VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

Artificial Intelligence (23CS5PCAIN)

Submitted by

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

B.M.S. COLLEGE OF ENGINEERING
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B.M.S. College of Engineering,
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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Artificial Intelligence (23CS5PCAIN)" carried out by **Shreyas T S (1BM23CS322),** 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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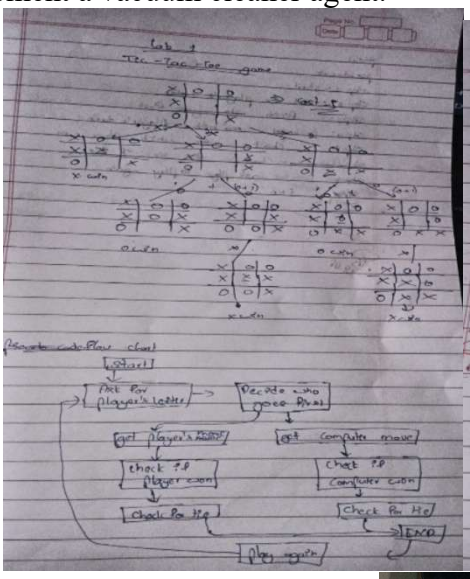
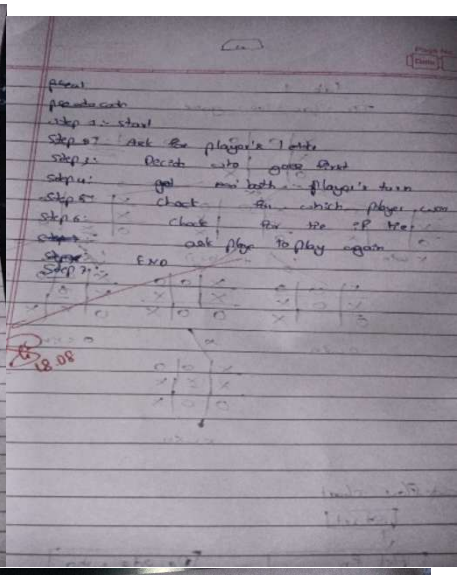
Github Link: https://github.com/Shreyes45/AI-lab

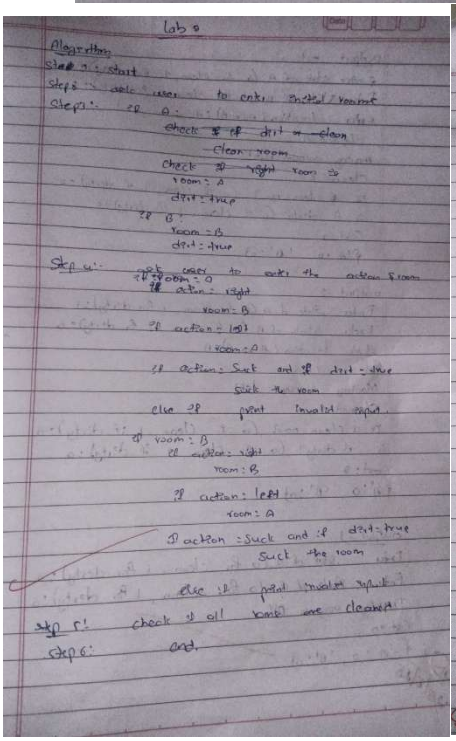
Program 1

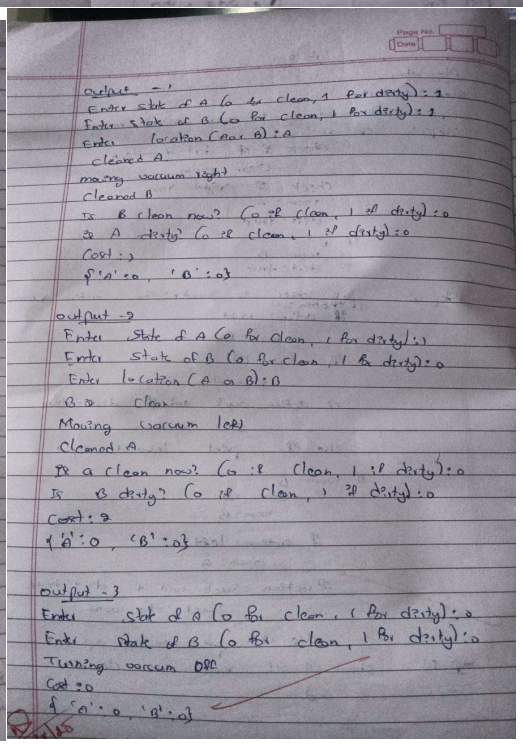
Implement Tic –Tac –Toe Game.

Implement a vacuum cleaner agent.









