

# **VISVESVARAYA TECHNOLOGICAL UNIVERSITY**

**“JnanaSangama”, Belgaum -590014, Karnataka.**



## **LAB REPORT on**

## **Artificial Intelligence (23CS5PCAIN)**

*Submitted by*

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

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**B.M.S. COLLEGE OF ENGINEERING**  
**(Autonomous Institution under VTU)**  
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**B.M.S. College of Engineering,**  
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**Department of Computer Science and Engineering**



**CERTIFICATE**

This is to certify that the Lab work entitled “Artificial Intelligence (23CS5PCAIN)” carried out by **Shreyas Gouda M (1BM22CS270)**, 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/Sakshishetty24/Artificial-Intelligence>

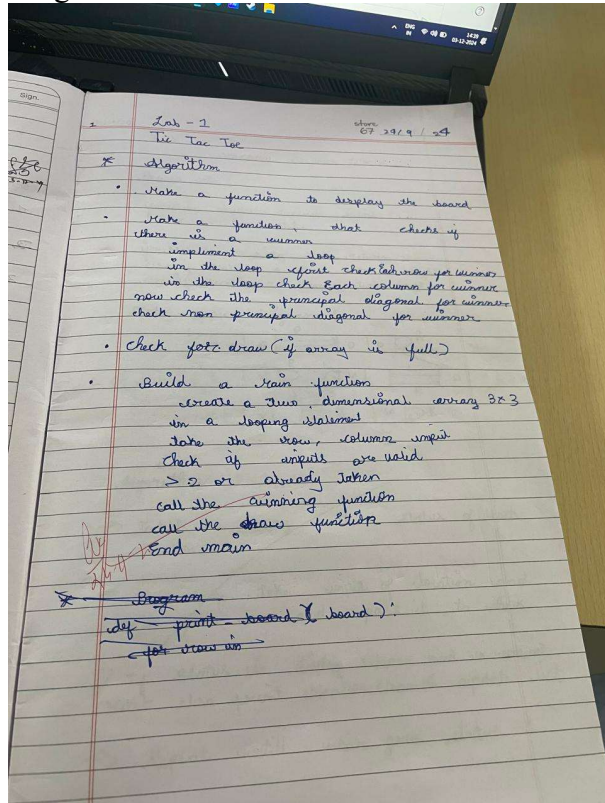
## Program 1

Implement Tic - Tac - Toe Game

Implement vacuum cleaner agent

Tic-Tac-Toe

Algorithm:



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("O wins")
            flag=1
            break
    if flag==0:
        print("Draw")
    print("Game Over")

```

```

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

```

```

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

```

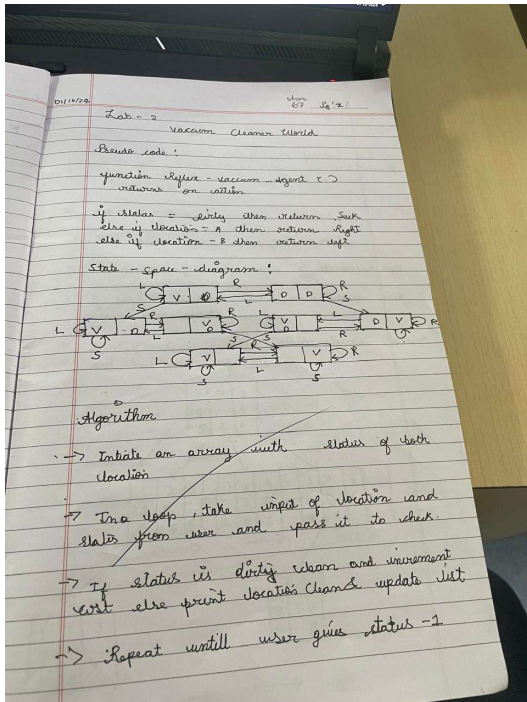
```

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

```

## Vacuum Cleaner

### Algorithm:



### 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}

