorithm



Algorithm:

Code:

```
from collections import deque

class PuzzleState:
    def __init__(self, board, zero_pos, moves=0, previous=None):
        self.board = board
        self.zero_pos = zero_pos # Position of the zero tile
        self.moves = moves         # Number of moves taken to reach this state
        self.previous = previous    # For tracking the path

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

    def get_possible_moves(self):
        moves = []
        x, y = self.zero_pos
        directions = [(-1, 0), (1, 0), (0, -1), (0, 1)] # Up, Down, Left, Right
        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 = [row[:] for row in self.board]
```

```
            # Swap the zero tile with the adjacent tile
            new_board[x][y], new_board[new_x][new_y] = new_board[new_x][new_y],
new_board[x][y]
            moves.append((new_board, (new_x, new_y)))
        return moves

def ids(initial_state, goal_state, max_depth):
    for depth in range(max_depth):
        visited = set()
        result = dls(initial_state, goal_state, depth, visited)
        if result:
            return result
    return None

def dls(state, goal_state, depth, visited):
    if state.is_goal(goal_state):
        return state
    if depth == 0:
        return None

    visited.add(tuple(map(tuple, state.board))) # Mark this state as visited
    for new_board, new_zero_pos in state.get_possible_moves():
        new_state = PuzzleState(new_board, new_zero_pos, state.moves + 1, state)
        if tuple(map(tuple, new_board)) not in visited:
            result = dls(new_state, goal_state, depth - 1, visited)
            if result:
                return result
    visited.remove(tuple(map(tuple, state.board))) # Unmark this state
    return None

def print_solution(solution):
    path = []
    while solution:
        path.append(solution.board)
        solution = solution.previous
    for board in reversed(path):
        for row in board:
            print(row)
        print()

# Define the initial state and goal state
initial_state = PuzzleState(
    board=[[1, 2, 3],
           [4, 0, 5],
           [7, 8, 6]],
    zero_pos=(1, 1)
)
```

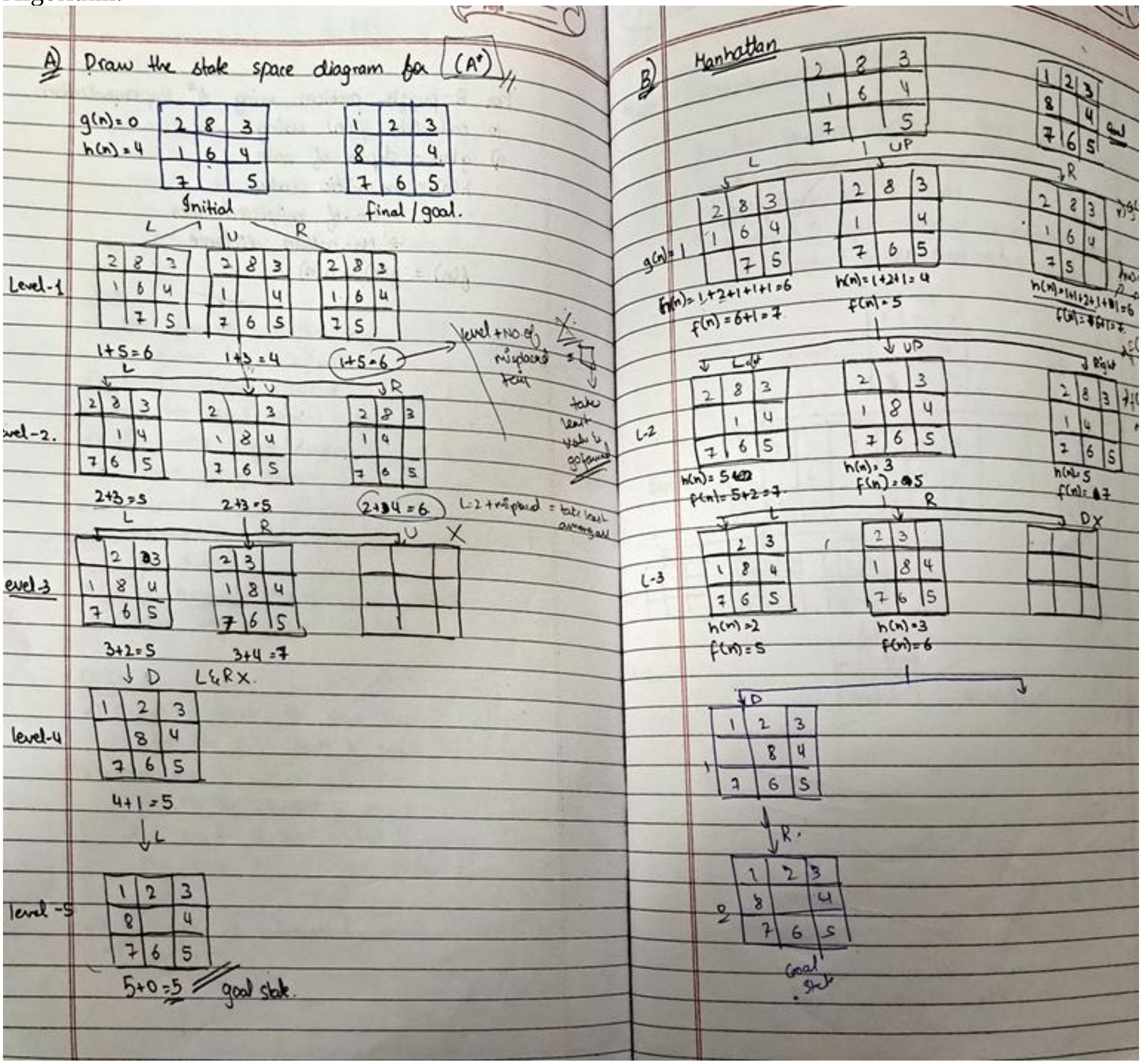
```
goal_state = [
    [1, 2, 3],
    [4, 5, 6],
    [7, 8, 0]
]

# Perform Iterative Deepening Search
max_depth = 20  # You can adjust this value
solution = ids(initial_state, goal_state, max_depth)

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

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

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

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

Program 3

Implement A* search algorithm

Algorithm:



Code:
Misplaced Tiles

