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 **Dharunya Balavelavan (1BM23CS090),** who is a 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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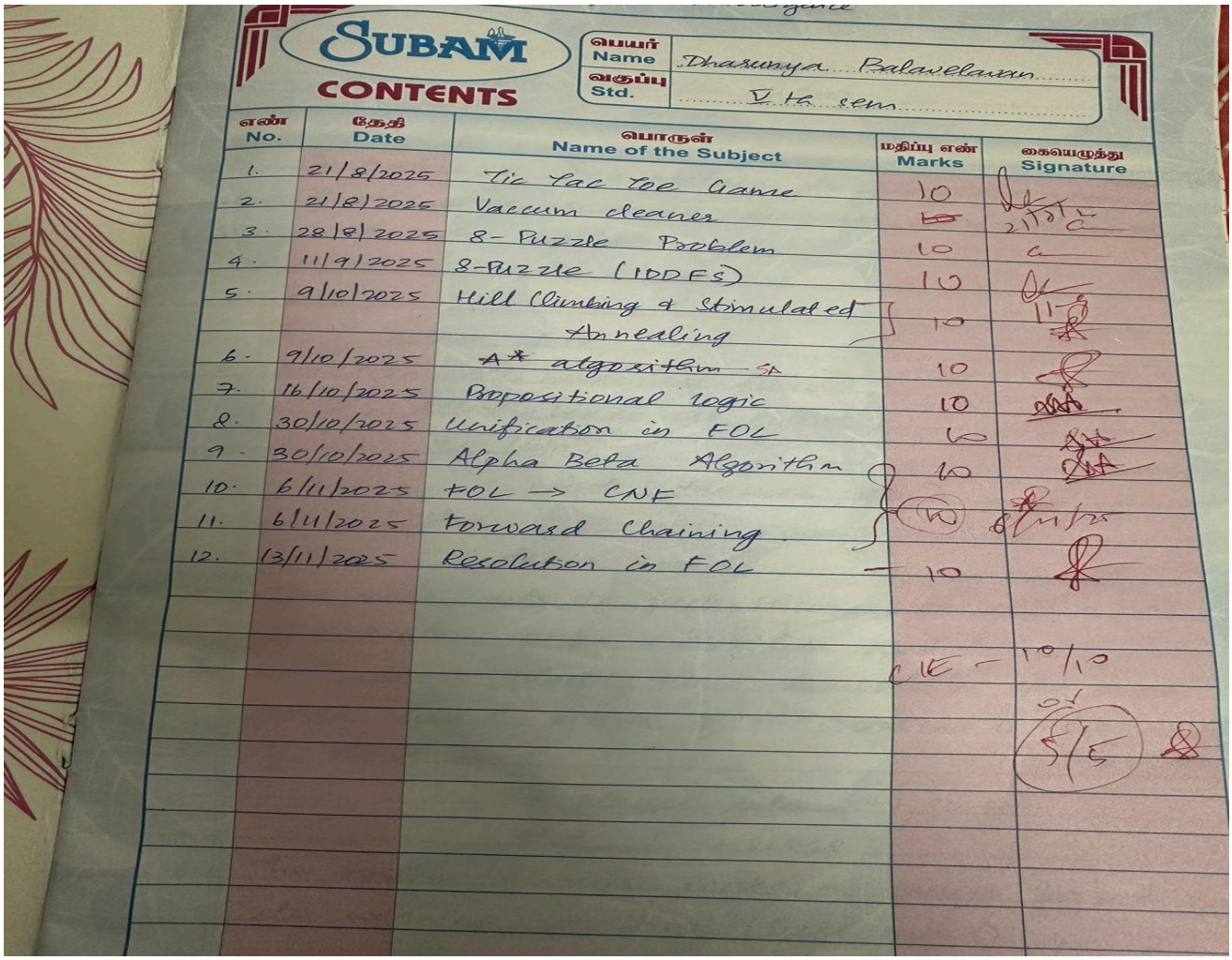
Github Link:
https://github.com/Dharunya21/Artificial-Intelligence



SUBAM

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பெயர் Name: Dharunya Balavelavan

வகுப்பு Std.: V th sem

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Program 1

Implement Tic –Tac –Toe Game

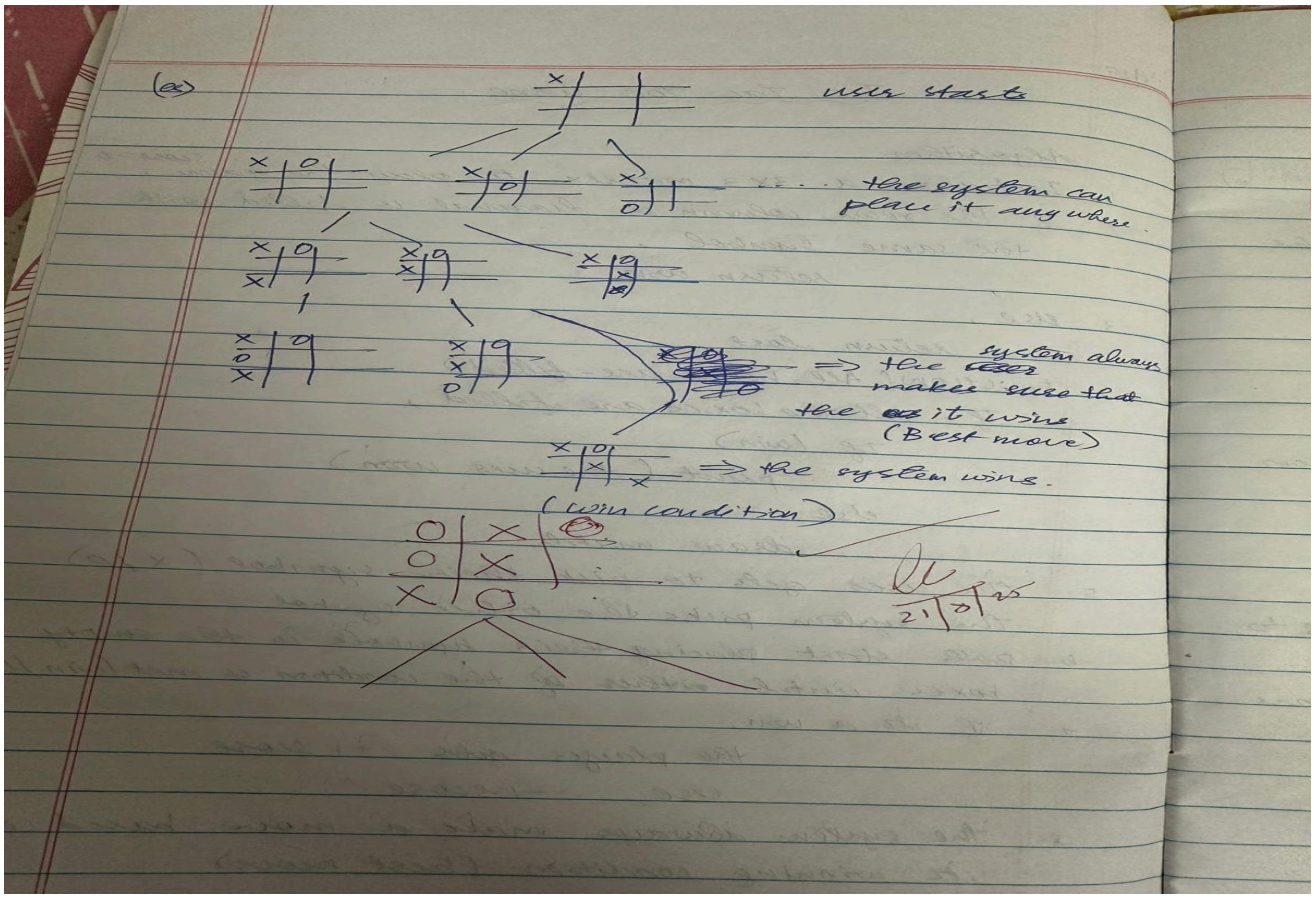
Algorithm:

21/8/25

Tic Tac Toe Game

Algorithm:

1. Initialize a 3x3 matrix to play the game, score=0
2. If the rows, column or diagonal is filled with the same symbol,
   return win
3. else,
   return lost
4. FUNCTION(All_boxes_are_filled)
   If, All the boxes are filled,
   If (win)
   print (the user won)
   else
   draw match
5. The user gets to pick their symbol (X/O).
   The system picks the other symbol.
6. Both start placing their symbols in the empty boxes, until either of the condition is met (win/lose)
7. If its a win,
   the player gets +1 score
   else, -1 score.
8. The system always make a move based on its winning condition (best move)

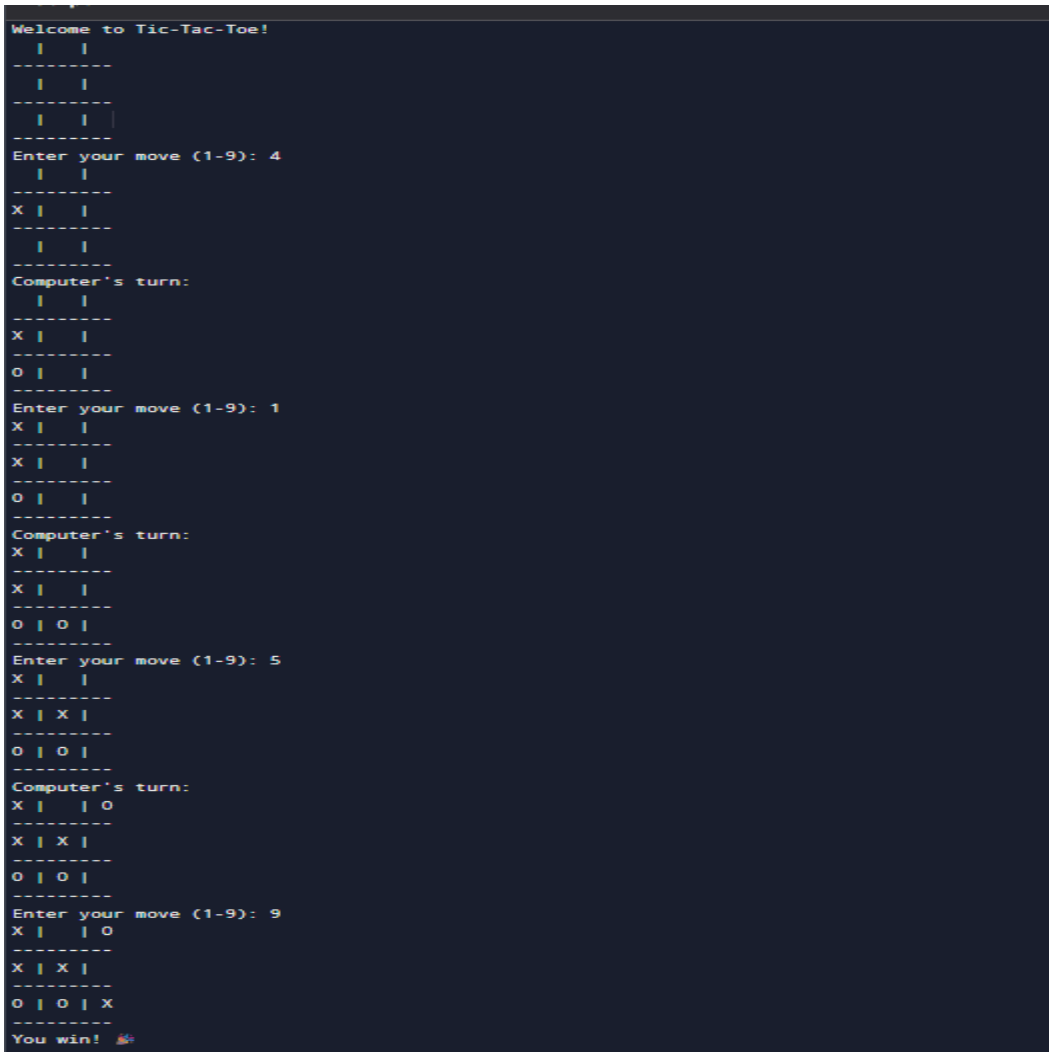


Code:

```
import random
board = [' ' for _ in range(9)]

def print_board():
    print()
    for i in range(3):
        print(" " + " | ".join(board[i*3:(i+1)*3]))
        if i < 2:
            print("---+---+---")
    print()
def check_winner(player):
    win_conditions = [
        [0,1,2], [3,4,5], [6,7,8],
        [0,3,6], [1,4,7], [2,5,8],
        [0,4,8], [2,4,6]
    ]
    for cond in win_conditions:
        if all(board[i] == player for i in cond):
            return True
    return False
def is_full():
```

