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VISVESVARAYA TECHNOLOGICAL UNIVERSITY

“JnanaSangama”, Belgaum -590014, Karnataka.

LAB REPORT
on

Artificial Intelligence (23CS5PCAIN)

Submitted by

Nihal Manjunath (1BM22CS178)

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

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B.M.S. COLLEGE OF ENGINEERING
(Autonomous Institution under VTU)
BENGALURU-560019
Sep-2024 to Jan-2025

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B.M.S. College of Engineering,

Bull Temple Road, Bangalore 560019

(Affiliated To Visvesvaraya Technological University, Belgaum)

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Artificial Intelligence (23CS5PCAIN)" carried out by Nihal Manjunath **(1BM22CS178),** who is bonafide student of **B.M.S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum. The Lab report has been approved as it satisfies the academic requirements in respect of an Artificial Intelligence (23CS5PCAIN) work prescribed for the said degree.

Prof. Swathi Sridharan Assistant Professor Department of CSE, BMSCE	Dr. Kavitha Sooda Professor & HOD Department of CSE, BMSCE

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GitHub Link: *https://github.com/nihal-25/AI-LAB*

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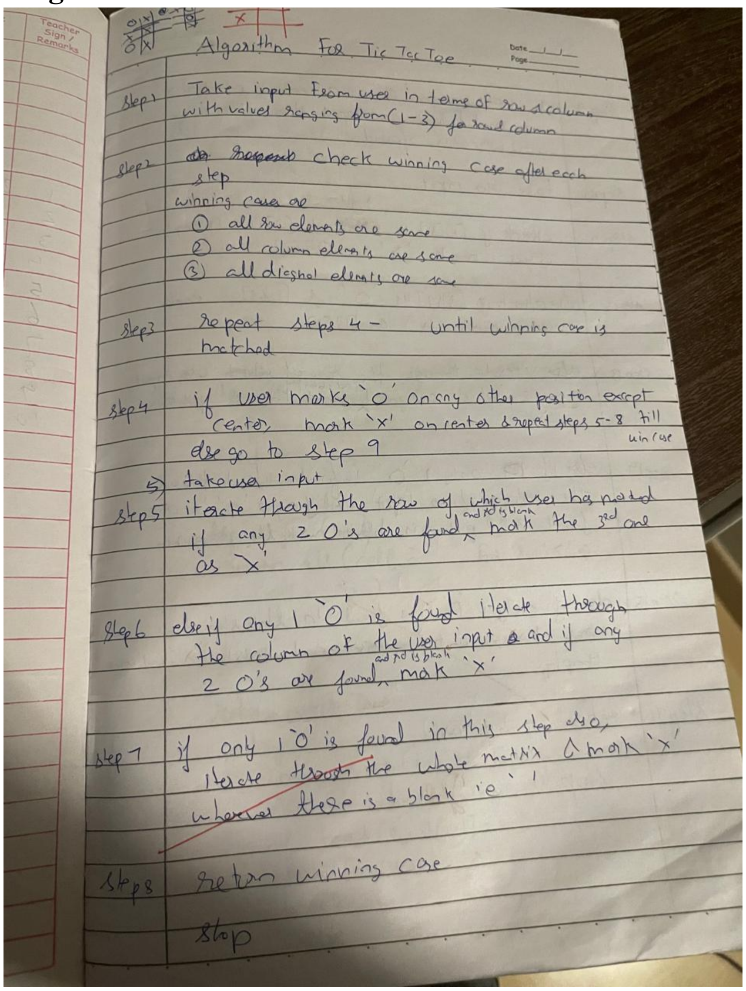
<u>Program 1</u>

Implement Tic –Tac –Toe Game

Implement vacuum cleaner agent

Tic-Tac-Toe

Algorithm:


Algorithm For Tic Tac Toe

Date / /
Page

Step1 Take input from user in terms of row & column with values ranging from (1-3) for row & column

Step2 ~~repeat~~ check winning case after each step
winning cases are
① all row elements are same
② all column elements are same
③ all diagonal elements are same

Step3 repeat steps 4 – until winning case is matched

Step4 if user marks 'O' on any other position except center, mark 'x' on center & repeat steps 5-8 till win case
else go to step 9

5) take user input

Step5 iterate through the row of which user has marked if any 2 O's are found and 3rd is blank mark the 3rd one as 'X'

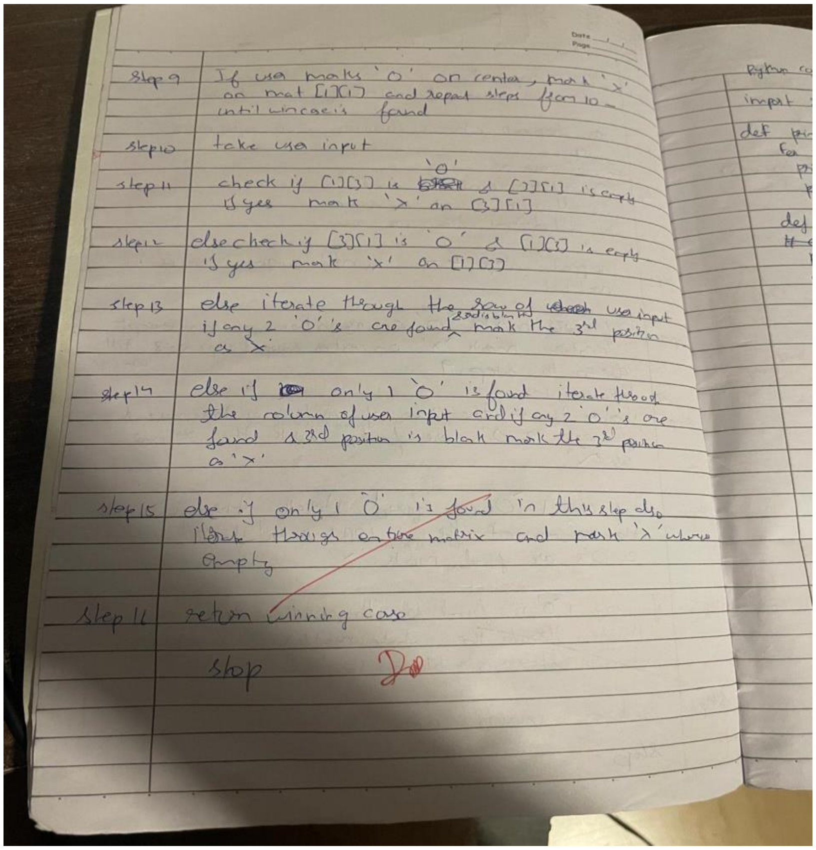
Step6 else if any 1 'O' is found iterate through the column of the user input and if any 2 O's are found and 3rd is blank mark 'x'

Step7 ~~if only 1 'O' is found in this step also, iterate through the whole matrix & mark 'x' wherever there is a blank i.e ' '~~

Step8 return winning case

Stop

`



Step 9 If user marks 'O' on center, mark 'x' on mat [1][1] and repeat steps from 10 until wincase is found

Step 10 take user input

Step 11 check if [1][3] is 'O' & [3][1] is empty if yes mark 'x' on [3][1]

Step 12 else check if [3][1] is 'O' & [1][3] is empty if yes mark 'x' on [1][3]

Step 13 else iterate through the row of user input if any 2 'O''s are found and is blank mark the 3rd position as 'x'