```
def mistil(state, goal):
    count = 0
    for i in range(3):
        for j in range(3):
            if state[i][j] != goal[i][j]:
                count += 1
    return count

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

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

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

def apply_move(state, blank_pos, move):
    i, j = blank_pos
    new_state = [row[:] for row in state]
    if move == 'up' and i > 0:
```

```
        new_state[i][j], new_state[i - 1][j] = new_state[i - 1][j], new_state[i][j]
    elif move == 'down' and i < 2:
        new_state[i][j], new_state[i + 1][j] = new_state[i + 1][j], new_state[i][j]
    elif move == 'left' and j > 0:
        new_state[i][j], new_state[i][j - 1] = new_state[i][j - 1], new_state[i][j]
    elif move == 'right' and j < 2:
        new_state[i][j], new_state[i][j + 1] = new_state[i][j + 1], new_state[i][j]
    else:
        return None
    return new_state

def print_state(state):
    for row in state:
        print(' '.join(map(str, row)))

initial_state = [[2,8,3], [1,6,4], [7,0,5]]
goal_state = [[1,2,3], [8,0,4], [7,6,5]]
open_list = [{'state': initial_state, 'parent': None, 'move': None, 'g': 0}]
visited_states = []

while open_list:
    best_state = findmin(open_list, goal_state)
    print("Current state:")
    print_state(best_state['state'])
    h = mistil(best_state['state'], goal_state)
    f = best_state['g'] + h
    print(f"g(n): {best_state['g']}, h(n): {h}, f(n): {f}")
    if best_state['move'] is not None:
        print(f"Move: {best_state['move']}")
    print()
    if mistil(best_state['state'], goal_state) == 0:
        goal_state_reached = best_state
        break
    visited_states.append(best_state['state'])
    next_states = operation(best_state)
    for state in next_states:
        if state['state'] not in visited_states:
            open_list.append(state)

moves = []
while goal_state_reached['move'] is not None:
    moves.append(goal_state_reached['move'])
    goal_state_reached = goal_state_reached['parent']
moves.reverse()

print("\nMoves to reach the goal state:", moves)
print("\nGoal state reached:")
```

print_state(goal_state)

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

Current state:
2 8 3
1 0 4
7 6 5
g(n): 1, h(n): 3, f(n): 4
Move: up

Current state:
2 0 3
1 8 4
7 6 5
g(n): 2, h(n): 4, f(n): 6
Move: up

Current state:
2 8 3
0 1 4
7 6 5
g(n): 2, h(n): 4, f(n): 6
Move: left

Current state:
0 2 3
1 8 4
7 6 5
g(n): 3, h(n): 3, f(n): 6
Move: left

Current state:
1 2 3
0 8 4
7 6 5
g(n): 4, h(n): 2, f(n): 6
Move: down
```

```
Current state:
1 2 3
8 0 4
7 6 5
g(n): 5, h(n): 0, f(n): 5
Move: right


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

Goal state reached:
1 2 3
8 0 4
7 6 5
```