```

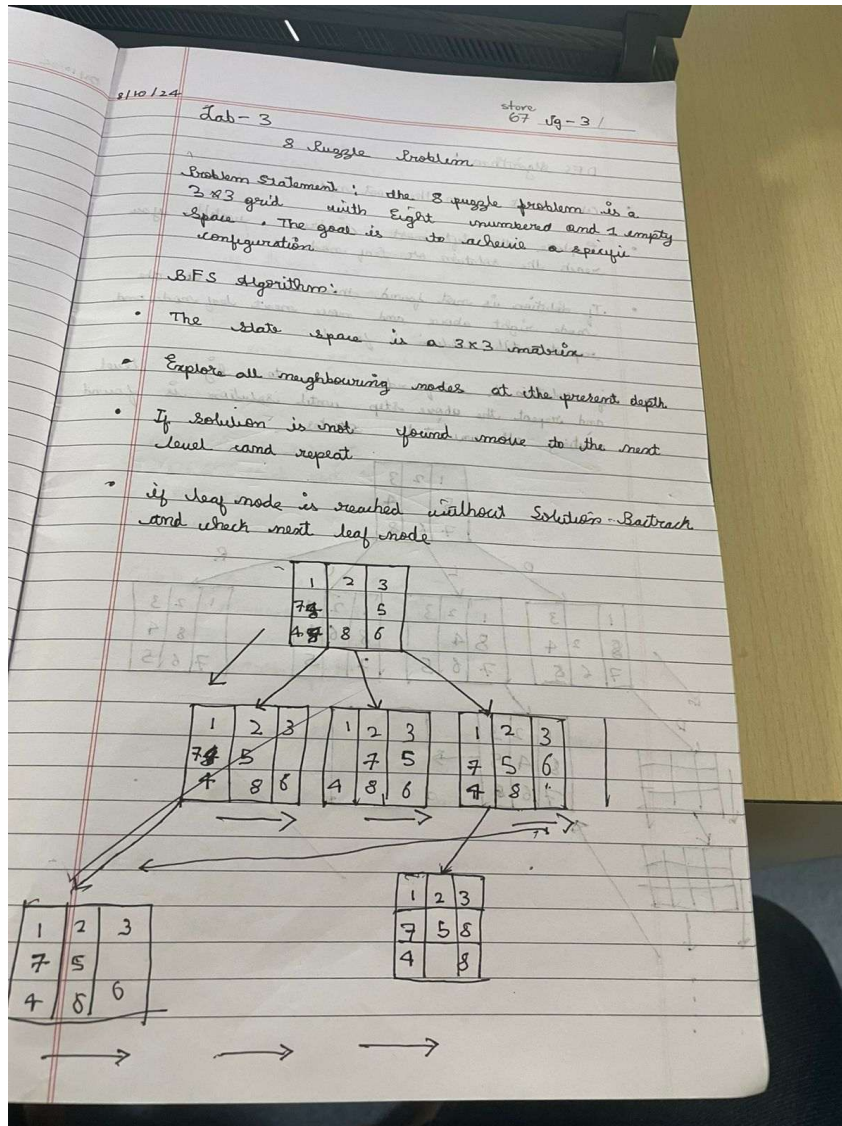
## Program 2

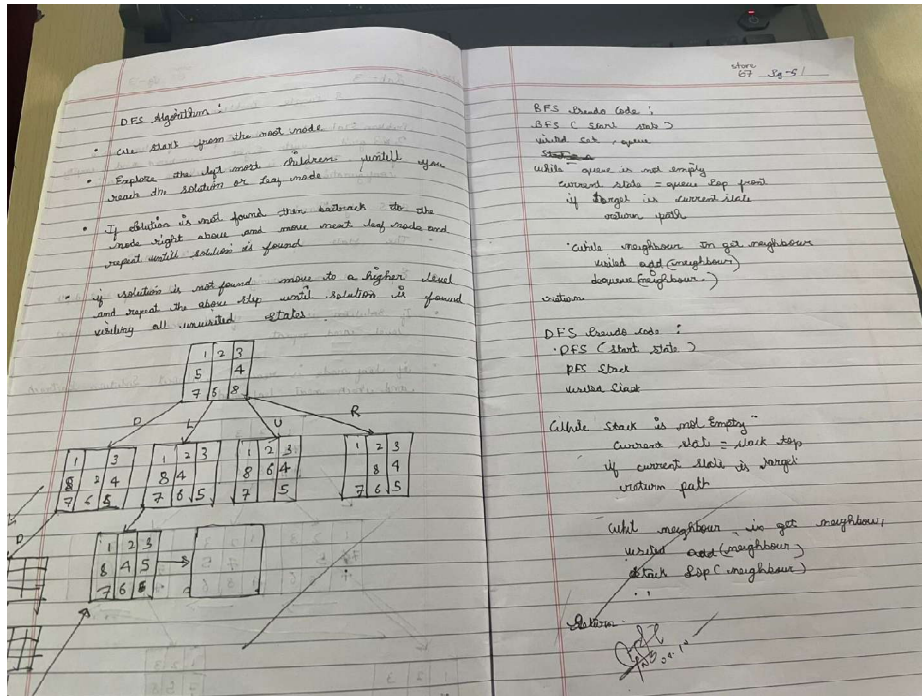
Implement 8 puzzle problems using Depth First Search (DFS)

Implement Iterative deepening search algorithm

8 puzzle using DFS

Algorithm:





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]
```

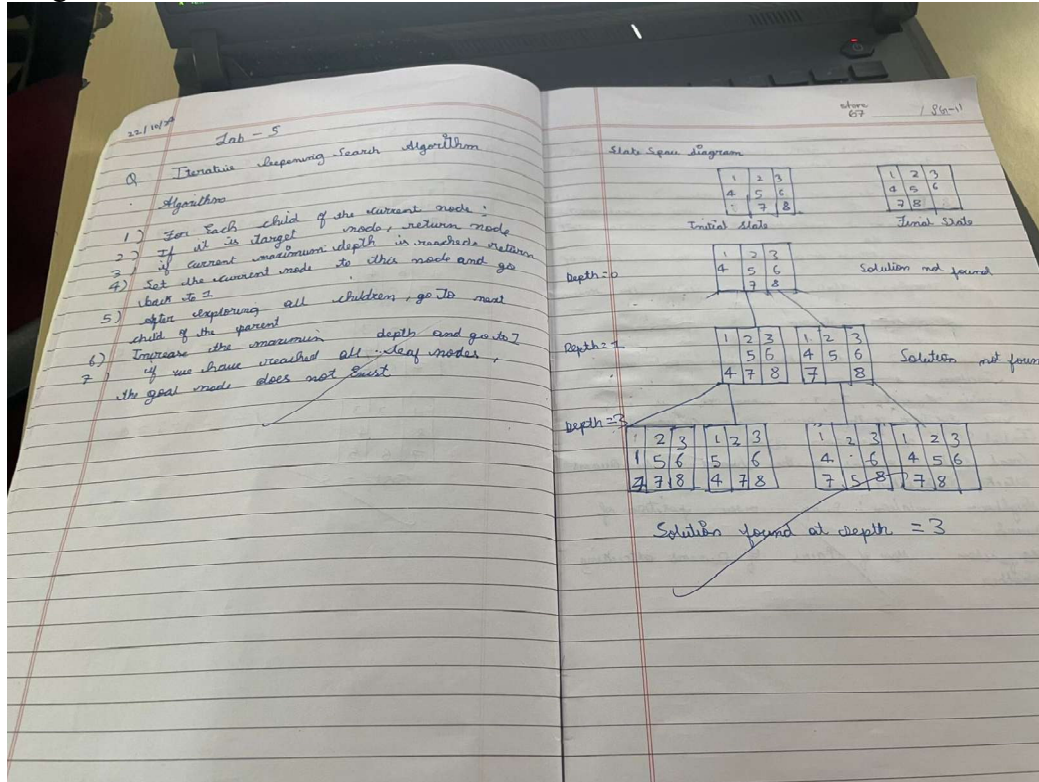
```
[1, 2, 3]
[4, 5, 0]
[7, 8, 6]
```

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

### Program 3

Implement Iterative deepening search algorithm

Algorithm:



Code:

from collections import deque

class PuzzleState:

def \_\_init\_\_(self, board, zero\_pos, moves=0, previous=None):

self.board = board

self.zero\_pos = zero\_pos # Position of the zero tile

self.moves = moves # Number of moves taken to reach this state

self.previous = previous # For tracking the path

def is\_goal(self, goal\_state):

return self.board == goal\_state

def get\_possible\_moves(self):

moves = []

x, y = self.zero\_pos

directions = [(-1, 0), (1, 0), (0, -1), (0, 1)] # Up, Down, Left, Right

for dx, dy in directions:

new\_x, new\_y = x + dx, y + dy

if 0 <= new\_x < 3 and 0 <= new\_y < 3:

new\_board = [row[:] for row in self.board]

