VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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LAB REPORT
on

Artificial Intelligence (23CS5PCAIN)

Submitted by

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

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

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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 **PRAJWAL K K (1BM22CS199)** 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/PRAJWALKK007/ARTIFICIAL-INTELLIGANCE.git

Program 1

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

Algorithm:

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A. Algorithm for Tic Tac Toe:

→ Player → ['X']
&
AI → ['O']

→ Analyse the current state of the board.

- Chance → Random
- Assuming only 9 boxes.
- Totally 8 match winning combination {3×3 grid}
- mention preference

→ Player need to place ['X'] randomly on the board.

→ After every move check for winning or draw
so, // i ranges (0,2)

```
def check_win(board):
    //mainly 3 rows, 3 columns, 2 diagonals.
if board[i][0] == board[i][1] == board[i][2] != " ";
    return True;
if board[0][i] == board[1][i] == board[2][i] != " ";
    return True;
if board[0][0] == board[1][1] == board[2][2] != " ";
    return True;
if board[0][2] == board[1][1] == board[2][0] != " ";
    return True
```

→ AI moves in following preference

- first AI checks if it can win
- Second to block the player winning.
- Neither selecting random available cell, which may also lead to draw.

Repeat.

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Page ______

Enter row (0-2): 0
Enter column(0-2): 0

```
x | |
 |x|
O | |
```

```
x||
|x|
O||O
```

Enter row(0-2): 2
Enter column(0-2) : 1

```
x |o|
 |x|
O |x|O
```

Enter row (0-2) : 1
Enter column(0-2): 2

```
x |O| x
O |x| O
O |x O
```

It's a draw!

Code:

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

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

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

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

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

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

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

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

Vacuum Cleaner

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Algorithm for Working of Vaccum Cleaner :-

→ · Considering 2 rooms for cleaning
· Also making sure Vaccum Cleaner comes to initial state after doing it's work
· location and Status considering two prescepts
· Now,

1 → represents a dirty room
0 → represents a clean room

· Vaccum cleaner working in 2-d grid, So it can move left, Right, up and down.

```
def is-dirty ():

    return self.rooms [self.position] ==1

def clean ():

    if self.is-dirty():
        self.rooms [self.position ]=0
        self.cleaned-rooms+=1

def move ():

self.position = 1-self.position

def run(steps):

for step in range (steps):

        clean()
        move()
rooms = [1,0]
```

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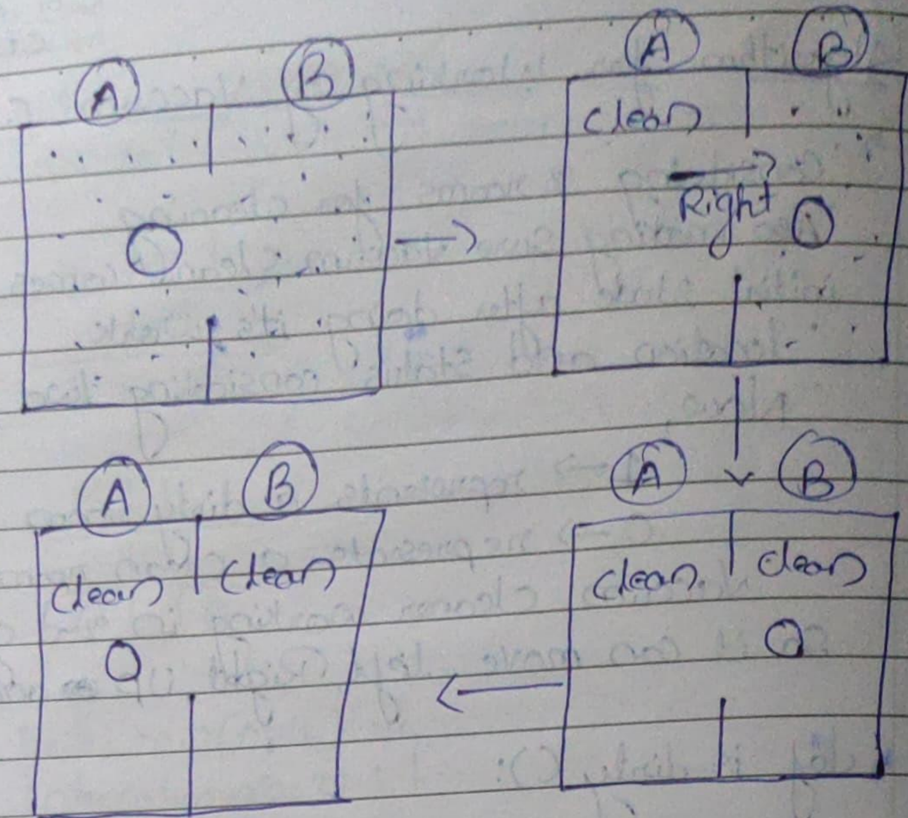