Manhattan Distance

```
def manhattan_distance(state, goal):
    distance = 0
    for i in range(3):
        for j in range(3):
            tile = state[i][j]
            if tile != 0: # Ignore the blank space (0)
                # Find the position of the tile in the goal state
                for r in range(3):
                    for c in range(3):
                        if goal[r][c] == tile:
                            target_row, target_col = r, c
                            break
                # Add the Manhattan distance (absolute difference in rows and columns)
                distance += abs(target_row - i) + abs(target_col - j)
    return distance

def findmin(open_list, goal):
    minv = float('inf')
    best_state = None
    for state in open_list:
        h = manhattan_distance(state['state'], goal) # Use Manhattan distance here
        f = state['g'] + h
        if f < minv:
            minv = f
            best_state = state
    open_list.remove(best_state)
    return best_state

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

def find_blank_position(state):
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
```

```
            return i, j
    return None

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

def print_state(state):
    for row in state:
        print(' '.join(map(str, row)))

# Initial state and goal state
initial_state = [[2,8,3], [1,6,4], [7,0,5]]
goal_state = [[1,2,3], [8,0,4], [7,6,5]]

# Open list and visited states
open_list = [{'state': initial_state, 'parent': None, 'move': None, 'g': 0}]
visited_states = []

while open_list:
    best_state = findmin(open_list, goal_state)

    print("Current state:")
    print_state(best_state['state'])

    h = manhattan_distance(best_state['state'], goal_state) # Using Manhattan distance here
    f = best_state['g'] + h
    print(f"g(n): {best_state['g']}, h(n): {h}, f(n): {f}")

    if best_state['move'] is not None:
        print(f"Move: {best_state['move']}")
    print()
    if h == 0: # Goal is reached if h == 0
        goal_state_reached = best_state
        break
```

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

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

# Reconstruct the path of moves
moves = []
while goal_state_reached['move'] is not None:
    moves.append(goal_state_reached['move'])
    goal_state_reached = goal_state_reached['parent']
moves.reverse()

print("\nMoves to reach the goal state:", moves)
print("\nGoal state reached:")
print_state(goal_state)
```

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

Current state:
2 8 3
1 0 4
7 6 5
g(n): 1, h(n): 4, f(n): 5
Move: up

Current state:
2 0 3
1 8 4
7 6 5
g(n): 2, h(n): 3, f(n): 5
Move: up

Current state:
0 2 3
1 8 4
7 6 5
g(n): 3, h(n): 2, f(n): 5
Move: left

Current state:
1 2 3
0 8 4
7 6 5
g(n): 4, h(n): 1, f(n): 5
Move: down
```

```
Current state:
1 2 3
8 0 4
7 6 5
g(n): 5, h(n): 0, f(n): 5
Move: right


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

Goal state reached:
1 2 3
8 0 4
7 6 5
```

Program 4

Implement Hill Climbing search algorithm to solve N-Queens problem

Algorithm:

⇒ Implement Hill Cli...

function Hill-Climbing (prob) return a state that a local maximum

current ← Make-NODE(prob.Initial-state)

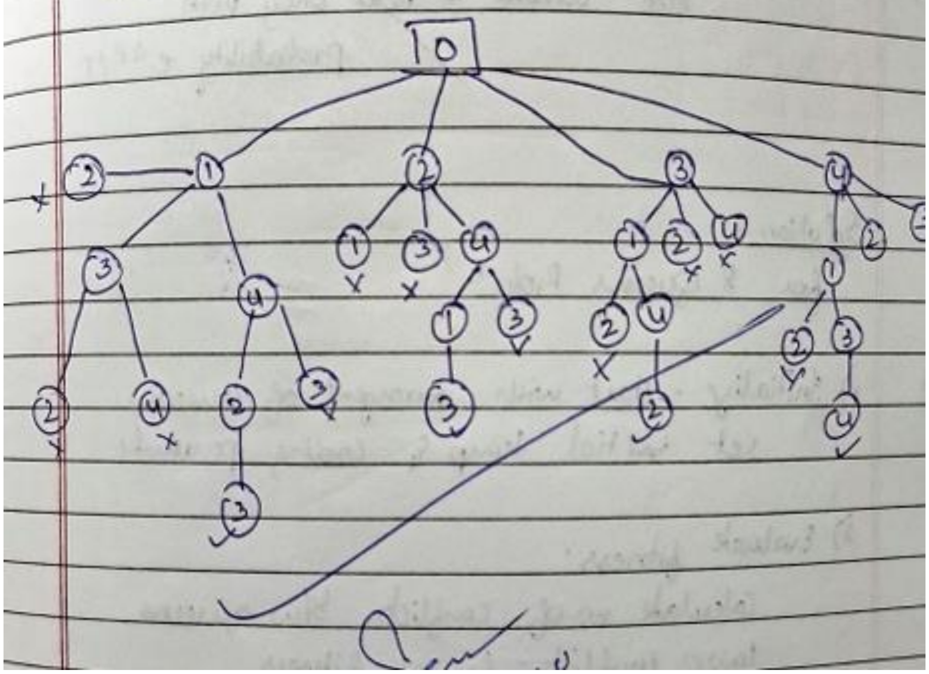
loop do

neighbor ← a highest-valued successor of current

if neighbour.value ≤ current.value then return current.state

current ← neighbor.