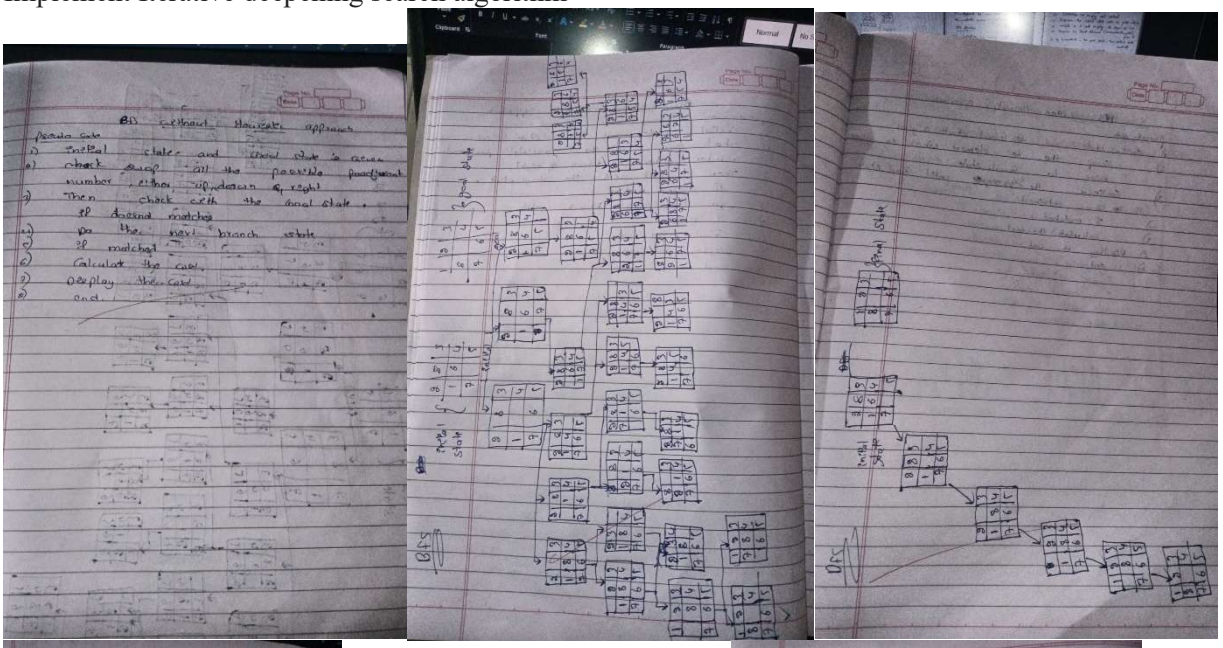
```
print("Shreyas t s 1BM23CS322")

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

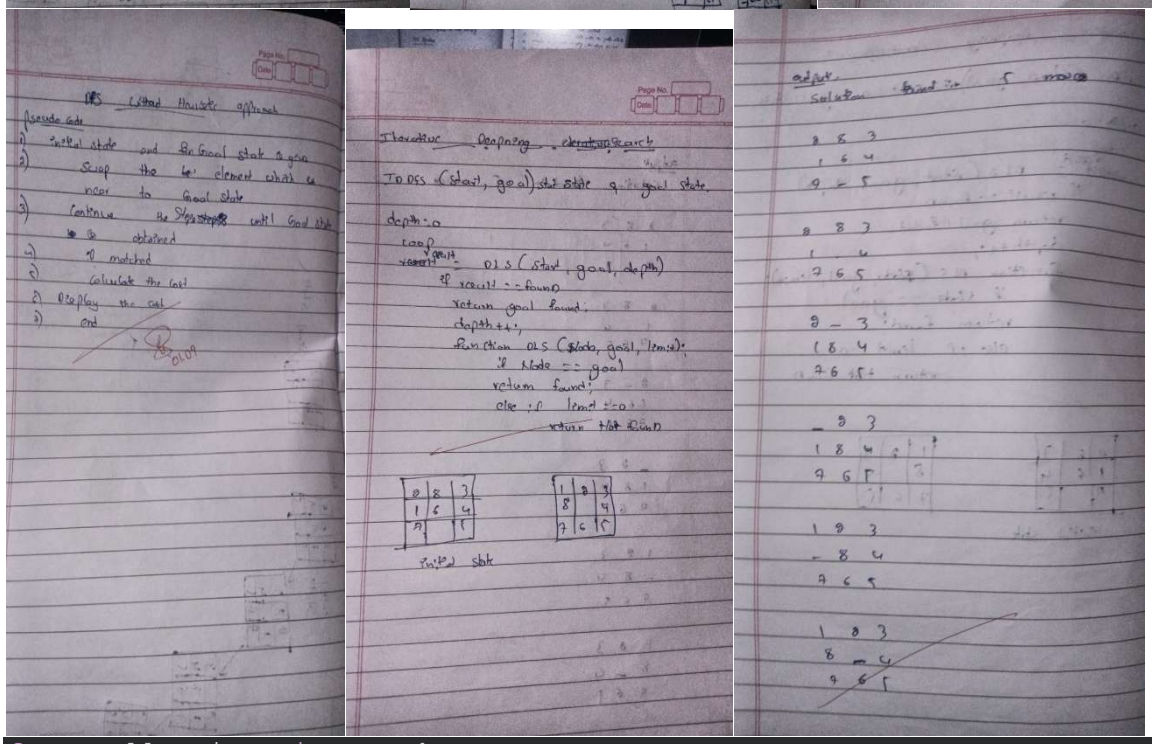
```
def check_win(board, player):
    for row in board:
        if all([cell == player for cell in row]):
            return True
    for col in range(3):
        if all([board[row][col] == player for row in range(3)]):
            return True
    if board[0][0] == board[1][1] == board[2][2] == player:
        return True
    if board[0][2] == board[1][1] == board[2][0] == player:
        return True
    return False

def check_draw(board):
    for row in board:
        if " " in row:
            return False
    return True

def play_game():
    board = [[" " for _ in range(3)] for _ in range(3)]
    players = ["X", "O"]
    current_player = 0

    while True:
        print_board(board)
        player = players[current_player]
        try:
            row = int(input(f"Player {player}, enter row (0-2): "))
            col = int(input(f"Player {player}, enter column (0-2): "))
            if not (0 <= row <= 2 and 0 <= col <= 2):
                print("Invalid input. Row and column must be between 0 and 2.")
                continue
        except ValueError:
            print("Invalid input. Please enter a number.")
            continue


        if board[row][col] == " ":
            board[row][col] = player
            if check_win(board, player):
                print_board(board)
                print(f"Player {player} wins!")
                break
            elif check_draw(board):
                print_board(board)
                print("It's a draw!")
```

```
            break
        else:
            current_player = (current_player + 1) % 2
    else:
        print("That spot is already taken! Try again.")

play_game()
print("Shreyas t s 1BM23CS322")

rooms = {'A': True, 'B': True}

current_room = input("Enter starting room (A/B): ").upper()
while current_room not in rooms:
    current_room = input("Invalid input. Enter starting room (A/B): ").upper()

def suck(room):
    if rooms[room]:
        print(f"Sucking dirt in room {room}.")
        rooms[room] = False
    else:
        print(f"Room {room} is already clean.")

def move(direction):
    global current_room
    if direction == "left" and current_room == "B":
        current_room = "A"
        print("Moved left to room A.")
    elif direction == "right" and current_room == "A":
        current_room = "B"
        print("Moved right to room B.")
    else:
        print("Cannot move in that direction from current room.")

while rooms['A'] or rooms['B']:
    print(f"\nCurrent room: {current_room}")
    print(f"Room A dirty? {rooms['A']}")
    print(f"Room B dirty? {rooms['B']}")
    action = input("Enter action (left, right, suck): ").lower()
    if action == "suck":
        suck(current_room)
    elif action in ["left", "right"]:
        move(action)
    else:
        print("Invalid action. Try again.")

print("Both rooms are clean.")
```

Program 2

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





```
from collections import deque

print("Shreyas ts , 1BM23CS322\n")

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

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

directions = {'Up': (-1, 0), 'Down': (1, 0), 'Left': (0, -1), 'Right': (0,
1)}

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

def swap_positions(state, pos1, pos2):
    state_list = [list(row) for row in state]
    r1, c1 = pos1
    r2, c2 = pos2
    state_list[r1][c1], state_list[r2][c2] = state_list[r2][c2],
state_list[r1][c1]
    return tuple(tuple(row) for row in state_list)

def get_neighbors(state):
    neighbors = []
    r, c = get_blank_pos(state)
    for move, (dr, dc) in directions.items():
        nr, nc = r + dr, c + dc
        if 0 <= nr < 3 and 0 <= nc < 3:
            new_state = swap_positions(state, (r, c), (nr, nc))
            neighbors.append((new_state, move))
    return neighbors

def dfs_8_puzzle(start, goal):
    stack = []
    visited = set()
    visited.add(start)
    stack.append((start, []))

    levels = []

    while stack:
```

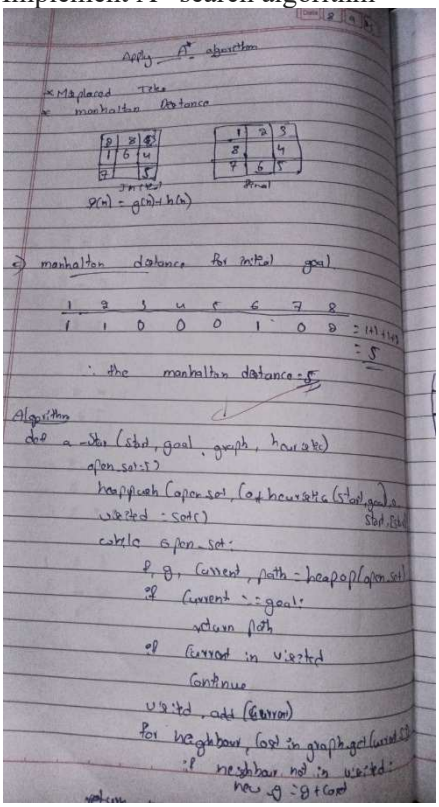
```
        state, path = stack.pop()
        levels.append(state)

