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

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in

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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 S Rakhal(1BM22CS229), 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/Rakhal01234/AI-lab

LAB 1: Tic –Tac –Toe Game

Algorithm:

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Tic Tac Toe

1) step 1: Make an array of 9 blocks

2) step 2: Let CPU or human make any random move one by one.

3) Step 3: For the second step choose the nearest free box from the last entered value.

4) step 4: check for computer :-
if any (n mod 3) == same.
values place the 3rd value
from the cpu to the next position.

5) Step 5:- transpose the matrix of array values and check for the columns using step 4

6) Step 6: If all n mod 3 matches connect the points and declare that player as a winner

7) Step 7:- check for diagonal elements
if [block 1=5=9] mark win
if [block 3=5=7] mark win

8) Step 8: stop clock

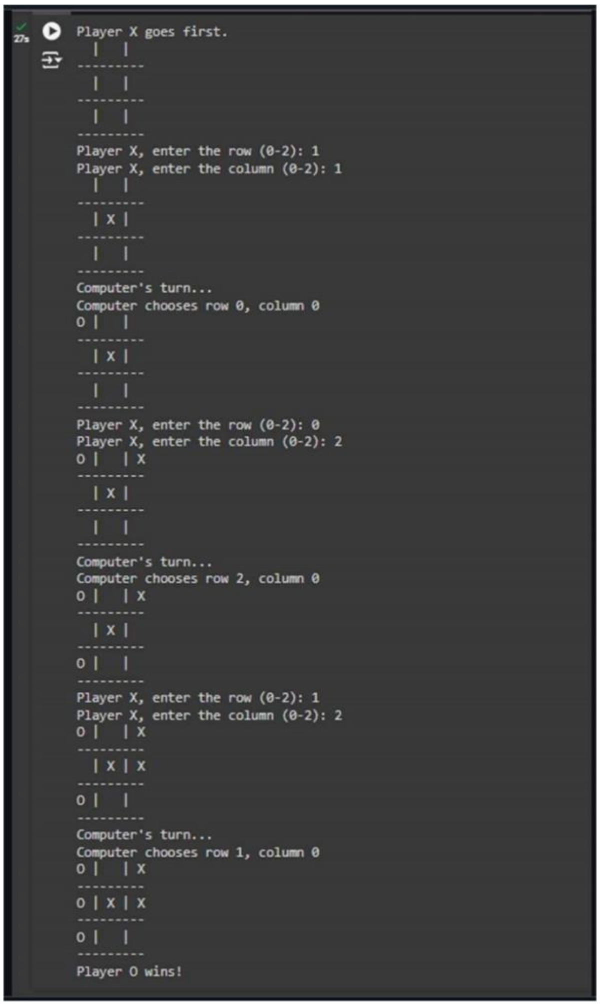
Code:

```
import random

def print_board(board):
    for row in board:
        print(" | ".join(row))
        print("-" * 9)

def check_winner(board):
    # Check rows, columns, and diagonals for a winner
    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 find_winning_move(board, player):
    for i in range(3):
        for j in range(3):
            if board[i][j] == " ": board[i][j] =
                player if check_winner(board) ==
                player: board[i][j] = " " # Undo
                move
                    return (i, j)
                board[i][j] = " " # Undo move
    return None

def get_computer_move(board): # Check
    for winning move move =
    find_winning_move(board, "O") if
    move:
        return move
```

```
    # Check for blocking move move =
    find_winning_move(board, "X") if
    move:
        return move

    # Take the center if available
    if board[1][1] == " ":
        return (1, 1)

    # Take a corner if available corners =
    [(0, 0), (0, 2), (2, 0), (2, 2)] for
    corner in corners:
        if board[corner[0]][corner[1]] == " ":
            return corner

    # Take any remaining space
    for i in range(3):
        for j in range(3):
            if board[i][j] == " ":
                return (i, j)

def tic_tac_toe():
    board = [[" " for _ in range(3)] for _ in
    range(3)] current_player = "X" # X is the
    human player computer_player = "O"
    print("Player X goes first.")

    while True:
        print_board(board)

        if current_player == "X":
            while True:
                try:
                    row = int(input("Player X, enter the row (0-2): "))
                    col = int(input("Player X, enter the column (0-2): "))
                    if board[row][col] == " ":
                        break
                    else:
                        print("Cell is already taken! Try again.")
                except (ValueError, IndexError):
                    print("Invalid input! Please enter numbers between 0 and 2.")
        else:
            print("Computer's turn...") row, col =
        get_computer_move(board) print(f"Computer chooses
        row {row}, column {col}") board[row][col] =
        current_player

        winner = check_winner(board)
        if winner:
```

```
            print_board(board)
            print(f"Player {winner} wins!")
            break

        if is_full(board):
            print_board(board)
            print("It's a tie!") break current_player = computer_player if

        current_player == "X" else "X"

if _name_== "_main_": tic_tac_toe()
```

OUTPUT:



```
Player X goes first.
  |   |
---------
  |   |
---------
  |   |
---------
Player X, enter the row (0-2): 1
Player X, enter the column (0-2): 1
  |   |
---------
  | X |
---------
  |   |
---------
Computer's turn...
Computer chooses row 0, column 0
O |   |
---------
  | X |
---------
  |   |
---------
Player X, enter the row (0-2): 0
Player X, enter the column (0-2): 2
O |   | X
---------
  | X |
---------
  |   |
---------
Computer's turn...
Computer chooses row 2, column 0
O |   | X
---------
  | X |
---------
O |   |
---------
Player X, enter the row (0-2): 1
Player X, enter the column (0-2): 2
O |   | X
---------
  | X | X
---------
O |   |
---------
Computer's turn...
Computer chooses row 1, column 0
O |   | X
---------
O | X | X
---------
O |   |
---------
Player O wins!
```

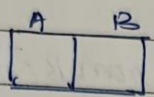
LAB 2: Vacuum World

Algorithm:

Vaccum cleaner agent

Write an algorithm and a program for an AI controlled vaccum cleaner.

S-1:- Create 2 rooms using AB array. The room A is on the left side of B and Room B is on the Ri-



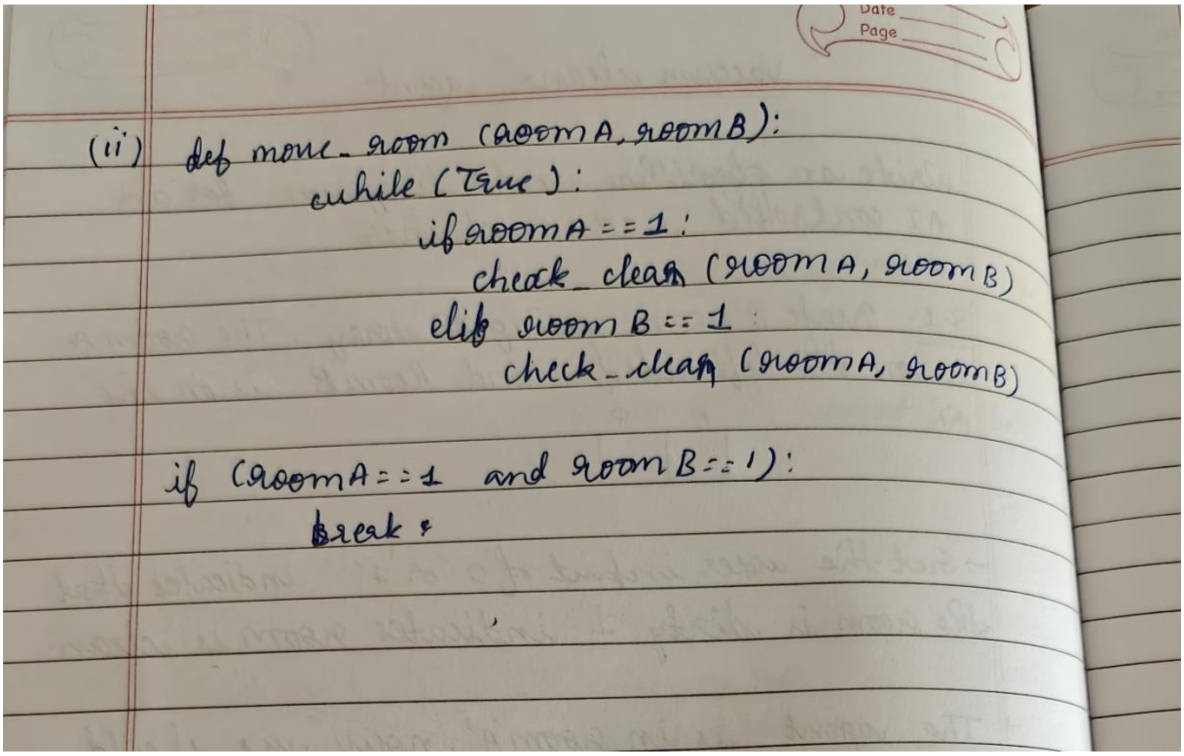
→ Get the user input of '0' or '1' indicates that the room is dirty. '1' indicates room is clean.