4 Queens (using Hill climbing).



Code:

```
import random

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

```
    return conflicts

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

        while True:
            # Generate neighbors by moving each queen to a different position
            found_better = False
            for i in range(n):
                for j in range(n):
                    if j != current_board[i]:  # Only consider different positions
                        neighbor_board = list(current_board)
                        neighbor_board[i] = j
                        neighbor_conflicts = calculate_conflicts(neighbor_board)
                        if neighbor_conflicts < current_conflicts:
                            print_board(current_board)
                            print(current_conflicts)
                            print_board(neighbor_board)
                            print(neighbor_conflicts)
                            current_board = neighbor_board
                            current_conflicts = neighbor_conflicts
                            cost+=1
                            found_better = True
                            break
                if found_better:
                    break

            # If no better neighbor found, stop searching
            if not found_better:
                break

        # If a solution is found (zero conflicts), return the board
        if current_conflicts == 0:
            return current_board, current_conflicts, cost

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

```
print("===============")
# Example Usage
n = 4
solution, conflicts, cost = hill_climbing(n)
print("Final Board Configuration:")
print_board(solution)
print("Number of Cost:", cost)
```

```
===============
Q . . .
. . . Q
. . Q .
. Q . .

4
Q . . .
Q . . .
. . Q .
. Q . .

3
Q . . .
Q . . .
. . Q .
. Q . .

3
. . Q .
Q . . .
. . Q .
. Q . .

2
. . Q .
Q . . .
. . Q .
. Q . .

2
. . . Q
Q . . .
. . Q .
. Q . .

1
Final Board Configuration:
. Q . .
. . . Q
Q . . .
. . Q .
```

Program 5
Simulated Annealing to Solve 8-Queens problem
Algorithm:

29/10/24 LAB-6

=> Write a program to implement simulated Annealing Algo

function Simulated Annealing (problem, schedule)
current ← Make_Node(problem. Initial_State)
for t=1 to ∞ do
T ← schedule (t)
if T=0 then return current
next ← a randomly selected successor of current

ΔE ← next. Value - current value
if ΔE > 0 then current ← next
else current ← next only with probability $e^{\Delta E/T}$

Solution -
for 8 Queens Prob:

1) Initialize - start with arrangement of queens
set initial temp & cooling parameter

2) Evaluate fitness:
calculate no. of conflicts b/w queens
lower conflict = fewer fitness
3) Generate Neighbour:
Create a neighbour by swapping 2 queens
calculate its fitness

4) Accept or Reject Neighbour:
5) Gradually Reduce the temp & repeat until
the temp is very low
6) Return the best arrangement found.

Output -
Result structure : (array([1, 0, 3, 5, 4, 2]), 21.0293,
Best route found : [1 0 3 5 4 2]
Total distance of best route : 21.029348535

29.10

Code:

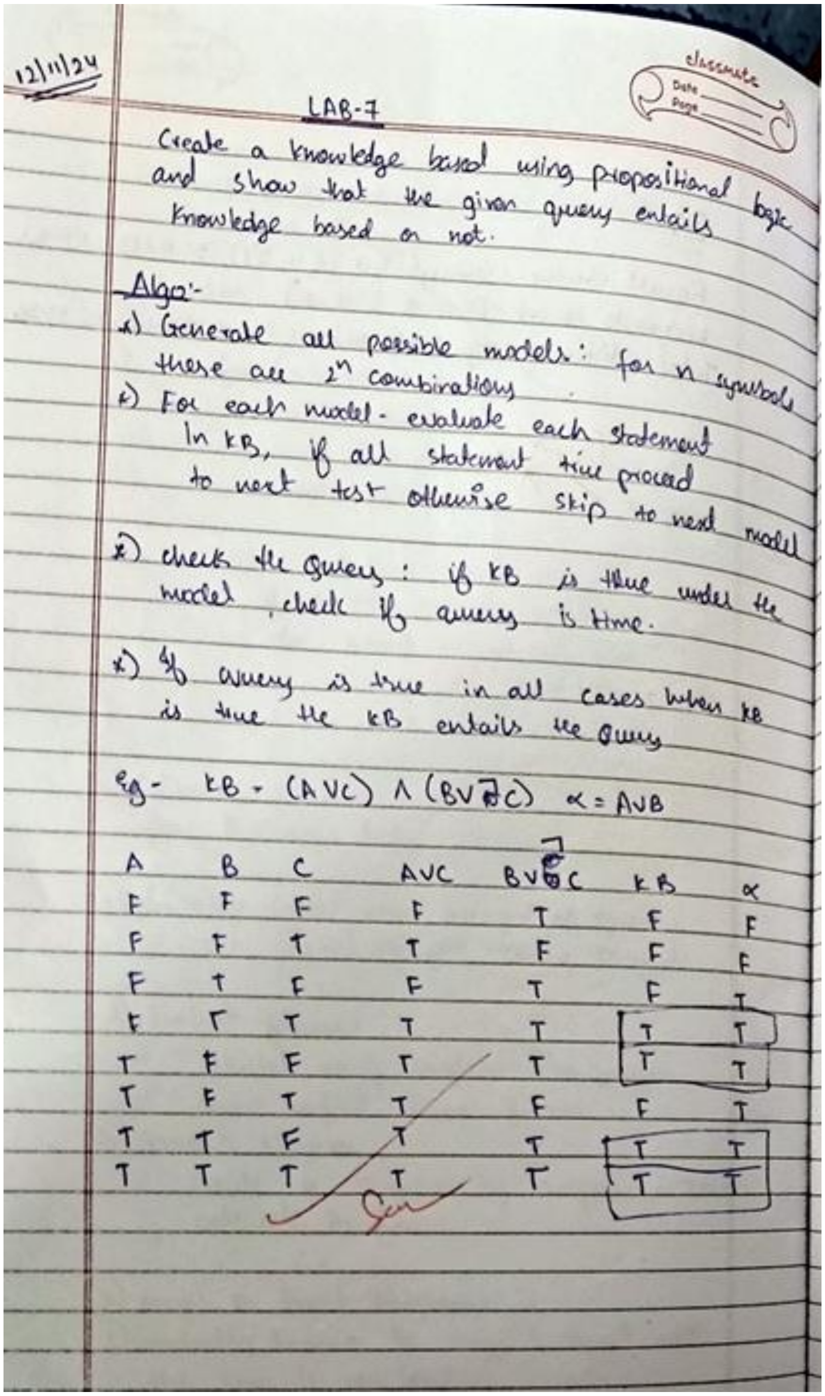
```
import numpy as np
from scipy.optimize import dual_annealing

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) # Round and convert to integers for queen positions
    n = len(position)
    queen_not_attacking = 0

    for i in range(n - 1):
        no_attack_on_j = 0
        for j in range(i + 1, n):
            # Check if queens are on the same row or on the same diagonal
            if position[i] != position[j] and abs(position[i] - position[j]) != (j - i):
                no_attack_on_j += 1
        if no_attack_on_j == n - 1 - i:
            queen_not_attacking += 1
    if queen_not_attacking == n - 1:
        queen_not_attacking += 1
    return -queen_not_attacking # Negative because we want to maximize this value

# Bounds for each queen's position (0 to 7 for an 8x8 chessboard)
bounds = [(0, 8) 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 # Flip sign to get the number of non-attacking queens

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