        if state == goal:
            return path, levels, len(visited)

        for neighbor, move in get_neighbors(state):
            if neighbor not in visited:
                visited.add(neighbor)
                stack.append((neighbor, path + [move]))

    return None, levels, len(visited)

solution_path, level_states, total_visited = dfs_8_puzzle(initial_state,
goal_state)

print(f"Solution length: {len(solution_path)} moves")
print("Solution moves:", solution_path)
print(f"Total states visited: {total_visited}\n")

print("States traversed:")
for i, state in enumerate(level_states):
    print(f"\nState {i+1}:")
    for row in state:
        print(row)
    print("---")
```

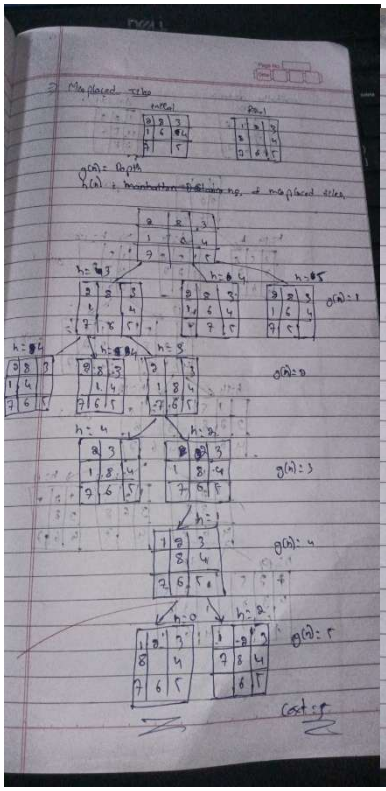
```
print("Shreyas ts  1BM23CS322")

def goal_state_reached(state, goal_state):
    return state == goal_state

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

def get_neighbors(state):
    neighbors = []
```

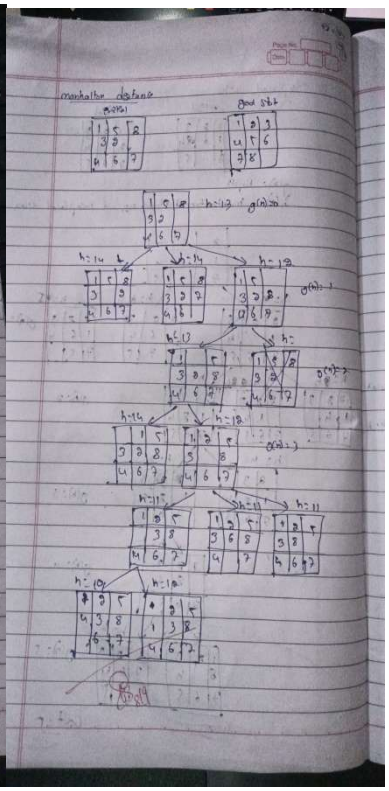
```
    x, y = find_empty(state)
    directions = [(-1, 0), (1, 0), (0, -1), (0, 1)]
    for dx, dy in directions:
        nx, ny = x + dx, y + dy
        if 0 <= nx < 3 and 0 <= ny < 3:
            new_state = [row[:] for row in state]
            new_state[x][y], new_state[nx][ny] = new_state[nx][ny],
new_state[x][y]
            neighbors.append(new_state)
    return neighbors

def depth_limited_dfs(state, goal_state, depth):
    if depth == 0:
        return [state] if goal_state_reached(state, goal_state) else None
    elif depth > 0:
        for neighbor in get_neighbors(state):
            path = depth_limited_dfs(neighbor, goal_state, depth - 1)
            if path:
                return [state] + path
    return None

def iterative_deepening_dfs(start_state, goal_state):
    depth = 0
    while True:
        path = depth_limited_dfs(start_state, goal_state, depth)
        if path:
            return path
        depth += 1

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

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

solution = iterative_deepening_dfs(start_state, goal_state)
for step in solution:
    print(step)
```

Program 3

Implement A* search algorithm







```
import heapq

print("Shreyas t s 1BM23CS322")
goal_state = [[1, 2, 3],
              [4, 5, 6],
              [7, 8, 0]]

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

```
    return distance

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

def get_neighbors(state):
    neighbors = []
    x, y = find_empty(state)
    directions = [(-1, 0), (1, 0), (0, -1), (0, 1)]
    for dx, dy in directions:
        nx, ny = x + dx, y + dy
        if 0 <= nx < 3 and 0 <= ny < 3:
            new_state = [row[:] for row in state]
            new_state[x][y], new_state[nx][ny] = new_state[nx][ny],
new_state[x][y]
            neighbors.append(new_state)
    return neighbors

def a_star(start_state, goal_state):
    open_list = []
    heapq.heappush(open_list, (manhattan_distance(start_state, goal_state), 0,
start_state, []))
    closed_list = set()

    while open_list:
        _, g, current_state, path = heapq.heappop(open_list)
        if current_state == goal_state:
            return path + [current_state]

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

        for neighbor in get_neighbors(current_state):
            if tuple(map(tuple, neighbor)) not in closed_list:
                f = g + 1 + manhattan_distance(neighbor, goal_state)
                heapq.heappush(open_list, (f, g + 1, neighbor, path +
[current_state]))

    return None
```