Step 14 else if only 1 'O' is found iterate through the column of user input and if any 2 'O''s are found & 3rd position is blank mark the 3rd position as 'x'

Step 15 else if only 1 'O' is found in this step also iterate through entire matrix and mark 'x' where empty

Step 16 return winning case

stop

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

`

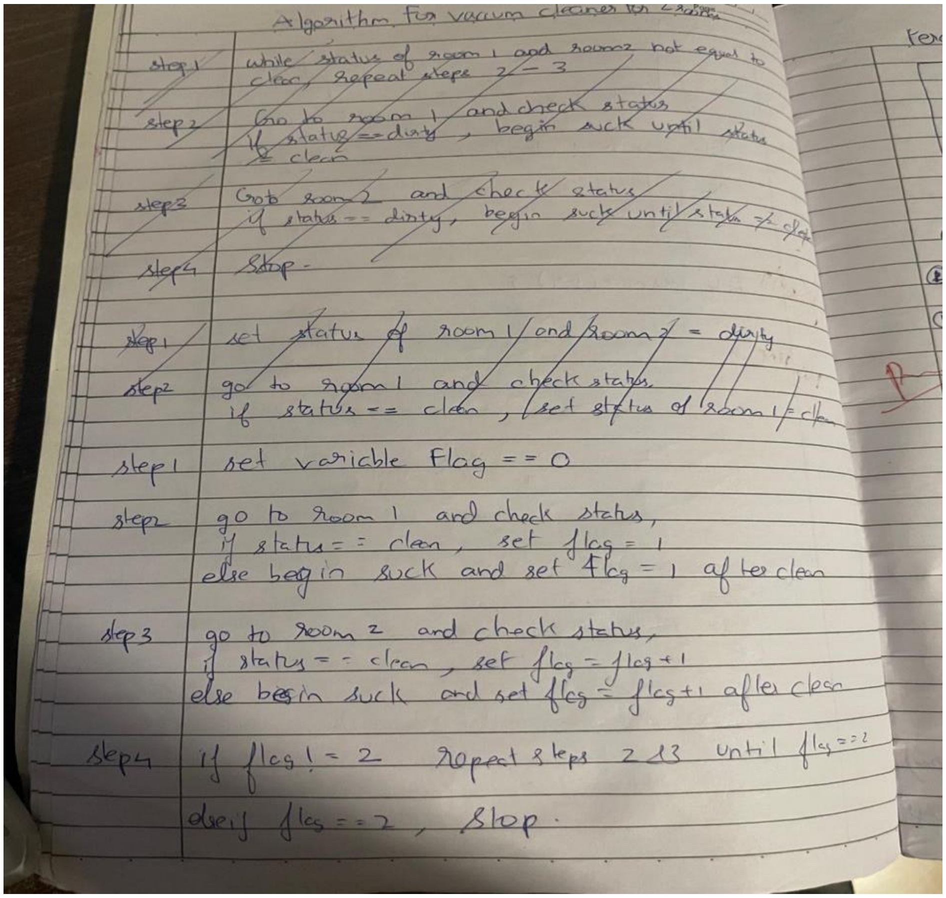
```
['-', '-', '-']
['-', '-', '-']
['-', '-', '-']
enter position to place X:
1
1
['X', '-', '-']
['-', '-', '-']
['-', '-', '-']
enter position to place O:
2
2
['X', '-', '-']
['-', 'O', '-']
['-', '-', '-']
enter position to place X:
3
3
['X', '-', '-']
['-', 'O', '-']
['-', '-', 'X']
enter position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

Algorithm:



Algorithm for vaccum cleaner for 2 rooms

~~step 1 while status of room 1 and room2 not equal to clean, repeat steps 2 - 3~~

~~step 2 Go to room 1 and check status if status == dirty, begin suck until status = clean~~

~~step 3 Go to room 2 and check status if status == dirty, begin suck until status ≠ clean~~

~~step 4 Stop.~~

~~step 1 set status of room 1 and room 2 = dirty~~

~~step 2 go to room 1 and check status, if status == clean, set status of room 1 = clean~~

step 1 set variable Flag == 0

step 2 go to room 1 and check status, if status == clean, set flag = 1 else begin suck and set flag = 1 after clean

step 3 go to room 2 and check status, if status == clean, set flag = flag + 1 else begin suck and set flag = flag + 1 after clean

step 4 if flag != 2 repeat steps 2 & 3 until flag == 2 elseif flag == 2, stop.

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}
```