```

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

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

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

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

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

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

```



```

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

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

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

```

```
Solution found:
```

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

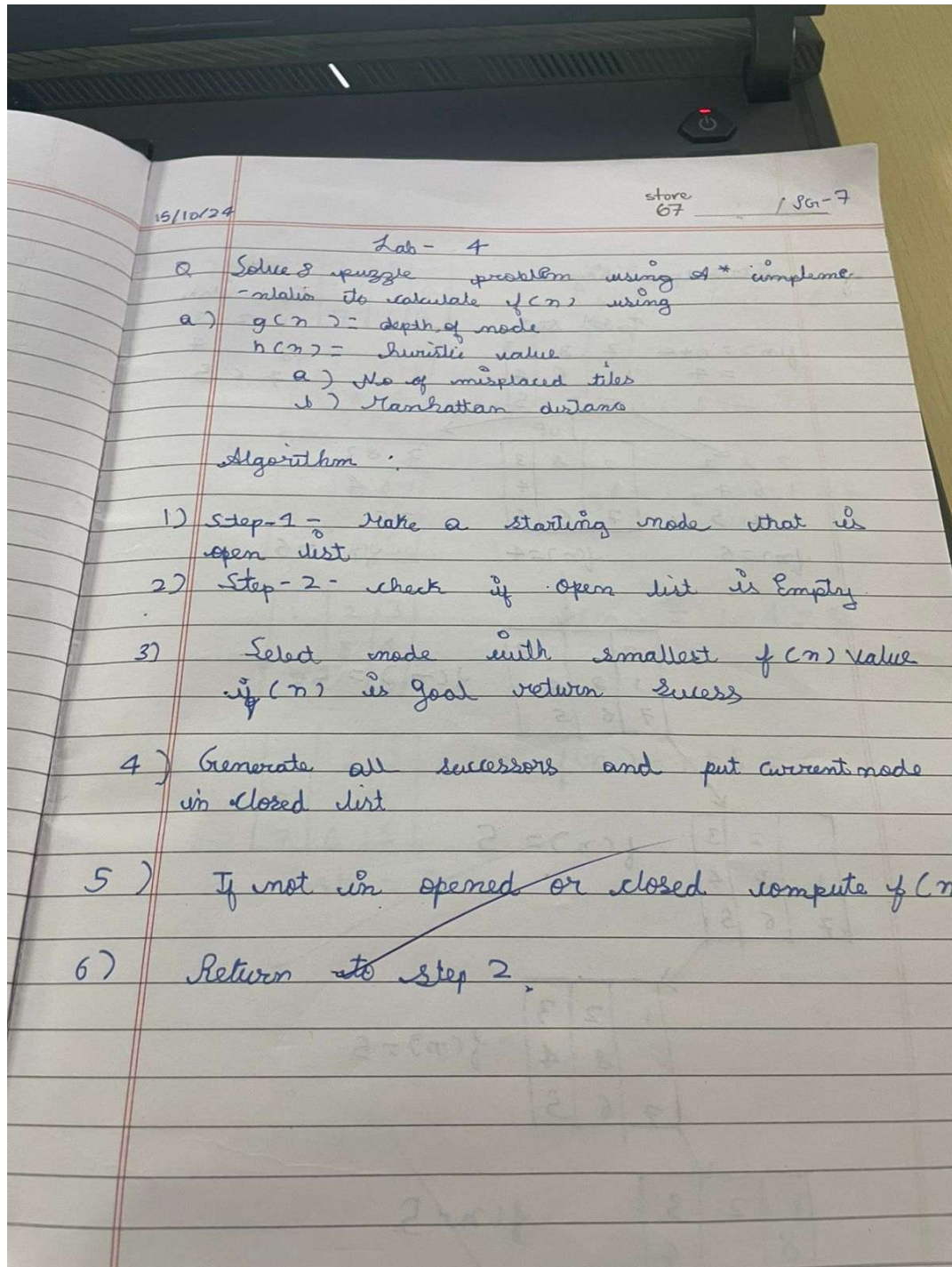
```
[1, 2, 3]
[4, 5, 0]
[7, 8, 6]
```

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

### Program 3

Implement A\* search algorithm

Algorithm:





Code:

Misplaced Tiles

```
def mistil(state, goal):
```

```
    count = 0
```

```
    for i in range(3):
```

```
        for j in range(3):
```

```
            if state[i][j] != goal[i][j]:
```

```
                count += 1
```

```
    return count
```

```
def findmin(open_list, goal):
```

```
    minv = float('inf')
```

```
    best_state = None
```

```
    for state in open_list:
```

```
        h = mistil(state['state'], goal)
```

```
        f = state['g'] + h
```

```
        if f < minv:
```

```
            minv = f
```

```
            best_state = state
```

```
    open_list.remove(best_state)
```

```
    return best_state
```

```
def operation(state):
```

```
    next_states = []
```

```
    blank_pos = find_blank_position(state['state'])
```

```
    for move in ['up', 'down', 'left', 'right']:
```

```
        new_state = apply_move(state['state'], blank_pos, move)
```

```
        if new_state:
```

```
            next_states.append({
```

```
                'state': new_state,
```

```
                'parent': state,
```

```
                'move': move,
```

```
                'g': state['g'] + 1
```

```
            })
```

```
    return next_states
```

```
def find_blank_position(state):
```

```
    for i in range(3):
```

```
        for j in range(3):
```

```
            if state[i][j] == 0:
```

```
                return i, j
```

```
    return None
```

```
def apply_move(state, blank_pos, move):
```

```
    i, j = blank_pos
```

```
    new_state = [row[:] for row in state]
```

```
    if move == 'up' and i > 0:
```

```

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

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

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

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

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

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

```

```
print_state(goal_state)
```

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

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

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

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

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

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

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

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

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

### Manhattan Distance

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

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

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

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

```

        return i, j
    return None

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

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

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

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

while open_list:
    best_state = findmin(open_list, goal_state)

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

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

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

```

```

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

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

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

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

```

```

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

```

```

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

```

```

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

```

```

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

```

```

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

```

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

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

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

#### Program 4

Implement Hill Climbing search algorithm to solve N-Queens problem

Algorithm:

27/10/2020

On Implement Hill climbing search algorithm to N-Queens Problem

function HillClimb (Problem, Problem) return a state that is local maximum

state  $\leftarrow$  rand - NQUE (problem, INITIAL-STATE)

loop do

  neighbour  $\leftarrow$  a higher + - values successor of current

  if neighbour.state < current.state then the value

  current  $\leftarrow$  neighbour

\* State: 4 queens on the board one queen each column

  variables:  $x_1, x_2, x_3, x_4$  where  $x_i$  is the row position of the queen in column  $i$

  Initial State: a random state

  Goal state: 4 queens on the board, no queens attack each other

  Neighbour relation: Swap row position of Queens

  Cost function: No. of Pairs of Queens attacking each other

State Space diagram

Signature



Code:

```
import random
```

```
def calculate_conflicts(board):
```

```
    conflicts = 0
```

```
    n = len(board)
```

```
    for i in range(n):
```

```
        for j in range(i + 1, n):
```

```
            if board[i] == board[j] or abs(board[i] - board[j]) == abs(i - j):
```