⇒ Percept Sequence

Check: RoomA, Dirty
Action: Clean RoomA & move

check: RoomB, Dirty
Action: clean RoomB & move

I : → (Room1, Dirty)
II : → (Room2, clean)
III : → (Room1, clean)
IV : → (Room2, clean)
V : → (Room1, clean).

Algorithm:

Code:

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

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

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

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

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

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

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

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

Program 2

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

8 puzzle using DFS

Algorithm:

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☆ Solving 8-puzzle problem using A* and Implementing Iterative Deeping Search Algorithm

→

Step 1 : initialize the Problem
- define the initial state in a puzzle of (3×3 grid)
- define Goal state in a puzzle of (3×3 grid)
- determine the empty tile → '0'

Initial State

1	2	3
8	0	4
7	6	5

Final State

2	8	1
0	4	3
7	6	5

Now, getting the lowest value using priority queue
Calculating each tile from initial state to Final State.

	V	H	Total Distance	Priority Queue
1	0	2	2	2
2	0	1	1	1
3	1	0	1	1
8	1	1	2	2
4 0	0	1	1	1
7	0	0	0	0
6	0	0	0	0
5	0	0	0	0

Apply this to priority queue.

So,

considering the lowest cost $= g(n)$

essitmed cost $= h(n)$

$$f(n) = g(n) + h(n)$$

lowest distance $= |i - goal\ i| + |j - goal\ j|$

fetching neighbour state moves [(0 1) (1 0) (-1 0) (0 -1)]

Initial State

Step 1

1	2	3
8	0	4
7	6	5

Step 2

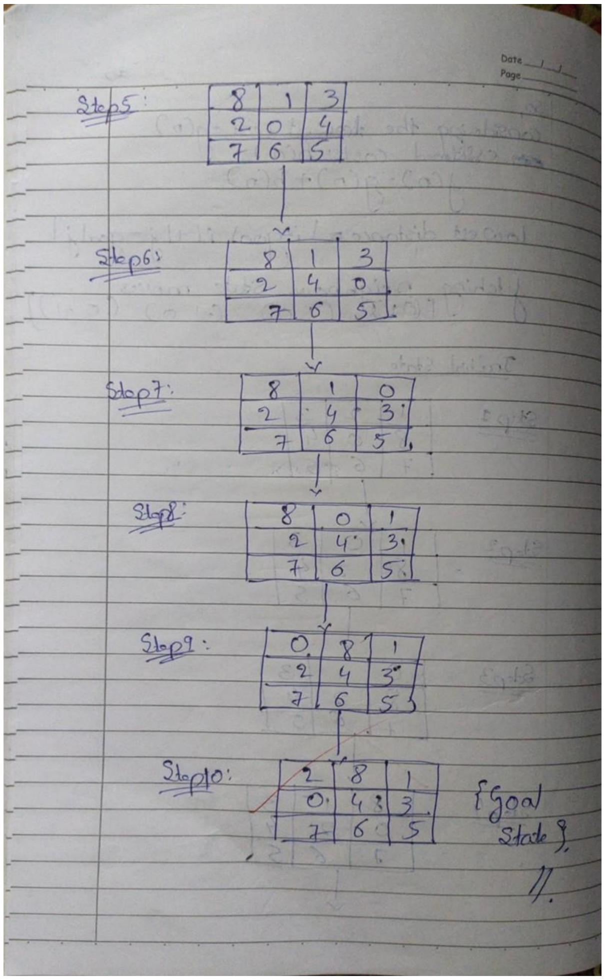
1	0	3
8	2	4
7	6	5

Step 3

0	1	3
8	2	4
7	6	5

Step 4

8	1	3
0	2	4
7	6	5



Code:

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

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

        if is_goal(current_board):
            return moves, len(moves) # Return moves and their count

        visited.add(tuple(current_board))

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Implement Iterative deepening search algorithm

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→ IDF

Step 1 :
initialize the tree with node
and the parent leaf node
? mention the initial and the start
node and also the final destination
node.

find the destination node first

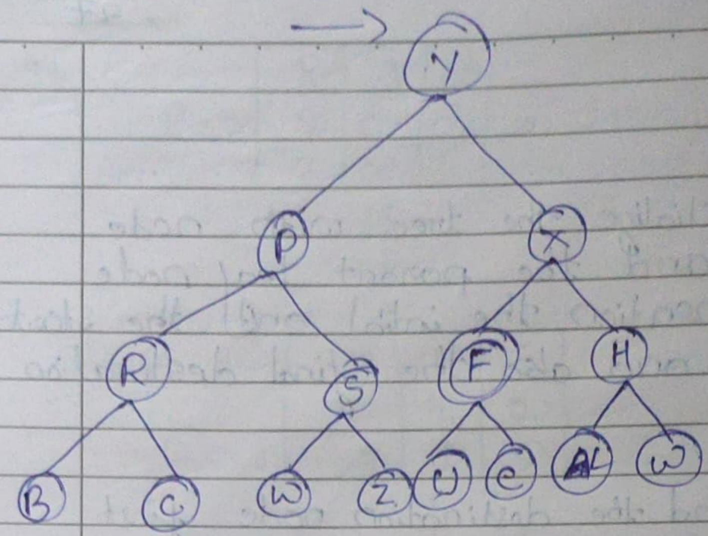
find(){
using BFS method ():
level after level search
for destination node.

if present
return level
else
go to next level

find the parent node using back
tracking.

fint parent node(){
Back track the parent node
to figure out the path.

Back track and print the node
from start to End
if found.



Start node → Y
destination node → F

BFS :- ~~[illegible]~~

Step 1 ⟶ Y

Step 2 ⟶ P , X

Step 3 ⟶ R S F

destination node found.

Now: backtracking to X — F → Y — X

Final State is

Y → X → F

Code:
```
from collections import deque

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

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

    def get_possible_moves(self):
        moves = []
        x, y = self.zero_pos
        directions = [(-1, 0), (1, 0), (0, -1), (0, 1)] # Up, Down, Left, Right
        for dx, dy in directions:
            new_x, new_y = x + dx, y + dy
            if 0 <= new_x < 3 and 0 <= new_y < 3:
                new_board = [row[:] for row in self.board]
```