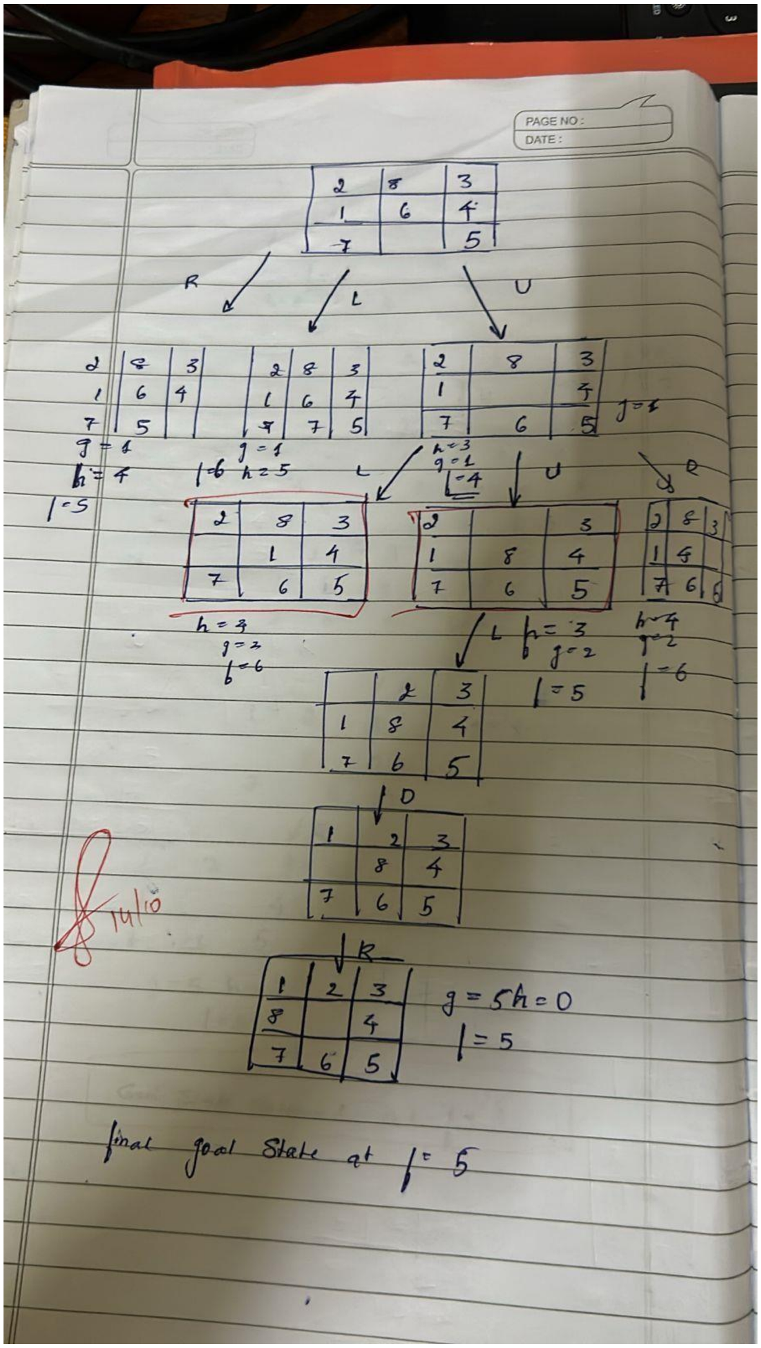
```
Enter state of A (0 for clean, 1 for dirty): 1
Enter state of B (0 for clean, 1 for dirty): 0
Enter location (A or B): A
Cleaned A.
Is A clean now? (0 if clean, 1 if dirty): 0
Is B dirty? (0 if clean, 1 if dirty): 0
A is clean
Moving vacuum right
Cost: 1
{'A': 0, 'B': 0}
```

```
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:



`

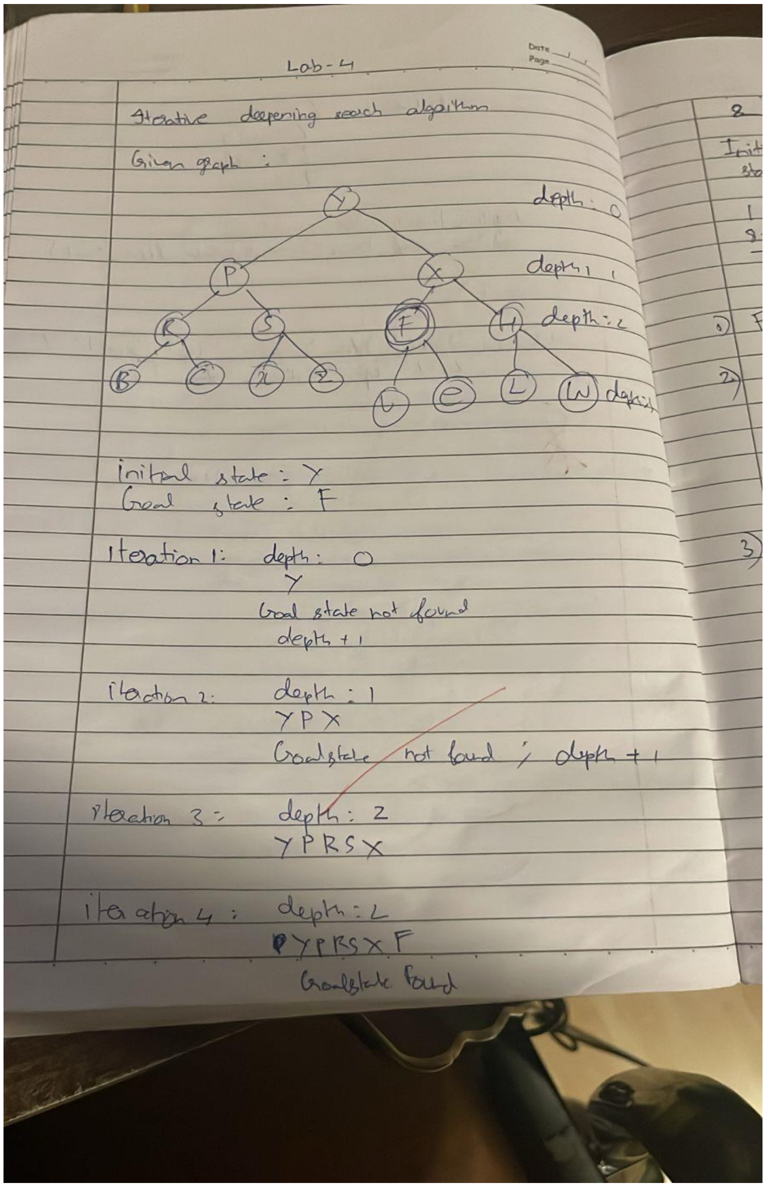
Code: def dfs(initial_board,
zero_pos):

```
    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:


Lab-4

Iterative deepening search algorithm

Given graph :

depth : 0

depth : 1

depth : 2

Initial state : Y

Goal state : F

Iteration 1: depth : 0

Y

Goal state not found

depth + 1

Iteration 2: depth : 1

Y P X

Goalstate not found ; depth + 1

Iteration 3 : depth : 2

Y P R S X

Iteration 4 : depth : 2

Y P R S X F

Goalstate found

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:
```

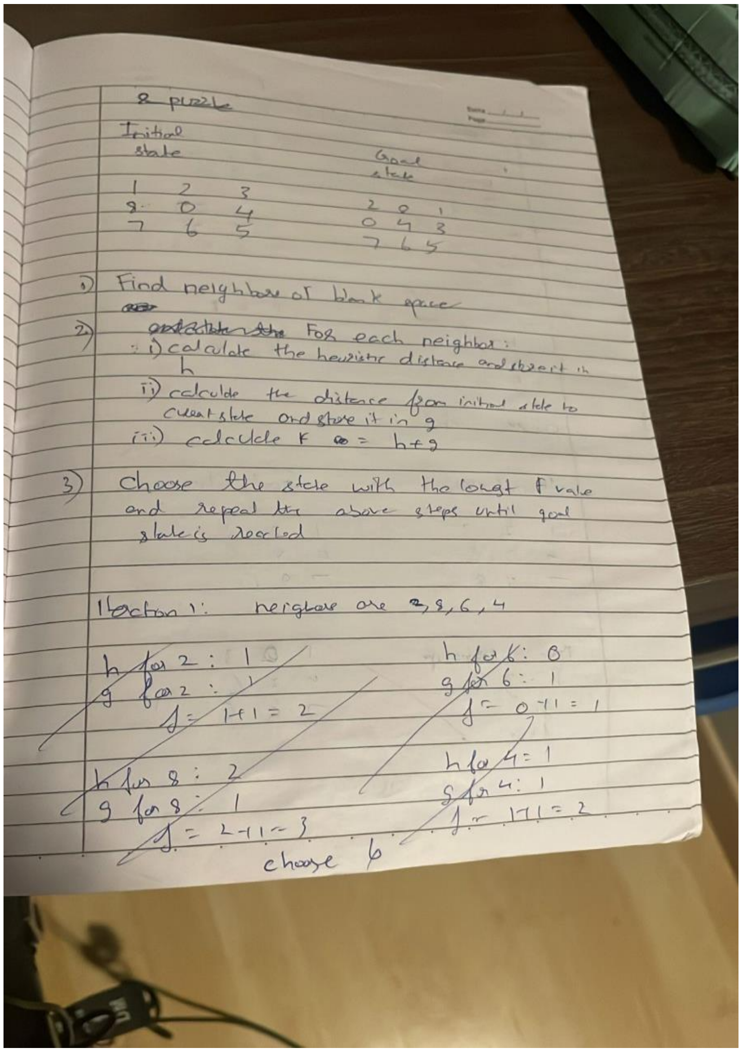
```
        path.append(solution.board) solution
        = solution.previous
    for board in reversed(path):
        for row in board:
            print(row)
        print()