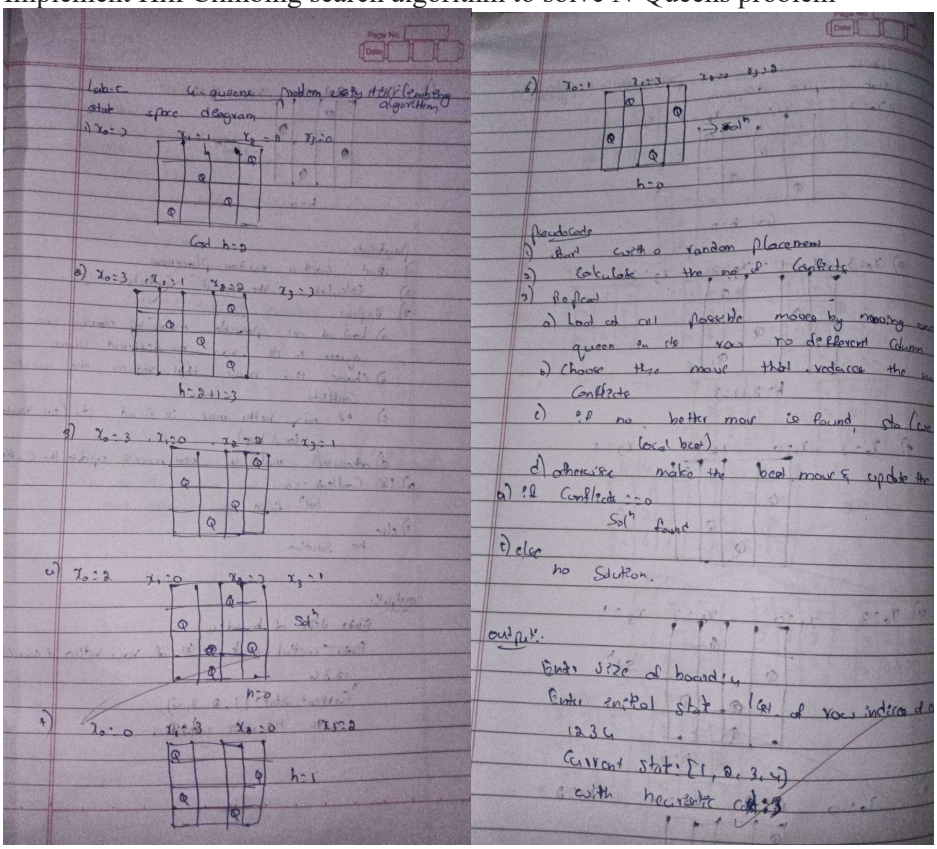
```
start_state = [[1, 2, 3],
               [4, 5, 6],
               [7, 8, 0]]

solution = a_star(start_state, goal_state)
for step in solution:
   print(step)
```

```
import heapq

print("Shreyas ts  1BM23CS322")
goal_state = [[1, 2, 3],
              [4, 5, 6],
              [7, 8, 0]]

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

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

def get_neighbors(state):
   neighbors = []
   x, y = find_empty(state)
   directions = [(-1, 0), (1, 0), (0, -1), (0, 1)]
   for dx, dy in directions:
       nx, ny = x + dx, y + dy
       if 0 <= nx < 3 and 0 <= ny < 3:
           new_state = [row[:] for row in state]
           new_state[x][y], new_state[nx][ny] = new_state[nx][ny],
```

```
new_state[x][y]
            neighbors.append(new_state)
    return neighbors

def a_star(start_state, goal_state):
    open_list = []
    heapq.heappush(open_list, (misplaced_tiles(start_state, goal_state), 0,
start_state, []))
    closed_list = set()

    while open_list:
        _, g, current_state, path = heapq.heappop(open_list)
        if current_state == goal_state:
            return path + [current_state]

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

        for neighbor in get_neighbors(current_state):
            if tuple(map(tuple, neighbor)) not in closed_list:
                f = g + 1 + misplaced_tiles(neighbor, goal_state)
                heapq.heappush(open_list, (f, g + 1, neighbor, path +
[current_state]))

    return None

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

solution = a_star(start_state, goal_state)
for step in solution:
    print(step)
```

Program 4

Implement Hill Climbing search algorithm to solve N-Queens problem

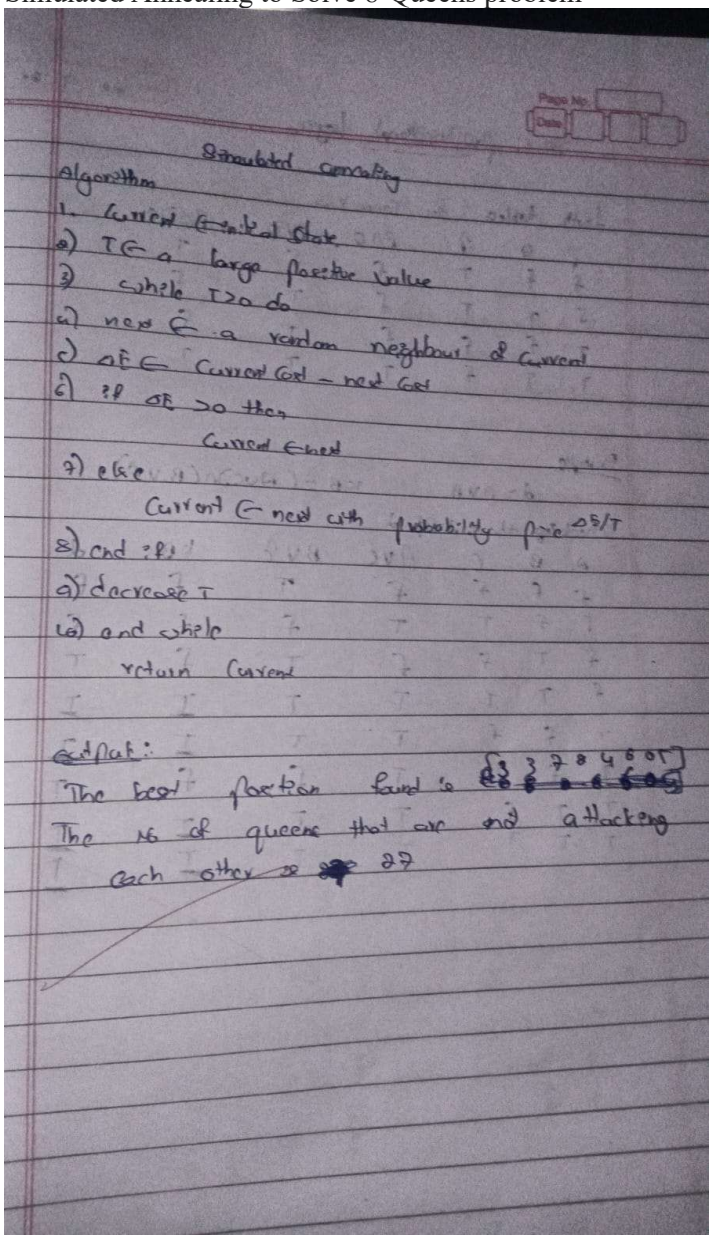


```
import random

def create_board():
    return [random.randint(0, 3) for _ in range(4)]

def calculate_conflicts(board):
    conflicts = 0
    for i in range(4):
        for j in range(i + 1, 4):
            if board[i] == board[j] or abs(board[i] - board[j]) == j - i:
                conflicts += 1
    return conflicts

def hill_climbing():
    board = create_board()
    print(f"Initial board: {board} with conflicts: {calculate_conflicts(board)}")

    while True:
        current_conflicts = calculate_conflicts(board)
        if current_conflicts == 0:
            return board
        next_board = None
```

```
        next_conflicts = float('inf')
        for i in range(4):
            temp_board = board[:]
            for j in range(4):
                if temp_board[i] != j:
                    temp_board[i] = j
                    temp_conflicts = calculate_conflicts(temp_board)
                    print(f"Board: {temp_board} with conflicts: {temp_conflicts}")
                    if temp_conflicts < next_conflicts:
                        next_conflicts = temp_conflicts
                        next_board = temp_board[:]
        if next_conflicts >= current_conflicts:
            return board
        board = next_board

solution = hill_climbing()
print(f"Final solution: {solution}")
```