→ The agent is in room 'A', now we should define a function to check if the room is clean or dirty

user input ⇒ room A, room B → variable 0 ~~or~~ 1

① def check - clean (var1, var2)

```
if: var 1 == 0:        if var 2 == 0;
  # clean                #clean
  var = 1                var = 1
else:
    move-room (var 1, var 2)
    break
```



```
(ii) def move_room (roomA, roomB):
        while (True):
            if roomA == 1:
                check_clean (roomA, roomB)
            elif roomB == 1:
                check_clean (roomA, roomB)

     if (roomA == 1 and roomB == 1):
            break;
```

Code:

```
class VacuumCleaner:
    def _init_(self, room_a_status, room_b_status): # Initialize the
        status of the rooms and the vacuum's position self.rooms =
        {'A': room_a_status, 'B': room_b_status} self.current_room
        = 'A'

    def check_clean(self):
        """Checks if the current room is clean.""" if
        self.rooms[self.current_room] == 'dirty': print(f"Room
        {self.current_room} is dirty. Cleaning now...")
        self.rooms[self.current_room] = 'clean'
```

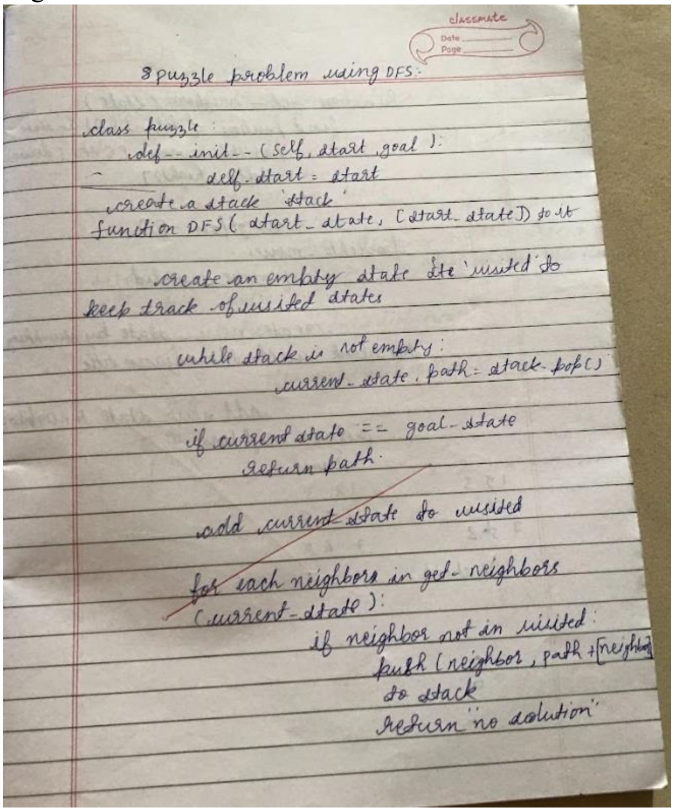
```
        else:
            print(f"Room {self.current_room} is already clean.")

    def print_status(self):
        """Prints the status of both rooms."""
        print("\nRoom   Status:")   for   room,
        status in self.rooms.items():
            print(f"Room {room}: {status}")
        print()

    def move_rooms(self):
        """Moves the vacuum cleaner to the other room."""
        if self.current_room == 'A':
            self.current_room = 'B'
        else:
            self.current_room = 'A'
        print(f"Moved to Room {self.current_room}.")

    def start_cleaning(self, steps):
        """Runs the cleaning process for a specified number of
        steps.""" for step in range(steps): print(f"\nStep {step + 1}:")
        self.print_status() self.check_clean() self.move_rooms()
        print("\nFinal Room Status:")
        self.print_status()


# Main execution
def main():
    print("Enter the initial status of Room A (clean/dirty):")
    room_a_status = input().strip().lower() print("Enter the
    initial status of Room B (clean/dirty):") room_b_status
    = input().strip().lower()

    # Validate input valid_statuses = {'clean', 'dirty'} if room_a_status not in
    valid_statuses or room_b_status not in valid_statuses: print("Invalid input!
    Please enter 'clean' or 'dirty' for room statuses.") return

    vacuum = VacuumCleaner(room_a_status, room_b_status)
    steps = 4 # Number of steps for the simulation
    vacuum.start_cleaning(steps)


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

OUTPUT:

```
Enter the initial status of Room A (clean/dirty):
dirty
Enter the initial status of Room B (clean/dirty):
dirty

Step 1:

Room Status:
Room A: dirty
Room B: dirty

Room A is dirty. Cleaning now...
Moved to Room B.

Step 2:

Room Status:
Room A: clean
Room B: dirty

Room B is dirty. Cleaning now...
Moved to Room A.

Step 3:

Room Status:
Room A: clean
Room B: clean

Room A is already clean.
Moved to Room B.

Step 4:

Room Status:
Room A: clean
Room B: clean

Room B is already clean.
Moved to Room A.

Final Room Status:

Room Status:
Room A: clean
Room B: clean
```

LAB 3: Implement 8 puzzle problems

Algorithm:



8 puzzle problem using DFS:-

class puzzle:
    def __init__(self, start, goal):
        self.start = start
create a stack 'stack'
function DFS(start_state, [start_state]) to it

create an empty state ste 'visited' to
keep track of visited states

while stack is not empty:
    current_state, path = stack.pop()

if current state == goal_state
    return path.

add current state to visited

for each neighbors in get_neighbors
(current_state):
    if neighbor not in visited:
        push (neighbor, path + [neighbor]
        to stack
        return "no solution"

classmate
Date
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function get_neighbors (state):
find position of blank (0) in state
possible moves - [(up), (down), (left), (right)]

neighbors = [ ]
possible_moves:
if move is valid:

create new_state by swapping the blank with the adjacent tile

add new_state to neighbors
return neighbors

Goal state

1 2 3			1 2 3		
4 0 6			4 5 6		
7 5 8			7 8 0		

y check

5
0

classmate
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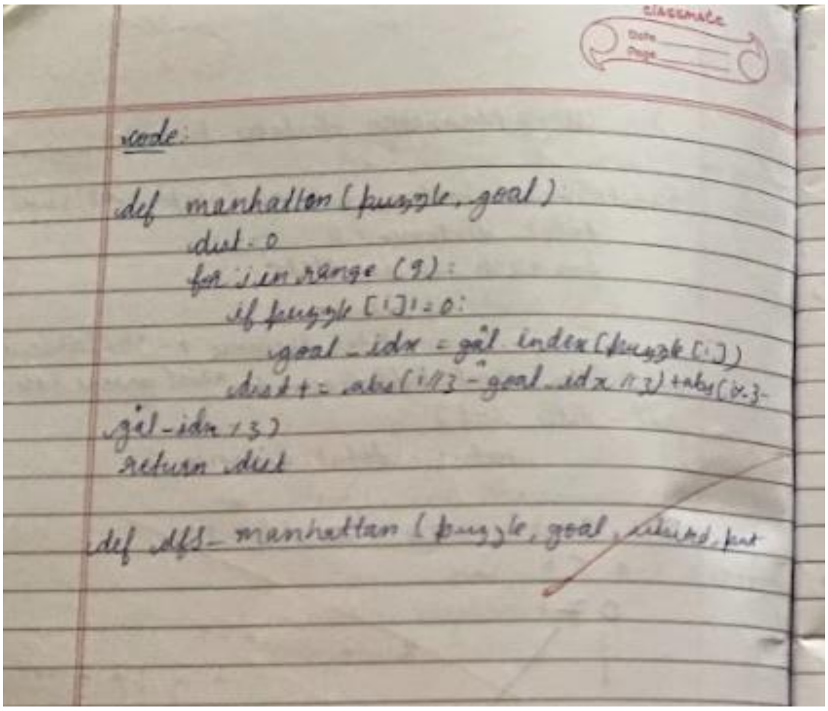
Using Manhatten distance heuristic

function Manhatten_distance (state, goal_state):
total_distance = 0
for each tile in state:
if tile != 0:
total distance += abs(current tile.row - goal_tile.row) + abs(current_tile.col - goal_tile.col)
return total_distance

1 2 3 Tile 8 is at position
4 5 6
~~0~~ ~~7~~ 8
2, 2   2, 1
2-2 + 2-1 = 0+1 = 1

8/10/24



```
code:

def manhattan (puzzle, goal)
    dist = 0
    for i in range (9):
        if puzzle [i] != 0:
            goal_idx = goal.index(puzzle[i])
        dist += abs(i//3 - goal_idx //3) + abs(i%3 -
goal_idx %3)
    return dist

def dfs_manhattan (puzzle, goal, visited, pat
```

Code:

```
import numpy as np
from copy import deepcopy

class PuzzleSolver:
    def _init_(self, initial_state, goal_state):
        self.initial_state = initial_state
        self.goal_state = goal_state
        self.visited = set()

    def manhattan_distance(self, state):
        """Calculate the Manhattan distance of a
        state.""" distance = 0 for i in range(3):
            for j in range(3):
                value = state[i][j]
                if value != 0: # Skip the blank tile
                    goal_x, goal_y = [(x, y) for x in range(3) for y in range(3) if self.goal_state[x][y] == value][0]
                    distance += abs(goal_x - i) + abs(goal_y - j)
        return distance

    def is_goal_state(self, state):
        """Check if a state matches the goal state."""
        return state == self.goal_state

    def get_neighbors(self, state):
        """Generate all valid neighbor states from the current state."""
        neighbors = [] state_array = np.array(state) x, y =
        np.where(state_array == 0)
```

```
        x, y = x.item(), y.item() # Blank tile's position as scalars moves =
        [(-1, 0), (1, 0), (0, -1), (0, 1)] # Up, Down, Left, Right

        for dx, dy in moves:
            new_x, new_y = x + dx, y + dy if 0 <=
            new_x < 3 and 0 <= new_y < 3: # Swap
            blank tile with the adjacent tile new_state
            = deepcopy(state)
                new_state[x][y], new_state[new_x][new_y] = new_state[new_x][new_y], new_state[x][y]
                neighbors.append(new_state)

        return neighbors

    def dfs(self, state, depth=0, max_depth=50):
        """Perform DFS to find the solution.""" if depth >
        max_depth: # Depth limit to avoid infinite loops
            return None

        if self.is_goal_state(state):
            return [state]

        # Convert state to a tuple to hash it
        self.visited.add(tuple(map(tuple, state)))

        neighbors = self.get_neighbors(state)
        # Sort neighbors by Manhattan distance to prioritize promising states
        neighbors.sort(key=lambda n: self.manhattan_distance(n))

        for neighbor in neighbors:
            if tuple(map(tuple, neighbor)) not in self.visited:
                path = self.dfs(neighbor, depth + 1, max_depth)
                if path:
                    return [state] + path

        return None


# Main execution
def main():
    initial_state = [
        [1, 2, 3],
        [4, 0, 5],
        [7, 8, 6]
    ]
    goal_state = [
        [1, 2, 3],
        [4, 5, 6],
        [7, 8, 0]
    ]

    solver = PuzzleSolver(initial_state, goal_state)
    solution = solver.dfs(initial_state)

    if solution:
```

```
        print("Solution found:") for step,
        state in enumerate(solution):
            print(f"Step {step}:")
            for row in state:
                print(row)
            print()
    else:
        print("No solution found within the depth limit.")


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

OUTPUT:

```
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]

Total moves taken to reach the final state: 2
```

LAB 4: Iterative deepening search algorithm

Algorithm:

Date 15/10/21

Lab-4

8 puzzle using A*

Initial state

1	2	3
8		4
7	6	5

Goal state

2	8	1
	4	3
7	6	5

A* Algorithm

put node_start in the OPEN list with f(node_start) = h(node_start) (initialisation)
while the OPEN list is not empty {
    Take from the open list the node node_current with the lowest
        f(node_current) = g(node_current) + h(node_current)
    if node_current is node_goal we have found the solution; break
Generate each state node_successor that come after node_current
for each node_successor of node_current {
        Set successor_current_cost = g(node_current) + w(node_current, node_successor)

if node-successor is in the OPEN list {
if g(node-successor) ≤ successor-current-cost continue
} else if node-successor is in CLOSED LIST {
if g(node-successor) ≤ successor-current-cost continue
Move node-successor from the CLOSED list to the open list
} else {
Add node-successor to the OPEN list.
Set h(node-successor to the OPEN list
} }
Set g(node-successor) = successor-current-cost.
Set the parent of node-successor to node-current
}
Add node-current to the CLOSED list
}
if (node-current != node-goal) exit with error

Code:

```
import heapq
from copy import deepcopy

class PuzzleSolver:
    def _init_(self, initial_state, goal_state):
        self.initial_state = initial_state
        self.goal_state = goal_state

    def manhattan_distance(self, state):
        """Calculate the Manhattan distance of a state."""
        distance = 0 for i in range(3):
```

```
        for j in range(3):
            value = state[i][j]
            if value != 0: # Skip the blank tile
                goal_x, goal_y = [(x, y) for x in range(3) for y in range(3) if self.goal_state[x][y] == value][0]
                distance += abs(goal_x - i) + abs(goal_y - j)
    return distance

def is_goal_state(self, state):
    """Check if a state matches the goal state."""
    return state == self.goal_state

def get_neighbors(self, state):
    """Generate all valid neighbor states from the current state."""
    neighbors = []
    x, y = [(i, j) for i in range(3) for j in range(3) if state[i][j] == 0][0] # Locate blank tile
    moves = [(-1, 0), (1, 0), (0, -1), (0, 1)] # Up, Down, Left, Right

    for dx, dy in moves:
        new_x, new_y = x + dx, y + dy if 0 <=
        new_x < 3 and 0 <= new_y < 3: # Swap
        blank tile with the adjacent tile new_state
        = deepcopy(state)
            new_state[x][y], new_state[new_x][new_y] = new_state[new_x][new_y], new_state[x][y]
            neighbors.append(new_state)

    return neighbors

def iddfs(self, state, max_depth=50):
    """Perform Iterative Deepening Depth First Search (IDDFS)."""
    def dls(current_state, depth):
        if depth == 0:
            return None
        if self.is_goal_state(current_state):
            return [current_state]

        for neighbor in self.get_neighbors(current_state):
            result = dls(neighbor, depth - 1)
            if result:
                return [current_state] + result
        return None

    for depth in range(1, max_depth + 1):
        result = dls(state, depth)
        if result:
            return result
    return None

def a_star(self):
    """Perform A* search to solve the puzzle."""
    open_set = []
    heapq.heappush(open_set, (0, self.initial_state, [])) # (f, state, path)

    closed_set = set()
```

```
        while open_set:
            f, current_state, path = heapq.heappop(open_set)

            if self.is_goal_state(current_state):
                return path + [current_state]

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

            for neighbor in self.get_neighbors(current_state):
                if tuple(map(tuple, neighbor)) not in closed_set: g =
                    len(path) + 1 # Cost to reach this neighbor h =
                    self.manhattan_distance(neighbor) # Heuristic cost
                    heapq.heappush(open_set, (g + h, neighbor, path + [current_state]))

        return None


# Main execution
def main():
    initial_state = [
        [1, 2, 3],
        [4, 0, 5],
        [7, 8, 6]
    ]
    goal_state = [
        [1, 2, 3],
        [4, 5, 6],
        [7, 8, 0]
    ]

    solver = PuzzleSolver(initial_state, goal_state)

    print("Using IDDFS:") iddfs_solution =
    solver.iddfs(initial_state) if
    iddfs_solution:
        for step, state in enumerate(iddfs_solution):
            print(f"Step {step}:")
            for row in state:
                print(row)
            print()
    else:
        print("No solution found with IDDFS.")

    print("Using A* Algorithm:")
    a_star_solution = solver.a_star()
    if a_star_solution:
        for step, state in enumerate(a_star_solution):
            print(f"Step
            {step}:") for row in
            state: print(row)
            print()
    else:
        print("No solution found with A* Algorithm.")
```

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

OUTPUT:

```
Using IDDFS:
Step 0:
[1, 2, 3]
[4, 0, 5]
[7, 8, 6]

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

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

Using A* Algorithm:
Step 0:
[1, 2, 3]
[4, 0, 5]
[7, 8, 6]

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

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

LAB 5: Simulated Annealing

Algorithm:

22/10/2024

Lab 5

Simulated Annealing Algorithm.

1) Initialise parameter

- Set the initial solution S
- Set the initial temperature T
- Define cooling rate α $(0 < \alpha < 1)$.
- Set the stopping criterion.

2) Iterate:

Repeat until a stopping condition (like a low temperature or a certain no. of iterations) are met.

- Generate a neighboring state: Slightly modify the current state to explore new solutions.

- Evaluate energy: Calculate the energy (objective function) of the new state.

- Acceptance decision:

- If the new state has lower energy than the prev. solution accept it.
- If the higher energy is found, accept it with

the probability that the temp (is is) dependant and how much worse the new state is

metropolis criteria.

$$P(accept) = e^{-\frac{(E_{new} - E_{current})}{T}}$$

update temperature $T = T \times \alpha$

1) Cool down: Gradually reduce the temperature according to the cooling schedule

2) Stop: Once the temperature is low or after a set number of iterations, stop and return the best solution found.

Code:

```
import math
import random

def objective_function(x):
    """Calculate the value of the objective function: f(x) = x^2 + 5*sin(x)."""
    return x**2 + 5 * math.sin(x)

def simulated_annealing(objective, x_start, temperature, cooling_rate, max_iterations):
    """
    Solve the objective function using the Simulated Annealing algorithm.