# 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)
```

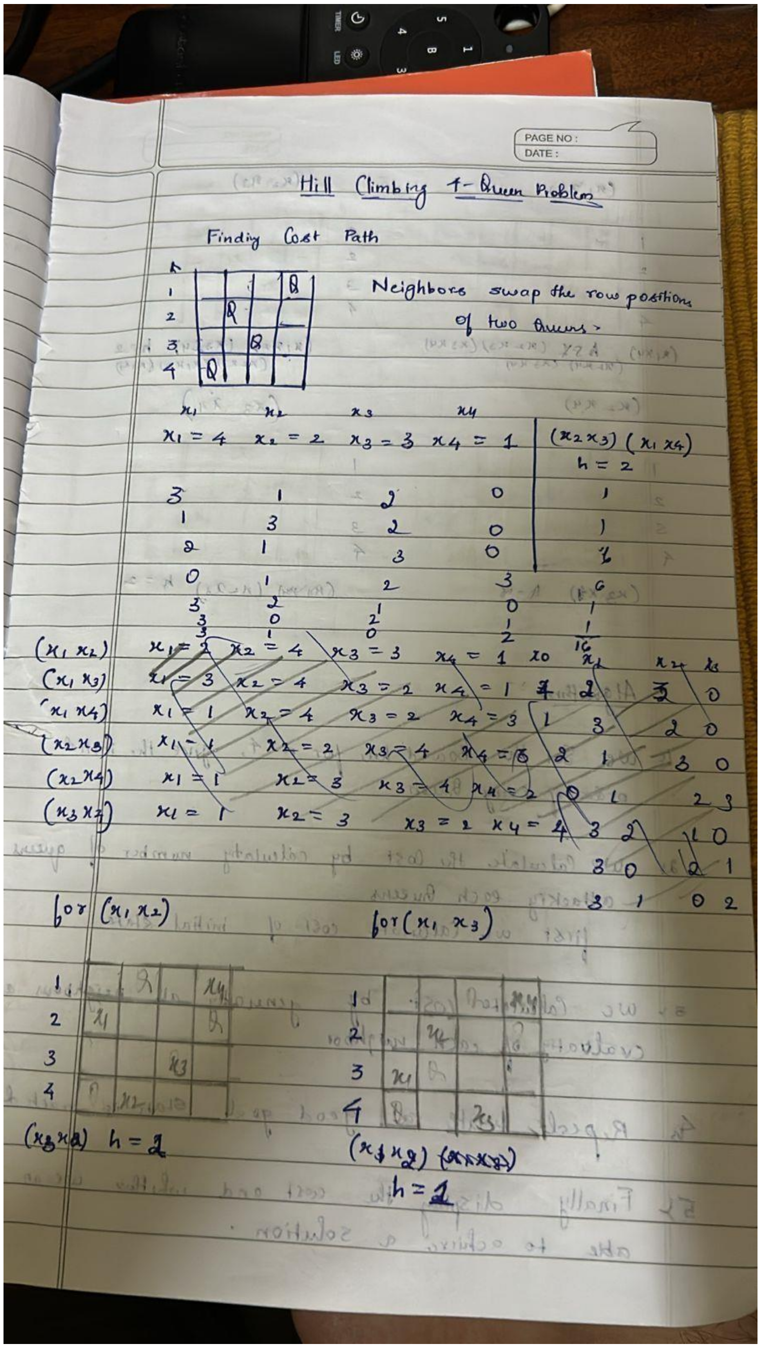
```
Current state:
2 8 3
1 6 4
7 0 5
g(n): 0, h(n): 5, f(n): 5

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:



Hill Climbing 4-Queen Problem

Finding Cost Path

Neighbors swap the row positions of two queens.

$x_1 = 4 \quad x_2 = 2 \quad x_3 = 3 \quad x_4 = 1$

$(x_2 x_3) \; (x_1 x_4)$

$h = 2$

$(x_1 x_2)$ $x_1 = 2$ $x_2 = 4$ $x_3 = 3$ $x_4 = 1$

$(x_1 x_3)$ $x_1 = 3$ $x_2 = 4$ $x_3 = 2$ $x_4 = 1$

$(x_1 x_4)$ $x_1 = 1$ $x_2 = 4$ $x_3 = 2$ $x_4 = 3$

$(x_2 x_3)$ $x_1 = 4$ $x_2 = 2$ $x_3 = 4$ $x_4 = 3$

$(x_2 x_4)$ $x_1 = 1$ $x_2 = 3$ $x_3 = 4$ $x_4 = 2$

$(x_3 x_4)$ $x_1 = 1$ $x_2 = 3$ $x_3 = 2$ $x_4 = 4$

for (x_1, x_2)