Program 5

Simulated Annealing to Solve 8-Queens problem

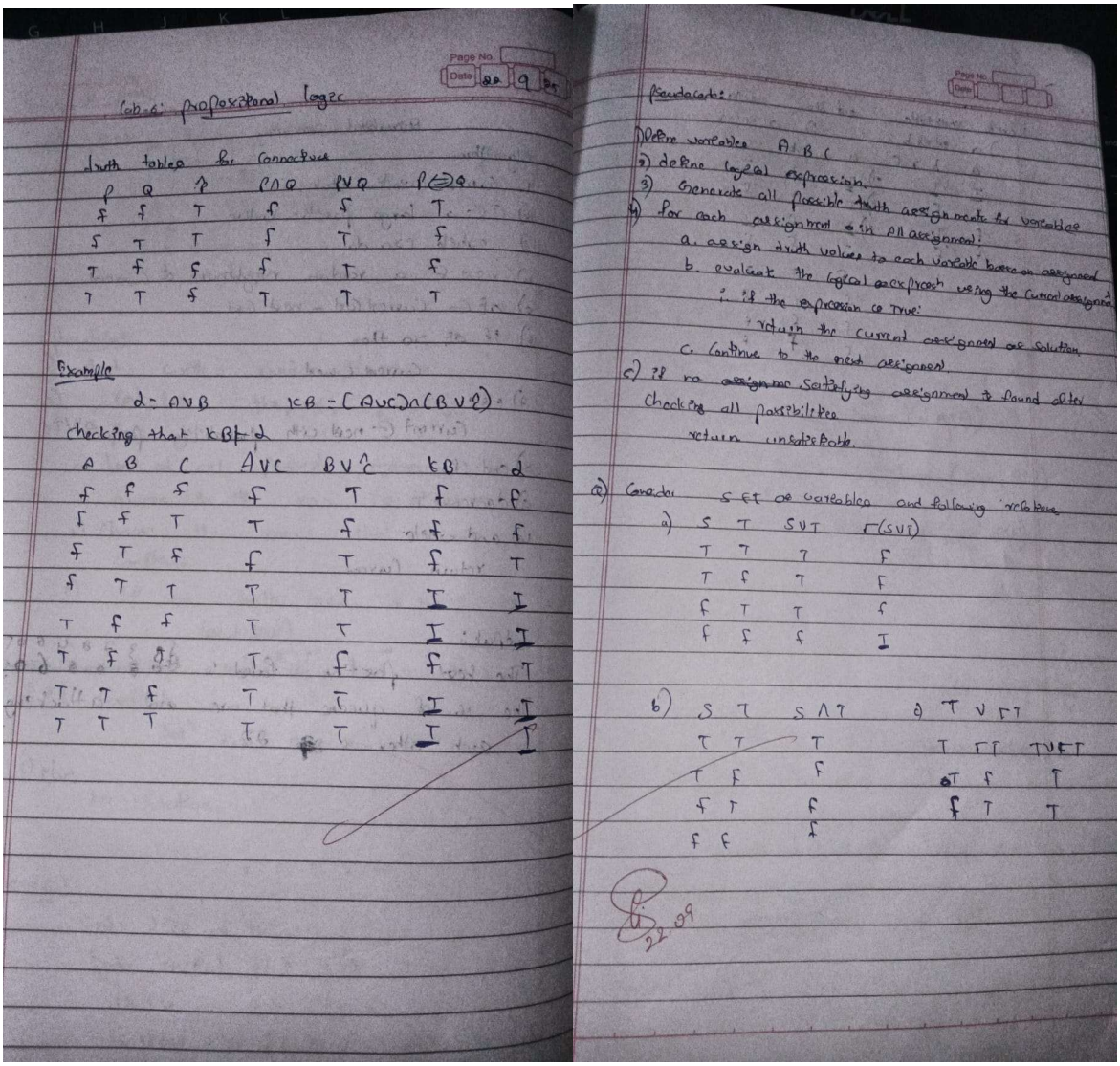



```
import random
import math

print("Shreyas ts  1BM23CS322")
def objective_function(state):
    return sum(state)

def generate_neighbor(state):
    neighbor = state[:]
    index = random.randint(0, len(state) - 1)
```

```
    neighbor[index] = random.randint(1, 100)
    return neighbor

def simulated_annealing(initial_state, initial_temp, cooling_rate,
iterations):
    current_state = initial_state
    current_temp = initial_temp
    best_state = current_state
    best_score = objective_function(current_state)

    for i in range(iterations):
        neighbor = generate_neighbor(current_state)
        current_score = objective_function(current_state)
        neighbor_score = objective_function(neighbor)
        if neighbor_score < best_score:
            best_state = neighbor
            best_score = neighbor_score

        if neighbor_score < current_score or random.random() <
math.exp((current_score - neighbor_score) / current_temp):
            current_state = neighbor

        current_temp *= cooling_rate

    return best_state, best_score

initial_state = [random.randint(1, 100) for _ in range(10)]
initial_temp = 1000
cooling_rate = 0.99
iterations = 1000

best_state, best_score = simulated_annealing(initial_state, initial_temp,
cooling_rate, iterations)
print("Best State:", best_state)
print("Best Score:", best_score)
```

Program 6

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

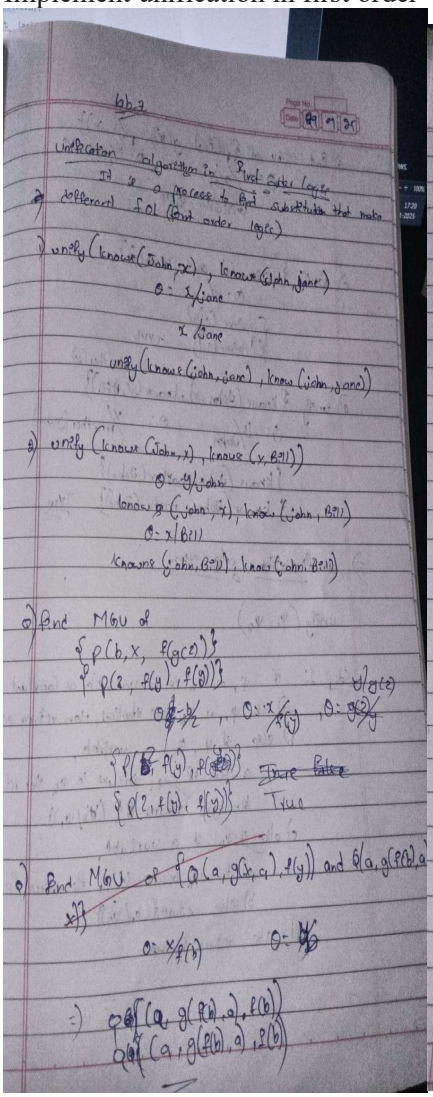


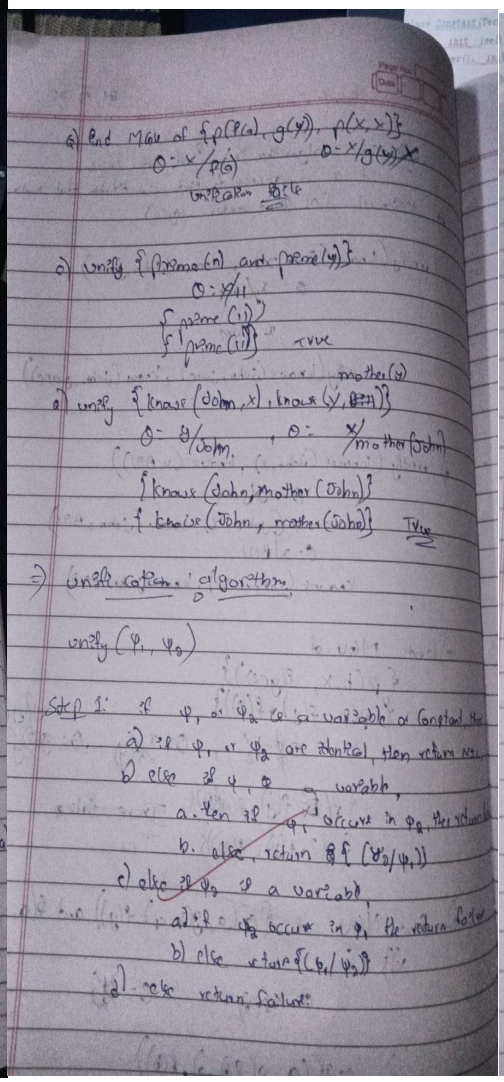
```
import itertools

def evaluate_expression(expression, assignment):
    expression = expression.replace('A', str(assignment[0]))
    expression = expression.replace('B', str(assignment[1]))
    expression = expression.replace('C', str(assignment[2]))
    expression = expression.replace('and', 'and').replace('or', 'or').replace('not', 'not')
    return eval(expression)

def check_entailment(alpha, kb):
    variables = ['A', 'B', 'C']
    all_assignments = list(itertools.product([False, True], repeat=len(variables)))
```