```
The best position found is: [0 8 5 2 6 3 7 4]
The number of queens that are not attacking each other is: 8
```

Program 6

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

Algorithm:



12/11/24

LAB-7

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

Algo:-

*) Generate all possible models: for n symbols there are 2^n combinations

*) For each model - evaluate each statement In KB, if all statement true proceed to next test otherwise skip to next model

*) check the Query: if KB is true under the model, check if query is true.

*) If query is true in all cases when KB is true the KB entails the Query

eg- KB = $(A \vee C) \wedge (B \vee \neg C)$ $\alpha = A \vee B$

A	B	C	$A \vee C$	$B \vee \neg C$	KB	α
F	F	F	F	T	F	F
F	F	T	T	F	F	F
F	T	F	F	T	F	T
F	T	T	T	T	T	T
T	F	F	T	T	T	T
T	F	T	T	F	F	T
T	T	F	T	T	T	T
T	T	T	T	T	T	T

Code:

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

# Function to evaluate an expression
def evaluate_expression(a, b, c, expression):
    # Use eval() to evaluate the logical expression
    return eval(expression)

# Function to generate the truth table and evaluate a logical expression
def truth_table_and_evaluation(kb, query):
    # All possible combinations of truth values for a, b, and c
    truth_values = [True, False]
    combinations = list(itertools.product(truth_values, repeat=3))

    # Reverse the combinations to start from the bottom (False -> True)
    combinations.reverse()

    # Header for the full truth table
    print(f"{'a':<5}  {'b':<5} {'c':<5} {'KB':<20}{'Query':<20}")

    # Evaluate the expressions for each combination
```

```
    for combination in combinations:
        a, b, c = combination

        # Evaluate the knowledge base (KB) and query expressions
        kb_result = evaluate_expression(a, b, c, kb)
        query_result = evaluate_expression(a, b, c, query)

        # Replace True/False with string "True"/"False"
        kb_result_str = "True" if kb_result else "False"
        query_result_str = "True" if query_result else "False"

        # Convert boolean values of a, b, c to "True"/"False"
        a_str = "True" if a else "False"
        b_str = "True" if b else "False"
        c_str = "True" if c else "False"

        # Print the results for the knowledge base and the query
        print(f"{a_str:<5} {b_str:<5} {c_str:<5} {kb_result_str:<20} {query_result_str:<20}")

    # Additional output for combinations where both KB and query are true
    print("\nCombinations where both KB and Query are True:")
    print(f"{'a':<5} {'b':<5} {'c':<5} {'KB':<20}{'Query':<20}")

    # Print only the rows where both KB and Query are True
    for combination in combinations:
        a, b, c = combination

        # Evaluate the knowledge base (KB) and query expressions
        kb_result = evaluate_expression(a, b, c, kb)
        query_result = evaluate_expression(a, b, c, query)

        # If both KB and query are True, print the combination
        if kb_result and query_result:
            a_str = "True" if a else "False"
            b_str = "True" if b else "False"
            c_str = "True" if c else "False"
            kb_result_str = "True" if kb_result else "False"
            query_result_str = "True" if query_result else "False"
            print(f"{a_str:<5} {b_str:<5} {c_str:<5} {kb_result_str:<20} {query_result_str:<20}")

# Define the logical expressions as strings
kb = "(a or c) and (b or not c)" # Knowledge Base
query = "a or b" # Query to evaluate

# Generate the truth table and evaluate the knowledge base and query
truth_table_and_evaluation(kb, query)
```

```
a       b      c      KB                    Query
False False False False                    False
False False True  False                    False
False True  False False                    True
False True  True  True                     True
True  False False True                     True
True  False True  False                    True
True  True  False True                     True
True  True  True  True                     True

Combinations where both KB and Query are True:
a       b      c      KB                    Query
False True  True  True                     True
True  False False True                     True
True  True  False True                     True
True  True  True  True                     True
```