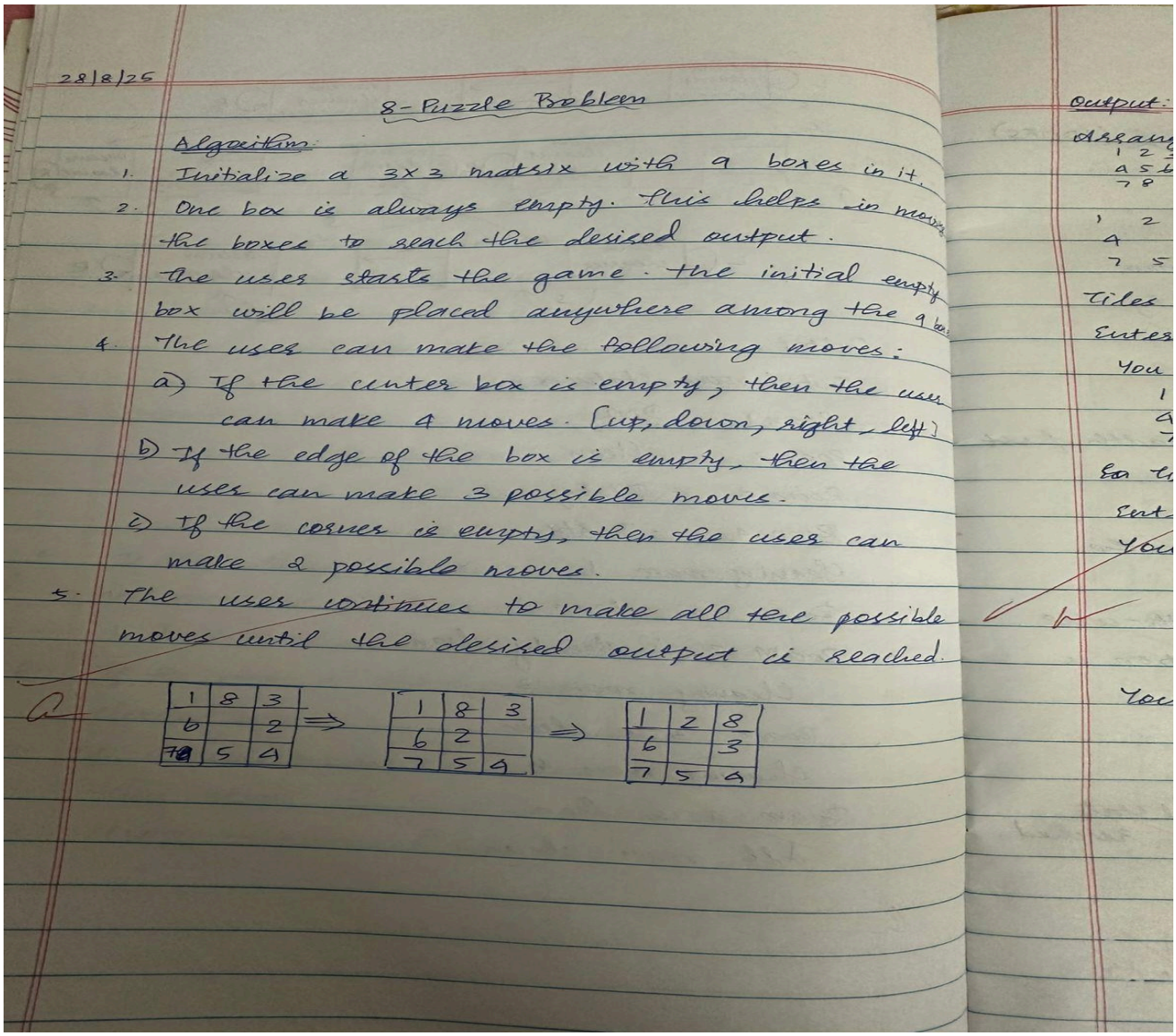
```
    return all(cell != ' ' for cell in board)
def player_move():
    while True:
        try:
            move = int(input("Enter your move (1-9): ")) - 1
            if move < 0 or move >= 9:
                print("Invalid move. Choose between 1-9.")
            elif board[move] != ' ':
                print("That spot is taken.")
            else:
                board[move] = 'X'
                break
        except ValueError:
            print("Please enter a valid number.")
def ai_move():
    empty_spots = [i for i, val in enumerate(board) if val == ' ']
    move = random.choice(empty_spots)
    board[move] = 'O'
    print(f"System placed 'O' in position {move+1}")
def play_game():
    print("Welcome to Tic Tac Toe!")
    print_board()
    while True:
        player_move()
        print_board()
        if check_winner('X'):
            print("Congratulations! You win!")
            break
        if is_full():
            print("It's a tie!")
            break
        ai_move()
        print_board()
        if check_winner('O'):
            print("System wins. Better luck next time!")
            break
        if is_full():
            print("It's a tie!")
            break
if __name__ == "__main__":
    play_game()
```

ScreenShots:



Program 2:

Solve 8 puzzle problems.
Algorithm:



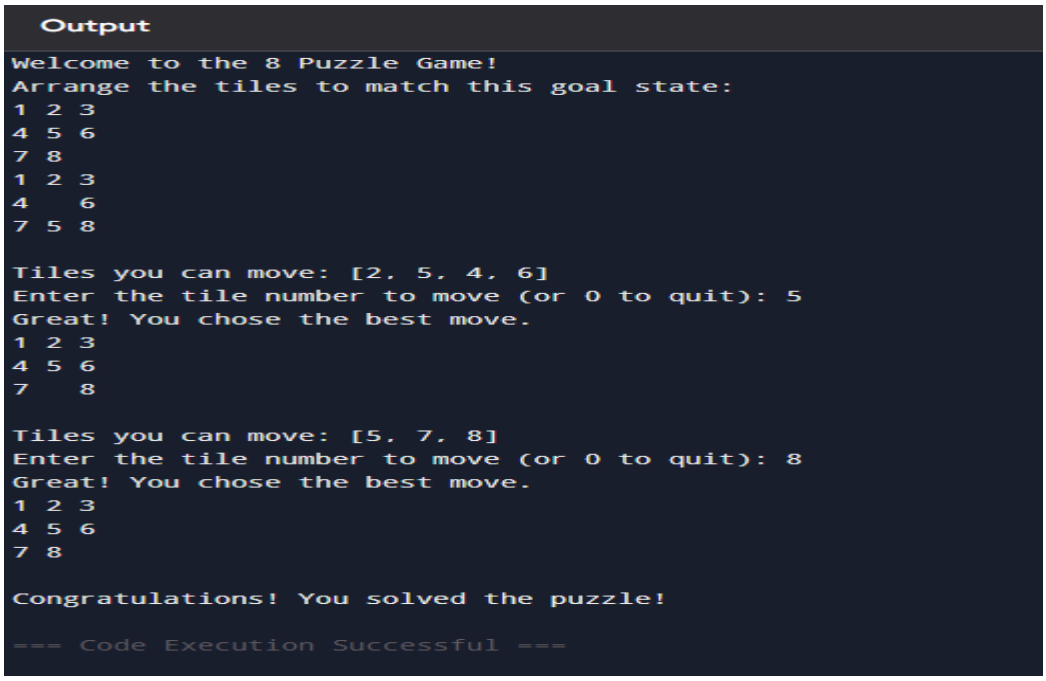
Code:

```
import copy
def print_board(board):
    for row in board:
        print(' '.join(str(x) if x != 0 else ' ' for x in row))
    print()
def find_zero(board):
    for i in range(3):
        for j in range(3):
            if board[i][j] == 0:
                return i, j
def is_solved(board):
    solved = [1,2,3,4,5,6,7,8,0]
    flat = [num for row in board for num in row]
```

```
    return flat == solved
def valid_moves(zero_pos):
    i, j = zero_pos
    moves = []
    if i > 0: moves.append((i-1, j))
    if i < 2: moves.append((i+1, j))
    if j > 0: moves.append((i, j-1))
    if j < 2: moves.append((i, j+1))
    return moves
def correct_tiles_count(board):
    """Count how many tiles are in their correct position."""
    count = 0
    goal = [1,2,3,4,5,6,7,8,0]
    flat = [num for row in board for num in row]
    for i in range(9):
        if flat[i] != 0 and flat[i] == goal[i]:
            count += 1
    return count
def get_user_move(board):
    zero_pos = find_zero(board)
    moves = valid_moves(zero_pos)
    movable_tiles = [board[i][j] for (i,j) in moves]
    print(f"Tiles you can move: {movable_tiles}")
    while True:
        try:
            move = int(input("Enter the tile number to move (or 0 to quit): "))
            if move == 0:
                return None
            if move in movable_tiles:
                return move
            else:
                print("Invalid tile. Please choose a tile adjacent to the empty space.")
        except ValueError:
            print("Please enter a valid number.")
def evaluate_move(board, tile):
    """Compare user move to all possible moves and tell if it's best/worst."""
    zero_pos = find_zero(board)
    moves = valid_moves(zero_pos)
    movable_tiles = [board[i][j] for (i,j) in moves]
    scores = {}
    for t in movable_tiles:
        temp_board = copy.deepcopy(board)
        make_move(temp_board, t)
        scores[t] = correct_tiles_count(temp_board)
    user_score = scores[tile]
    best_score = max(scores.values())
    worst_score = min(scores.values())
```