    Parameters:
    - objective: The objective function to minimize.
    - x_start: Initial guess.
    - temperature: Initial temperature.
    - cooling_rate: Rate at which the temperature decreases.
    - max_iterations: Maximum number of iterations.

    Returns:
    - Best solution found and its objective value.
    """
    current_x = x_start
    current_value = objective(current_x)
    best_x = current_x best_value =
    current_value
```

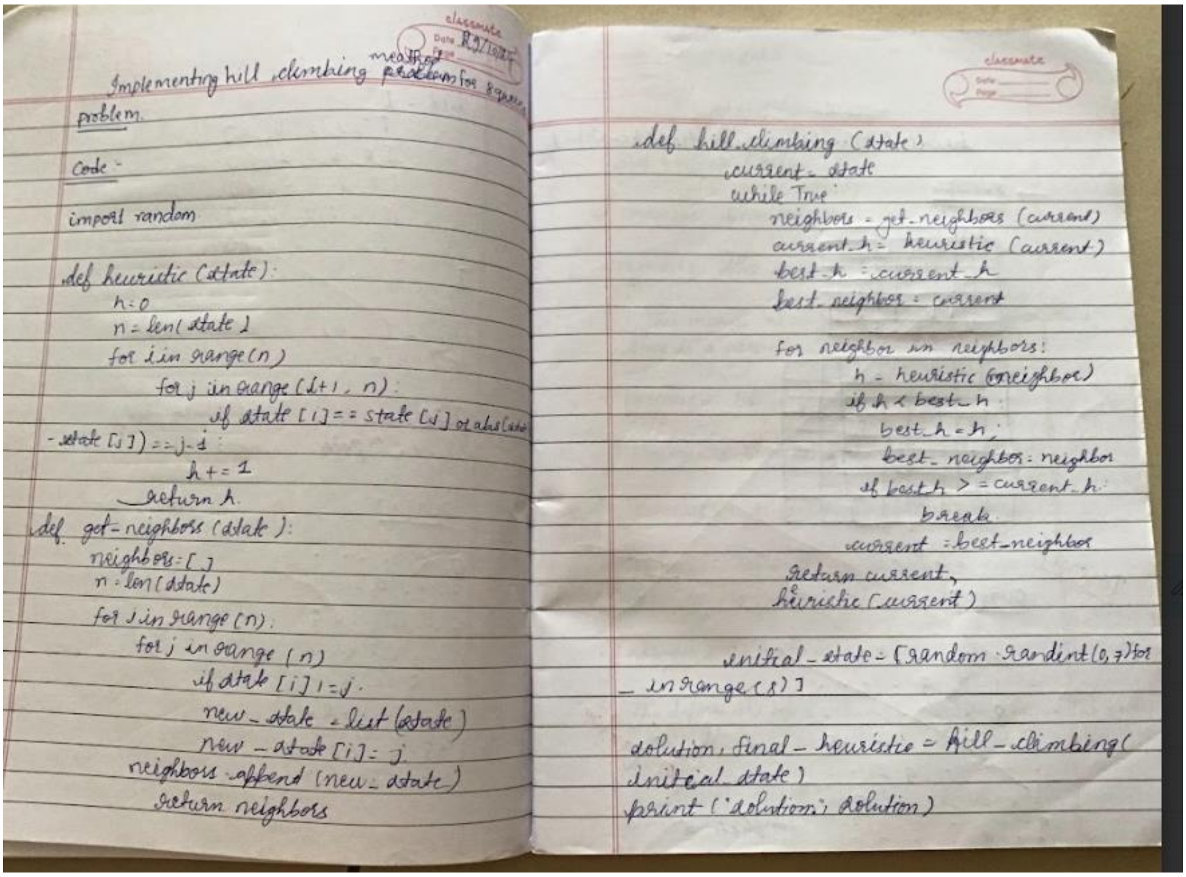
```
    for i in range(max_iterations):
        # Generate a new candidate solution in the neighborhood
        new_x = current_x + random.uniform(-1, 1) new_value
        = objective(new_x)

        # Calculate the change in the objective function
        delta = new_value - current_value

        # Accept the new solution with probability based on temperature if
        delta < 0 or random.uniform(0, 1) < math.exp(-delta / temperature):
            current_x = new_x
            current_value = new_value

            # Update the best solution found
            if current_value < best_value:
            best_x = current_x
                best_value = current_value

        # Decrease the temperature
        temperature *= cooling_rate

        # Log the process
        print(f"Iteration {i + 1}: Current x = {current_x:.5f}, Current value = {current_value:.5f}, Temperature =
{temperature:.5f}")

        # Stop if temperature is very low
        if temperature < 1e-8:
            break

    return best_x, best_value



# Main execution if _name
== "_main_": # Problem
settings
    initial_guess = random.uniform(-10, 10) # Random initial guess in the range [-10, 10]
    initial_temperature = 1000 cooling_rate = 0.99 max_iterations = 1000

    # Solve using Simulated Annealing best_solution,
    best_value = simulated_annealing(
        objective_function,
        initial_guess,
        initial_temperature,
        cooling_rate,
        max_iterations
    )

    print("\nBest solution found:")
    print(f"x =
    {best_solution:.5f}")
    print(f"f(x) = {best_value:.5f}")
```

OUTPUT:

```
Iteration 1: Current x = -5.56416, Current value = 34.25313, Temperature = 990.00000
Iteration 2: Current x = -6.02604, Current value = 37.58479, Temperature = 980.10000
Iteration 3: Current x = -6.24016, Current value = 39.15466, Temperature = 970.29900
Iteration 4: Current x = -6.85487, Current value = 44.28396, Temperature = 960.59601
Iteration 5: Current x = -6.21720, Current value = 38.98326, Temperature = 950.99005
Iteration 6: Current x = -5.39550, Current value = 32.98950, Temperature = 941.48015
Iteration 7: Current x = -5.63427, Current value = 34.76662, Temperature = 932.06535
Iteration 8: Current x = -5.01814, Current value = 29.94981, Temperature = 922.74469
Iteration 9: Current x = -5.83909, Current value = 36.24321, Temperature = 913.51725
Iteration 10: Current x = -5.85223, Current value = 36.33726, Temperature = 904
    .38208
Iteration 11: Current x = -6.23692, Current value = 39.13040, Temperature = 895
    .33825
Iteration 12: Current x = -6.81731, Current value = 43.93031, Temperature = 886
    .38487
Iteration 13: Current x = -7.42666, Current value = 50.60492, Temperature = 877
    .52102
Iteration 14: Current x = -6.55917, Current value = 41.66021, Temperature = 868
    .74581
Iteration 15: Current x = -5.69145, Current value = 35.18161, Temperature = 860
    .05835
Iteration 16: Current x = -5.30006, Current value = 32.25183, Temperature = 851
    .45777
Iteration 17: Current x = -4.63293, Current value = 26.44825, Temperature = 842
    .94319
Iteration 18: Current x = -4.87561, Current value = 28.70509, Temperature = 834
    .51376
Iteration 19: Current x = -4.67690, Current value = 26.87028, Temperature = 826
    .16862
Iteration 20: Current x = -5.21288, Current value = 31.56089, Temperature = 817
    .90694
```

LAB 6: Implement Hill Climbing

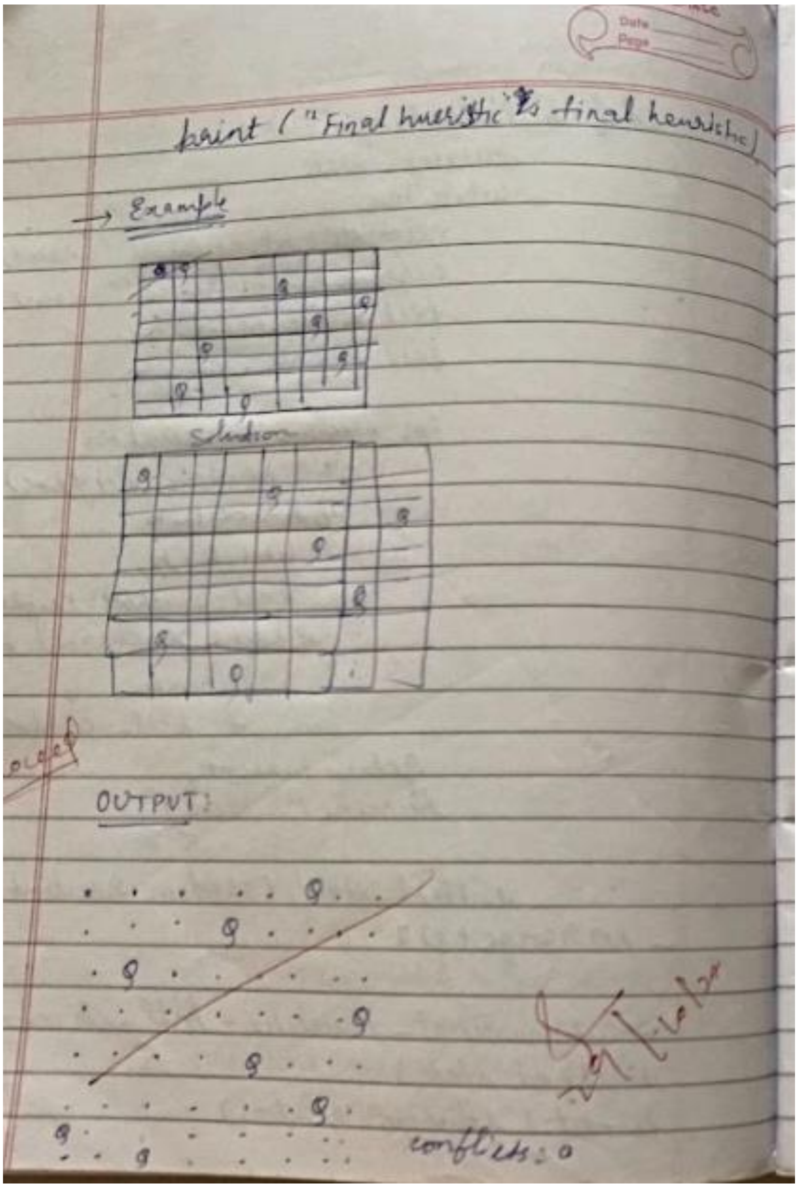
Algorithm:



Implementing hill climbing method for 8 queens problem.

Code -