Program 7

Implement unification in first order logic

Algorithm:

Impliment unification in First order logic

Algo : unify (Ψ_1, Ψ_2) → expression.

Step 1 :: If Ψ_1 or Ψ_2 is a variable or constant, then :

a) If Ψ_1 or Ψ_2 are identical, then return NIL.

b) Eles if Ψ_1 is a variable,

a. then if Ψ_1 occurs in Ψ_2, then return Failure

b. Eles return $\{(\Psi_2/\Psi_1)\}$.

c) Else if Ψ_2 is a variable,

a) if Ψ_2 occurs in Ψ_1 then return Failure

b) Else return $\{(\Psi_1/\Psi_2)\}$.

d) Else return Failure.

Step 2 ::

if the initial Predicate sybol in Ψ_1 & Ψ_2 are not same, then return Failure.

Step 3 :

if Ψ_1 & Ψ_2 have a diff no. of arguments, then return, failure.

Step 4 - set substitution set(subs) to Nil.

Step 5 - for i=1 to no of elements in Ψ_1

a) Call unify function with the i^{th} element of Ψ_1 and i^{th} element of Ψ_2, & put the result into S.

b) if S = failure then return Failure

c) if $S \neq$ Nil then do

Code:

```
import re

def occurs_check(var, x):
    """Checks if var occurs in x (to prevent circular substitutions)."""
    if var == x:
        return True
    elif isinstance(x, list): # If x is a compound expression (like a function or predicate)
        return any(occurs_check(var, xi) for xi in x)
    return False

def unify_var(var, x, subst):
    """Handles unification of a variable with another term."""
```

```
    if var in subst: # If var is already substituted
        return unify(subst[var], x, subst)
    elif isinstance(x, (list, tuple)) and tuple(x) in subst: # Handle compound expressions
        return unify(var, subst[tuple(x)], subst)
    elif occurs_check(var, x):  # Check for circular references
        return "FAILURE"
    else:
        # Add the substitution to the set (convert list to tuple for hashability)
        subst[var] = tuple(x) if isinstance(x, list) else x
        return subst

def unify(x, y, subst=None):
    """
    Unifies two expressions x and y and returns the substitution set if they can be unified.
    Returns 'FAILURE' if unification is not possible.
    """
    if subst is None:
        subst = {} # Initialize an empty substitution set

    # Step 1: Handle cases where x or y is a variable or constant
    if x == y: # If x and y are identical
        return subst
    elif isinstance(x, str) and x.islower(): # If x is a variable
        return unify_var(x, y, subst)
    elif isinstance(y, str) and y.islower():  # If y is a variable
        return unify_var(y, x, subst)
    elif isinstance(x, list) and isinstance(y, list):  # If x and y are compound expressions (lists)
        if len(x) != len(y):  # Step 3: Different number of arguments
            return "FAILURE"

        # Step 2: Check if the predicate symbols (the first element) match
        if x[0] != y[0]:  # If the predicates/functions are different
            return "FAILURE"

        # Step 5: Recursively unify each argument
        for xi, yi in zip(x[1:], y[1:]): # Skip the predicate (first element)
            subst = unify(xi, yi, subst)
            if subst == "FAILURE":
                return "FAILURE"
        return subst
    else:  # If x and y are different constants or non-unifiable structures
        return "FAILURE"

def unify_and_check(expr1, expr2):
    """
    Attempts to unify two expressions and returns a tuple:
    (is_unified: bool, substitutions: dict or None)
```

```
    """
    result = unify(expr1, expr2)
    if result == "FAILURE":
        return False, None
    return True, result

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

def parse_input(input_str):
    """Parses a string input into a structure that can be processed by the unification algorithm."""
    # Remove spaces and handle parentheses
    input_str = input_str.replace(" ", "")

    # Handle compound terms (like p(x, f(y)) -> ['p', 'x', ['f', 'y']])
    def parse_term(term):
        # Handle the compound term
        if '(' in term:
            match = re.match(r'([a-zA-Z0-9_]+)(.*)', term)
            if match:
                predicate = match.group(1)
                arguments_str = match.group(2)
                arguments = [parse_term(arg.strip()) for arg in arguments_str.split(',')]
                return [predicate] + arguments
        return term

    return parse_term(input_str)

# Main function to interact with the user
def main():
    while True:
        # Get the first and second terms from the user
        expr1_input = input("Enter the first expression (e.g., p(x, f(y))): ")
        expr2_input = input("Enter the second expression (e.g., p(a, f(z))): ")

        # Parse the input strings into the appropriate structures
        expr1 = parse_input(expr1_input)
        expr2 = parse_input(expr2_input)

        # Perform unification
        is_unified, result = unify_and_check(expr1, expr2)
```

```
        # Display the results
        display_result(expr1, expr2, is_unified, result)

        # Ask the user if they want to run another test
        another_test = input("Do you want to test another pair of expressions? (yes/no): ").strip().lower()
        if another_test != 'yes':
            break

if __name___== "_main_":
    main()
```