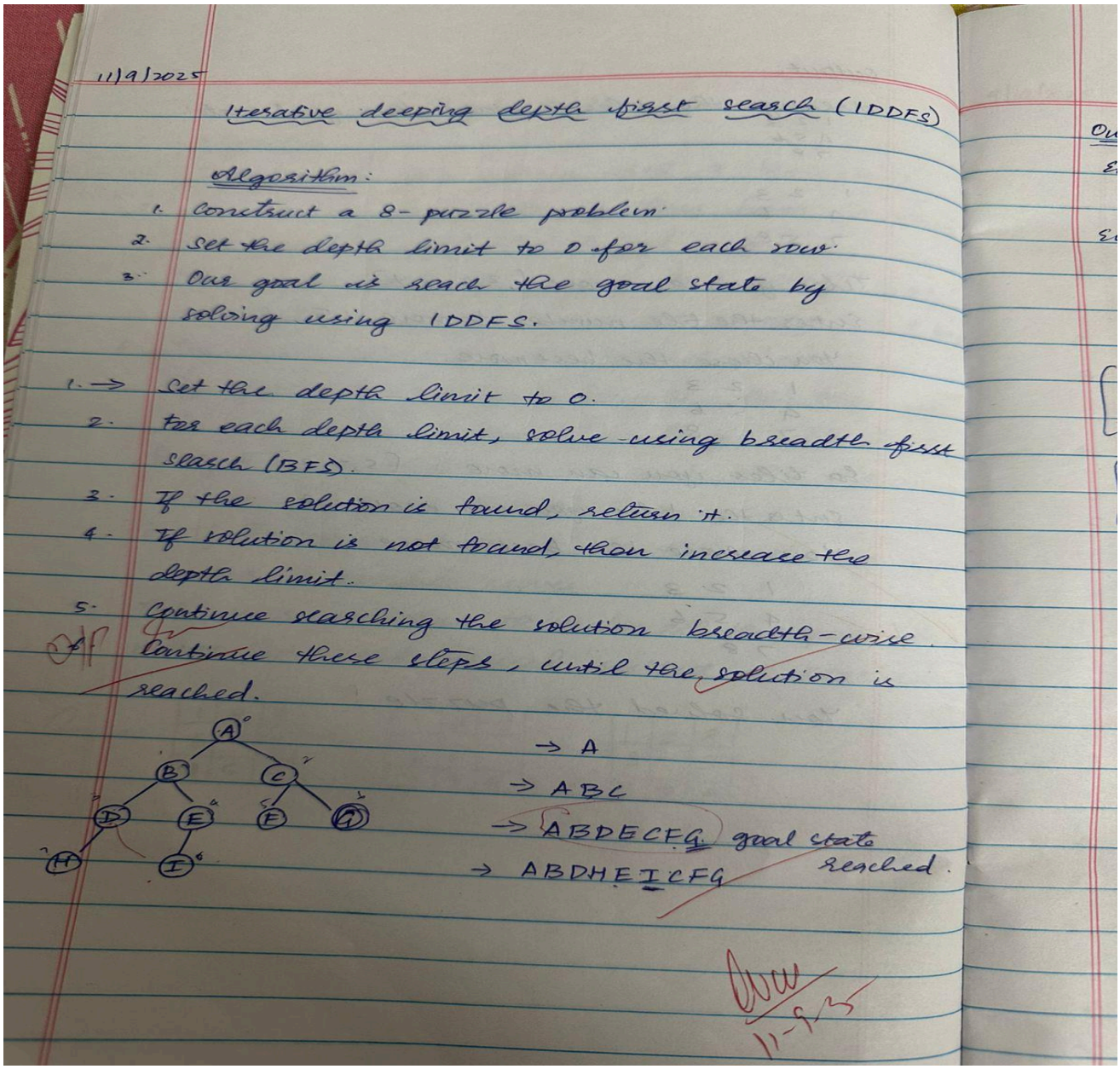
```
    if user_score == best_score and user_score == worst_score:
        return "Your move is the only possible move."
    elif user_score == best_score:
        return "Great! You chose the best move."
    elif user_score == worst_score:
        return "Oops! You chose the worst move."
    else:
        return "Your move is neither the best nor the worst."
def make_move(board, tile):
    zero_i, zero_j = find_zero(board)
    for i, j in valid_moves((zero_i, zero_j)):
        if board[i][j] == tile:
            board[zero_i][zero_j], board[i][j] = board[i][j], board[zero_i][zero_j]
            return
def main():
    board = [
        [1, 2, 3],
        [4, 0, 6],
        [7, 5, 8]
    ]
    print("Welcome to the 8 Puzzle Game!")
    print("Arrange the tiles to match this goal state:")
    print("1 2 3\n4 5 6\n7 8  ")
    while True:
        print_board(board)
        if is_solved(board):
            print("Congratulations! You solved the puzzle!")
            break
        move = get_user_move(board)
        if move is None:
            print("Game exited. Goodbye!")
            break
        feedback = evaluate_move(board, move)
       print(feedback)
        make_move(board, move)
if __name__ == "__main__":
    main()
```

ScreenShot:



Program 3:

Implement Iterative deepening search algorithm.
Algorithm:



Code:

```
import copy
def get_puzzle(name):
    print(f"\nEnter the {name} puzzle (3x3, use -1 for blank):")
    puzzle = []
    for i in range(3):
        row = list(map(int, input(f'Row {i+1} (space-separated 3 numbers): ").split()))
        puzzle.append(row)
    return puzzle
def move(temp, movement):
    for i in range(3):
        for j in range(3):
            if temp[i][j] == -1:
```

```
            if movement == "up" and i > 0:
                temp[i][j], temp[i-1][j] = temp[i-1][j], temp[i][j]
            elif movement == "down" and i < 2:
                temp[i][j], temp[i+1][j] = temp[i+1][j], temp[i][j]
            elif movement == "left" and j > 0:
                temp[i][j], temp[i][j-1] = temp[i][j-1], temp[i][j]
            elif movement == "right" and j < 2:
                temp[i][j], temp[i][j+1] = temp[i][j+1], temp[i][j]
            return temp
    return temp
def dls(puzzle, depth, limit, last_move, goal):
    if puzzle == goal:
        return True, [puzzle], []
    if depth >= limit:
        return False, [], []
    for move_dir, opposite in [("up","down"), ("left","right"), ("down","up"), ("right","left")]:
        if last_move == opposite:  # avoid direct backtracking
            continue
        temp = copy.deepcopy(puzzle)
        new_state = move(temp, move_dir)
        if new_state != puzzle:  # valid move
            found, path, moves = dls(new_state, depth+1, limit, move_dir, goal)
            if found:
                return True, [puzzle] + path, [move_dir] + moves
    return False, [], []
def ids(start, goal):
    for limit in range(1, 50):  # reasonable max depth
        print(f"\nTrying depth limit = {limit}")
        found, path, moves = dls(start, 0, limit, None, goal)
        if found:
            print("Solution found!")
            for step in path:
                print(step)
            print("Moves:", moves)
            print("Path cost =", len(path)-1)
            return
    print(" Solution not found within depth limit.")
start_puzzle = get_puzzle("start")
goal_puzzle = get_puzzle("goal")
print("\n~~~~~~~~~~~~ IDDFS ~~~~~~~~~~~~")
ids(start_puzzle, goal_puzzle)
```

ScreenShot:

Output

```
Enter the start puzzle (3x3, use -1 for blank):
Row 1 (space-separated 3 numbers): 1 2 3
Row 2 (space-separated 3 numbers): 4 7 8
Row 3 (space-separated 3 numbers): 5 6 -1

Enter the goal puzzle (3x3, use -1 for blank):
Row 1 (space-separated 3 numbers): 1 2 3
Row 2 (space-separated 3 numbers): 4 5 6
Row 3 (space-separated 3 numbers): 7 8 -1

~~~~~~~~~~~~~ IDDFS ~~~~~~~~~~~~~

Trying depth limit = 1

Trying depth limit = 2

Trying depth limit = 3

Trying depth limit = 4

Trying depth limit = 5

Trying depth limit = 6

Trying depth limit = 7

Trying depth limit = 8

Trying depth limit = 9

Trying depth limit = 10
```

Program 4:

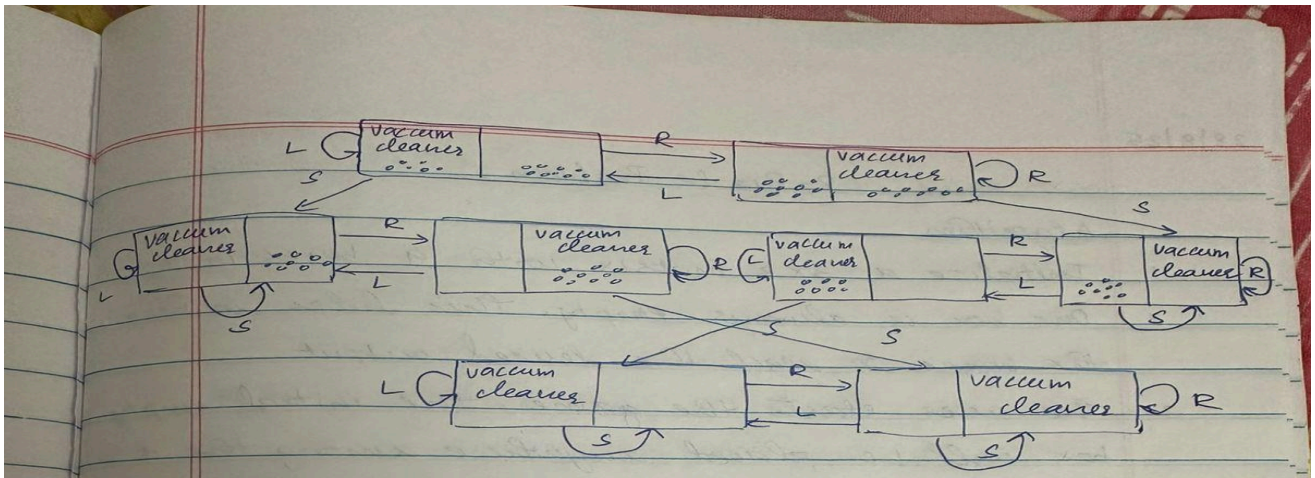
Implement a vacuum cleaner agent.
Algorithm:

21/8/25

2.) Vaccum cleaner

Algorithm:

1. Consider four rooms (A, B, C, D) that has to be cleaned by the vaccum cleaner.
2. FUNCTION CLEAN.
   If the room is clean,
   move to the next room.
3. FUNCTION DIRTY
   If the room is dirty
   , it has to apply suck function and clean the room.
4. If the room is clean, then move to the next room in clock wise direction.
5. Initialize cleaned_room ~~=~~ = status
6. If the room is clean, increment the status to cleaned rooms.
7. If cleaned_rooms = status, for all the rooms then stop.
8. Else, continue cleaning.



Output :

Initial room statuses :

Room 1 : Dirty

Room 2 : Clean

Room 3 : Dirty

Room 4 : Dirty

Cleaning room 1 ....

Room 1 is clean

Room 2 is already clean

Cleaning room 3

Room 3 is clean

Cleaning room 4 ....

Room 4 is clean

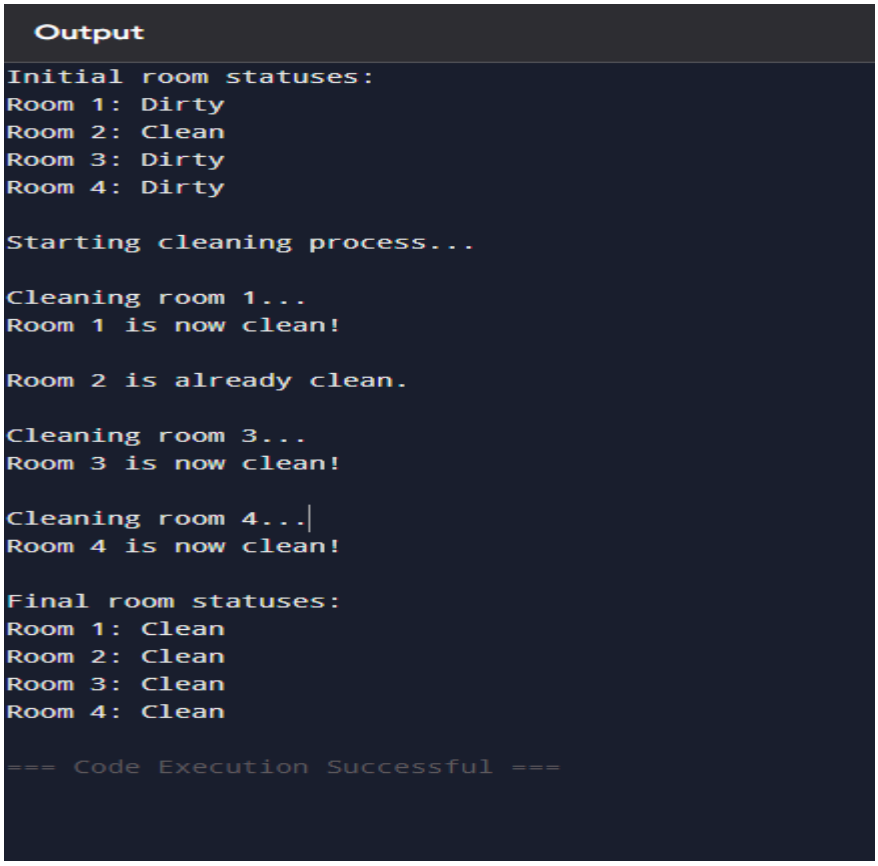
All room clean!

Code:

```
def show_rooms_status(rooms):
    for room_number, status in rooms.items():
        print(f"Room {room_number}: {'Clean' if status else 'Dirty'}")
def clean_room(rooms, room_number):
    if rooms[room_number]:
        print(f"Room {room_number} is already clean.")
    else:
        print(f"Cleaning room {room_number}...")
        rooms[room_number] = True
        print(f"Room {room_number} is now clean!")
def clean_all_rooms(rooms):
    print("Initial room statuses:")
    show_rooms_status(rooms)
```

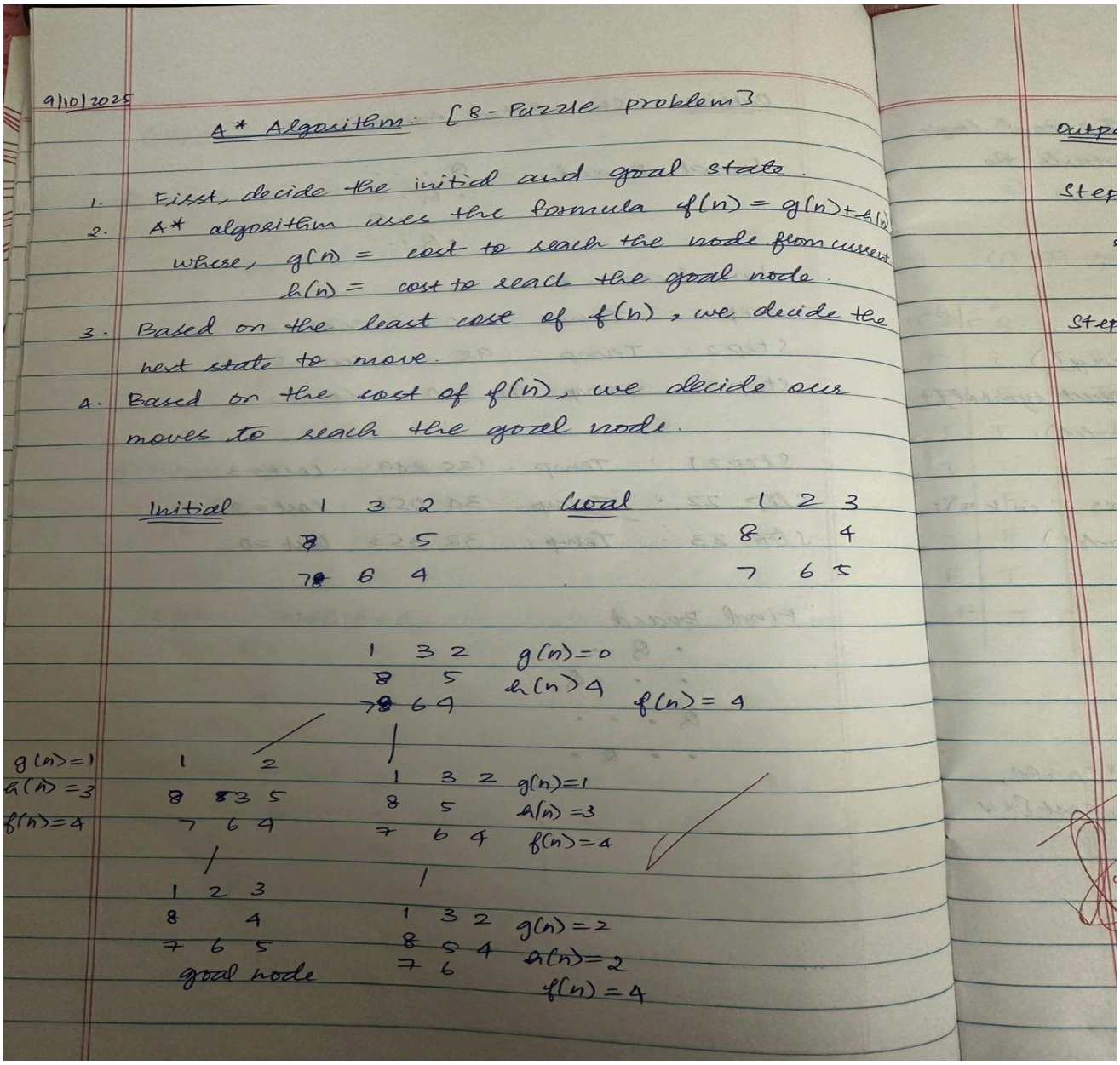
```
    print("\nStarting cleaning process...\n")
    for room_number in rooms:
        clean_room(rooms, room_number)
        print()
    print("Final room statuses:")
    show_rooms_status(rooms)
if __name__ == "__main__":
    rooms = {
        1: False,
        2: True,
        3: False,
        4: False
    }
    clean_all_rooms(rooms)
```

ScreenShot:



Program 5:

Implement A* search algorithm.
Algorithm:



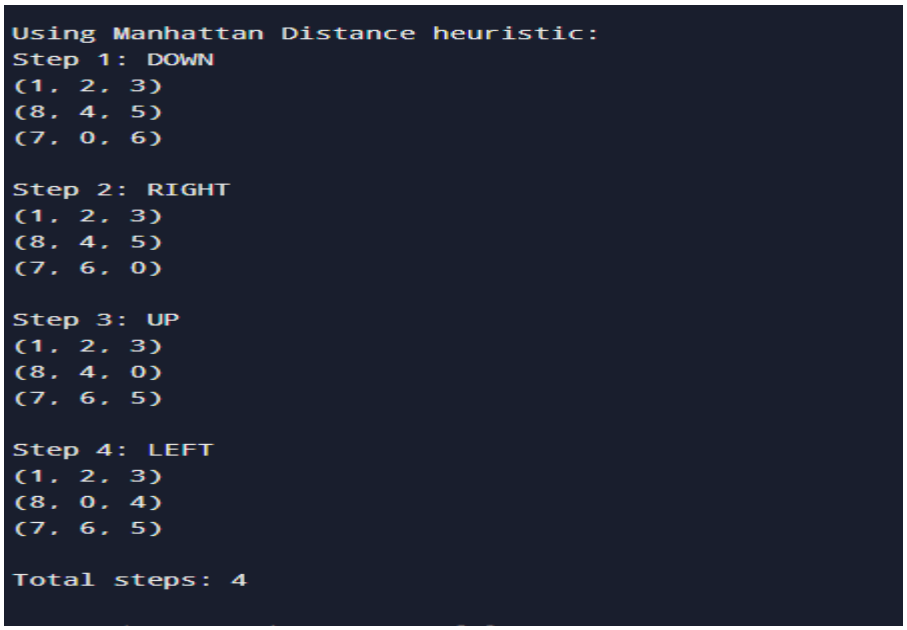
Code:

```
from heapq import heappush, heappop
goal_state = [
    [1, 2, 3],
    [8, 0, 4],
    [7, 6, 5]
]
directions = [(-1, 0), (1, 0), (0, -1), (0, 1)]
direction_names = ["UP", "DOWN", "LEFT", "RIGHT"]
def misplaced_tiles(state):
    count = 0
    for i in range(3):
        for j in range(3):
```

```
            if state[i][j] != 0 and state[i][j] != goal_state[i][j]:
                count += 1
    return count
def manhattan_distance(state):
    distance = 0
    for i in range(3):
        for j in range(3):
            tile = state[i][j]
            if tile != 0:
                goal_x, goal_y = divmod(tile - 1, 3)
                distance += abs(i - goal_x) + abs(j - goal_y)
    return distance
def get_neighbors_with_actions(state):
    neighbors = []
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
                x, y = i, j
                break
    for (dx, dy), action in zip(directions, direction_names):
        nx, ny = x + dx, y + dy
        if 0 <= nx < 3 and 0 <= ny < 3:
            new_state = [list(row) for row in state]
            new_state[x][y], new_state[nx][ny] = new_state[nx][ny], new_state[x][y]
            neighbors.append((new_state, action))
    return neighbors
def state_to_tuple(state):
    return tuple(tuple(row) for row in state)
def reconstruct_path(came_from, current):
    actions = []
    states = []
    while current in came_from:
        prev_state, action = came_from[current]
        actions.append(action)
        states.append(current)
        current = prev_state
    states.append(current)
    actions.reverse()
    states.reverse()
    return actions, states
def a_star_search_with_steps(initial_state, heuristic_func):
    open_list = []
    closed_set = set()
    g_score = {state_to_tuple(initial_state): 0}
    f_score = {state_to_tuple(initial_state): heuristic_func(initial_state)}
    came_from = {}
    heappush(open_list, (f_score[state_to_tuple(initial_state)], initial_state))
```

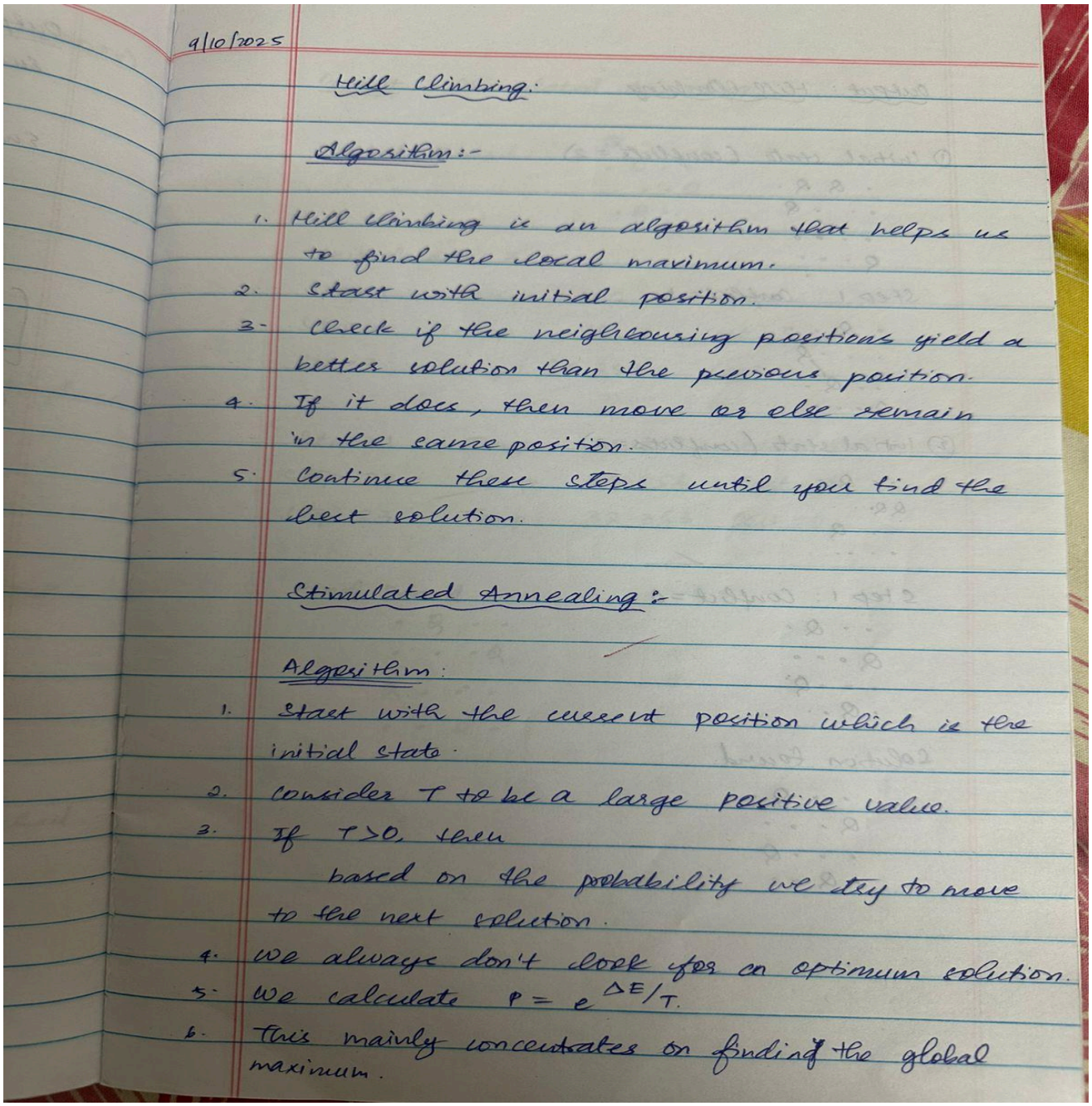
```
    while open_list:
        _, current_state = heappop(open_list)
        current_t = state_to_tuple(current_state)
        if current_state == goal_state:
            return reconstruct_path(came_from, current_t)
        closed_set.add(current_t)
        for neighbor, action in get_neighbors_with_actions(current_state):
            neighbor_t = state_to_tuple(neighbor)
            if neighbor_t in closed_set:
                continue
            tentative_g = g_score[current_t] + 1
            if neighbor_t not in g_score or tentative_g < g_score[neighbor_t]:
                came_from[neighbor_t] = (current_t, action)
                g_score[neighbor_t] = tentative_g
                f_score[neighbor_t] = tentative_g + heuristic_func(neighbor)
                heappush(open_list, (f_score[neighbor_t], neighbor))
    return None, None
def print_path(actions, states):
    for i, (action, state) in enumerate(zip(actions, states[1:]), 1):
        print(f"Step {i}: {action}")
        for row in state:
            print(row)
        print()
initial_state = [
    [1, 2, 3],
    [8, 0, 5],
    [7, 4, 6]
]
print("Using Misplaced Tiles heuristic:")
actions, states = a_star_search_with_steps(initial_state, misplaced_tiles)
if actions:
    print_path(actions, states)
    print("Total steps:", len(actions))
else:
    print("No solution found.")
print("\nUsing Manhattan Distance heuristic:")
actions, states = a_star_search_with_steps(initial_state, manhattan_distance)
if actions:
    print_path(actions, states)
    print("Total steps:", len(actions))
else:
    print("No solution found.")
```

ScreenShot:



b. Implement Hill Climbing Algorithm

Algorithm:



9/10/2025

Hill climbing:

Algorithm:-

1. Hill climbing is an algorithm that helps us to find the local maximum.
2. Start with initial position.
3. Check if the neighbouring positions yield a better solution than the previous position.
4. If it does, then move or else remain in the same position.
5. Continue these steps until you find the best solution.

Stimulated Annealing:

Algorithm:

1. Start with the current position which is the initial state.
2. Consider T to be a large positive value.
3. If $T > 0$, then
   based on the probability we try to move to the next solution.
4. We always don't look for an optimum solution.
5. We calculate $P = e^{\Delta E/T}$.
6. This mainly concentrates on finding the global maximum.

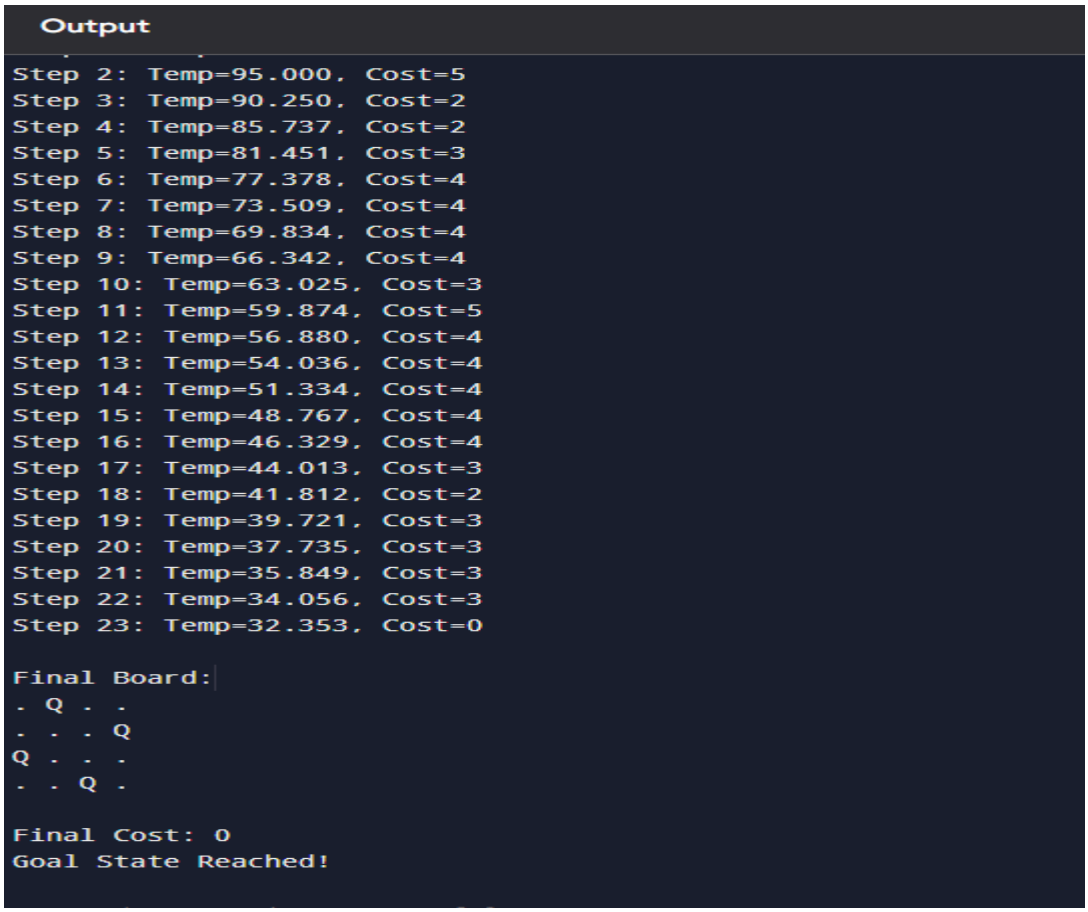
Code:

```
import random
import time
def generate_initial_state(n=4):
    return [random.randint(0, n - 1) for _ in range(n)]
def calculate_conflicts(state):
    conflicts = 0
    n = len(state)
    for i in range(n):
        for j in range(i + 1, n):
```

```
            if state[i] == state[j]:
                conflicts += 1
            if abs(state[i] - state[j]) == abs(i - j):
                conflicts += 1
    return conflicts
def get_neighbors(state):
    neighbors = []
    n = len(state)
    for col in range(n):
        for row in range(n):
            if state[col] != row:
                neighbor = state.copy()
                neighbor[col] = row
                neighbors.append(neighbor)
    return neighbors
def print_board(state):
    n = len(state)
    for row in range(n):
        line = ""
        for col in range(n):
            if state[col] == row:
                line += "Q "
            else:
                line += ". "
        print(line)
    print()
def hill_climbing_with_steps(n=4, max_restarts=100):
    for restart in range(max_restarts):
        current = generate_initial_state(n)
        step = 0
        print(f"Restart #{restart+1}: Initial state (Conflicts = {calculate_conflicts(current)})")
        print_board(current)
        while True:
            current_conflicts = calculate_conflicts(current)
            if current_conflicts == 0:
                print(f"Solution found in {step} steps!")
                return current
            neighbors = get_neighbors(current)
            neighbor_conflicts = [calculate_conflicts(nbr) for nbr in neighbors]
            min_conflict = min(neighbor_conflicts)
            if min_conflict >= current_conflicts:
                print("Reached local minimum, restarting...\n")
                break
            best_neighbor = neighbors[neighbor_conflicts.index(min_conflict)]
            step += 1
            print(f"Step {step}: Conflicts = {min_conflict}")
            print_board(best_neighbor)
```

```
            current = best_neighbor
    return None
solution = hill_climbing_with_steps()
if solution:
    print("Final Solution:")
    print_board(solution)
else:
    print("No solution found.")
```

ScreenShot:



Program 6:

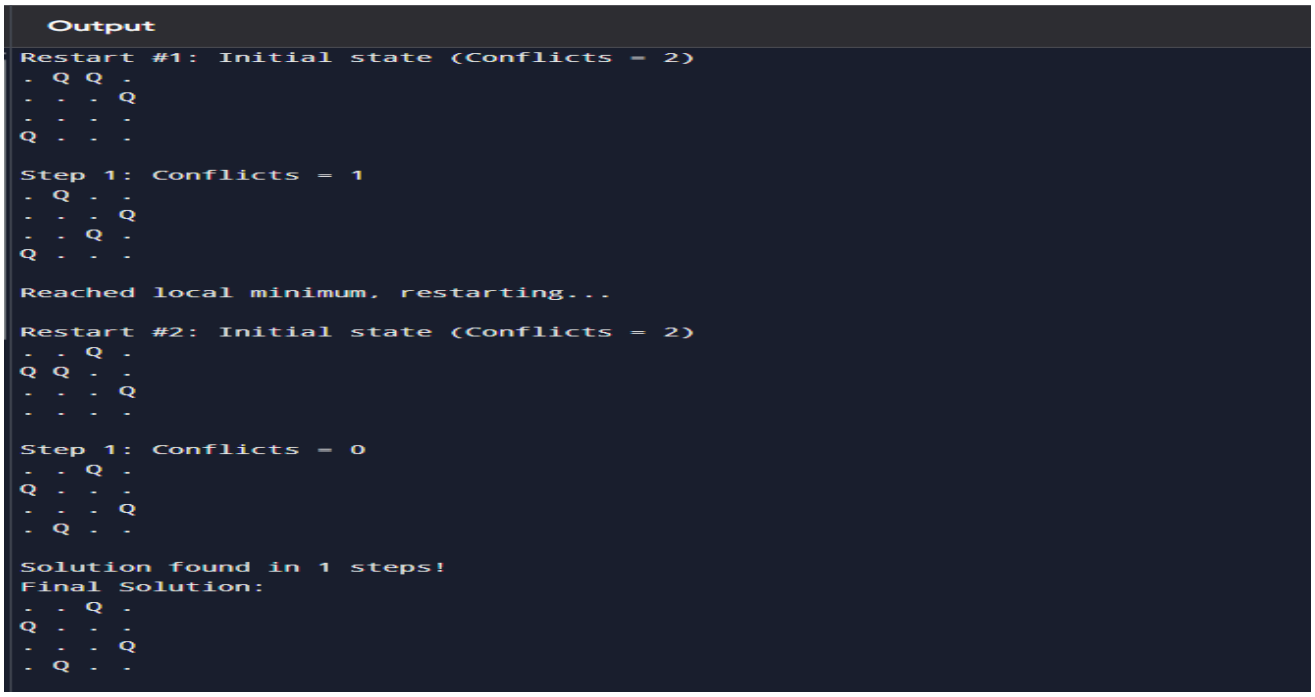
Write a program to implement Simulated Annealing Algorithm

Code:

```
import random
import math
def print_board(board):
    n = len(board)
    for i in range(n):
```