```
import random

def heuristic (state):
    h=0
    n = len( state )
    for i in range(n)
        for j in range (i+1 , n):
            if state [i] == state [j] or abs(state[i]
- state [j]) == j-i :
                h += 1
    return h.
def get-neighbors (state ):
    neighbors = [ ]
    n = len(state)
    for i in range (n):
        for j in range (n)
            if state [i] != j :
                new_state = list (state)
                new_state [i] = j
        neighbors.append (new_state)
        return neighbors

def hill_climbing (state)
    current = state
    while True
        neighbors = get_neighbors (current)
        current_h = heuristic (current)
        best_h = current_h
        best_neighbor = current

        for neighbor in neighbors:
            h = heuristic (neighbor)
            if h < best_h :
                best_h = h;
                best_neighbor = neighbor
            if best_h > = current_h :
                break
            current = best_neighbor
        return current,
        heuristic (current)

    initial_state = [random.randint(0,7) for
_ in range (8) ]

solution, final_heuristic = hill_climbing(
initial_state)
print ('solution', solution)
```


print ("Final heuristic", final heuristic)

→ Example

Solution

OUTPUT:

conflicts: 0

Code:

```
import random

class EightQueensSolver:
    def _init_(self, size=8):
        self.size = size
        self.board = self.initialize_board()

    def initialize_board(self):
        """Initialize the board with one queen in each column at a random row."""
        return [random.randint(0, self.size - 1) for _ in range(self.size)]

    def calculate_conflicts(self, board):
```

```
        """Calculate the number of conflicts for a given
        board.""" conflicts = 0 for i in range(self.size):
            for j in range(i + 1, self.size):
                # Check if queens are in the same row or diagonal if board[i]
                == board[j] or abs(board[i] - board[j]) == abs(i - j):
                    conflicts += 1
        return conflicts

    def get_neighbors(self, board):
        """Generate all possible neighbors of the current board."""
        neighbors = [] for col in range(self.size):
            for row in range(self.size):
                if row != board[col]:
                    new_board = board[:]
                    new_board[col] = row
                    neighbors.append(new_board
                    )
        return neighbors

    def hill_climbing(self):
        """Solve the 8-Queens problem using the Hill Climbing algorithm."""
        current_board = self.board
        current_conflicts = self.calculate_conflicts(current_board)

        while True:
            neighbors = self.get_neighbors(current_board)
            # Evaluate neighbors and find the best one
            neighbor_conflicts = [(self.calculate_conflicts(neighbor), neighbor) for neighbor in neighbors]
            best_neighbor_conflicts, best_neighbor = min(neighbor_conflicts, key=lambda x: x[0])

            # If no better neighbor is found, return the current board
            if best_neighbor_conflicts >= current_conflicts:
                return current_board, current_conflicts

            # Move to the better neighbor
            current_board = best_neighbor
            current_conflicts = best_neighbor_conflicts

    def print_board(self, board):
        """Print the chessboard."""
        for row in range(self.size):
        line = "" for col in
        range(self.size):
                if board[col] == row:
                    line += "Q "
                else:
                    line += ". "
            print(line)
        print()


# Main execution if _name_==
"_main_": solver =
EightQueensSolver()
```

```
    solution, conflicts = solver.hill_climbing()

    print("Solution found:")
    solver.print_board(solution)
    print(f"Number of conflicts: {conflicts}")
```

OUTPUT:

```
Solution found:
. . . . . Q Q . .
. Q . . . . . . .
. . . . . . . . .
. . . . . . . Q .
. . Q . . . . . .
. . . . . . . . Q
. . . Q . . . . .
Q . . . . . . . .

Number of conflicts: 2
Solution board (column positions for each row): [0, 6, 3, 5, 7, 1, 4, 2]
```

Code :

```
import heapq

 class EightQueensSolverAStar:
    def _init_(self, size=8):
        self.size = size

    def calculate_conflicts(self, board):
        """Calculate the number of conflicts for a given
        board.""" conflicts = 0 for i in range(len(board)):
            for j in range(i + 1, len(board)):
                # Check for conflicts in rows or diagonals if board[i] ==
                board[j] or abs(board[i] - board[j]) == abs(i - j):
                    conflicts += 1
        return conflicts

    def get_neighbors(self, board):
        """Generate all possible neighbors of the current board."""
        neighbors = [] for col in range(len(board)):
            for row in range(self.size):
                if board[col] != row: new_board
                    = board[:] new_board[col] =
                    row
                    neighbors.append(new_boar
                    d)
        return neighbors
```

```
def a_star(self):
    """Solve the 8-Queens problem using the A* algorithm."""
    # Priority queue for A* search
    open_set = []
    initial_board = [0] * self.size # Start with all queens in the first row
    heapq.heappush(open_set, (0, 0, initial_board)) # (f, g, state)

    while open_set:
        f, g, current_board = heapq.heappop(open_set)

        # Calculate conflicts in the current state current_conflicts
        =          self.calculate_conflicts(current_board)          if
        current_conflicts == 0:
            return current_board # Solution found

        # Generate neighbors and add them to the priority queue for
    neighbor in self.get_neighbors(current_board): h =
    self.calculate_conflicts(neighbor) # Heuristic cost
    heapq.heappush(open_set, (g + 1 + h, g + 1, neighbor)) # f = g + h
    return None # No solution found

def  print_board(self,  board):
    """Print  the  chessboard."""
    for  row  in  range(self.size):
    line    =    ""    for    col    in
    range(self.size):
          if board[col] == row:
              line += "Q "
          else:
              line += ". "
        print(line)
    print()


# Main execution if _name_== "_main_":
solver = EightQueensSolverAStar(size=8)
    solution = solver.a_star()

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

OUTPUT:

```
Solution found:
. . . Q . . . .
. Q . . . . . .
. . . . . . . Q
. . . . . Q . .
Q . . . . . . .
. . Q . . . . .
. . . . Q . . .
. . . . . . Q .
```

LAB 7: Propositional Logic

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

Algorithm:

Lab 6.

propositional logic.

Step by Step Solution.

1) Premises from knowledge Base:

- premise 1: Alice is the mother of Bob

This means alice is bob's mother, and thus, Alice is a parent of Bob.

- premise 2: Bob is the father of charlie.

This means that Bob is charlie's father

- premise 3: A father is a parent

→ This means ~~Bob is~~ it defines role of a parent. Since the ∴ bob is a parent

- premise 4: A mother is a parent.

→ This defines the role of a parent. Since Alice is the mo
of Bob, Alice is a parent.