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

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

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

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

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

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

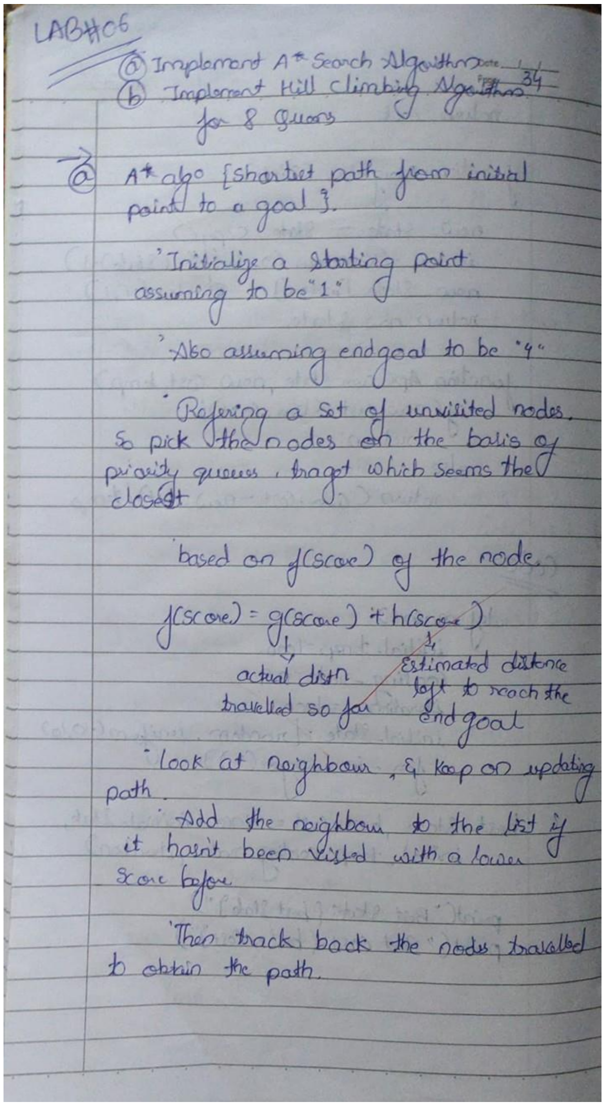
```
goal_state = [
    [1, 2, 3],
    [4, 5, 6],
    [7, 8, 0]
]

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

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

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

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

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

Program 3

Implement A* search algorithm

Algorithm:



LAB#06

(a) Implement A* Search Algorithm

(b) Implement Hill climbing Algorithms for 8 Queens

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(a) A* algo {shortest path from initial point to a goal }.

- Initialize a starting point assuming to be "1"
- Also assuming endgoal to be "4"
- Referring a set of unvisited nodes. So pick the nodes on the basis of priority queues, target which seems the closest
- based on f(score) of the node.

f(score) = g(score) + h(score)

g(score): actual distn travelled so far

h(score): Estimated distance left to reach the end goal

- Look at neighbour, & keep on updating path.
- Add the neighbour to the list if it hasn't been visited with a lower score before.
- Then track back the nodes travelled to obtain the path.

Heuristic (h) = No. of queens pair attacking each other.
(g) = No. of queens placed so far.

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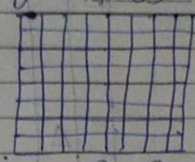
goal:- placing all queens on the board such that they do not attack each other.



8×8

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

def a_star_8_queens (n=8):

    open set = PriorityQueue ()
    open_set.put((0, []))

        for col in range(n):
            new_board = board + [col]
            if len (new_board) <= n:
                g_score = len (new_board)
                h_score = calculate_attacking_
                    pairs (new_board)
                f_score = g_score + h_score
```

So, now

Code:
Misplaced Tiles

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

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

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

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

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

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

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

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

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

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

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

print_state(goal_state)

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

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

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

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

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

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

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


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

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

Manhattan Distance

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

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

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

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

```
            return i, j
    return None

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

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

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

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

while open_list:
    best_state = findmin(open_list, goal_state)

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

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

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

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

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

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

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

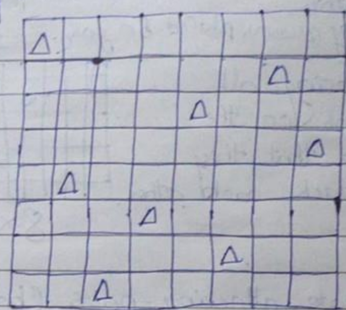
```
Current state:
2 8 3
1 6 4
7 0 5
g(n): 0, h(n): 5, f(n): 5

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

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

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

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

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


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

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

Program 4
Implement Hill Climbing search algorithm to solve N-Queens problem

Algorithm:

one of the answers will be



→ {0,4,7,5,2,6,1,3}.

→ (b) Implementing Hill climbing Algo, for 8-queens and explain

"Always keep on improving the solution unit you reach the best one.

```
def hill_climbing(n=8):
    board = [random.randint(0, n-1) for _ in range(n)]
    while True:
        current_attacks = calculate_attacking_pairs(board)
        if current_attacks == 0:
            return board
    neighbours[]
        for row in range(n):
            for col in range(n):
            if col != board[row]
```

local search algo

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· Count the no. of pair of queens attacking each other

· for each queen, we try to move it to every other column in its row.

· choose one with the fewest attacking pairs

· If we find configuration = 0 attacks we have a solution.

Executed

=> Output for A* algo:-

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

=> Output for Hill climbing algo:-

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Program 5

Simulated Annealing to Solve 8-Queens problem

Algorithm:

LAB-05 :-

Stimulated Annealing :-

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~~Algo~~ ~~step~~:- objective function :- $x^2 + 5\sin x$

function Stimulated Annealing (intial_state, initial_temperature, cooling_state iteration)

current_state = initial_state
best_state = current_state
best_cost = objective function (current_state)
temp = initial_temperature

while temp >1:

for i ← 1 to iterations
new_state = Neighbour (current_state)
curr_cost = objective Function (curr_state)
new_cost = objective Function (new_state)

if Ap (curr_cost, new_cost, temp) > Random (0,1)
current_state = new_state

if new_cost < best_cost
best state = new_state
best_cost = new cost

temp * = cooling_rate

return (best_state, best_cost)

Function Objective Function (state):
cost = 0
for x in state
cost = $x^2 + 5 \sin x$

Code:

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

def queens_max(position):
    # This function calculates the number of pairs of queens that are not attacking each other
    position = np.round(position).astype(int) # Round and convert to integers for queen positions
    n = len(position)
    queen_not_attacking = 0

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

# Bounds for each queen's position (0 to 7 for an 8x8 chessboard)
bounds = [(0, 8) for _ in range(8)]

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

# Display the results
best_position = np.round(result.x).astype(int)
best_objective = -result.fun # Flip sign to get the number of non-attacking queens

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

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

Program 6

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

Algorithm:

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Logical Reasoning :-

① From statement ① & ④
M(A,B) & (y,x) → Alice is parent

② From statement ② & ④
F(B,C) & (y,x) → Bob is a parent

③ From statement ① & ② & ④
M(A,B) & F(B,C) & (d & (x,y))
→ bob & charile are not siblings.

#Code :-

```
class Knowledge:
    def __init__(self):
        self.rules = []
        self.facts = set()

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

    def add_rule(self, promise, conclusion):
        self.rule.append((permis, conclusion))

    def infer(self):
        new_inform = True
        while new_inform:

        if all(fact in self.facts for fact in permise)
        if conclusion not in self.facts:
            self.facts.add(conclusion)
```

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new_inferences = True

def entails (self, hypothesis)

return hypothesis in self.facts

kb = KnowledgeBase()

Kb.add_fact("Alice is mother of Bob")
kb.add_fact("Bob is the father of charlie")
kb.add_fact("A father is a parent")
kb.add_fact("A mother is a parent")
kb.add_fact("All the parents have children")
Kb.add_fact("if someone is parent, their children are not siblings")
Kb.add rule(["Bob is father of charlie", "A father is a parent"], "Bob is a parent")
Kb.add rule(["Alice is mother of Bob", 'A mother is parent']; Alice is a parent']
hypothesis = "charlie & Bob are siblings
if kb, nfact (hypothesis):
print(f"{hypothesis}", J entailed by knowledge base")
else:
print(f"{hypothesis}", J not entailed by Kb")

Code:

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

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

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

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

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

    # Evaluate the expressions for each combination
    for combination in combinations:
        a, b, c = combination

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

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

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

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

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

    # Print only the rows where both KB and Query are True
```

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

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

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

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

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

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

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

Program 7
Implement unification in first order logic

Algorithm:

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Unification :-

→ Statements :-

1. Doctors treat patients who are sick.
2. John is a doctor
3. Mary is sick
4. Doctors work in hospitals.
5. General Hospital is a Hospital.
6. John works at General Hospital.

⇒ Quantification Statements :-

1. $\forall x \forall y$ (Doctor(x) ∧ Sick(y) → Treats(x, y))
2. Doctor (John)
3. Sick (Mary)
4. $\forall x$ (Doctor(x) → $\exists h$ (Hospital(h) ∧ WorksAt (x, h)))
5. Hospital (General Hospital)
6. WorksAt (John, General Hospital)

→ Unify Statements :-

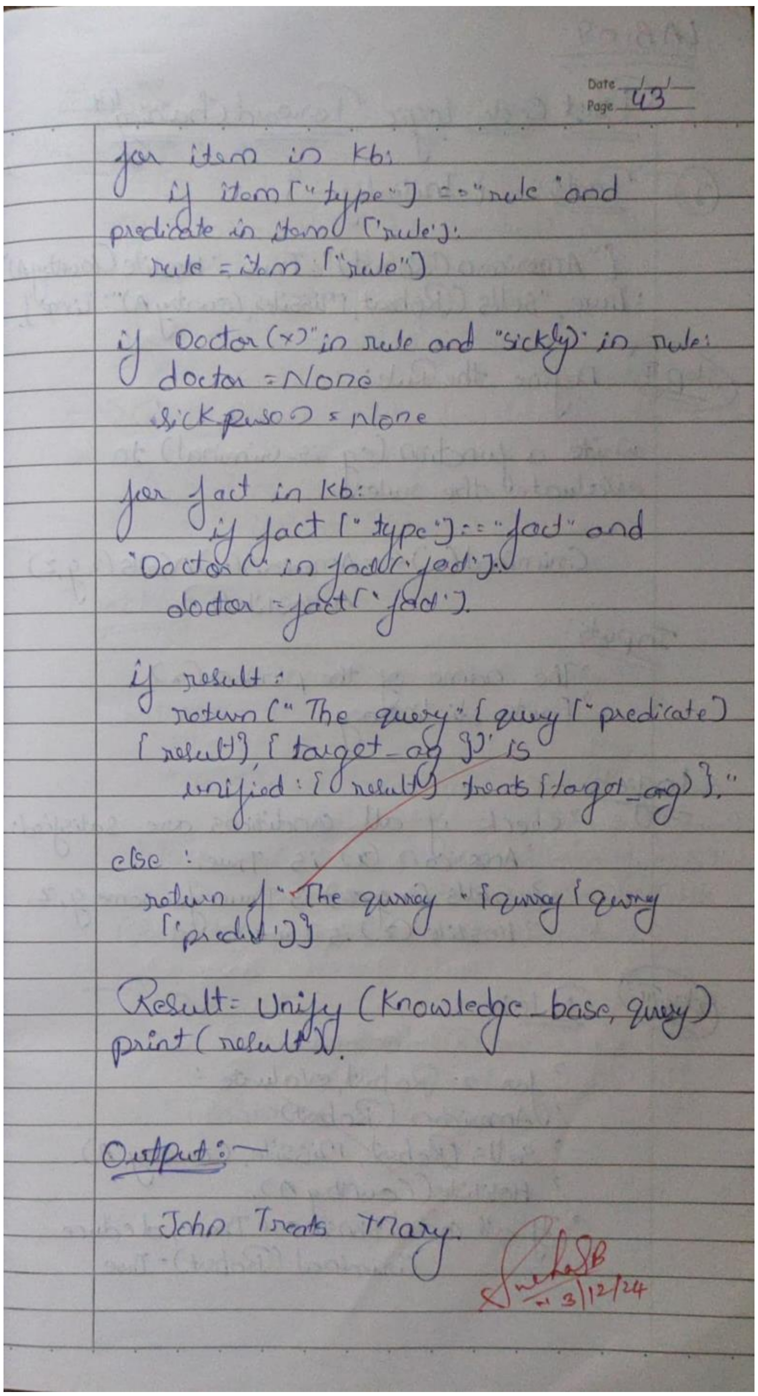
$\exists x$ (Treats (x, Mary))

1. From statement (1), unify Treats (x, y) with Treats (x, Mary), binding y = Mary.
2. Statements (3), confirm Sick (Mary) is true, activating statement (1).
3. Use statement (2) to deduce that

Code:
```
import re

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

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



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```
for item in kb:
    if item["type"] == "rule" and
predicate in item["rule"]:
    rule = item["rule"]

if "Doctor(x)" in rule and "sick(y)" in rule:
    doctor = None
    sickperson = None

for fact in kb:
    if fact["type"] == "fact" and
"Doctor(" in fact["fact"]:
    doctor = fact["fact"].

if result:
    return("The query" {query["predicate"]
    {result}, {target_arg}}' is
        unified: {result} treats {target_arg}}."

else:
    return f"The query" {query{query
    ['pred']}}

Result = Unify(Knowledge_base, query)
print(result).
```

Output:—

John Treats Mary.

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

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

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

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

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

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

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

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

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

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

    return parse_term(input_str)

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

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

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

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

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

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

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

Program 8

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

Algorithm:

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Step II

(a) $\forall x \neg food(x) \vee likes(John, x)$.

(b) $food(Apple) \wedge food(vegetables)$

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

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

(e) $\forall x \neg eats(Anil, x) \vee eats(Harry, x)$

(f) $\forall x \neg[\neg killed(x)] \vee alive(x)$

(g) $\forall x \neg alive(x) \vee \neg killed(x)$

(h) $likes(John, Peanuts)$.

Step III

~~Move negation (¬) inwards~~

(a) ~~∀x ¬food(x) ∨ likes(John, x)~~

Applying Resolution.

(i) From (4):

$Eats(Anil, Peanuts) \wedge \neg Killed(Anil)$

(ii) From (3):

Substitute y = Anil, x = Peanuts:

$\neg Eats(Anil, peanuts) \vee Killed(Anil) \vee food(peanuts)$

Resolve with Eats(Anil, peanuts):

$Killed(Anil) \vee Food(peanuts)$

Resolve with ¬Killed(Anil):

Food(Peanuts)

(iii) From [i]:

Substitute x = Peanuts:

$\neg Food(Peanuts) \vee Likes(John, Peanuts)$

:

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()

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First Order Logic: Forward Chaining

(I) → Facts = { Initialize }

{"American (Robert)": True, "Hostile (Country A)": True, "Sells (Robert, Missiles, Country A)": True}.

Step II Define the Rule:

Write a function (eg is-Criminal) to evaluate the rule:

$$Criminal(x) \leftarrow American(x) \wedge Sells(x, y, z) \wedge Hostile(z).$$

Inputs:

- The name of the person (x).
- Facts dictionary.

Logic:

- Check if all conditions are satisfied:
  - American (x) is True.
  - Sells (x, y, z) is True for some y, z.
  - Hostile (z) is True.

Step III Rule:-

- for x = Robert, evaluate:
- American (Robert)
- Sells (Robert, Missile, Country A).
- Hostile (Country A).
- If all conditions are True, deduce Criminal (Robert) = True

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

Program 9

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

Algorithm:

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(1) → Resolution in FOL :-

Q. Given the KB or Premises:

John likes all kind of food.
Apple and vegetables are food.
Anything anyone eats and not killed is food
Anil eats peanuts and still alive.
Harry eats everything that Anil eats.
Anyone who is alive implies not killed
Anyone who is not killed implies alive.

⇒ Prove by resolution that:

John like peanuts.

Sol^n

Step 1 Eliminate implication

(a) $\forall x: food(x) \rightarrow likes(John, x)$
(b) $food(Apple) \land food(Vegetables)$
(c) $\forall x \forall y: eats(x, y) \land \neg killed(x) \rightarrow food(y)$
(d) $eats(Anil, Peanuts) \land alive(Anil)$
(e) $\forall x: eats(Anil, x) \rightarrow eats(Harry, x)$
(f) $\forall x: Killed(x) \rightarrow alive(x)$
(g) $\forall x: alive(x) \rightarrow \neg killed(x)$
(h) $likes(John, Peanuts)$

Code:

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

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

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

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

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

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

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

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

Program 10

Implement Alpha-Beta Pruning.

Algorithm:

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③ Solve 8-Queens using Alpha-Beta

```
def alpha-beta (self. board, col, alpha, beta,
        max_player):

if col>= self_size:
    return 0. [row[:] for row in board]

  if max-player:
     Max_eval= float('-inf')
     but board = None
     for row in range (self_size)

        if self_Is safe (board, row, col):
           board [row][col]=1

eval-score, potential-board= self. alpha-beta-
 search
        (board, col+1, alpha, beta, p_false)

board [row][col]=0

   if eval-score> max_eval:
      text-board = potential_board

   best_board = potential-board

alpha = max(alpha, eval_score)

   if beta <= alpha
      break;
```

Code:

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

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

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

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

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

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

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

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

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

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

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

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

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