```
        row = ["Q" if board[i] == j else "." for j in range(n)]
        print(" ".join(row))
    print()
def calculate_cost(board):
    """Heuristic: number of pairs of queens attacking each other"""
    n = len(board)
    cost = 0
    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):
                cost += 1
    return cost
def random_neighbor(board):
    """Generate a random neighboring board by moving one queen"""
    n = len(board)
    neighbor = list(board)
    row = random.randint(0, n - 1)
    col = random.randint(0, n - 1)
    neighbor[row] = col
    return neighbor
def simulated_annealing(n, initial_temp=100, cooling_rate=0.95, stopping_temp=1):
    current_board = [random.randint(0, n - 1) for _ in range(n)]
    current_cost = calculate_cost(current_board)
    temperature = initial_temp
    step = 1
    print("Initial Board:")
    print_board(current_board)
    print(f"Initial Cost: {current_cost}\n")
    while temperature > stopping_temp and current_cost > 0:
        neighbor = random_neighbor(current_board)
        neighbor_cost = calculate_cost(neighbor)
        delta = neighbor_cost - current_cost
        if delta < 0 or random.random() < math.exp(-delta / temperature):
            current_board = neighbor
            current_cost = neighbor_cost
        print(f"Step {step}: Temp={temperature:.3f}, Cost={current_cost}")
        step += 1
        temperature *= cooling_rate
    print("\nFinal Board:")
    print_board(current_board)
    print(f"Final Cost: {current_cost}")
    if current_cost == 0:
        print("Goal State Reached!")
    else:
        print("Terminated before reaching goal.")
simulated_annealing(4)
```

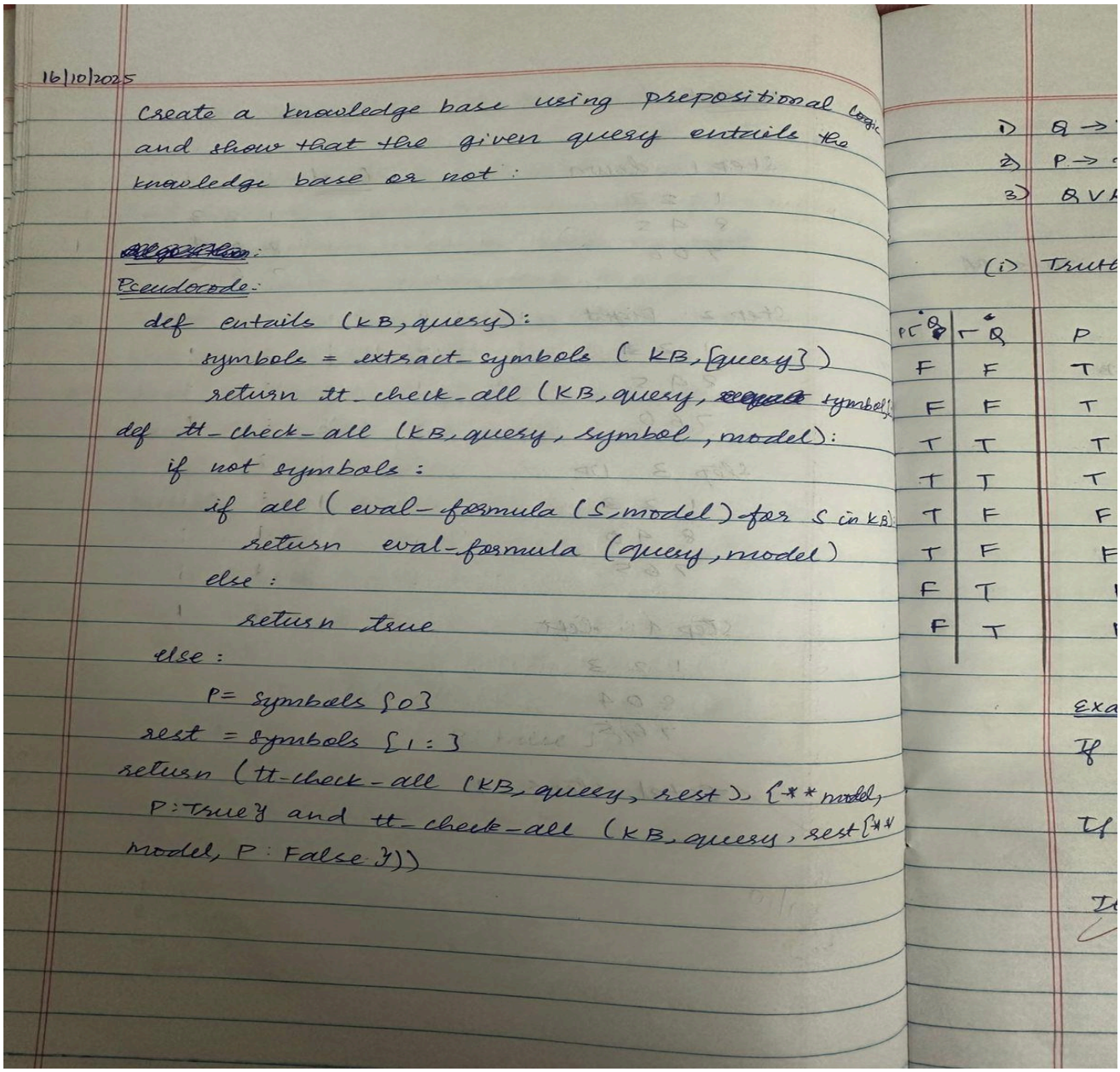
ScreenShot:



Program 7:

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

Algorithm:



Code:

```
import itertools
import pandas as pd
variables = ['P', 'Q', 'R']
combinations = list(itertools.product([False, True], repeat=3))
rows = []
for (P, Q, R) in combinations:
    s1 = (not Q) or P
    s2 = (not P) or (not Q)   # P → ¬Q
    s3 = Q or R               # Q ∨ R
    KB = s1 and s2 and s3
    entail_R = R
```

```
    entail_R_imp_P = (not R) or P
    entail_Q_imp_R = (not Q) or R
    rows.append({
        'P': P, 'Q': Q, 'R': R,
        'Q → P': s1,
        'P → ¬Q': s2,
        'Q ∨ R': s3,
        'KB True?': KB,
        'R': entail_R,
        'R → P': entail_R_imp_P,
        'Q → R': entail_Q_imp_R
    })
df = pd.DataFrame(rows)
print("Truth Table for Knowledge Base:\n")
print(df.to_string(index=False))
models_true = df[df['KB True?'] == True]
print("\nModels where KB is True:\n")
print(models_true[['P', 'Q', 'R']])
def entails(column):
    """Check if KB entails the given statement."""
    return all(models_true[column])
print("\nEntailment Results:")
print(f"KB ⊨ R ? {'Yes' if entails('R') else 'No'}")
print(f"KB ⊨ R → P ? {'Yes' if entails('R → P') else 'No'}")
print(f"KB ⊨ Q → R ? {'Yes' if entails('Q → R') else 'No'}")
```

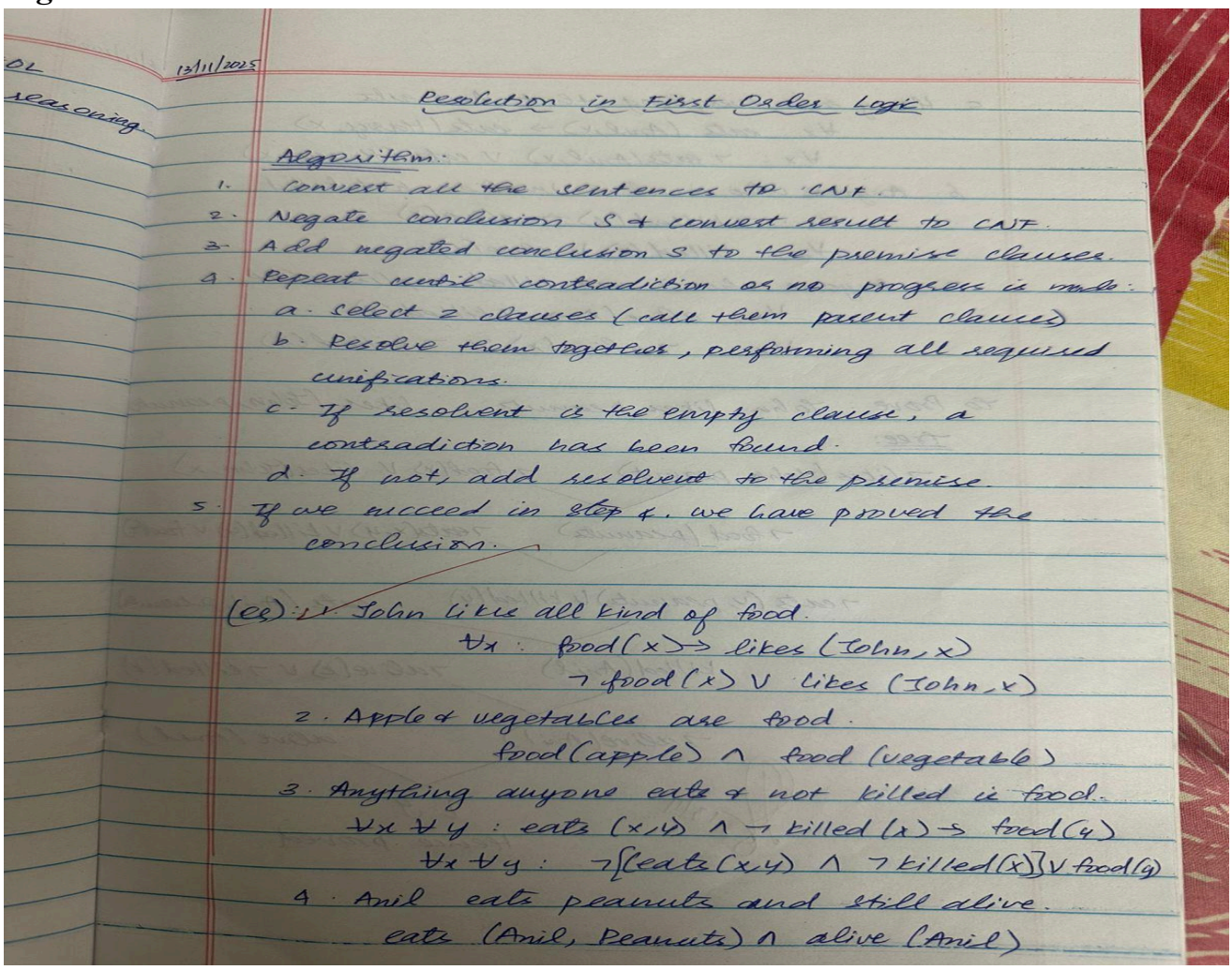
ScreenShot:

```
Output
Truth Table for Knowledge Base:

    P      Q      R  Q → P  P → ¬Q  Q ∨ R  KB True?  R → P  Q → R
False  False  False   True    True  False     False   True   True
False  False   True   True    True   True      True  False   True
False   True  False  False    True   True     False   True  False
False   True   True  False    True   True     False  False   True
 True  False  False   True    True  False     False   True   True
 True  False   True   True    True   True      True   True   True
 True   True  False   True   False   True     False   True  False
 True   True   True   True   False   True     False   True   True

Models where KB is True:

       P      Q     R
1  False  False  True
5   True  False  True

Entailment Results:
KB ⊨ R ? Yes
KB ⊨ R → P ? No
KB ⊨ Q → R ? Yes

=== Code Execution Successful ===
```

Program 8:

Create a knowledge base using prepositional logic and prove the given query using resolution.

Algorithm:



OL 13/11/2025

reasoning

Resolution in First Order Logic

Algorithm:

1. Convert all the sentences to CNF.
2. Negate conclusion S & convert result to CNF.
3. Add negated conclusion S to the premise clauses.
4. Repeat until contradiction or no progress is made:
   a. Select 2 clauses (call them parent clauses)
   b. Resolve them together, performing all required unifications.
   c. If resolvent is the empty clause, a contradiction has been found.
   d. If not, add resolvent to the premise.
5. If we succeed in step 4, we have proved the conclusion.

(eg): 1. John likes all kind of food.

$\forall x$: food(x) → likes(John, x)

$\neg$ food(x) $\vee$ likes(John, x)

2. Apple & vegetables are food.

food(apple) $\wedge$ food(vegetables)

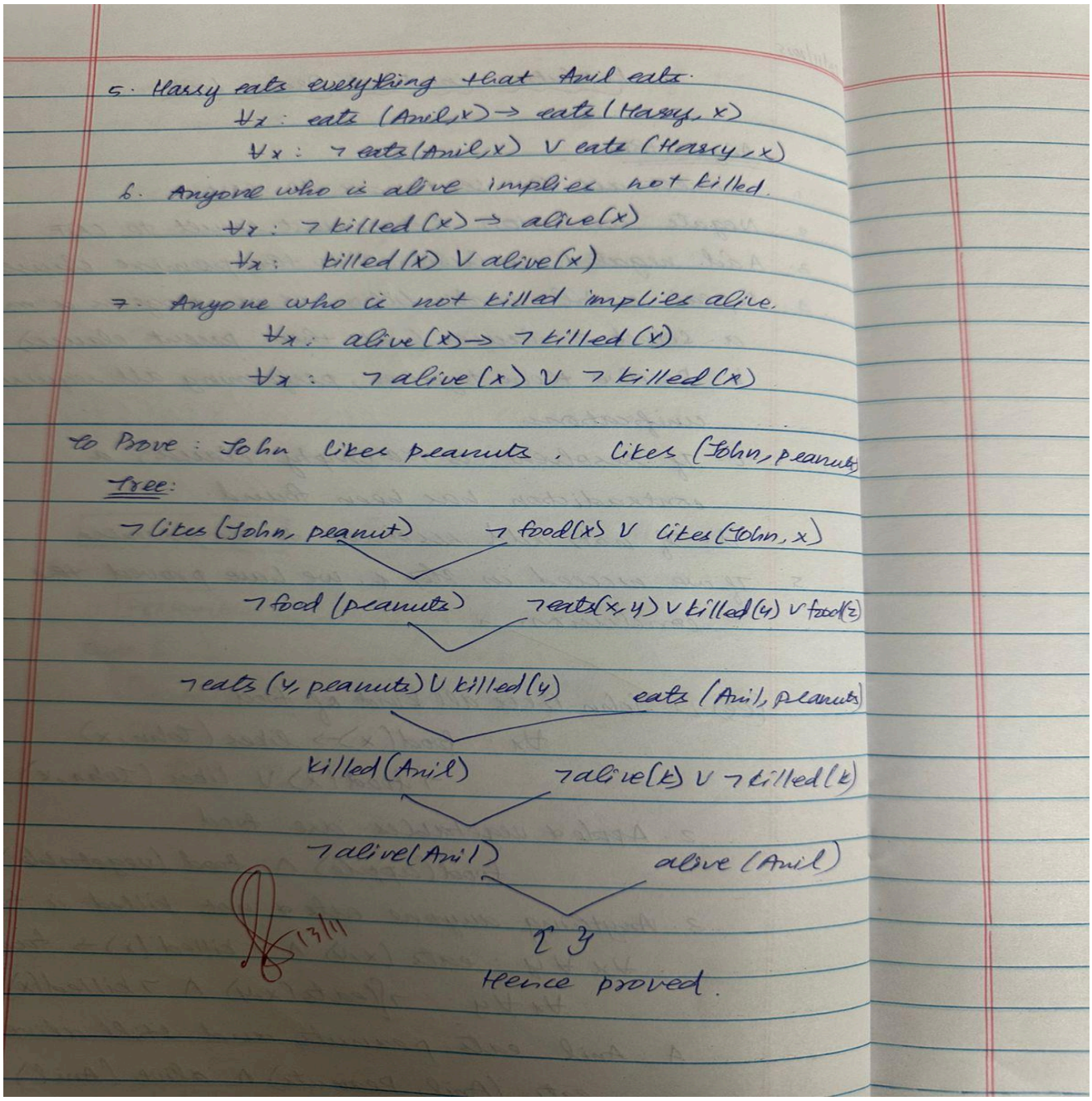
3. Anything anyone eats & not killed is food.

$\forall x \forall y$: eats(x, y) $\wedge \neg$ killed(x) → food(y)

$\forall x \forall y$: $\neg$[eats(x, y) $\wedge \neg$ killed(x)] $\vee$ food(y)

4. Anil eats peanuts and still alive.

eats(Anil, Peanuts) $\wedge$ alive(Anil)



Program 9:

Implement unification in first order logic.
Algorithm:

30/10/2025

Unification in First Order Logic

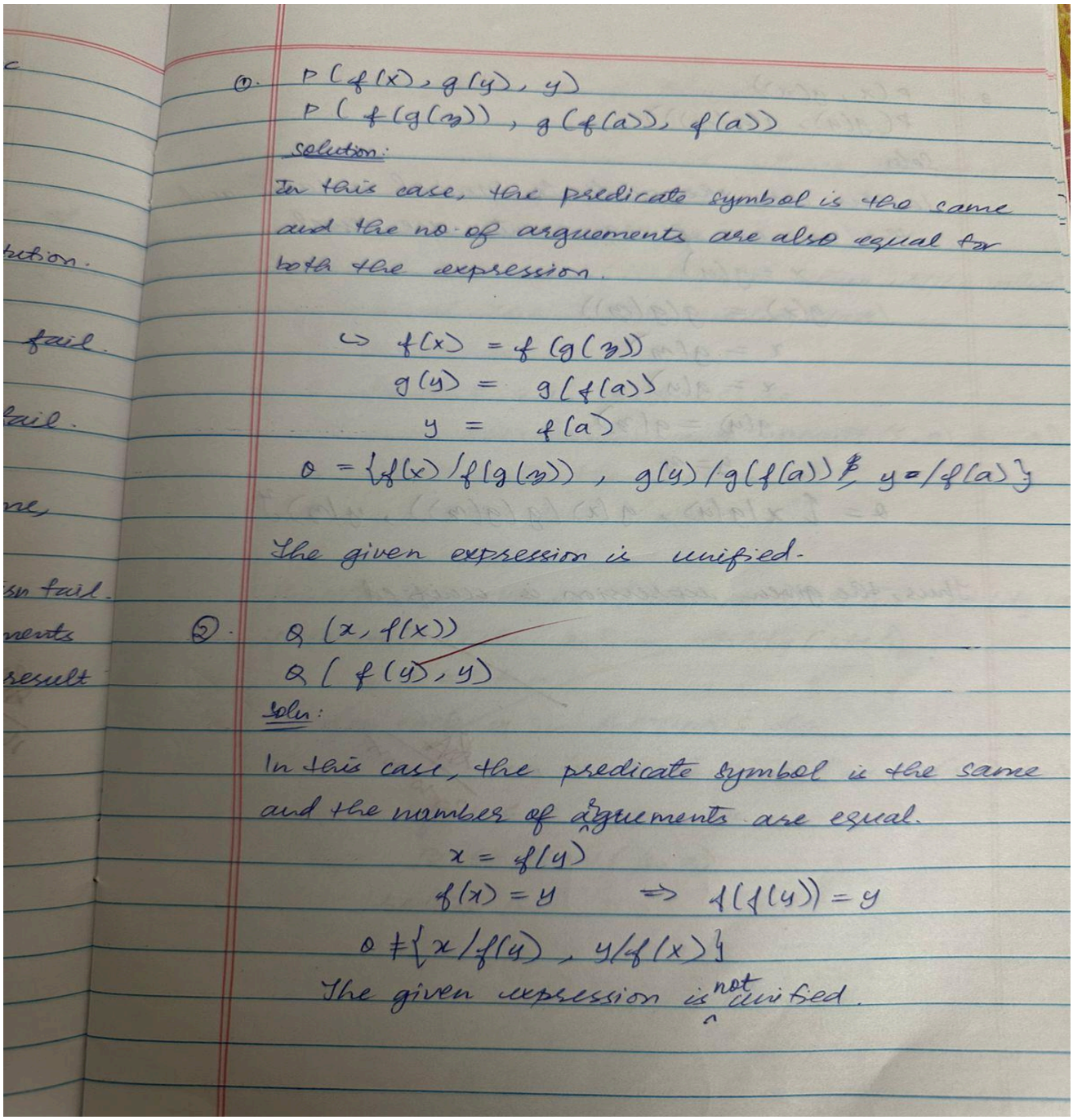
①

Algorithm:

1. If a1 and a2 are a variable / constant,
   If a1 & a2 are identical → No substitution.
   else if a1 is variable
   then, a1 occurs in a2, then return fail.
   else if a2 is variable
   then a2 occurs in a1, then return fail.
   else return fail.
2. If the initial predicate symbol is not same, then return fail.
3. If the number of arguement are not same, return fail.
4. For substitution, set i = 1 to the number of elements in a1, apply unification of a1 with a2, put the result in S

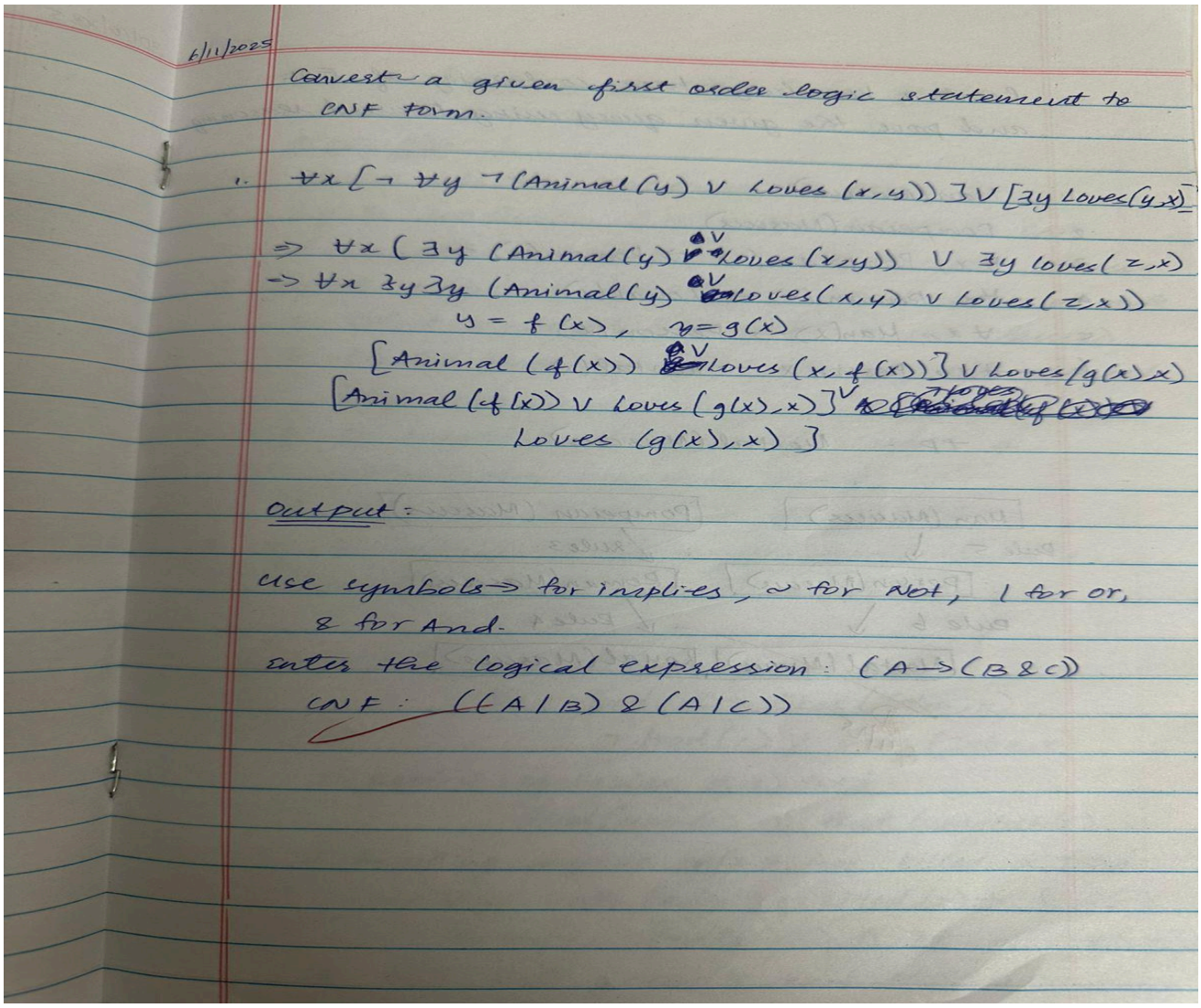
②

If S ≠ No substitution
Apply the remainder to both the expression, and append the result.
return result.



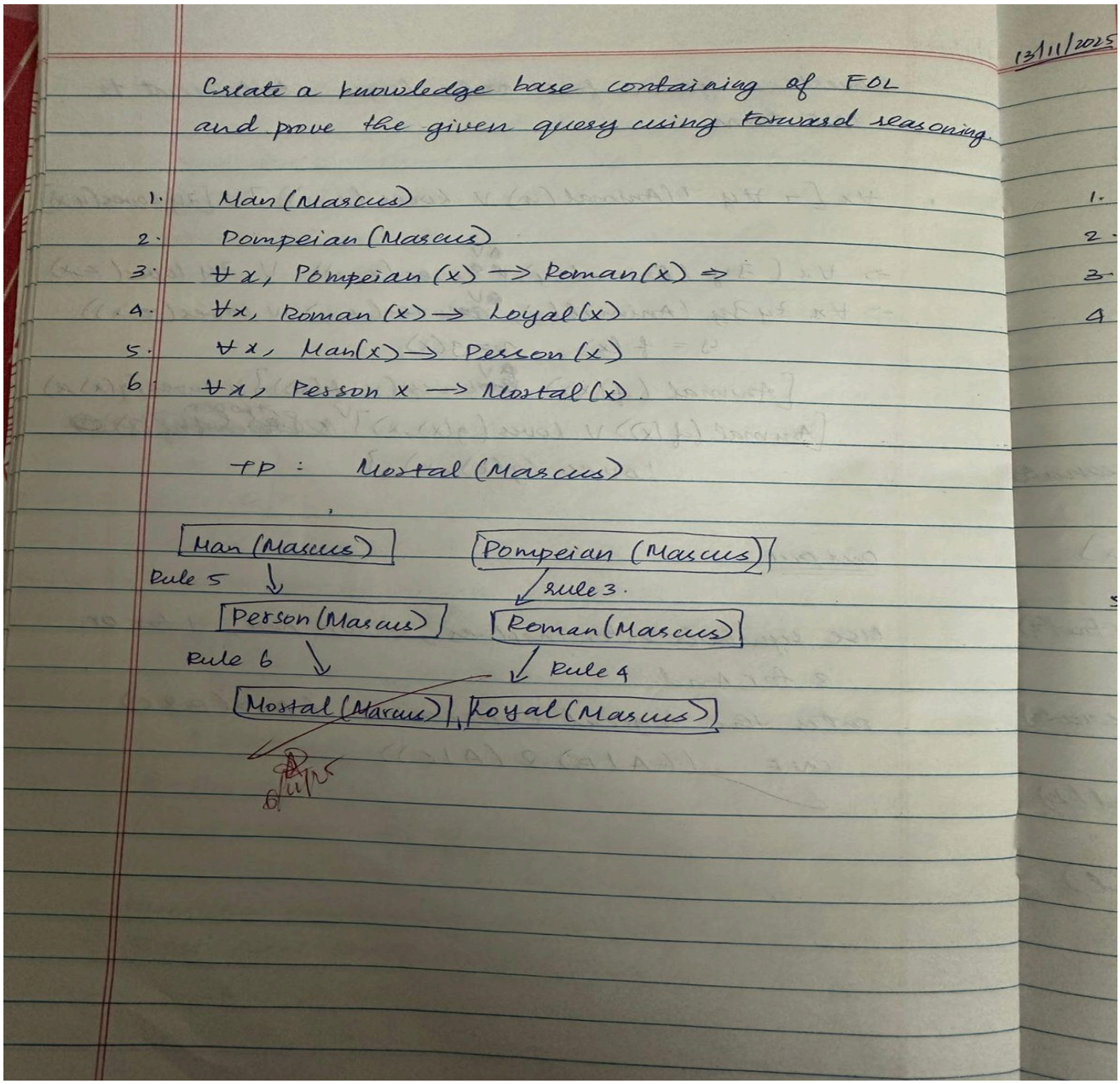
Program 10:

Convert a given first order logic statement into Conjunctive Normal Form (CNF).
Algorithm:



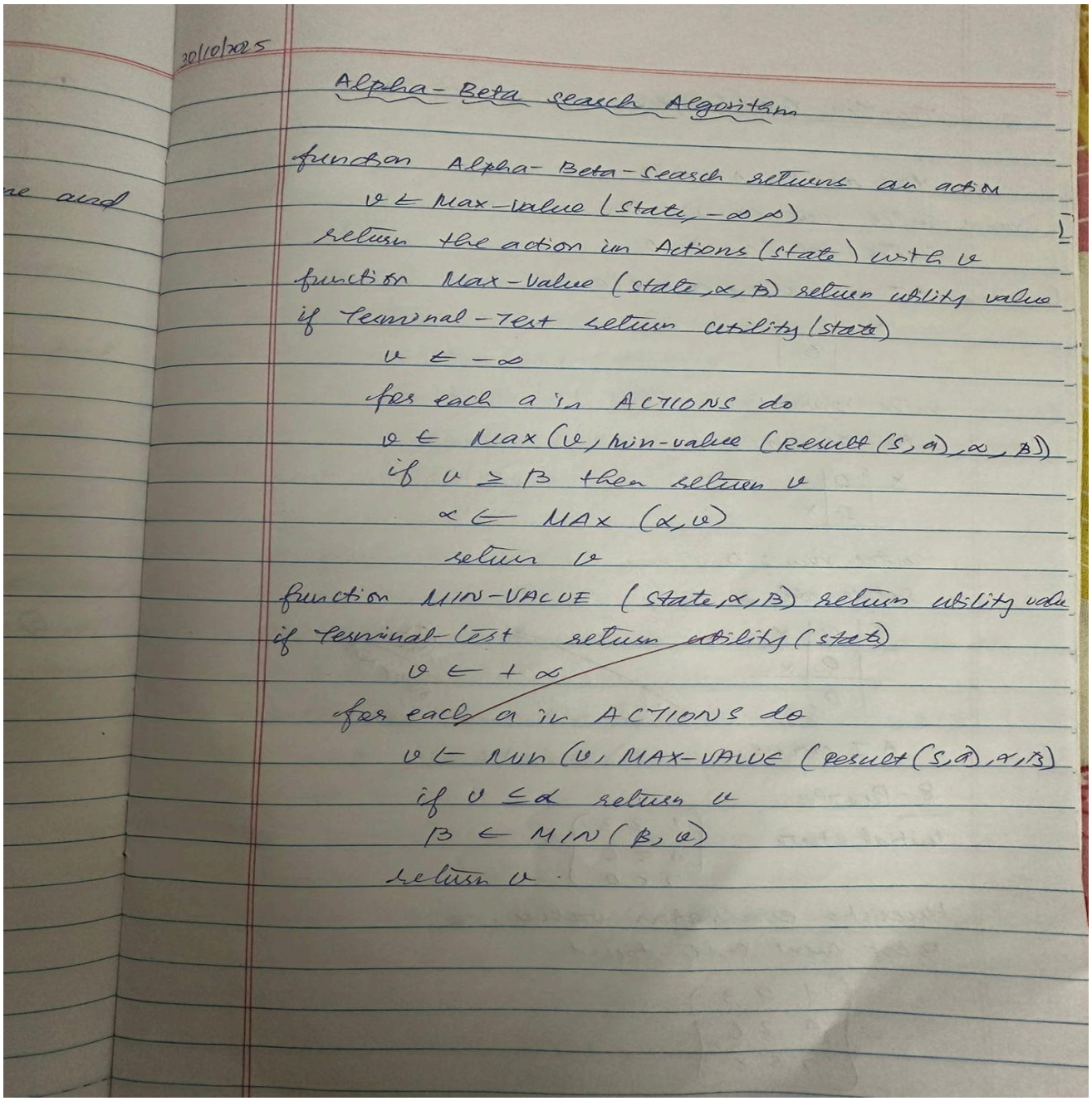
Program 11:

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



Program 12:

Implement Alpha-Beta Pruning.
Algorithm:



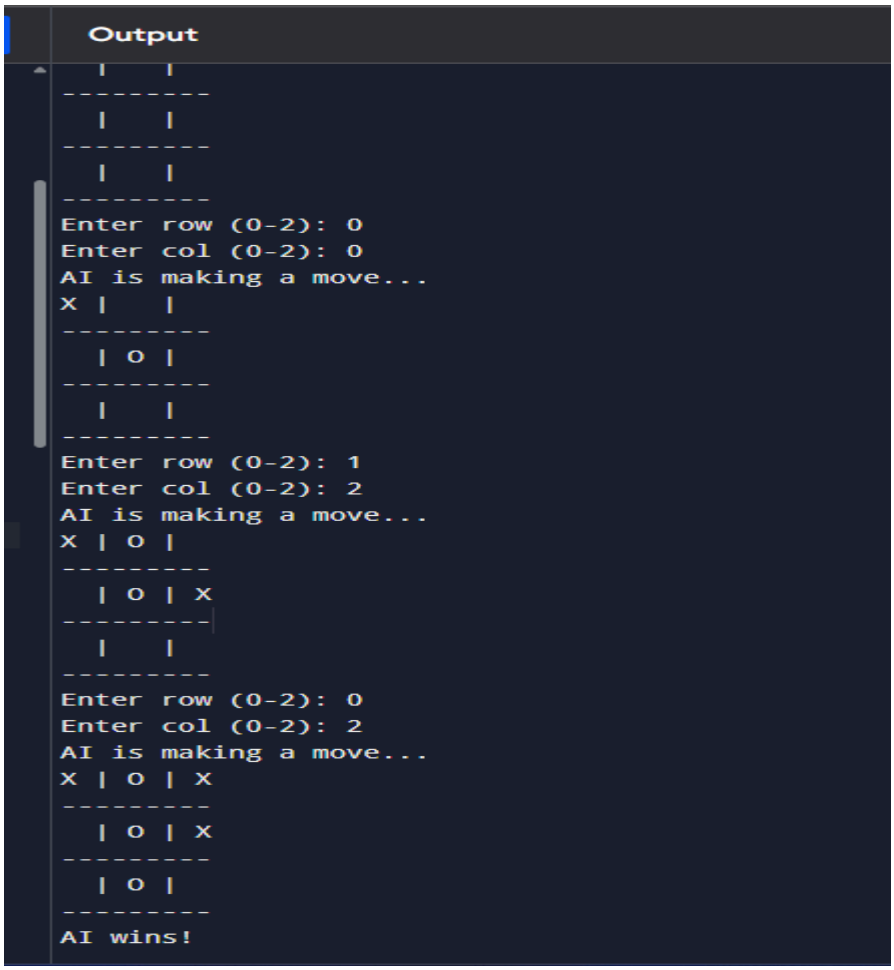
Code:

```
import math
PLAYER = "X"  # Human
AI = "O"      # Computer
def print_board(board):
    for row in board:
        print(" | ".join(row))
        print("-" * 9)
def available_moves(board):
    """Return list of available (row, col) moves."""
    moves = []
```

```
    for i in range(3):
        for j in range(3):
            if board[i][j] == " ":
                moves.append((i, j))
    return moves
def check_winner(board):
    """Return 'X' if X wins, 'O' if O wins, or None otherwise."""
    for i in range(3):
        if board[i][0] == board[i][1] == board[i][2] != " ":
            return board[i][0]
        if board[0][i] == board[1][i] == board[2][i] != " ":
            return board[0][i]
    if board[0][0] == board[1][1] == board[2][2] != " ":
        return board[0][0]
    if board[0][2] == board[1][1] == board[2][0] != " ":
        return board[0][2]
    return None
def is_full(board):
    return all(cell != " " for row in board for cell in row)
def minimax(board, depth, is_maximizing):
    winner = check_winner(board)
    if winner == AI:
        return 1
    elif winner == PLAYER:
        return -1
    elif is_full(board):
        return 0
    if is_maximizing:
        best_score = -math.inf
        for (i, j) in available_moves(board):
            board[i][j] = AI
            score = minimax(board, depth + 1, False)
            board[i][j] = " "
            best_score = max(score, best_score)
        return best_score
    else:
        best_score = math.inf
        for (i, j) in available_moves(board):
            board[i][j] = PLAYER
            score = minimax(board, depth + 1, True)
            board[i][j] = " "
            best_score = min(score, best_score)
        return best_score
def best_move(board):
    """Find the best move for the AI."""
    best_score = -math.inf
    move = None
```

```
    for (i, j) in available_moves(board):
        board[i][j] = AI
        score = minimax(board, 0, False)
        board[i][j] = " "
        if score > best_score:
            best_score = score
            move = (i, j)
    return move
def play_game():
    board = [[" " for _ in range(3)] for _ in range(3)]
    print("Tic Tac Toe - You are X, AI is O")
    print_board(board)
    while True:
        row = int(input("Enter row (0-2): "))
        col = int(input("Enter col (0-2): "))
        if board[row][col] != " ":
            print("Cell taken, try again.")
            continue
        board[row][col] = PLAYER
        if check_winner(board) == PLAYER:
            print_board(board)
            print("You win!")
            break
        elif is_full(board):
            print_board(board)
            print("It's a draw!")
            break
        print("AI is making a move...")
        move = best_move(board)
        if move:
            board[move[0]][move[1]] = AI
        print_board(board)
        if check_winner(board) == AI:
            print("AI wins!")
            break
        elif is_full(board):
            print("It's a draw!")
            break
if __name__ == "__main__":
    play_game()
```

ScreenShot:


Output
| |

| |

| |

Enter row (0-2): 0
Enter col (0-2): 0
AI is making a move...
X | |

| O |

| |

Enter row (0-2): 1
Enter col (0-2): 2
AI is making a move...
X | O |

| O | X

| |

Enter row (0-2): 0
Enter col (0-2): 2
AI is making a move...
X | O | X

| O | X

| O |

AI wins!