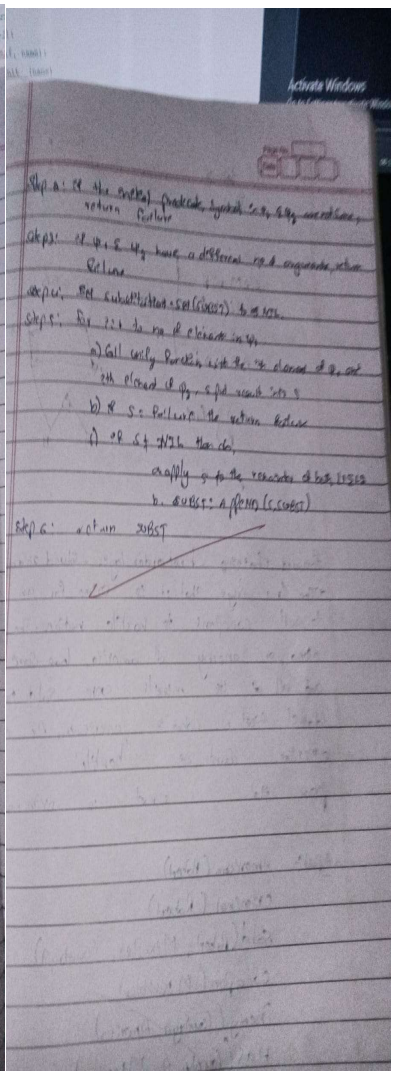
```
    print("Truth Table:")
    print("A\tB\tC\tKB\tα")
    for assignment in all_assignments:
        kb_result = evaluate_expression(kb, assignment)
        alpha_result = evaluate_expression(alpha, assignment)

        print(f"{assignment[0]}\t{assignment[1]}\t{assignment[2]}\t{kb_result}\t{alpha_result}")

        if kb_result and not alpha_result:
            return False

    return True

alpha = "A or B"
kb = "(A or C) and (B and not C)"

if check_entailment(alpha, kb):
    print("KB entails α")
else:
    print("KB does not entail α")
```

Program 7

Implement unification in first order logic.







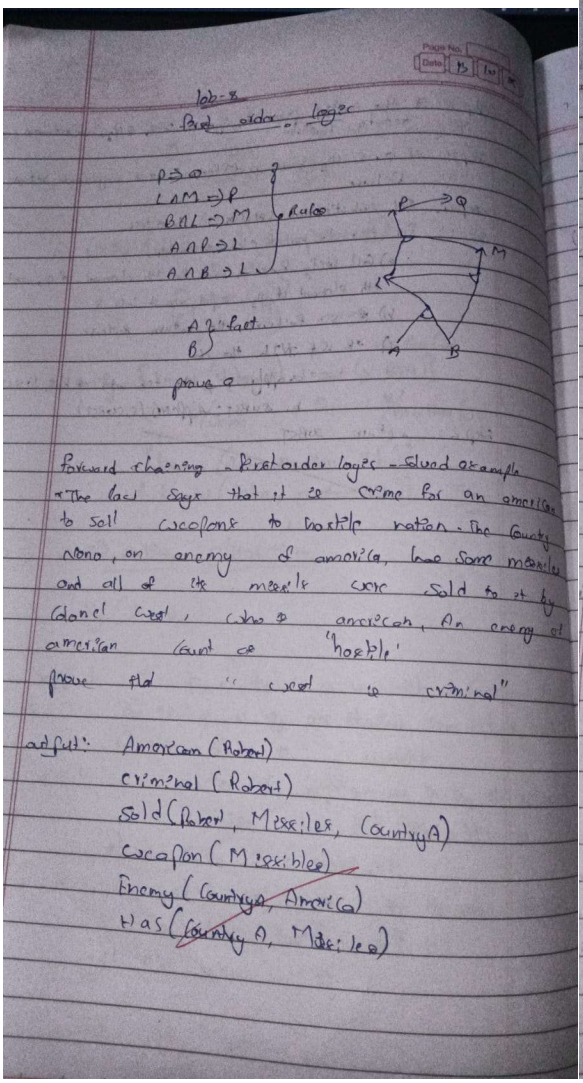
```
print("Shreyas ts  1BM23CS322")
class Term:
    def __init__(self, name):
        self.name = name

    def __repr__(self):
        return self.name

class Variable(Term):
    def __init__(self, name):
        super().__init__(name)

class Constant(Term):
```