- premise 5: All parents have children

Entailment

Step:	Logical Expression	Conclusion
1)	P1	Alice is the mother of Bob
2)	P3	A mother is a parent
3)	$P1 \land P_3 \rightarrow P8$	Alice is a parent (P8)
4)	P2	Bob is the father of charlie
5)	P4	A father is a parent
6)	$P2 \land P4$	Bob is a parent (P9)
7)	P5	All parents have children
8)	$P8 \land P5$	Alice has children
9)	$P9 \land P5$	Bob has children
10)	P6	Parents children are siblings

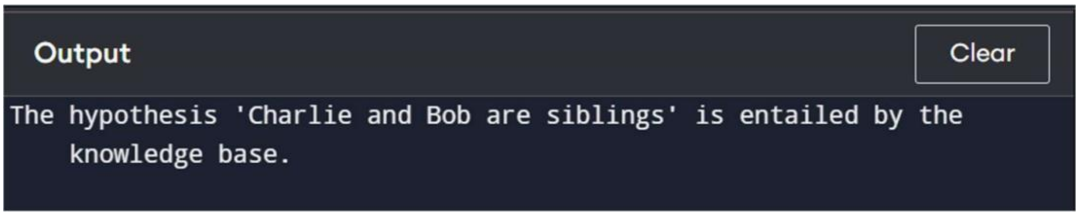
11) ∴ Bob is a child and charlie is a child
the above hypothesis is entailed by the knowledgebase

Code: class
KnowledgeBase:

```
    def _init_(self): self.facts =
        []
        self.rules = []

    def add_fact(self, fact):
        self.facts.append(fact)

    def add_rule(self, premise, conclusion):
        self.rules.append((premise, conclusion))

    def infer(self):
        new_inferences = True
```

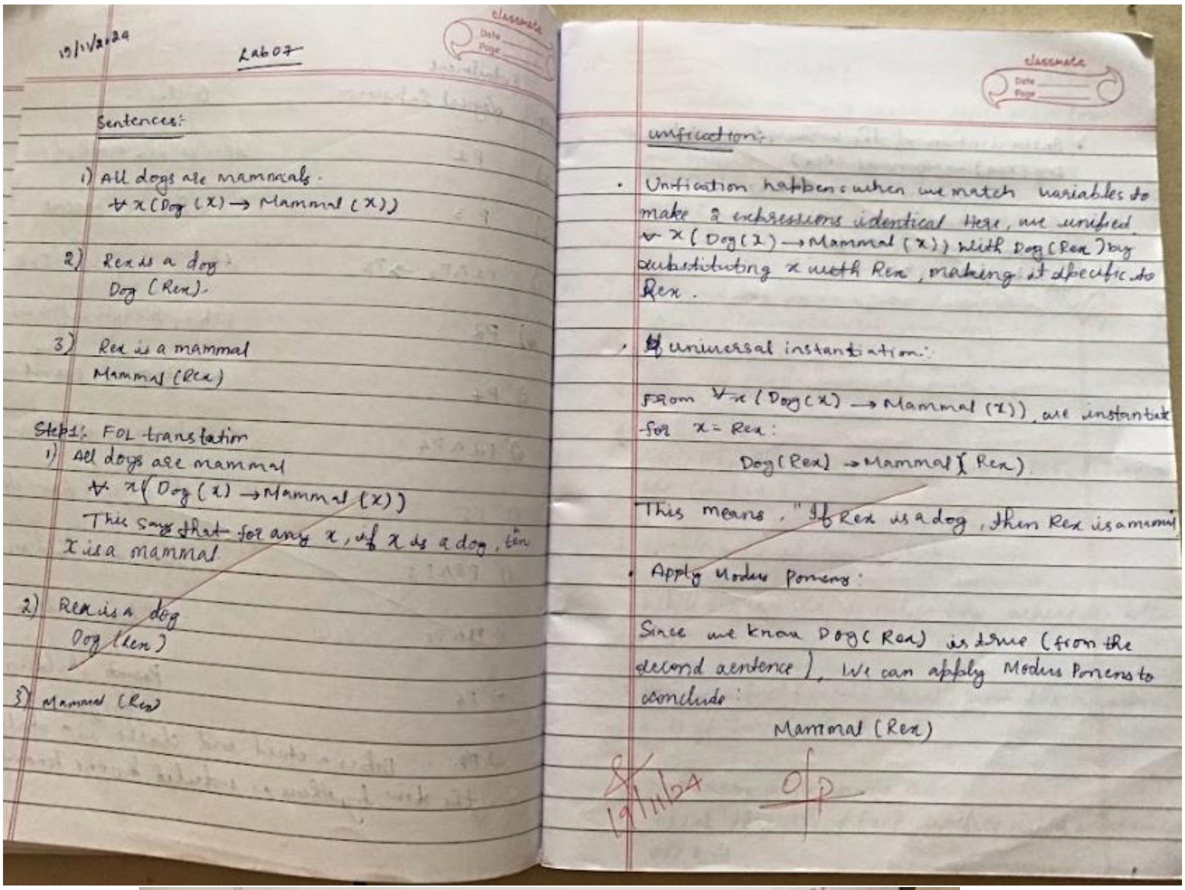
```
        while new_inferences:
            new_inferences = False

            for premise, conclusion in self.rules:
                if all(fact in self.facts for fact in premise) and conclusion not in self.facts:
                    self.facts.append(conclusion)
                    new_inferences = True

    def entails(self, hypothesis):
        return hypothesis in self.facts

# Example Usage kb
= KnowledgeBase()

# Adding facts
kb.add_fact("Alice is mother of Bob")
kb.add_fact("Bob is father of Charlie")
kb.add_fact("A father is a parent")
kb.add_fact("A mother is a parent")
kb.add_fact("All parents have children")
kb.add_fact("Alice is married to Davis")

# Adding rules
kb.add_rule(["Bob is father of Charlie", "A father is a parent"], "Bob is parent")
kb.add_rule(["Alice is mother of Bob", "A mother is a parent"], "Alice is parent")
kb.add_rule(["Bob is parent", "All parents have children"], "Charlie and Bob are siblings")

# Perform inference
kb.infer()

# Hypothesis
hypothesis = "Charlie and Bob are siblings"

if kb.entails(hypothesis):
    print(f"The hypothesis '{hypothesis}' is entailed by the knowledge base.")
else:
    print(f"The hypothesis '{hypothesis}' is not entailed by the knowledge base.")
```

OUTPUT:



LAB 8: Unification in first order logic

Algorithm:


19/11/2024

Lab 07

Sentences:

1) All dogs are mammals.
$\forall x (Dog(x) \rightarrow Mammal(x))$

2) Rex is a dog.
Dog(Rex).

3) Rex is a mammal
Mammal(Rex)

Step1: FOL translation

1) All dogs are mammal
$\forall x (Dog(x) \rightarrow Mammal(x))$
This says that for any x, if x is a dog, then x is a mammal

2) Rex is a dog
Dog(Rex)

3) Mammal(Rex)

Unification:

- Unification happens when we match variables to make 2 expressions identical. Here, we unified $\forall x (Dog(x) \rightarrow Mammal(x))$ with Dog(Rex) by substituting x with Rex, making it specific to Rex.

- Universal instantiation:

From $\forall x (Dog(x) \rightarrow Mammal(x))$, we instantiate for x = Rex:

Dog(Rex) → Mammal(Rex)

This means, "If Rex is a dog, then Rex is a mammal"

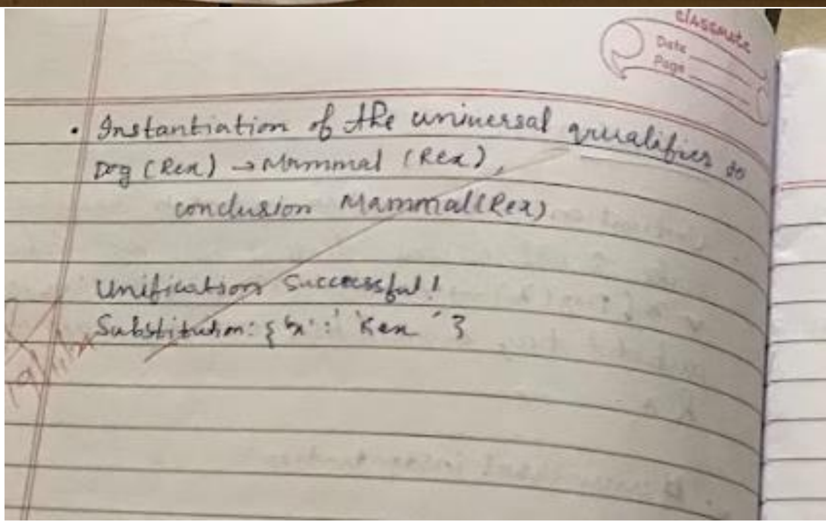
- Apply Modus Ponens:

Since we know Dog(Rex) is true (from the second sentence), we can apply Modus Ponens to conclude:

Mammal(Rex)