```
                conflicts += 1
```

```
def hill_climbing(n):
```

```
    cost=0
```

```
    while True:
```

```
        # Initialize a random board
```

```
        current_board = list(range(n))
```

```
        random.shuffle(current_board)
```

```
        current_conflicts = calculate_conflicts(current_board)
```

```
    while True:
```

```
        # Generate neighbors by moving each queen to a different position
```

```
        found_better = False
```

```
        for i in range(n):
```

```
            for j in range(n):
```

```
                if j != current_board[i]: # Only consider different positions
```

```
                    neighbor_board = list(current_board)
```

```
                    neighbor_board[i] = j
```

```
                    neighbor_conflicts = calculate_conflicts(neighbor_board)
```

```
                    if neighbor_conflicts < current_conflicts:
```

```
                        print_board(current_board)
```

```
                        print(current_conflicts)
```

```
                        print_board(neighbor_board)
```

```
                        print(neighbor_conflicts)
```

```
                        current_board = neighbor_board
```

```
                        current_conflicts = neighbor_conflicts
```

```
                        cost+=1
```

```
                        found_better = True
```

```
                        break
```

```
        if found_better:
```

```
            break
```

```
    # If no better neighbor found, stop searching
```

```
    if not found_better:
```

```
        break
```

```
    # If a solution is found (zero conflicts), return the board
```

```
    if current_conflicts == 0:
```

```

        return current_board, current_conflicts, cost

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

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

```

```

=====
Q . . .
. . . Q
. . Q .
. Q . .

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

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

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

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

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

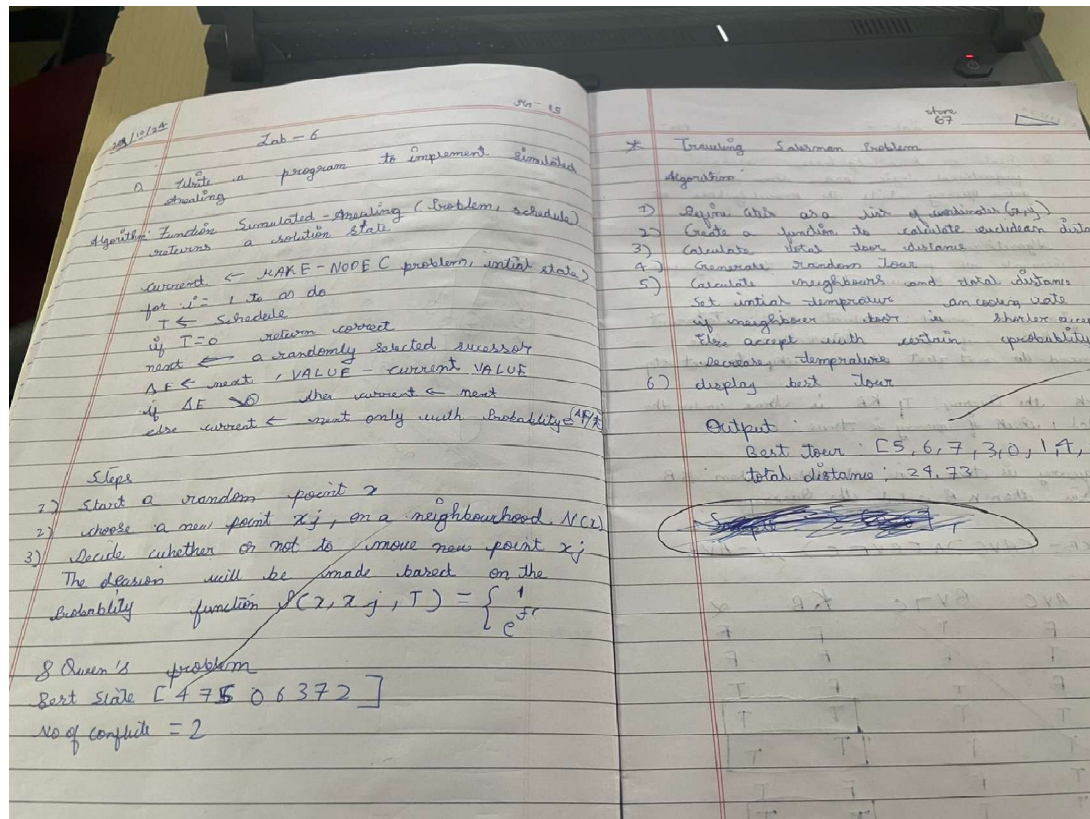
1
Final Board Configuration:
. Q . .
. . . Q
Q . . .
. . Q .

```

## Program 5

Simulated Annealing to Solve 8-Queens problem

Algorithm:



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

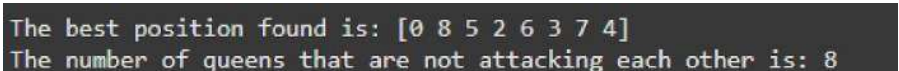
    for i in range(n - 1):
        no_attack_on_j = 0
        for j in range(i + 1, n):
            # Check if queens are on the same row or on the same diagonal
            if position[i] != position[j] and abs(position[i] - position[j]) != (j - i):
                no_attack_on_j += 1
        if no_attack_on_j == 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:

Lab-7

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

Algorithm:

- Generate all possible model: For  $n$  symbols there are  $2^n$  enumerations
- For each model, evaluate each statement in K.B. If all statements are true proceed to next else otherwise skip to next step.
- Check the Query: If K.B is true under the model, check if query is true
- If query is true in all cases when K.B is true then K.B entail the Query

Ex:  $KB = (A \vee C) \wedge (B \vee \neg C)$ ,  $\alpha = A \vee B$

A	B	C	$A \vee C$	$B \vee \neg C$	KB	$\alpha$
F	F	F	F	T	F	F
F	F	T	T	F	F	F
F	T	F	F	T	F	T
F	T	T	T	T	T	T
T	F	F	T	T	T	T
T	F	T	T	F	F	T
T	T	F	T	T	T	T
T	T	T	T	T	T	T

$\alpha$  does not Entail 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:

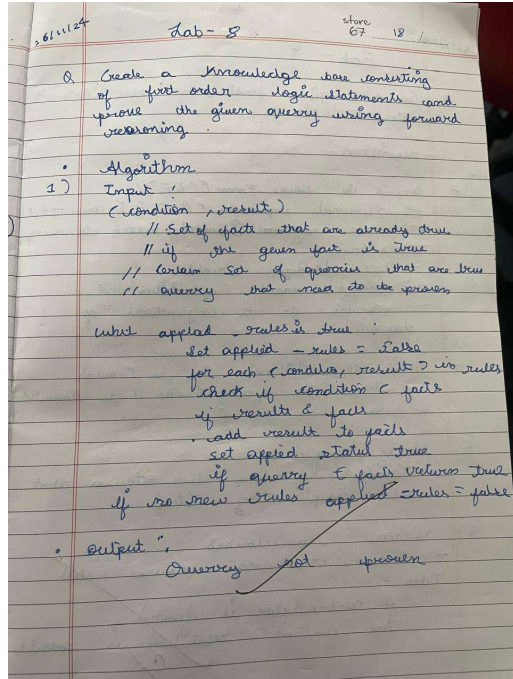
a	b	c	KB	Query
False	True	True	True	True
True	False	False	True	True
True	True	False	True	True
True	True	True	True	True



## Program 7

Implement unification in first order logic

Algorithm:



Code:

import re

```
def occurs_check(var, x):
```

```
    """Checks if var occurs in x (to prevent circular substitutions)."""
```

```
    if var == x:
```

```
        return True
```

```
    elif isinstance(x, list): # If x is a compound expression (like a function or predicate)
```

```
        return any(occurs_check(var, xi) for xi in x)
```

```
    return False
```

```
def unify_var(var, x, subst):
```

```
    """Handles unification of a variable with another term."""
```

```
    if var in subst: # If var is already substituted
```

```
        return unify(subst[var], x, subst)
```

```
    elif isinstance(x, (list, tuple)) and tuple(x) in subst: # Handle compound expressions
```

```
        return unify(var, subst[tuple(x)], subst)
```

```
    elif occurs_check(var, x): # Check for circular references
```

```
        return "FAILURE"
```

```
    else:
```

```
        # Add the substitution to the set (convert list to tuple for hashability)
```

```
        subst[var] = tuple(x) if isinstance(x, list) else x
```

```
    return subst
```



```

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

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

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

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

def unify_and_check(expr1, expr2):
    """
    Attempts to unify two expressions and returns a tuple:
    (is_unified: bool, substitutions: dict or None)
    """
    result = unify(expr1, expr2)
    if result == "FAILURE":
        return False, None
    return True, result

def display_result(expr1, expr2, is_unified, subst):
    print("Expression 1:", expr1)
    print("Expression 2:", expr2)
    if not is_unified:

```

```

        print("Result: Unification Failed")
    else:
        print("Result: Unification Successful")
        print("Substitutions:", {k: list(v) if isinstance(v, tuple) else v for k, v in subst.items()})

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

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

    return parse_term(input_str)

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

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

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

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

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

```

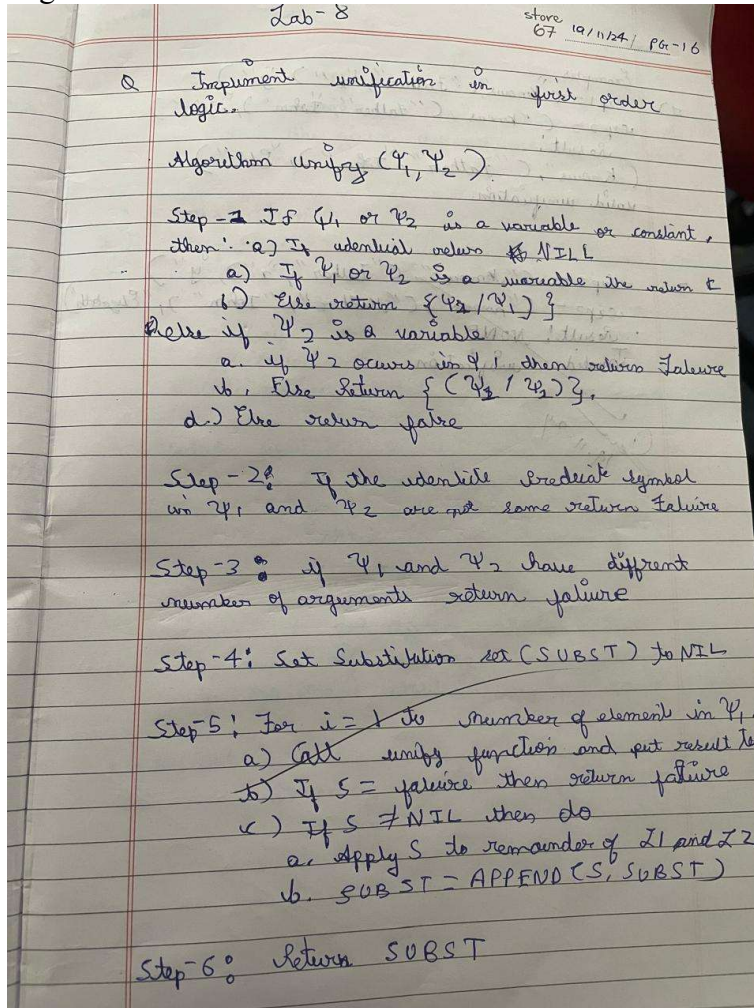
```
if __name__ == "__main__":  
    main()
```

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

## Program 8

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

Algorithm:



Code:

```
# Define the knowledge base (KB) as a set of facts
```

```
KB = set()
```

```
# Premises based on the provided FOL problem
```

```
KB.add('American(Robert)')
```

```
KB.add('Enemy(America, A)')
```

```
KB.add('Missile(T1)')
```

```
KB.add('Owns(A, T1)')
```

```
# Define inference rules
```

```
def modus_ponens(fact1, fact2, conclusion):
```

```
    """ Apply modus ponens inference rule: if fact1 and fact2 are true, then conclude conclusion """
```

```
    if fact1 in KB and fact2 in KB:
```

```
        KB.add(conclusion)
```

```

    print(f'Inferred: {conclusion}')

def forward_chaining():
    """ Perform forward chaining to infer new facts until no more inferences can be made """
    # 1. Apply: Missile(x) → Weapon(x)
    if 'Missile(T1)' in KB:
        KB.add('Weapon(T1)')
        print(f'Inferred: Weapon(T1)')

    # 2. Apply: Sells(Robert, T1, A) from Owns(A, T1) and Weapon(T1)
    if 'Owns(A, T1)' in KB and 'Weapon(T1)' in KB:
        KB.add('Sells(Robert, T1, A)')
        print(f'Inferred: Sells(Robert, T1, A)')

    # 3. Apply: Hostile(A) from Enemy(A, America)
    if 'Enemy(America, A)' in KB:
        KB.add('Hostile(A)')
        print(f'Inferred: Hostile(A)')

    # 4. Now, check if the goal is reached (i.e., if 'Criminal(Robert)' can be inferred)
    if 'American(Robert)' in KB and 'Weapon(T1)' in KB and 'Sells(Robert, T1, A)' in KB and
    'Hostile(A)' in KB:
        KB.add('Criminal(Robert)')
        print("Inferred: Criminal(Robert)")

    # Check if we've reached our goal
    if 'Criminal(Robert)' in KB:
        print("Robert is a criminal!")
    else:
        print("No more inferences can be made.")

# Run forward chaining to attempt to derive the conclusion
forward_chaining()

```

```

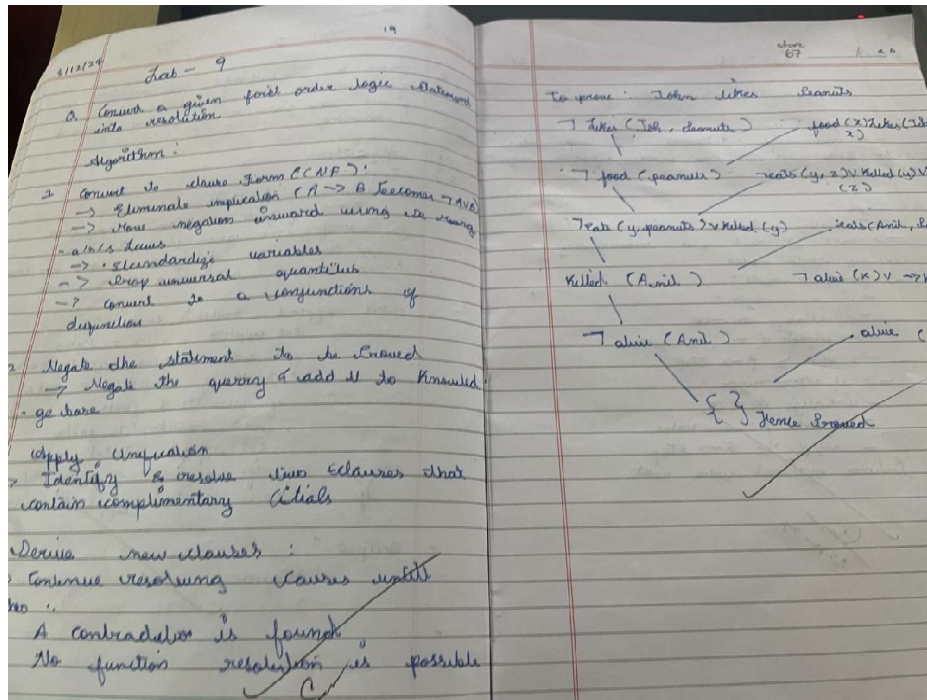
Inferred: Weapon(T1)
Inferred: Sells(Robert, T1, A)
Inferred: Hostile(A)
Inferred: Criminal(Robert)
Robert is a criminal!

```

## Program 9

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

Algorithm:



Code:

# Define the knowledge base (KB)

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

# Function to evaluate if a predicate is true based on the KB

def resolve(predicate):

# If it's a direct fact in KB

if predicate in KB and isinstance(KB[predicate], bool):  
 return KB[predicate]

# If it's a derived rule

if predicate in KB:

```

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

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

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

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

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

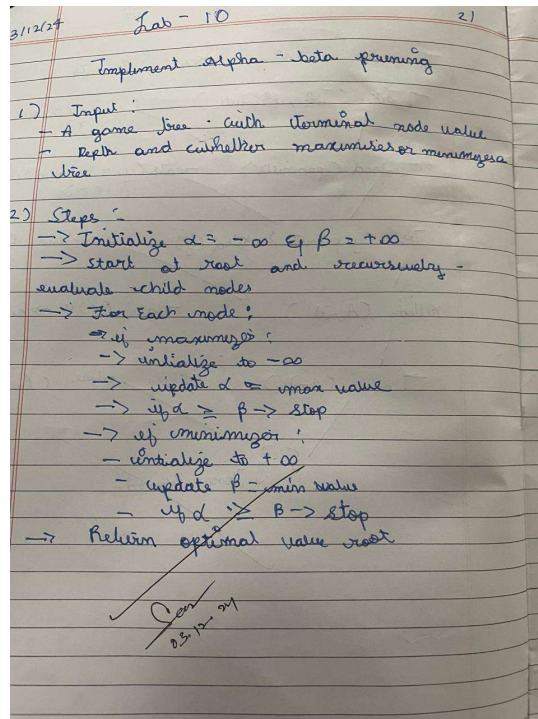
```

Does John like peanuts? Yes



## Program 10

Implement Alpha-Beta Pruning.



Algorithm:



Code:

# Alpha-Beta Pruning Implementation

```
def alpha_beta_pruning(node, alpha, beta, maximizing_player):
```

```
    # Base case: If it's a leaf node, return its value (simulating evaluation of the node)
```

```
    if type(node) is int:
```

```
        return node
```

```
    # If not a leaf node, explore the children
```

```
    if maximizing_player:
```

```
        max_eval = -float('inf')
```

```
        for child in node: # Iterate over children of the maximizer node
```

```
            eval = alpha_beta_pruning(child, alpha, beta, False)
```

```
            max_eval = max(max_eval, eval)
```

```
            alpha = max(alpha, eval) # Maximize alpha
```

```
            if beta <= alpha: # Prune the branch
```

```
                break
```

```
        return max_eval
```

```
    else:
```

```
        min_eval = float('inf')
```

```
        for child in node: # Iterate over children of the minimizer node
```

```
            eval = alpha_beta_pruning(child, alpha, beta, True)
```

```
            min_eval = min(min_eval, eval)
```

```
            beta = min(beta, eval) # Minimize beta
```

```
            if beta <= alpha: # Prune the branch
```

```
                break
```

```
        return min_eval
```

# Function to build the tree from a list of numbers

```
def build_tree(numbers):
```

```
    # We need to build a tree with alternating levels of maximizers and minimizers
```

```
    # Start from the leaf nodes and work up
```

```
    current_level = [[n] for n in numbers]
```

```
    while len(current_level) > 1:
```

```
        next_level = []
```

```
        for i in range(0, len(current_level), 2):
```

```
            if i + 1 < len(current_level):
```

```
                next_level.append(current_level[i] + current_level[i + 1]) # Combine two nodes
```

```
            else:
```

```
                next_level.append(current_level[i]) # Odd number of elements, just carry forward
```

```
        current_level = next_level
```

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

# Main function to run alpha-beta pruning

```
def main():
```

```
    # Input: User provides a list of numbers
```

```
numbers = list(map(int, input("Enter numbers for the game tree (space-separated): ").split()))

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

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

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

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

if __name__ == "__main__":
    main()
```

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