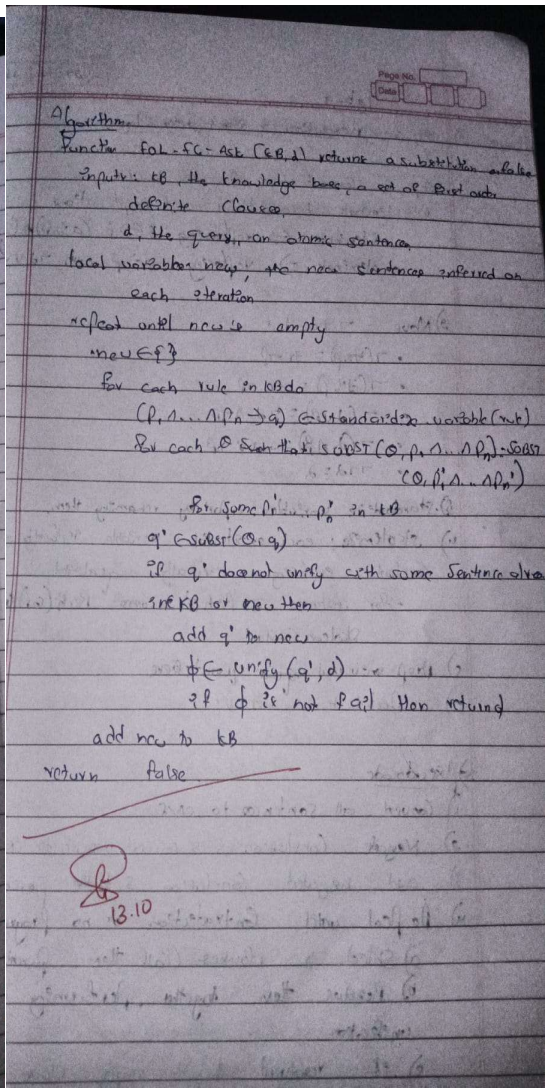
```
    def __init__(self, name):
        super().__init__(name)

class Predicate:
    def __init__(self, symbol, terms):
        self.symbol = symbol
        self.terms = terms

    def __repr__(self):
        return f"{self.symbol}({', '.join(map(str, self.terms))})"

def unify(x, y, subst):
    if subst is None:
        return None

    if x == y:
        return subst

    elif isinstance(x, Variable) and not isinstance(y, Variable):
        return unify_var(x, y, subst)

    elif isinstance(y, Variable) and not isinstance(x, Variable):
        return unify_var(y, x, subst)

    elif isinstance(x, Predicate) and isinstance(y, Predicate):
        if x.symbol != y.symbol:
            raise Exception(f"Cannot unify predicates with different symbols:
{x} and {y}")
        else:
            return unify_lists(x.terms, y.terms, subst)

    else:
        raise Exception(f"Unification failed: {x} and {y} are not unifiable")

def unify_var(var, term, subst):
    if var in subst:
        return unify(subst[var], term, subst)

    if occurs_check(var, term):
        raise Exception(f"Occurs check failed: {var} cannot be unified with
{term}")
```

```
    subst[var] = term
    return subst

def occurs_check(var, term):
    if isinstance(term, Variable):
        return term == var
    elif isinstance(term, Predicate):
        return any(occurs_check(var, t) for t in term.terms)
    return False

def unify_lists(list_x, list_y, subst):
    if len(list_x) != len(list_y):
        raise Exception(f"Cannot unify lists of different lengths: {list_x}
and {list_y}")

    for term_x, term_y in zip(list_x, list_y):
        subst = unify(term_x, term_y, subst)
        if subst is None:
            return None
    return subst

if __name__ == "__main__":
    x = Variable('X')
    y = Variable('Y')
    c = Constant('a')
    p1 = Predicate('father', [x, c])
    p2 = Predicate('father', [y, c])

    substitution = unify(p1, p2, {})
    if substitution is not None:
        print("Unification succeeded:", substitution)
    else:
        print("Unification failed.")
```

Program 8

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



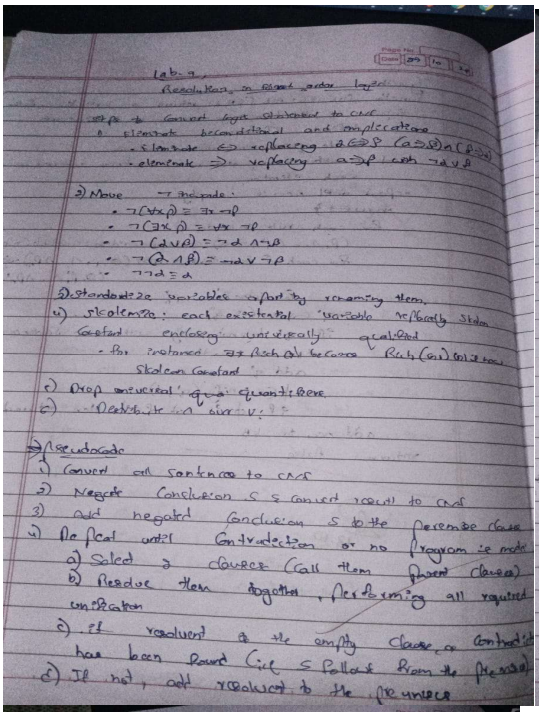


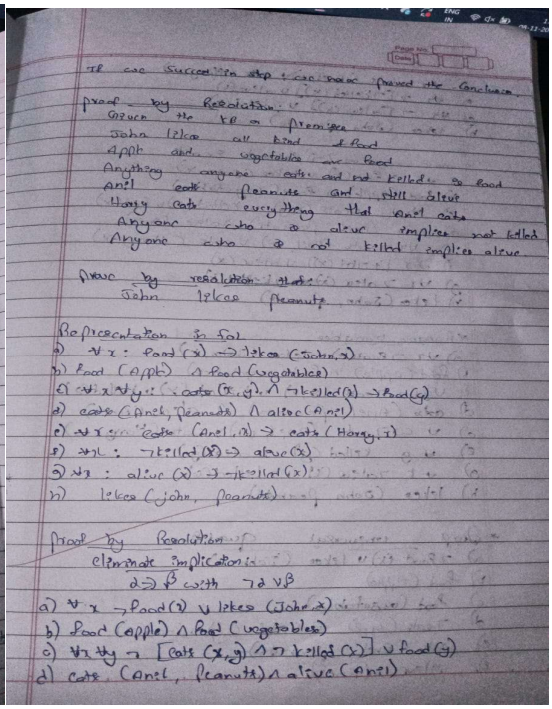

```
def parse_clause(clause):
    if "=>" in clause:
        premises, conclusion = clause.split("=>")
        premises = [p.strip() for p in premises.split("&")]
        conclusion = conclusion.strip()
        return premises, conclusion
    else:
        return [], clause.strip()

def forward_reasoning(kb, query):
    known = set()
    rules = []
    for clause in kb:
        premises, conclusion = parse_clause(clause)
```

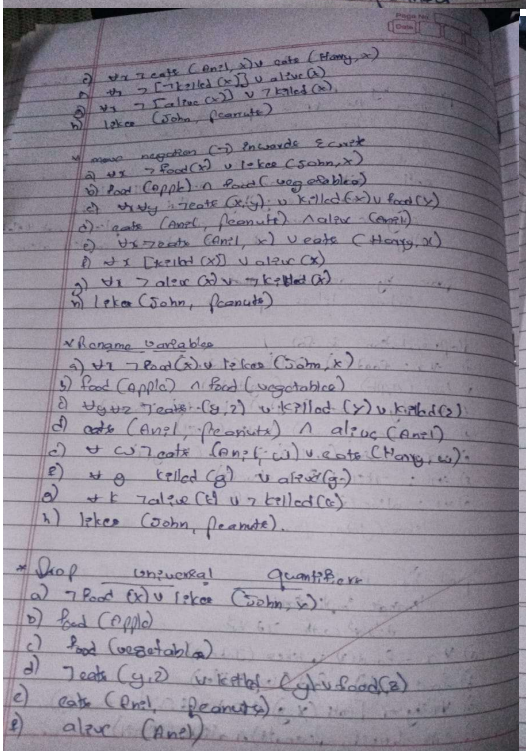
```
        if not premises:
            known.add(conclusion)
        else:
            rules.append((premises, conclusion))

    added = True
    while added:
        added = False
        for premises, conclusion in rules:
            if all(p in known for p in premises) and conclusion not in known:
                known.add(conclusion)
                added = True
            if query in known:
                return True
    return query in known

n = int(input("Enter number of statements in KB: "))
kb = [input(f"Statement {i+1}: ") for i in range(n)]
query = input("Enter query: ")

if forward_reasoning(kb, query):
    print("Query is proved by forward reasoning")
else:
    print("Query cannot be proved")
```