19/11/24

O/P

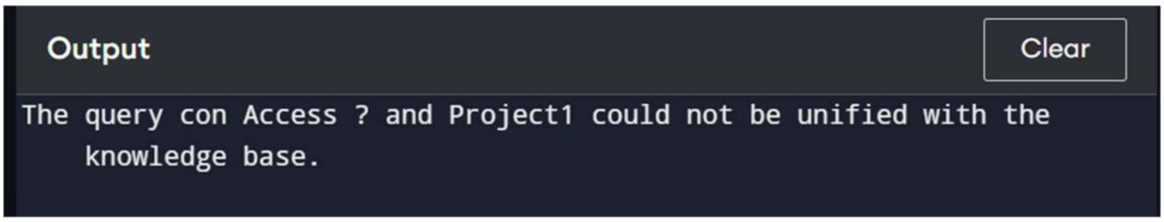

- Instantiation of the universal qualifier to Dog(Rex) → Mammal(Rex),
conclusion Mammal(Rex)

Unification Successful!
Substitution: {'x': 'Rex'}

Code: def

```
unify(kb, query):
    # Extract predicate and target project from the
    query predicate = query['predicate'] target_project
    = query['arguments'][1] result = []

    # Iterate through knowledge base (kb)
    for item in kb:
        if item["type"] == "eule" and predicate in item:
            rule = item["rule"]

            if "Assigned To" in rule and "con Access" in rule: #
                Check for the "Assigned To" and "con Access" facts
                for fact in kb:
                    if fact["type"] == "fort" and "Assigned To" in fact:
                        fact_parts = fact["Assigned To"].split("(")
                        fact_parts = fact_parts[1].strip(")").split(",")
                        person, project = fact_parts[0].strip(), fact_parts[1].strip()

                        if project == target_project:
                            result.append(person)

    if result: return f"The query {query['predicate']} {query['arguments'][0]} and {target_project} has been
        unified."
    else: return f"The query {query['predicate']} {query['arguments'][0]} and {target_project} could not be unified with
        the
knowledge base."

# Example knowledge base
kb = [
    {"type": "eule", "rule": "Writes( Alice, Project1)"},
    {"type": "fort", "Assigned To": "Alice(Project1)"},
    {"type": "fort", "Assigned To": "Bob(Project2)"},
]

# Example query
query = {"predicate": "con Access", "arguments": ["?", "Project1"]}

# Run unification result
=    unify(kb,    query)
print(result)
```

OUTPUT:



LAB 9: Forward Chaining

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

Lab 8

Date 26/11/24

Forward chaining using first order logic.

Initialization -

- Start with a knowledge base (KB) containing facts and rules in First Order Logic:
- Extract all facts (ground literals) and rules (Horn clauses) from the KB.
- Ste the agenda with all facts

2) Define goal:

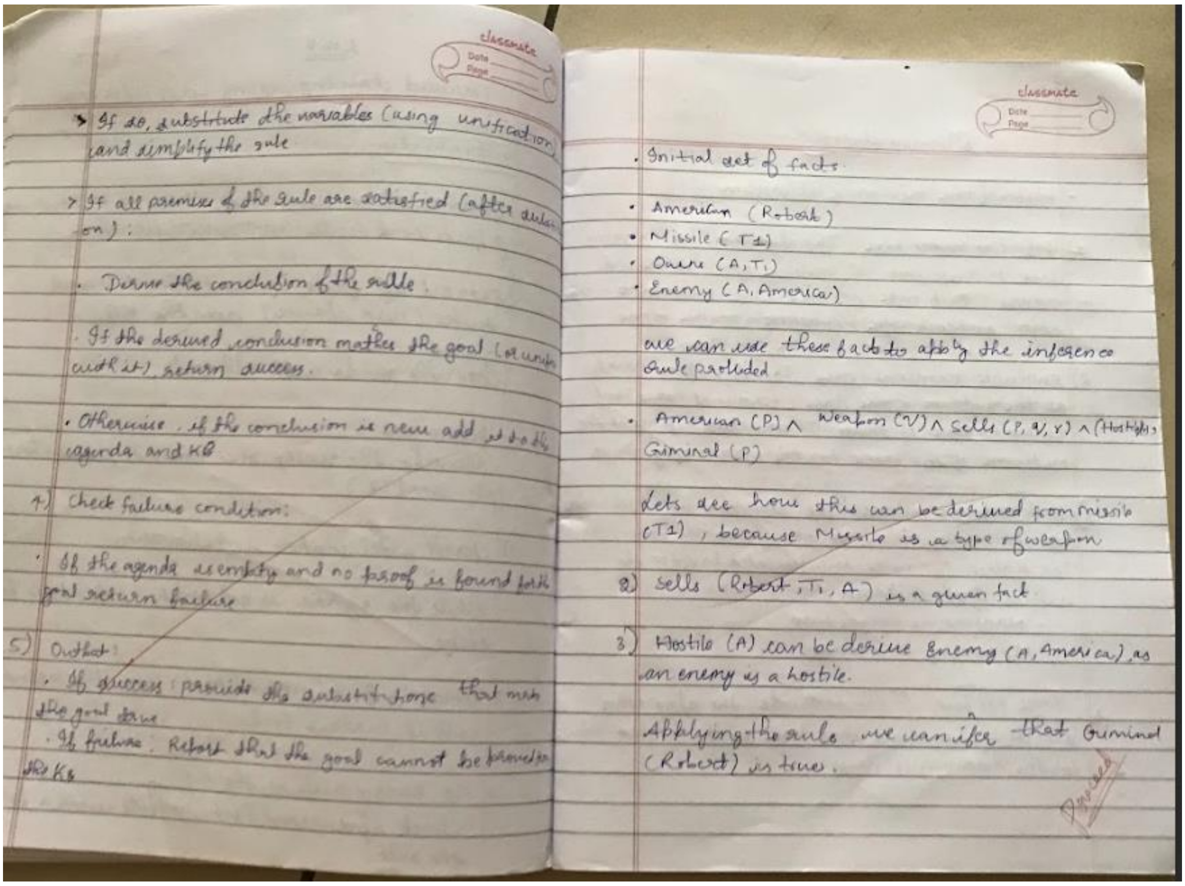
- Identify the query you want to prove. For example Goal(X)

3) Iterate until solution or Exhaustion.

- While the agenda is not empty, repeat the following steps:

> Remove a fact (ground literal) from the agenda. Call it Current Fact.

> For every rule in the KB:
Check if current Fact unifies with a premise the rule.



> If so, substitute the variables (using unification) and simplify the rule

> If all premises of the rule are satisfied (after substitution):

- Derive the conclusion of the rule.
- If the derived conclusion matches the goal (or unifies with it), return success.
- Otherwise, if the conclusion is new add it to the agenda and KB

4) Check failure condition:

- If the agenda is empty and no proof is found for the goal return failure

5) Output:

- If success provide the substitutions that make the goal true
- If failure, Report that the goal cannot be proved from the KB

- Initial set of facts

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

we can use these facts to apply the inference rule provided

- American (P) ∧ Weapon (Q) ∧ Sells (P, Q, R) ∧ (Hostile) ⇒ Criminal (P)

Lets see how this can be derived from missile (T1), because Missile is a type of weapon

2) Sells (Robert, T1, A) is a given fact

3) Hostile (A) can be derive Enemy (A, America), as an enemy is a hostile.

Applying the rule we can infer that Criminal (Robert) is true.