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

Program 8

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

Algorithm:

26/11/24

LAB-8

=> Create a knowledge base consisting of first order logic statement & prove the given query using forward reasoning.

1) Input :
-> (condition, result)
↳ set of facts that must be true.
↳ fact inferred if condition true
-> A set of initial facts known to be true
-> A query to determine if it can be inferred
-> applied_rules = true.

2) while applied_rules is true:
set applied_rules = False
for each (condition, result) in rules:
check if condition ⊆ facts
if result ∉ facts.
add result to facts
set applied_rules = True.
if query ∈ facts return true.
if no new rules applied_rules = False. exit loop

3) ~~Opu~~
Output -
if query ∈ facts return true (inferred)
else return false (query not inferred).

Code:

```python
# Define the knowledge base (KB) as a set of facts
KB = set()

# Premises based on the provided FOL problem
KB.add('American(Robert)')
KB.add('Enemy(America, A)')
KB.add('Missile(T1)')
KB.add('Owns(A, T1)')

# Define inference rules
def modus_ponens(fact1, fact2, conclusion):
    """ Apply modus ponens inference rule: if fact1 and fact2 are true, then conclude conclusion """
    if fact1 in KB and fact2 in KB:
        KB.add(conclusion)
        print(f"Inferred: {conclusion}")

def forward_chaining():
    """ Perform forward chaining to infer new facts until no more inferences can be made """
    # 1. Apply: Missile(x) → Weapon(x)
    if 'Missile(T1)' in KB:
        KB.add('Weapon(T1)')
        print(f"Inferred: Weapon(T1)")

    # 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()
```

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

Program 9

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

Algorithm:

11/10/24

-> convert a given first order logic statement into resolution.

1) convert to clause form (CNF):
   - -> Eliminate implication (A -> B becomes ¬A ∨ B)
   - -> Move negations inward using De Morgan's law.
   - -> Standardize variables.
   - -> Drop universal quantifiers.
   - -> convert to a conjunction of disjunctions (CNF).

2) Negate the statement to be proved:
   - -> Negate the query & add it to knowledge base

3) Apply unification
   - -> Identify & resolve two clauses that contain compulimentary literals.

4) Derive new clause:
   - -> continue resolving clauses until either:
     - ↳ A contradiction is found
     - ↳ No further resolution is possible (query cannot be proved).

Code:

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

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

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

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

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

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

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

```
Does John like peanuts? Yes
```

Program 10

Implement Alpha-Beta Pruning.

Algorithm:

3/10/24

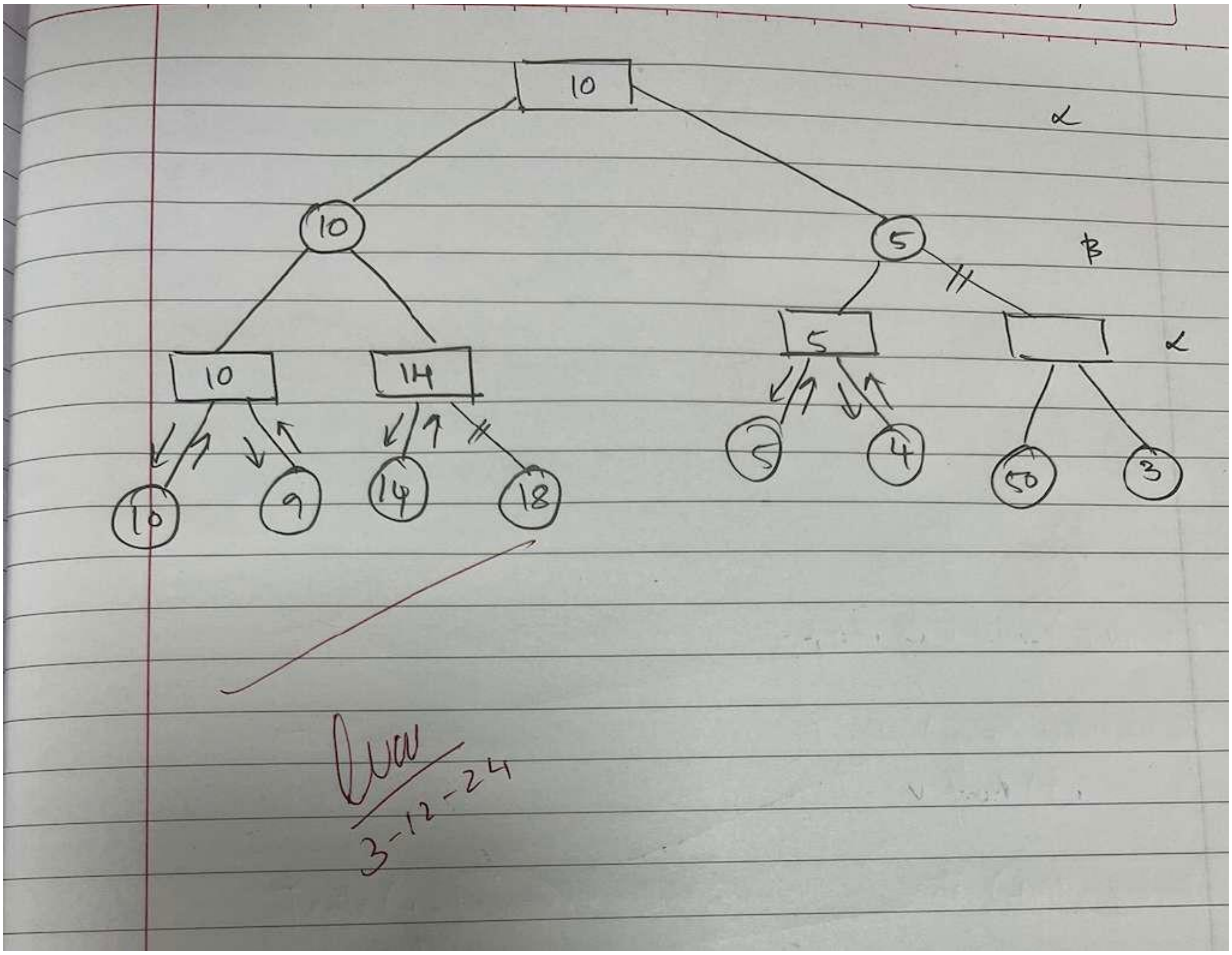
LAB - 10

Implement Alpha-beta pruning

1) Input:
-> A game tree with terminal node values
-> Depth & whether max or min true.

2) Steps:
-> Initialize $\alpha = -\infty$ & $\beta = +\infty$
-> start at root & recursively evaluate child nodes.
-> for each node:
  -> if maximizer:
    -> initialize to $-\infty$
    -> update α = max value
    -> if $\alpha \geq \beta$ -> stop
  -> if min:
    -> initialize to $+\infty$
    -> update β = min value
    -> if $\alpha \geq \beta$ -> stop

-> Return optimal value of root



Code:

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# Alpha-Beta Pruning Implementation
def alpha_beta_pruning(node, alpha, beta, maximizing_player):
    # Base case: If it's a leaf node, return its value (simulating evaluation of the node)
    if type(node) is int:
        return node

    # If not a leaf node, explore the children
    if maximizing_player:
        max_eval = -float('inf')
        for child in node: # Iterate over children of the maximizer node
            eval = alpha_beta_pruning(child, alpha, beta, False)
            max_eval = max(max_eval, eval)
            alpha = max(alpha, eval) # Maximize alpha
            if beta <= alpha: # Prune the branch
                break
        return max_eval
    else:
        min_eval = float('inf')
        for child in node: # Iterate over children of the minimizer node
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            eval = alpha_beta_pruning(child, alpha, beta, True)
            min_eval = min(min_eval, eval)
            beta = min(beta, eval) # Minimize beta
            if beta <= alpha: # Prune the branch
                break
        return min_eval

# Function to build the tree from a list of numbers
def build_tree(numbers):
    # We need to build a tree with alternating levels of maximizers and minimizers
    # Start from the leaf nodes and work up
    current_level = [[n] for n in numbers]

    while len(current_level) > 1:
        next_level = []
        for i in range(0, len(current_level), 2):
            if i + 1 < len(current_level):
                next_level.append(current_level[i] + current_level[i + 1]) # Combine two nodes
            else:
                next_level.append(current_level[i]) # Odd number of elements, just carry forward
        current_level = next_level

    return current_level[0] # Return the root node, which is a maximizer

# Main function to run alpha-beta pruning
def main():
    # Input: User provides a list of numbers
    numbers = list(map(int, input("Enter numbers for the game tree (space-separated): ").split()))

    # Build the tree with the given numbers
    tree = build_tree(numbers)

    # Parameters: Tree, initial alpha, beta, and the root node is a maximizing player
    alpha = -float('inf')
    beta = float('inf')
    maximizing_player = True  # The root node is a maximizing player

    # Perform alpha-beta pruning and get the final result
    result = alpha_beta_pruning(tree, alpha, beta, maximizing_player)

    print("Final Result of Alpha-Beta Pruning:", result)

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

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