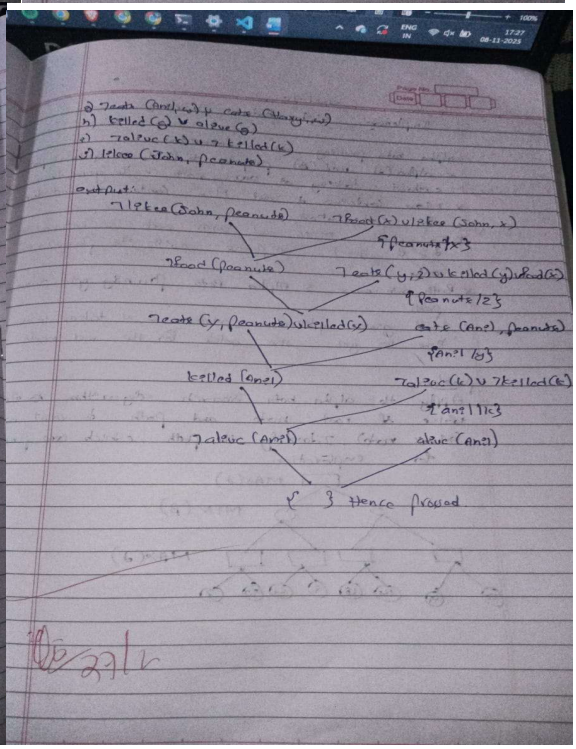
Program 9

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







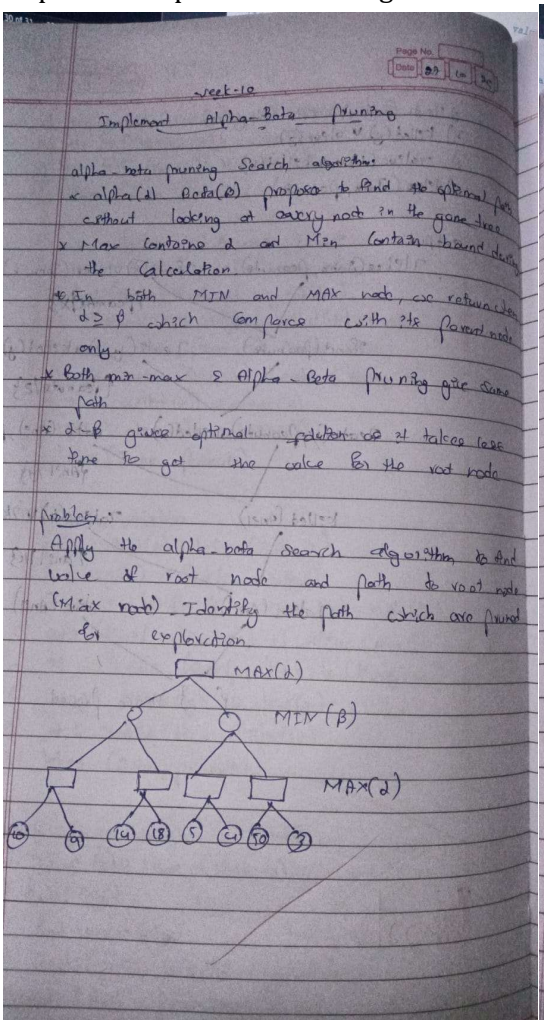


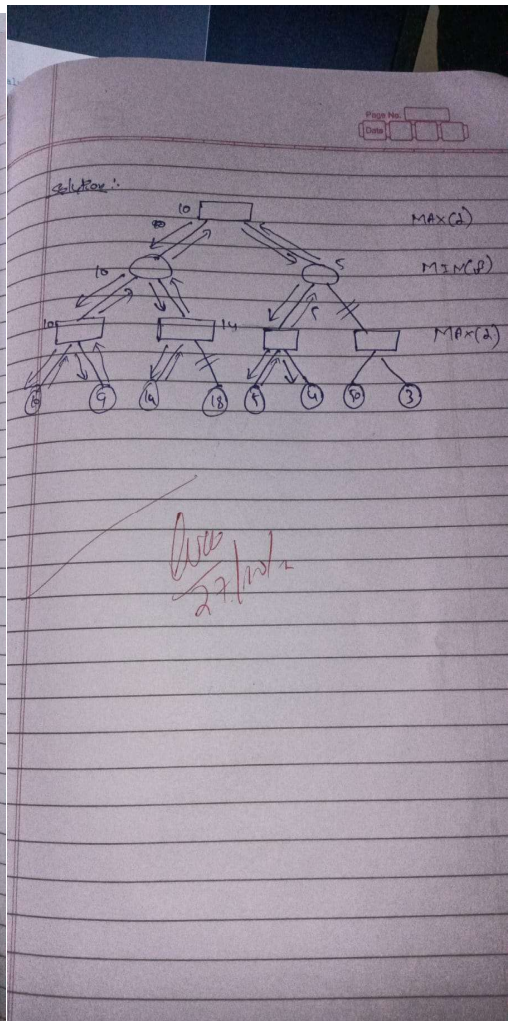
```
from sympy import symbols, Or, Not


P, Q, R = symbols('P Q R')
kb = [
```

```
    (Not(P), Q),
    (Not(Q), R),
    (P,)
]
query = R

def resolve(ci, cj):
    resolvents = set()
    for di in ci:
        for dj in cj:
            if di == Not(dj) or Not(di) == dj:
                new_clause = tuple(sorted(set(ci + cj) - {di, dj}, key=str))
                if not new_clause:
                    resolvents.add(())
                else:
                    resolvents.add(new_clause)
    return resolvents

def pl_resolution(kb, query):
    clauses = kb + [(Not(query),)]
    new = set()
    while True:
        pairs = [(clauses[i], clauses[j]) for i in range(len(clauses)) for j
in range(i+1, len(clauses))]
        for (ci, cj) in pairs:
            resolvents = resolve(ci, cj)
            if () in resolvents:
                return True
            new.update(resolvents)
        if new.issubset(set(clauses)):
            return False
        for c in new:
            if c not in clauses:
                clauses.append(c)

print(pl_resolution(kb, query))
```

Program 10

Implement Alpha-Beta Pruning.






```
import math

def alpha_beta(depth, node_index, is_maximizing, values, alpha, beta,
max_depth):
    indent = "    " * depth
    if depth == max_depth:
        print(f"{indent}Leaf node[{node_index}] = {values[node_index]}")
        return values[node_index]

    if is_maximizing:
        best = -math.inf
        print(f"{indent}MAX node (α={alpha}, β={beta})")
        for i in range(2):
            val = alpha_beta(depth + 1, node_index * 2 + i, False, values,
```

```
alpha, beta, max_depth)
            best = max(best, val)
            alpha = max(alpha, best)
            print(f"{indent}   MAX updating α={alpha}")
            if beta <= alpha:
                print(f"{indent}   β cut-off (β={beta}, α={alpha}) ")
                break
        return best
    else:
        best = math.inf
        print(f"{indent}MIN node (α={alpha}, β={beta})")
        for i in range(2):
            val = alpha_beta(depth + 1, node_index * 2 + i, True, values,
alpha, beta, max_depth)
            best = min(best, val)
            beta = min(beta, best)
            print(f"{indent}   MIN updating β={beta}")
            if beta <= alpha:
                print(f"{indent}   α cut-off (β={beta}, α={alpha}) ")
                break
        return best
values = [10, 9, 14, 18, 5, 4, 50, 3]
max_depth = int(math.log2(len(values)))

print("Leaf Nodes:", values)
result = alpha_beta(0, 0, True, values, -math.inf, math.inf, max_depth)
print("\nOptimal value:", result)
```