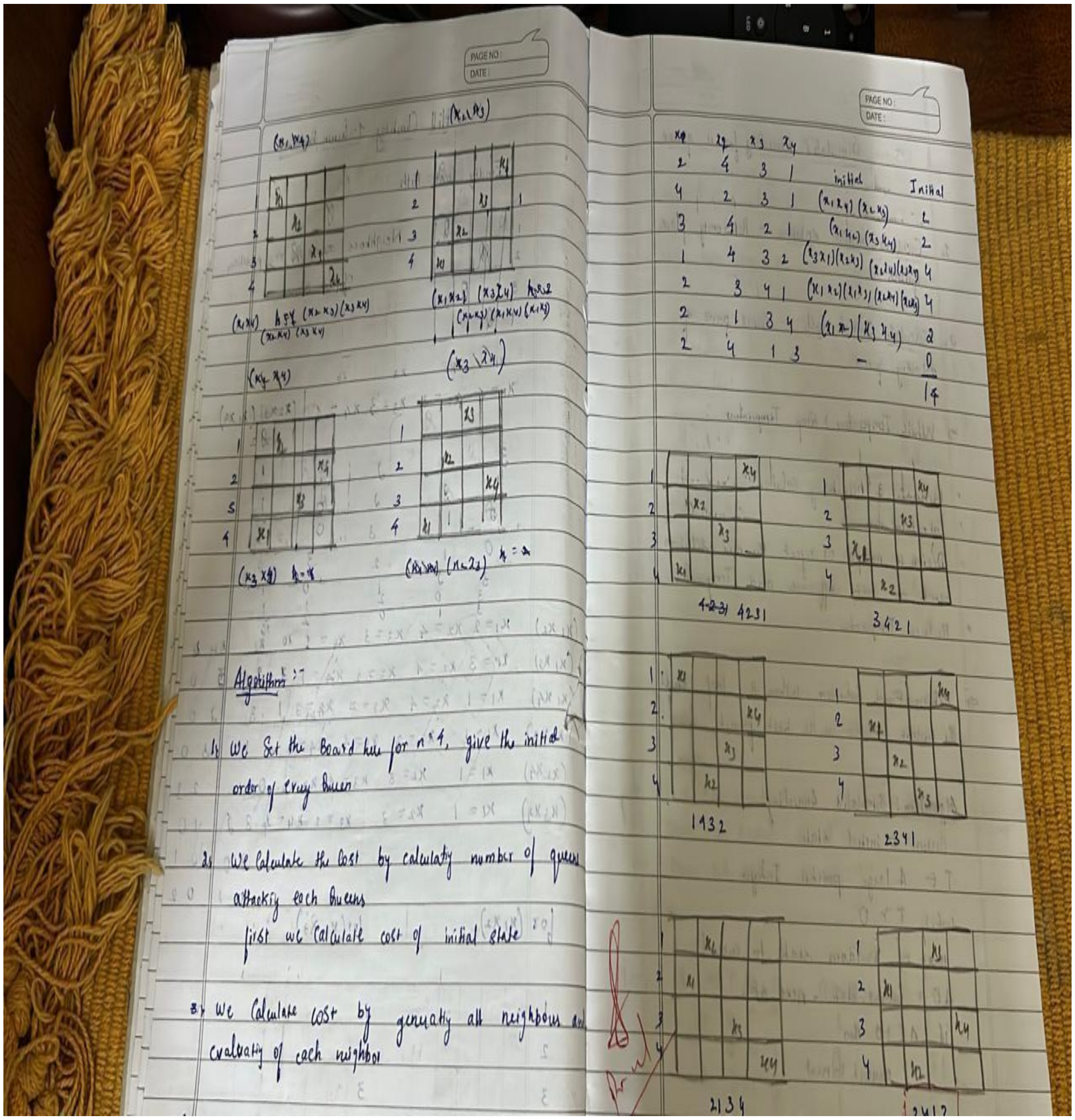
$(x_3 x_4)$ $h = 2$

for (x_1, x_3)

$(x_1 x_2)$

$h = 2$

`



Algorithm :-

1) We set the Board here for n=4, give the initial order of every queen

2) We calculate the cost by calculating number of queens attacking each queens
first we calculate cost of initial state

3) We calculate cost by generating all neighbours and evaluating of each neighbor

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 =
```

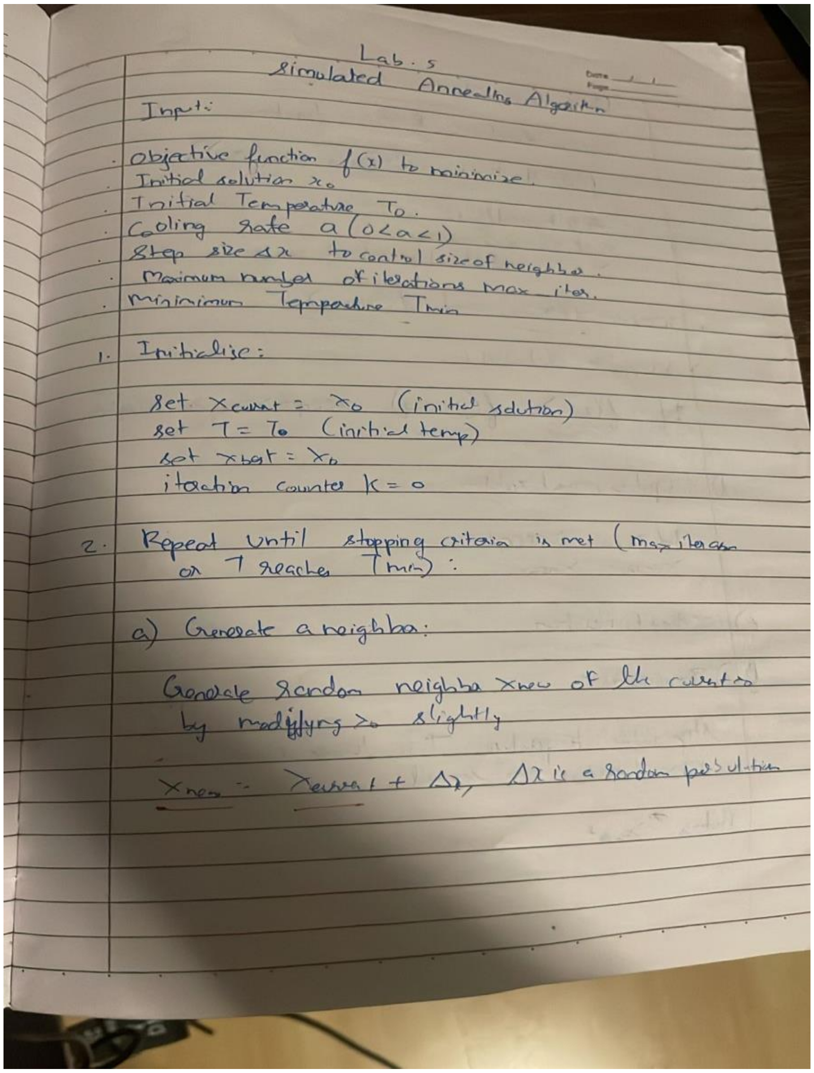
```
hill_climbing(n)
print("Final Board
Configuration:")
print_board(solution)
print("Number of Cost:",
cost)
```

```
================
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:



Lab. 5

Simulated Annealing Algorithm

Input:

- Objective function $f(x)$ to minimize.
- Initial solution x_0
- Initial Temperature T_0.
- Cooling rate a $(0 < a < 1)$
- Step size Δx to control size of neighbor.
- Maximum number of iterations max_iter.
- Minimum Temperature T_{min}

1. Initialise:

   set $x_{current} = x_0$ (initial solution)
   set $T = T_0$ (initial temp)
   set $x_{best} = x_0$
   iteration counter $k = 0$

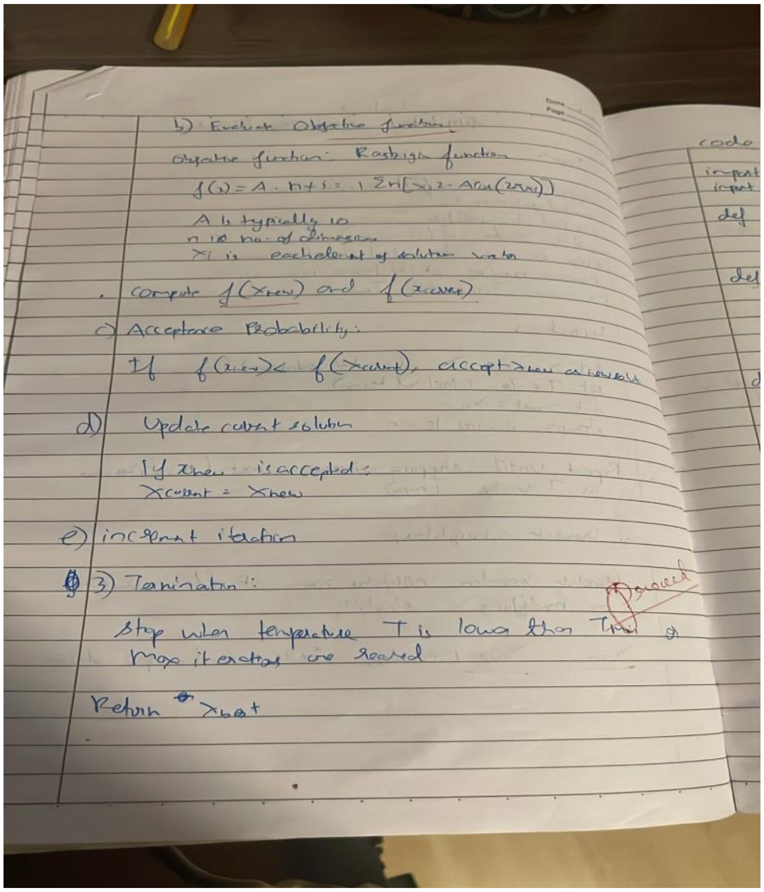
2. Repeat until stopping criteria is met (max iteration or T reaches T_{min}):

   a) Generate a neighbor:

   Generate random neighbor x_{new} of the current x_0 by modifying x_0 slightly

   $x_{new} = x_{current} + \Delta x$, Δx is a random perturbation

`


b) Evaluate Objective function
Objective function: Rastrigin function
$f(x) = A \cdot n + \sum_{i=1}^{n} [x_i^2 - A\cos(2\pi x_i)]$
A is typically 10
n is no. of dimension
x_i is each element of solution vector
• Compute $f(x_{new})$ and $f(x_{current})$
c) Acceptance Probability:
If $f(x_{new}) < f(x_{current})$, accept x_{new} as a new solution
d) Update current solution
If x_{new} is accepted:
$x_{current} = x_{new}$
e) increment iteration
3) Termination:
Stop when temperature T is lower than T_{min} or
Max iterations are reached
Return x_{best}

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)]
```

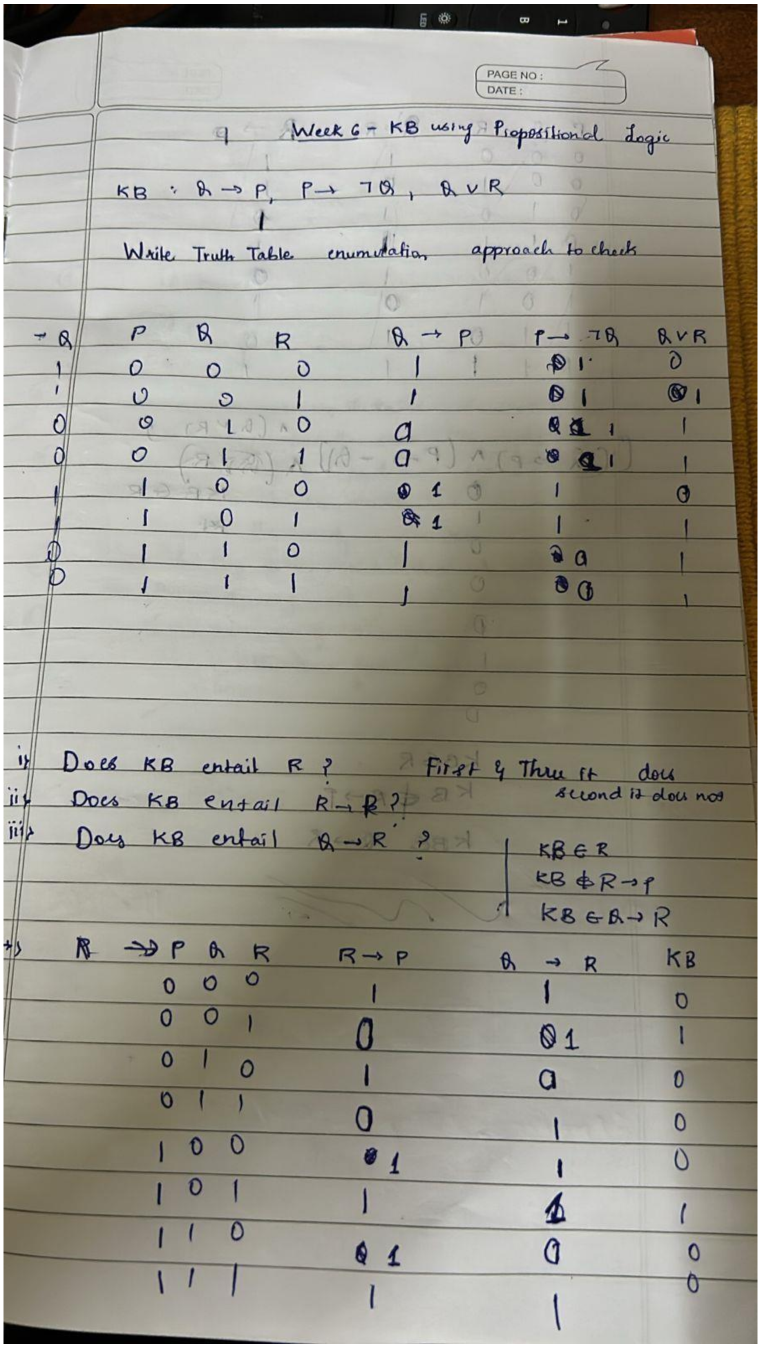
```
# Use dual_annealing for simulated annealing optimization result
= dual_annealing(queens_max, bounds)

# 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:



Week 6 - KB using Propositional Logic

KB : $Q \to P$, $P \to \neg Q$, $Q \vee R$

Write Truth Table enumeration approach to check

$\neg Q$	P	Q	R	$Q \to P$	$P \to \neg Q$	$Q \vee R$
1	0	0	0	1	1	0
1	0	0	1	1	1	1
0	0	1	0	0	1	1
0	0	1	1	0	1	1
1	1	0	0	1	1	0
1	1	0	1	1	1	1
0	1	1	0	1	0	1
0	1	1	1	1	0	1

i) Does KB entail R ? First & Three it does

ii) Does KB entail $R \to P$? second it does not

Does KB entail $Q \to R$?

$KB \models R$

$KB \not\models R \to P$

$KB \models Q \to R$

P	Q	R	$R \to P$	$Q \to R$	KB
0	0	0	1	1	0
0	0	1	0	1	1
0	1	0	1	0	0
0	1	1	0	1	0
1	0	0	1	1	0
1	0	1	1	1	1
1	1	0	1	0	0
1	1	1	1	1	0

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
```

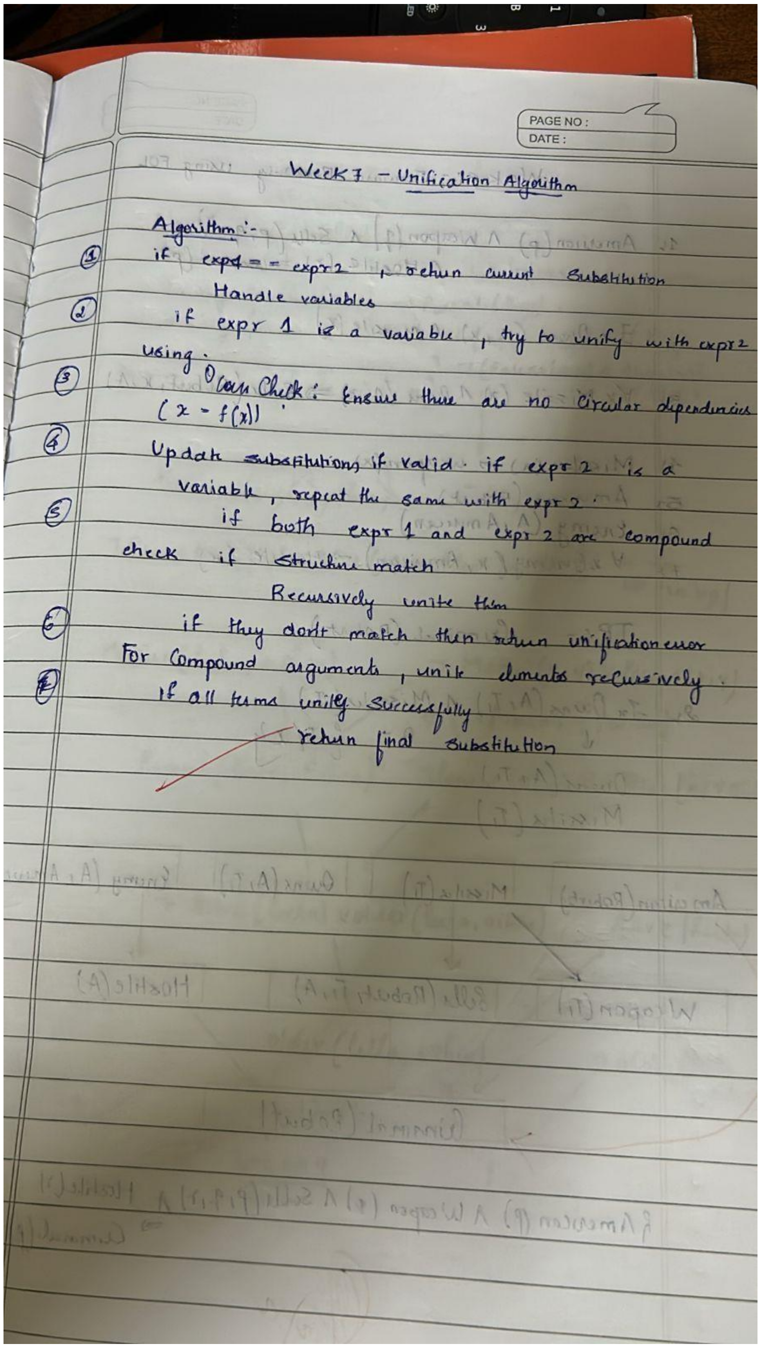
```
        # Evaluate the knowledge base (KB) and query expressions
        kb_result = evaluate_expression(a, b, c, kb)
        query_result = evaluate_expression(a, b, c, query)

        # 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: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Week 7 – Unification Algorithm

Algorithm :-

① if expr1 == expr2 , return current substitution
Handle variables

② if expr 1 is a variable , try to unify with expr2 using .

③ Occurs Check : Ensure there are no circular dependencies (x = f(x))

④ Update substitutions if valid . if expr 2 is a variable , repeat the same with expr 2 .

⑤ if both expr 1 and expr 2 are compound check if structure match
Recursively unite them

⑥ if they don't match then return unification error
For Compound arguments , unite elements recursively .

⑦ if all terms unify successfully
return final substitution

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()
```

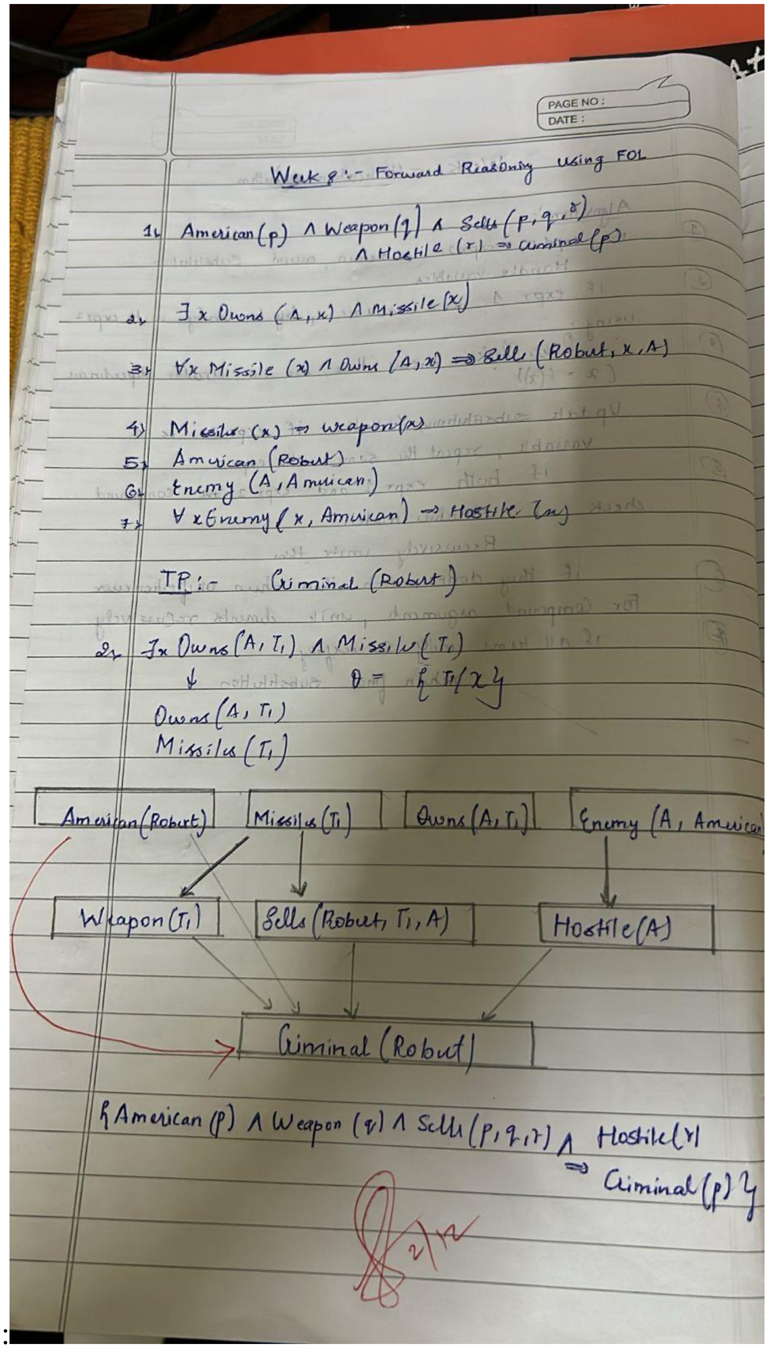
```
Enter the first expression (e.g., p(x, f(y))): p(b,x,f(g(z)))
Enter the second expression (e.g., p(a, f(z))): p(z,f(y),f(y))
Expression 1: ['p', '(b', 'x', ['f', '(g(z)))']]
Expression 2: ['p', '(z', ['f', '(y)'], ['f', '(y))']]
Result: Unification Successful
Substitutions: {'(b': '(z', 'x': ['f', '(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:



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Week 8 :- Forward Reasoning using FOL

1) American(p) ∧ Weapon(q) ∧ Sells(p, q, r) ∧ Hostile(r) ⇒ Criminal(p)

2) ∃x Owns(A, x) ∧ Missile(x)

3) ∀x Missile(x) ∧ Owns(A, x) ⇒ Sell(Robert, x, A)

4) Missile(x) ⇒ weapon(x)

5) American(Robert)

6) Enemy(A, America)

7) ∀x Enemy(x, America) → Hostile(x)

TP :- Criminal(Robert)

2) ∃x Owns(A, T1) ∧ Missile(T1)   θ = {T1/x}

Owns(A, T1)

Missile(T1)

American(Robert)   Missile(T1)   Owns(A, T1)   Enemy(A, America)

Weapon(T1)   Sells(Robert, T1, A)   Hostile(A)

Criminal(Robert)

{American(p) ∧ Weapon(q) ∧ Sells(p, q, r) ∧ Hostile(r) ⇒ Criminal(p)}

:

Code:

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()
```

`

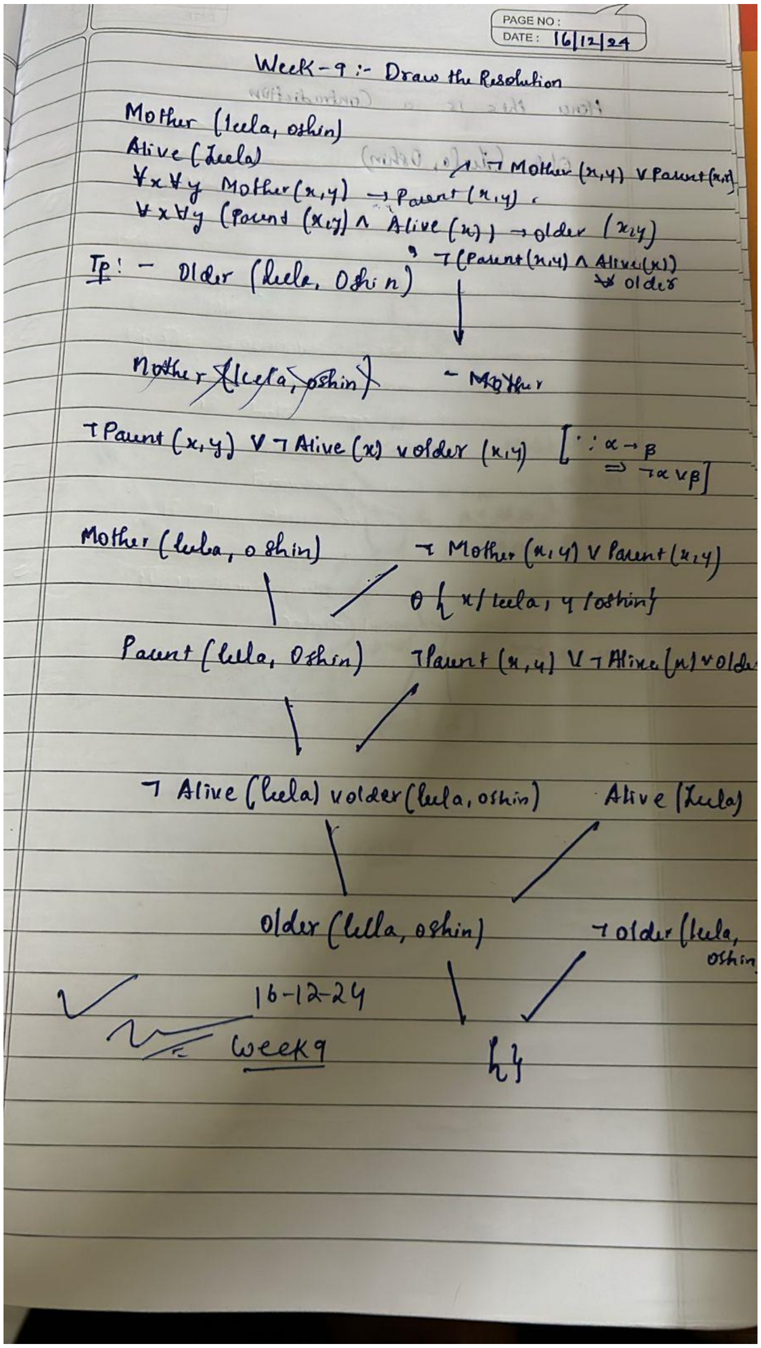
```
Inferred: Weapon(T1)
Inferred: Sells(Robert, T1, A)
Inferred: Hostile(A)
Inferred: Criminal(Robert)
Robert is a criminal!
```

`

Program 9

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

Algorithm:



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'}")
```

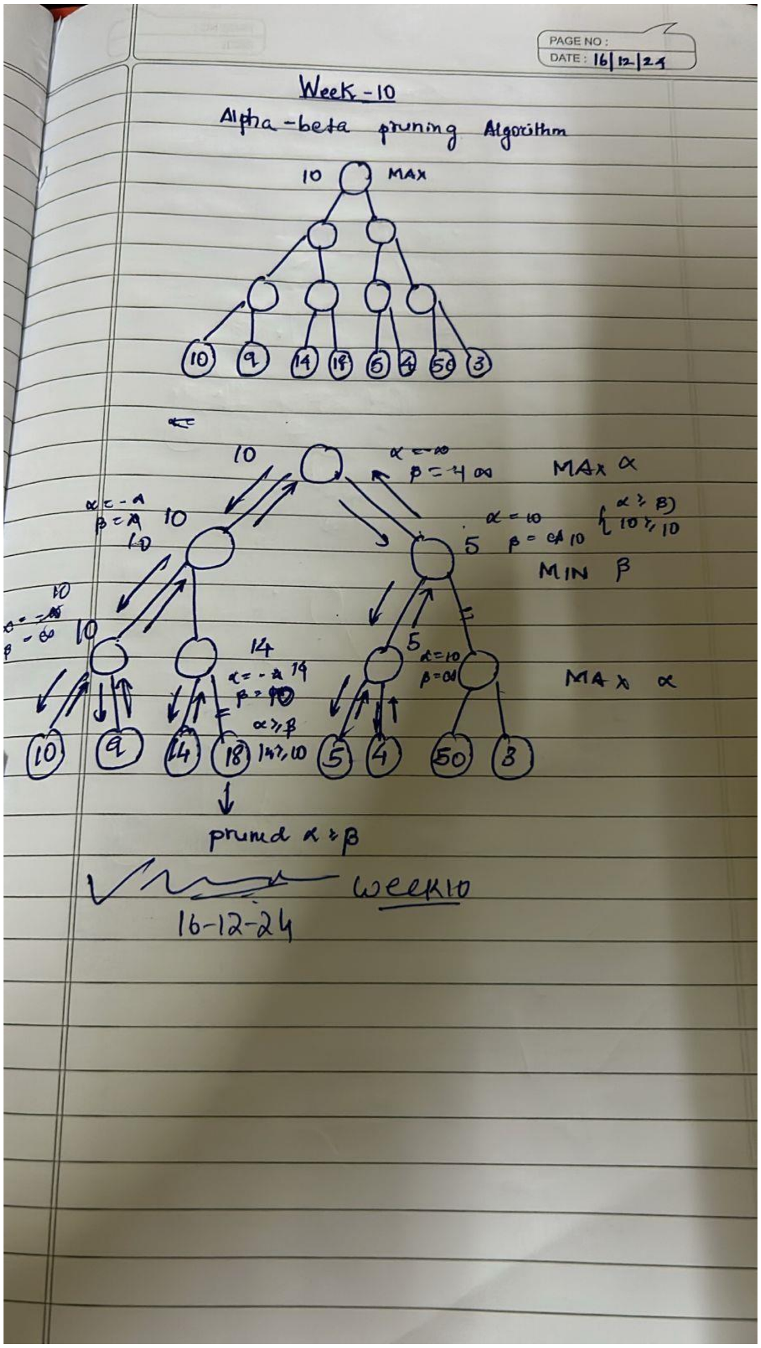
`

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

Program 10

Implement Alpha-Beta Pruning.

Algorithm:



Code:

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

`

```
    return node

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

`

```
            eval = alpha_beta_pruning(child, alpha, beta, True)
            min_eval = min(min_eval, eval) beta = min(beta,
            eval) # Minimize beta if beta <= alpha: # Prune the
            branch 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()
```

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