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()
```

OUTPUT:

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

LAB 10: Implement Tic Tac Toe using Min Max

Algorithm:

classmate
Date
Page

Minmax algorithm

- Steps of the min max algorithm

1) Define a Game tree: The algorithm uses a game tree to represent all possible game states and moves. Each node in the tree represents a game state, and each edge represents a possible move.

2) evaluate terminal nodes: The algorithm starts at the bottom of the tree (terminal nodes) and assigns value to them. These values represent the outcome of the game for the maximizing player.

3) Back propogate values: The algorithm uses backpropagation to assign values to non-terminal nodes. The value of a node is calculated based on the values of its children.
   - Maximizing player's turn
   - Minimizing player's turn.

4) Choose the best: At the root node, the algorithm selects the move that leads to the highest value for the maximizing player.

classmate
Date
Page

Let the terminal values be:

A: 5
B: 2
C: 8
D: 1

2) Min at first branch: min (A,B) = min(5,2)
Min at 2nd branch: (min (C,D)) = min(8,1) = 1

Max at the root: Max (2,1) = 2

The α, β search algorithm

This is an extension of the min max algorithm

How it works:

1) Initialisation:-
- Initialize 'alpha' to -∞' and β to '+∞')
- Begin at the root node of the game tree.

2) Minmax Recursion:
- For each node, perform the following:
  - If current node is maximizing node:
    - Traverse the children nodes
    - For each child, recursively call the alpha-beta pruning function

    - update 'alpha' to the maximum of the current 'alpha' β and the returned value from the recursive call.
    - If 'alpha' is greater than or equal to 'beta' prune the remaining children nodes

- If the current node is a minimizing node:
- Traverse the children nodes.
- For each child, recursively call the 'α' beta pruning
- update 'beta' to the minimum of the current 'beta' and returned value from recursive call
- If beta is less than or equal to 'alpha', prune the remaining children nodes.

3) Return value: i.e α for max and β for min.

Eg:- A is root node
B and C are minimizing player
D E F are maximizing players.

o/p:-
E = 5
F = 10
D = 8

A
B C D
E F

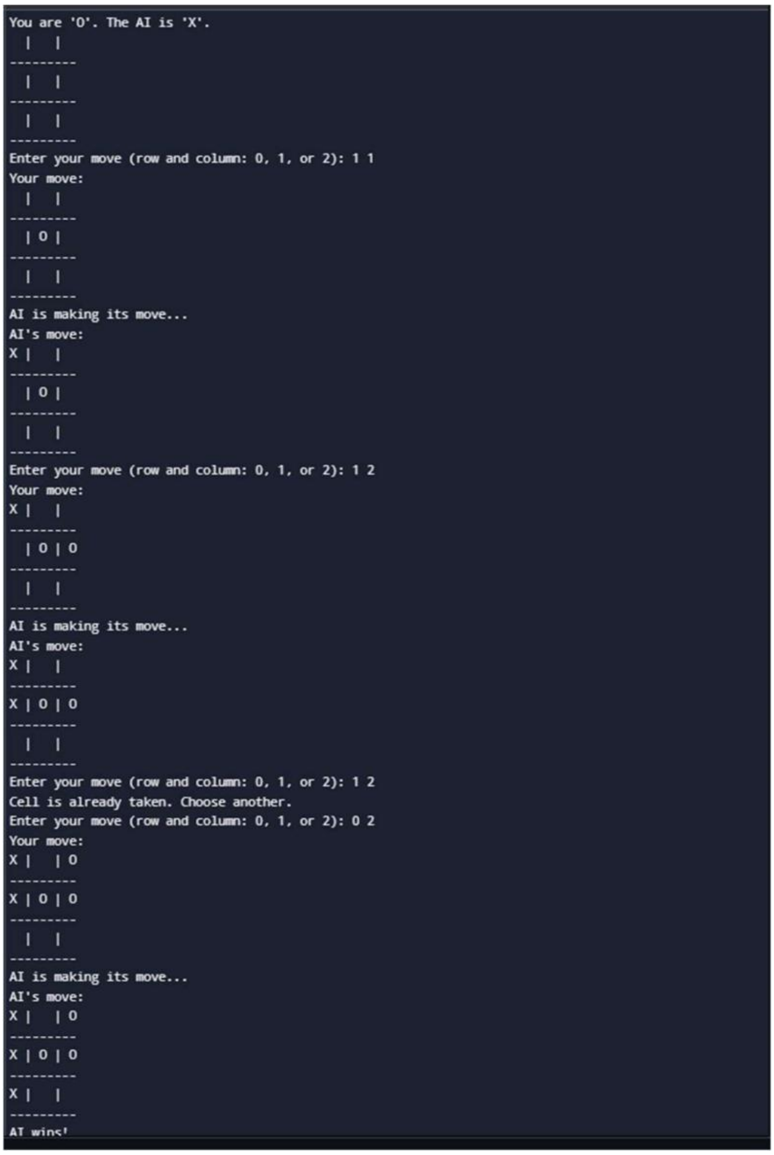
12/12/24

Code:

```
import math

 def printBoard(board):
    for row in board: print(" | ".join(cell if cell != "" else " "
       for cell in row)) print("-" * 9)

def evaluateBoard(board):
    for row in board:
        if row[0] == row[1] == row[2] and row[0] != "":
            return 10 if row[0] == 'X' else -10
    for col in range(3):
        if board[0][col] == board[1][col] == board[2][col] and board[0][col] != "":
            return 10 if board[0][col] == 'X' else -10
    if board[0][0] == board[1][1] == board[2][2] and board[0][0] != "":
        return 10 if board[0][0] == 'X' else -10
    if board[0][2] == board[1][1] == board[2][0] and board[0][2] != "":
        return 10 if board[0][2] == 'X' else -10
    return 0

 def isDraw(board):
```

```
 for row in board:
    if "" in row:
        return False
   return True

def minimax(board, depth, isMaximizing):
   score = evaluateBoard(board)
   if score == 10 or score == -10:
      return score
    if isDraw(board):
      return 0

   if            isMaximizing:
      bestScore = -math.inf
      for i in range(3):
         for j in range(3):
            if board[i][j] == "":
               board[i][j] = 'X'
               score = minimax(board, depth + 1, False)
               board[i][j] = "" bestScore =
               max(bestScore, score)
      return bestScore
   else:
      bestScore =
      math.inf for i in
      range(3): for j in
      range(3):
            if board[i][j] == "":
               board[i][j] = 'O'
               score = minimax(board, depth + 1, True)
               board[i][j] = "" bestScore =
               min(bestScore, score)
      return bestScore

def findBestMove(board):
   bestValue = -math.inf
   bestMove = (-1, -1)
   for i in range(3):
      for j in range(3):
         if board[i][j] == "":
            board[i][j] = 'X'
            moveValue = minimax(board, 0, False)
            board[i][j]     =     ""     if
            moveValue   >   bestValue:
            bestMove = (i, j) bestValue
            = moveValue
   return bestMove

def playGame():
   board = [["" for _ in range(3)] for _ in
   range(3)] print("Tic Tac Toe!") print("You are
   'O'. The AI is 'X'.")
   printBoard(board)
```

```
    while True:
        while True:
            try:
                row, col = map(int, input("Enter your move (row and column: 0, 1, or 2):
                ").split()) if board[row][col] == "": board[row][col] = 'O' break
                else:
                    print("Cell is already taken. Choose another.")
            except (ValueError, IndexError):
                print("Invalid input. Enter row and column as two numbers between 0 and 2.")

        print("Your move:")
        printBoard(board)

        if evaluateBoard(board) == -10:
            print("You win!")
            break
        if isDraw(board):
            print("It's a draw!")
            break

        print("AI is making its move...")
        bestMove = findBestMove(board)
        board[bestMove[0]][bestMove[1]] = 'X'

        print("AI's move:")
        printBoard(board)

        if evaluateBoard(board) == 10:
            print("AI wins!")
            break
        if isDraw(board):
            print("It's a draw!")
            break

playGame()
```
OUTPUT:



```
You are 'O'. The AI is 'X'.
  |   |
---------
  |   |
---------
  |   |
---------
Enter your move (row and column: 0, 1, or 2): 1 1
Your move:
  |   |
---------
  | O |
---------
  |   |
---------
AI is making its move...
AI's move:
X |   |
---------
  | O |
---------
  |   |
---------
Enter your move (row and column: 0, 1, or 2): 1 2
Your move:
X |   |
---------
  | O | O
---------
  |   |
---------
AI is making its move...
AI's move:
X |   |
---------
X | O | O
---------
  |   |
---------
Enter your move (row and column: 0, 1, or 2): 1 2
Cell is already taken. Choose another.
Enter your move (row and column: 0, 1, or 2): 0 2
Your move:
X |   | O
---------
X | O | O
---------
  |   |
---------
AI is making its move...
AI's move:
X |   | O
---------
X | O | O
---------
X |   |
---------
AI wins!
```

PART 2: Implement Alpha-Beta Pruning

Code:
```
def is_valid(board,
row, col):

    for i in range(row):
        if board[i] == col or \
           abs(board[i] - col) == abs(i - row):
            return False
    return True

def alpha_beta(board, row, alpha, beta, isMaximizing):

    if row == len(board):
        return 1
```

```
    if isMaximizing:
      max_score = 0
      for col in range(len(board)):
        if is_valid(board, row, col):
          board[row] = col
          max_score += alpha_beta(board, row + 1, alpha, beta,
          False) board[row] = -1 alpha = max(alpha, max_score) if
          beta <= alpha: break
      return max_score
   else:
      min_score = float('inf') for
      col in range(len(board)):
        if is_valid(board, row, col):
          board[row] = col
          min_score = min(min_score, alpha_beta(board, row + 1, alpha, beta,
          True)) board[row] = -1 beta = min(beta, min_score) if beta <= alpha:
          break
      return min_score

def solve_8_queens():

   board = [-1] * 8
   alpha = -float('inf')
   beta = float('inf')
   return alpha_beta(board, 0, alpha, beta, True)

solutions = solve_8_queens()
print(f"Number of solutions for the 8 Queens problem: {solutions}")
```

OUTPUT: