VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT

Artificial Intelligence (23CS5PCAIN)

Submitted by

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

B.M.S. COLLEGE OF ENGINEERING
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B.M.S. College of Engineering,
Bull Temple Road, Bangalore 560019
(Affiliated To Visvesvaraya Technological University, Belgaum)
Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Artificial Intelligence (23CS5PCAIN)" carried out by **Sana Subodh (1BM23CS296),** 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.

Seema Patil Assistant Professor Department of CSE, BMSCE	Dr. Kavitha Sooda Professor & HOD Department of CSE, BMSCE

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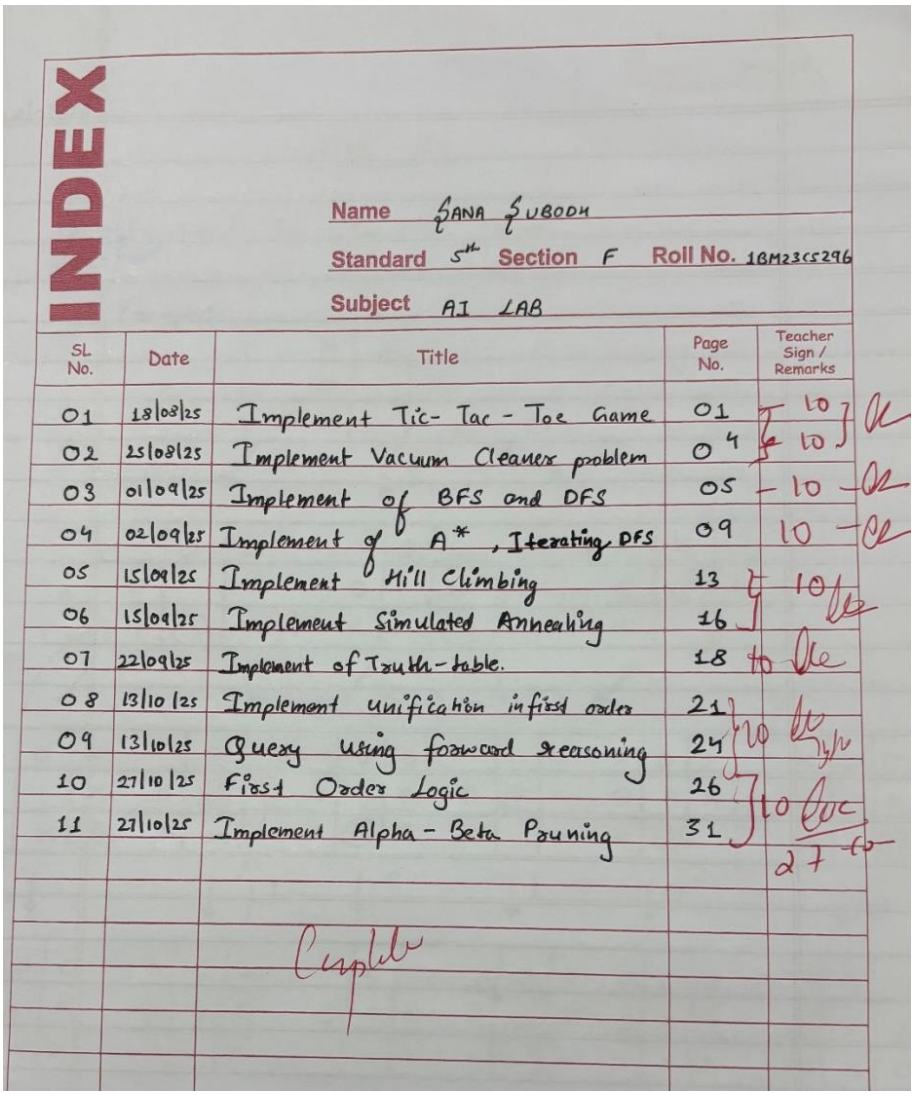

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Name SANA SUBODH

Standard 5th Section F Roll No. 1BM23CS296

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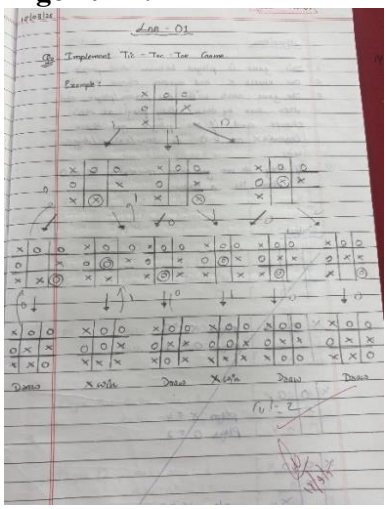
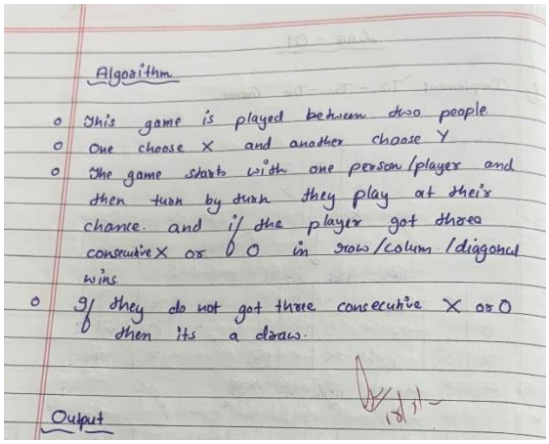
Github Link:
https://github.com/SANASUBODH/SANA-SUBODH-AI.git

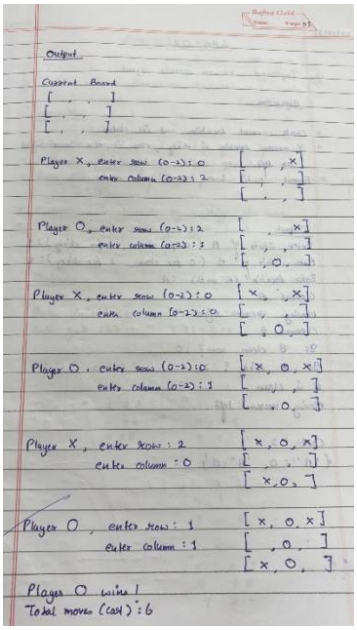
Program 1

Implement Tic –Tac –Toe Game

Algorithm:







Code:

```
def print_board(board):
print("\nCurrent Board:")
for row in board:
print(row)     print()


def check_winner(board, player):     for i in
range(3):         if all(cell == player for cell in
board[i]):
            return True         if all(board[j][i] ==
player for j in range(3)):
            return True


    if all(board[i][i] == player for i in range(3)):
        return True     if all(board[i][2 - i] == player
for i in range(3)):
        return True
```

```
    return False


def is_full(board):
    return all(cell != " " for row in board for cell in row)


def tic_tac_toe():
    board = [[" " for _ in range(3)] for _ in range(3)]
current_player = "X"      move_count = 0

    print("Tic-Tac-Toe Game (3x3 Matrix Format)\n")
print_board(board)

    while True:
try:
            row = int(input(f"Player {current_player}, enter row (0-2): "))
col = int(input(f"Player {current_player}, enter col (0-2): "))         except
ValueError:
            print("Please enter integers between 0 and 2.")
continue

        if not (0 <= row <= 2 and 0 <= col <= 2):
            print("Invalid position. Try again.")
continue         if board[row][col] != " ":
            print("Cell already filled. Choose another.")
continue

        board[row][col] = current_player
move_count += 1          print_board(board)

        if check_winner(board, current_player):
print(f"Player {current_player} wins!")              break

        if is_full(board):
            print("Game is a draw.")
break

        current_player = "O" if current_player == "X" else "X"

    print(f"Total moves (cost): {move_count}")

tic_tac_toe()
```

Output

Name: Sana Subodh
Roll No.: 1BM23CS296

Tic-Tac-Toe Simulation:

```
  |   |
---------
  |   |
---------
  |   |
---------
```

Move 1: Player X -> (0, 0)

```
X |   |
---------
  |   |
---------
  |   |
---------
```

Move 2: Player O -> (0, 1)

```
X | O |
---------
  |   |
---------
  |   |
---------
```

Move 3: Player X -> (1, 1)

```
X | O |
---------
  | X |
---------
  |   |
---------
```

Move 4: Player O -> (0, 2)

```
X | O | O
---------
  | X |
---------
  |   |
---------
```

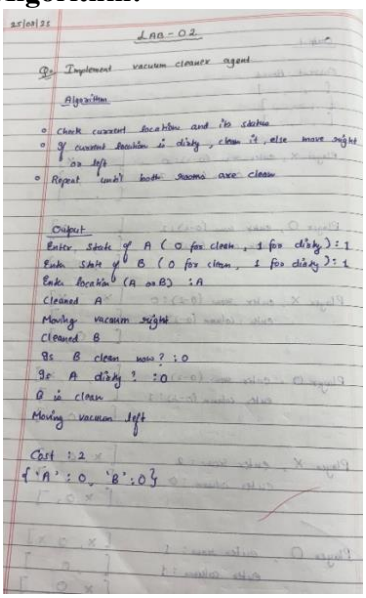
Move 5: Player X -> (2, 2)

```
X | O | O
---------
  | X |
---------
  |   | X
---------
```

Player X wins!
Total Cost: 50

Implement vacuum cleaner agent

Algorithm:



Code:

```
def vacuum_cleaner()
   A = int(input("Enter state of A (0 for clean, 1 for dirty): "))
B = int(input("Enter state of B (0 for clean, 1 for dirty): "))
location = input("Enter location (A or B): ").upper()

   cost = 0     state =
{'A': A, 'B': B}

   if location == 'A':
      if state['A'] == 1:  # If A is dirty
print("Cleaned A.")            state['A']
= 0            cost += 1         else:
          print("A is clean")

      if state['B'] == 1:  # If B is dirty
print("Moving vacuum right")
print("Cleaned B.")
          state['B'] = 0            cost += 1            print("Is B clean
now? (0 if clean, 1 if dirty):", state['B'])           print("Is A
dirty? (0 if clean, 1 if dirty):", state['A'])           print("B is
clean")           print("Moving vacuum left")        else:
          print("Turning vacuum off")
```

```
    elif location == 'B':         if
state['B'] == 1:  # If B is dirty
print("Cleaned B.")             state['B']
= 0             cost += 1         else:
           print("B is clean")


        if state['A'] == 1:  # If A is dirty              print("Moving
vacuum left")             print("Cleaned A.")             state['A'] = 0
cost += 1             print("Is A clean now? (0 if clean, 1 if dirty):",
state['A'])             print("Is B dirty? (0 if clean, 1 if dirty):",
state['B'])             print("A is clean")             print("Moving
vacuum right")         else:
           print("Turning vacuum off")


    print("Cost:", cost)
print(state)
    print("SANA SUBODH, 1BM23CS296")

vacuum_cleaner()
```

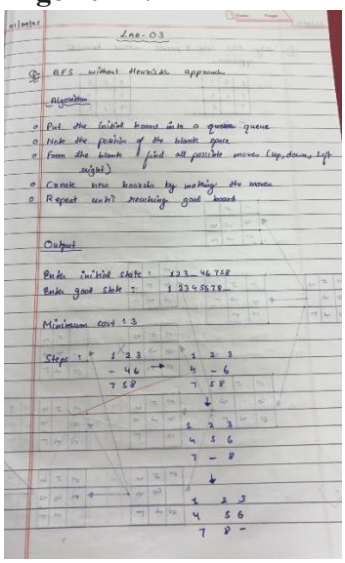
OUTPUT

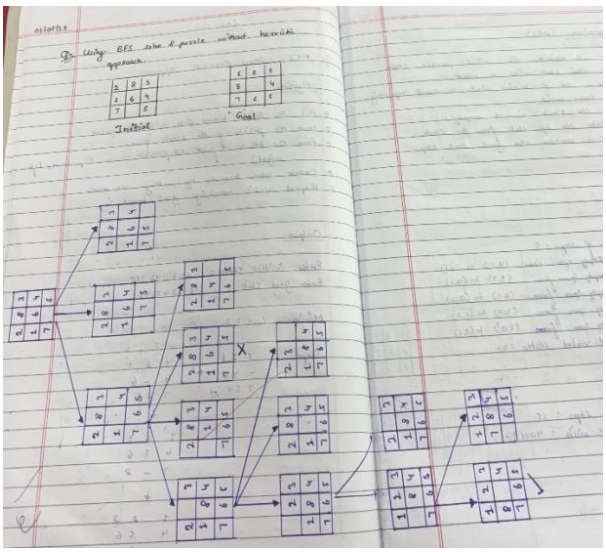
```
Is Room1 dirty or clean? (dirty/clean): dirty
Is Room2 dirty or clean? (dirty/clean): dirty
From which room should the vacuum start? (Room1/Room2): Room1
Vacuum cleaner is in Room1.
Room1 is dirty. Cleaning...
Moving to Room2.
Vacuum cleaner is in Room2.
Room2 is dirty. Cleaning...

Cleaning done.
Final room states: {'Room1': 'clean', 'Room2': 'clean'}
Total cost of cleaning and moving: 3 units.
SANA SUBODH
1BM23CS296
```

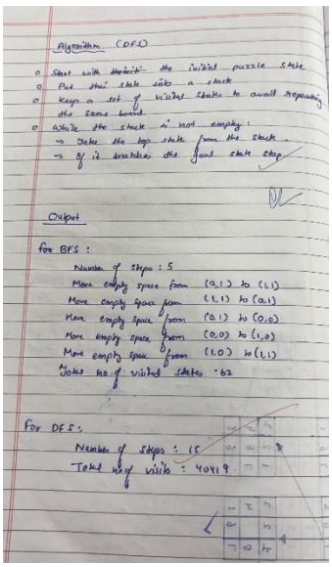
Program2

Implement 8 puzzle problems using Breath First Search (BFS)

Algorithm:







Code:

```
#bfs without heuristic approach showing visited node from
collections import deque

def get_moves(state):     idx =
state.index("_")     x, y = divmod(idx, 3)
moves = []     for dx, dy in [(-
1,0),(1,0),(0,-1),(0,1)]:
        nx, ny = x+dx, y+dy         if 0
<= nx < 3 and 0 <= ny < 3:
            nidx = nx*3 + ny             lst =
list(state)             lst[idx], lst[nidx] =
lst[nidx], lst[idx]
            moves.append("".join(lst))
    return moves

def bfs(start, goal):
```

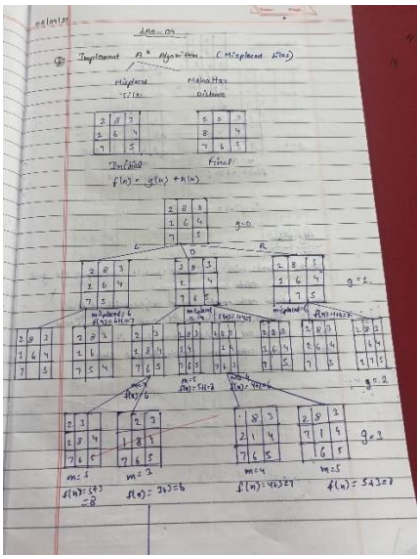
```
    q = deque([(start, 0)])
parent = {start: None} visited
= {start} order = []
  while q:
      state, cost = q.popleft()
order.append(state)       if state == goal:
# stop immediately
          path = []
while state:
              path.append(state)
               state = parent[state]
path.reverse()             return path,
cost, order         for move in
get_moves(state):             if move
not in visited:
visited.add(move)
parent[move] = state
               q.append((move, cost+1))
   return None, -1, order   # if no solution

start = input("Enter initial state (e.g., 54_618732): ")
goal = input("Enter goal state (e.g., 12345678_): ") path,
cost, visited = bfs(start, goal)

print("Minimum cost:", cost)
print("\nSteps:") for p in
path:     for i in range(0, 9,
3):         print(p[i:i+3])
   print()

print("Visited states:")
for v in visited:     for i
in range(0, 9, 3):
print(v[i:i+3])
   print()

print("SANA SUBODH ,1BM23CS296")
```

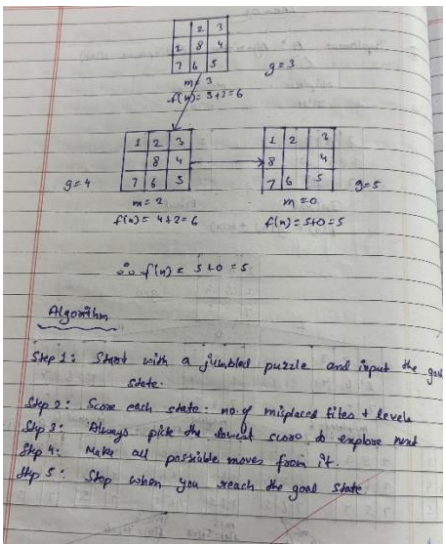
Output:

```
Enter initial state (9 values, use _ for blank, space separated): 1 2 3 4 5 _  6 7 8
Enter goal state (9 values, use _ for blank, space separated): 1 2 3 _ 4 5 6 7 8
SANA SUBODH
1BM23CS296
Solution found in 2 moves:
1 2 3
4 5 _
6 7 8

1 2 3
4 _ 5
6 7 8

1 2 3
_ 4 5
6 7 8
```

Implement A* search algorithm

Algorithm:





Code:

```
def get_moves(state):     idx =
state.index("_")     x, y = divmod(idx, 3)
moves = []     for dx, dy in [(-
1,0),(1,0),(0,-1),(0,1)]:
        nx, ny = x+dx, y+dy         if 0
<= nx < 3 and 0 <= ny < 3:
            nidx = nx*3 + ny
lst = list(state)
            lst[idx], lst[nidx] = lst[nidx], lst[idx]
moves.append("".join(lst))
   return moves

def dfs(start, goal):
stack = [(start, 0)]
parent = {start: None}
visited = {start}
   order = []

   while stack:
       state, cost = stack.pop()
order.append(state)
        if state == goal:
```

```
        path = []
        while state:
            path.append(state)            state =
parent[state]          path.reverse()
return path, cost, order, visited       for move
in reversed(get_moves(state)):          if
move not in visited:
visited.add(move)              parent[move] =
state              stack.append((move, cost+1))
    return None, -1, order, visited

start = input("Enter initial state (e.g., 54_618732): ") goal
= input("Enter goal state (e.g., 12345678_): ")
path, cost, visited_order, visited_set = dfs(start, goal)

print("Visited nodes (till goal found):")
for v in visited_order:     for i in
range(0, 9, 3):        print(v[i:i+3])
print()     if v == goal:        break

print("Steps (solution path):")
for p in path:     for i in
range(0, 9, 3):
print(p[i:i+3])
    print()

print("Cost (depth to goal):", cost)
print("Number of nodes visited:", len(visited_set))

print("SANA SUBODH ,1BM23CS296")
```

Output:

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

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

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

[0, 2, 3]
[1, 8, 4]
```

[7, 6, 5]

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

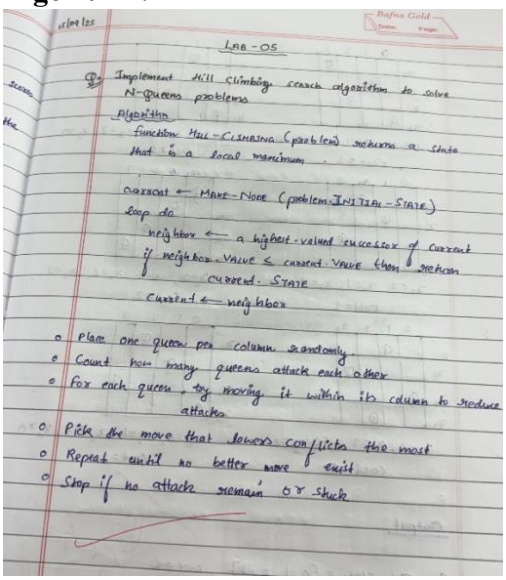
[1, 2, 3]
[8, 0, 4]
[7, 6, 5]

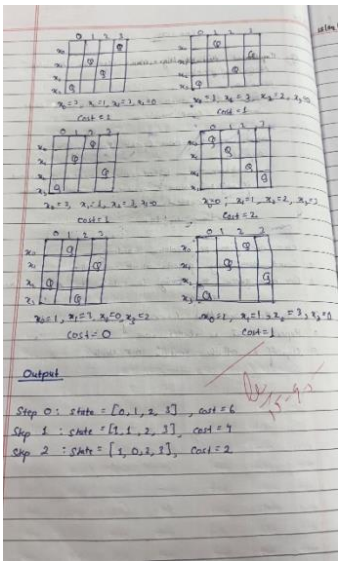
Total Cost: 5
USN: 1BM23CS296
SANA SUBODH

Program4

Implement Hill Climbing search algorithm to solve N-Queens problem

Algorithm:





Code: def
calculate_cost(state):
cost = 0 n = len(state) for i in range(n): for j in range(i + 1, n): if state[i] == state[j] or abs(state[i] - state[j]) == abs(i - j):
cost += 1
return cost

def generate_neighbors(state):
neighbors = [] n = len(state) for col in range(n): for row in range(n):
if state[col] != row: # move queen
new_state = list(state)
new_state[col] = row
neighbors.append(new_state) return neighbors

def hill_climbing(initial_state):
current = initial_state current_cost = calculate_cost(current)

```
    step = 0

    print(f"Step {step}: State = {current}, Cost = {current_cost}")

   while True:
      neighbors = generate_neighbors(current)
neighbor_costs = [(n, calculate_cost(n)) for n in neighbors]

      # Print state space for this step
print("\nNeighbors and their costs:")        for
n, c in neighbor_costs:
          print(f"   {n} -> Cost = {c}")

       # Pick the best neighbor (lowest cost)
       best_neighbor, best_cost = min(neighbor_costs, key=lambda x: x[1])

       if best_cost >= current_cost:
          break

       step += 1
       current, current_cost = best_neighbor, best_cost
       print(f"\nStep {step}: Move to {current}, Cost = {current_cost}")

       if current_cost == 0:
          print("\nGoal reached! Solution found.")
break

initial_state = [3, 1, 2, 0]

hill_climbing(initial_state)

print("SANA SUBODH- 1BM23CS296")
```

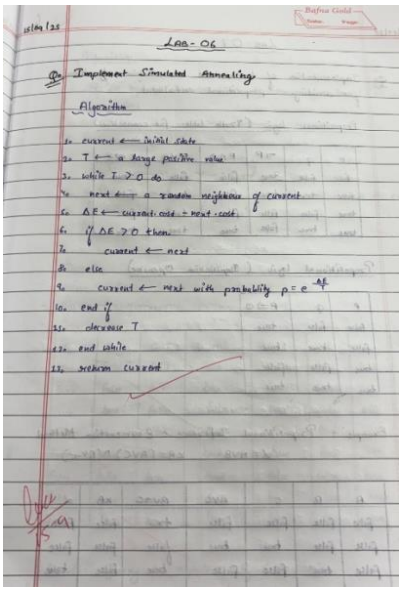
Output:

```
SANA SUBODH
1BM23CS296

--- Case 1 ---
Step 0: State=[0, 1, 2, 3], Cost=6
Step 1: State=[1, 1, 2, 3], Cost=4
Step 2: State=[1, 0, 2, 3], Cost=2
Stuck at local minimum, no better moves.

--- Case 2 ---
Step 0: State=[3, 1, 2, 0], Cost=2
Stuck at local minimum, no better moves.

--- Case 3 ---
Step 0: State=[1, 3, 0, 2], Cost=0
Solution found!

--- Case 4 ---
Step 0: State=[2, 0, 3, 1], Cost=0
Solution found!

--- Case 5 ---
Step 0: State=[3, 2, 1, 0], Cost=6
Step 1: State=[0, 2, 1, 0], Cost=4
Step 2: State=[0, 3, 1, 0], Cost=2
Step 3: State=[0, 3, 1, 2], Cost=1
Stuck at local minimum, no better moves.

--- Case 6 ---
Step 0: State=[0, 2, 3, 1], Cost=1
Stuck at local minimum, no better moves.
```

Program 5

Simulated Annealing to Solve 8-Queens problem

Algorithm:



Code:

```
import random
import math

def calculate_cost(state):
    cost = 0     n = len(state)     for i in range(n):         for j in
range(i + 1, n):             if state[i] == state[j] or abs(state[i] -
state[j]) == abs(i - j):
                cost += 1
    return cost

def get_random_neighbor(state):
n = len(state)     new_state =
list(state)     col =
random.randint(0, n - 1)     row =
random.randint(0, n - 1)
new_state[col] = row
    return new_state

def simulated_annealing(n=8, max_iterations=10000, initial_temp=100.0, cooling_rate=0.99):

    current = [random.randint(0, n - 1) for _ in range(n)]
    current_cost = calculate_cost(current)
```

```
    best = current
best_cost = current_cost
    temperature = initial_temp

    for _ in range(max_iterations):
if current_cost == 0:
            break

        neighbor = get_random_neighbor(current)
neighbor_cost = calculate_cost(neighbor)
        delta = neighbor_cost - current_cost

        if delta < 0 or random.random() < math.exp(-delta / temperature):
            current, current_cost = neighbor, neighbor_cost

            if current_cost < best_cost:
                best, best_cost = current, current_cost

        temperature *= cooling_rate
if temperature < 1e-6:
            break

    return best, best_cost

best_state, best_cost = simulated_annealing()

print("The best position found:", best_state) print("cost
=", best_cost)

print("SANA SUBODH - 1BM23CS296")
```

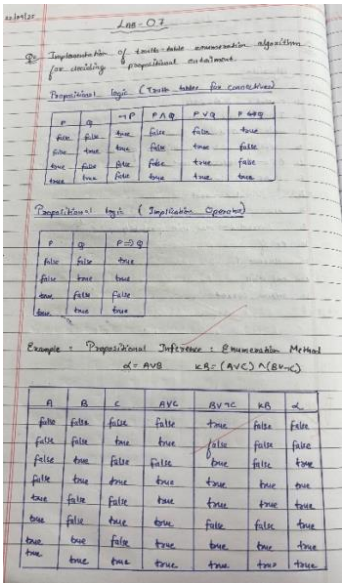
Output:

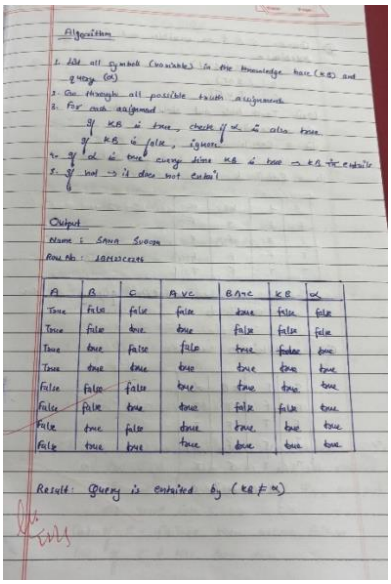
```
Name: SANA SUBODH
USN: 1BM23CS296

Final cost: 2
No perfect solution found, best found:
. . . Q . . . .
. Q . . . . . .
. . . . . Q Q
. . . . Q . . .
Q . Q . . . . .
. . . . . .
. . . . . Q . .
. . . . . .
```

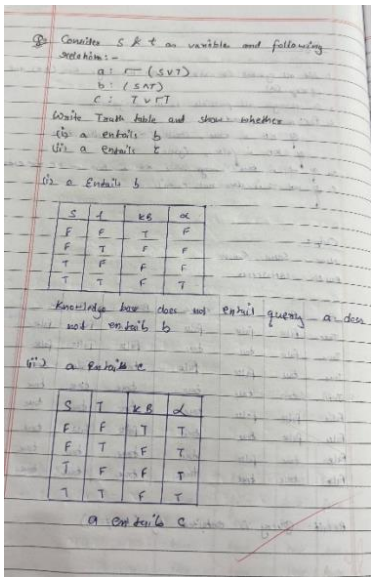
Program 6

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

Algorithm:







Code:

```
import itertools

def eval_expr(expr, model):
try:
        return eval(expr, {}, model)
except:
        return False

def tt_entails(KB, query):
    symbols = sorted(set([ch for ch in KB + query if ch.isalpha()]))

    print("\nTruth Table:")     print(" |
".join(symbols) + " | KB | Query")     print("-
" * (6 * len(symbols) + 20))

    entails = True     for values in itertools.product([False, True],
repeat=len(symbols)):
        model = dict(zip(symbols, values))
        kb_val = eval_expr(KB, model)
    query_val = eval_expr(query, model)
```

```
        row = " | ".join(["T" if model[s] else "F" for s in symbols])
print(f"{row} |  {kb_val}  |  {query_val}")

        if kb_val and not query_val:
entails = False

    return entails

KB = input("Enter Knowledge Base (use &, |, ~ for AND, OR, NOT): ")
query = input("Enter Query: ")

result = tt_entails(KB, query)

print("\nResult:") if
result:
    print("KB entails Query (True in all cases).") else:
    print("KB does NOT entail Query.")

print("SANA SUBODH , 1BM23CS296")
```

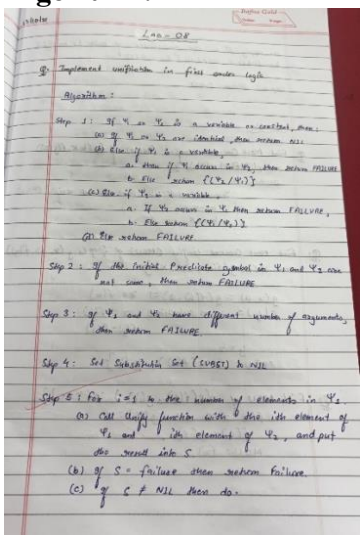
Output:

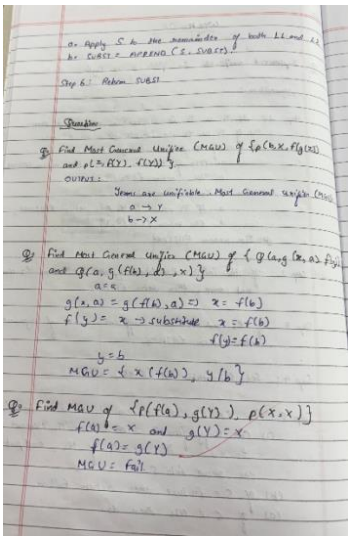
```
Name: SANA SUBODH
Roll No.: 1BM23CS296

    A |     B |     C |   A∨C |  B∧¬C |    KB |     α
-------------------------------------------------------
 True |  True |  True |  True | False | False |  True
 True |  True | False |  True |  True |  True |  True
 True | False |  True |  True | False | False |  True
 True | False | False |  True | False | False |  True
False |  True |  True |  True | False | False |  True
False |  True | False | False |  True | False | False
False | False |  True |  True | False | False |  True
False | False | False | False | False | False | False

Result:
Query is entailed by KB (KB ⊨ α).
```

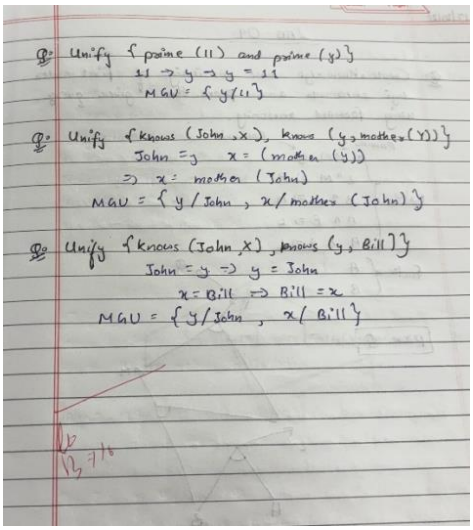
Program 7

Implement unification in first order logic

Algorithm:







Code:

```
def occurs_check(var, term, subst):
    if var == term:
        return True
    elif isinstance(term, tuple):
        return any(occurs_check(var, t, subst) for t in term)
    elif term in subst:
        return occurs_check(var, subst[term], subst)
    return False

def unify(x, y, subst):
    if subst is None:
        return None
    elif x == y:
        return subst
    elif isinstance(x, str) and x.isupper():
        return unify_var(x, y, subst)
    elif isinstance(y, str) and y.isupper():
        return unify_var(y, x, subst)
    elif isinstance(x, tuple) and isinstance(y, tuple):
        if x[0] != y[0] or len(x) != len(y):
            return None
        for a, b in zip(x[1:], y[1:]):
            subst = unify(a, b, subst)
```

```
        if subst is None:
return None       return
subst   else:       return
None

def unify_var(var, x, subst):
if var in subst:
      return unify(subst[var], x, subst)
elif x in subst:
      return unify(var, subst[x], subst)
elif occurs_check(var, x, subst):
      return None
else:
      subst[var] = x
      return subst

def parse_expr(s):    s =
s.replace(" ", "")    if '('
not in s:       return s
name_end = s.index('(')
   name = s[:name_end]
args = []    depth = 0
current = ""    for c in
s[name_end+1:-1]:       if c
== ',' and depth == 0:
         args.append(parse_expr(current))
         current = ""
else:
         if c == '(':
depth += 1
elif c == ')':
depth -= 1
current += c    if
current:
      args.append(parse_expr(current))
   return tuple([name] + args)

def expr_to_str(expr):
   if isinstance(expr, tuple):
      return expr[0] + "(" + ",".join(expr_to_str(e) for e in expr[1:]) + ")"
else:
      return expr

expr1_input = input("Enter first expression: ")
expr2_input = input("Enter second expression: ")

expr1 = parse_expr(expr1_input)
```

```
expr2 = parse_expr(expr2_input)

subst = unify(expr1, expr2, {})

if subst:
    formatted_subst = {var: expr_to_str(val) for var, val in subst.items()} else:
    formatted_subst = None

print("Most General Unifier (MGU):", formatted_subst)
print("SANA SUBODH ,1BM23CS296")
```

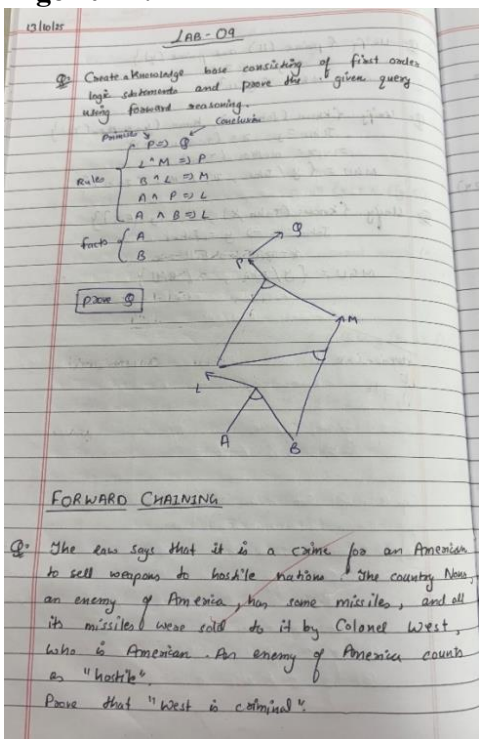
Output:

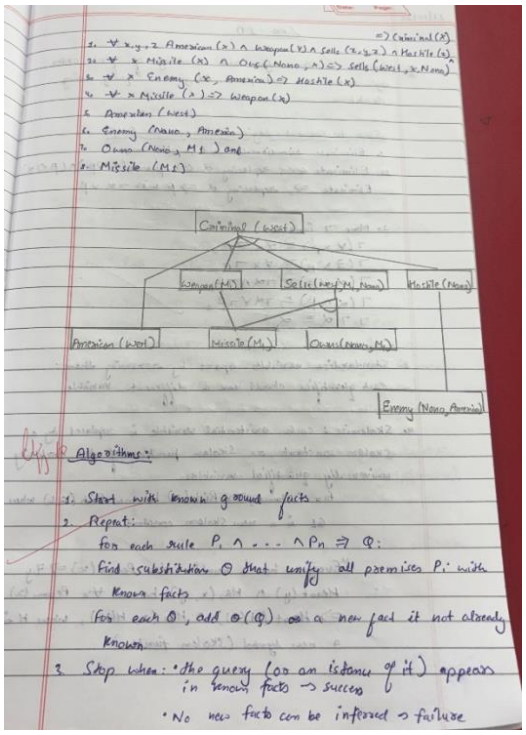
```
Name: SANA SUBODH
USN: 1BM23CS296

Terms are unifiable. Most General Unifier (MGU):
a -> Y
b -> X
```

Program 8

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

Algorithm:





Code:

```
facts = {
   'American(Robert)': True,
   'Hostile(A)': True,
   'Sells_Weapons(Robert, A)': True
}
```

If American(X) and Hostile(Y) and Sells_Weapons(X, Y), then Crime(X) def forward_reasoning(facts):

If American(X) and Hostile(Y) and Sells_Weapons(X, Y), then Crime(X) if facts.get('American(Robert)', False) and facts.get('Hostile(A)', False) and facts.get('Sells_Weapons(Robert, A)', False): facts['Crime(Robert)'] = True

```
forward_reasoning(facts)

if facts.get('Crime(Robert)', False):
   print("Robert is a criminal.")
else:     print("Robert is not a
criminal.")

print("SANA SUBODH 1BM23CS296")
```

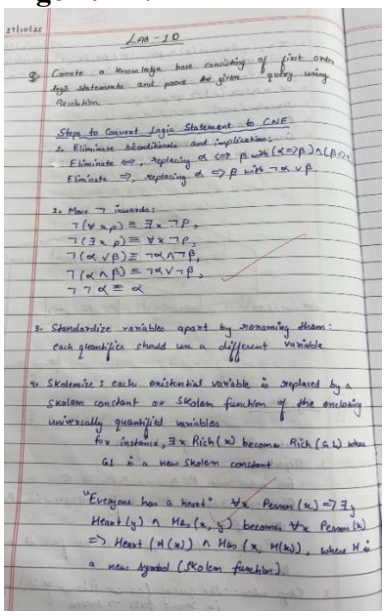
Output:

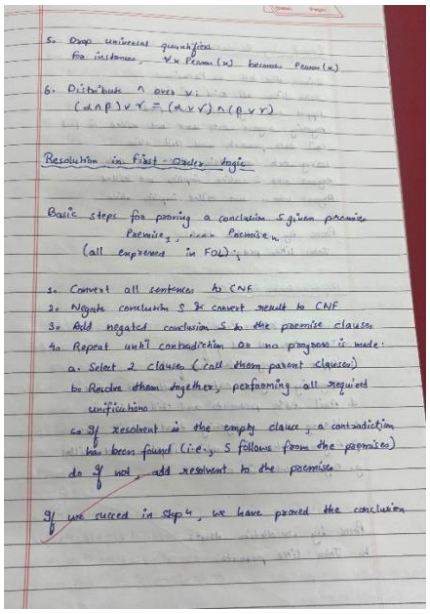
Robert is a criminal.
SANA SUBODH 1BM23CS296

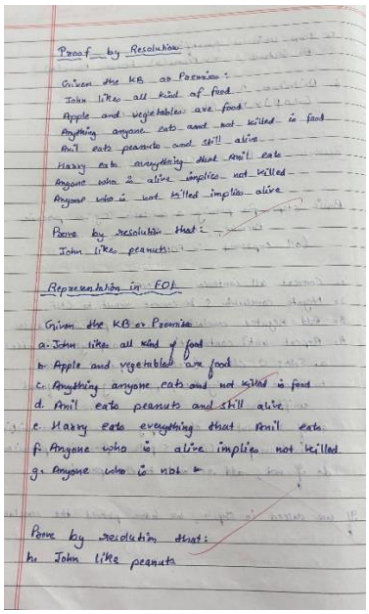
Program 9

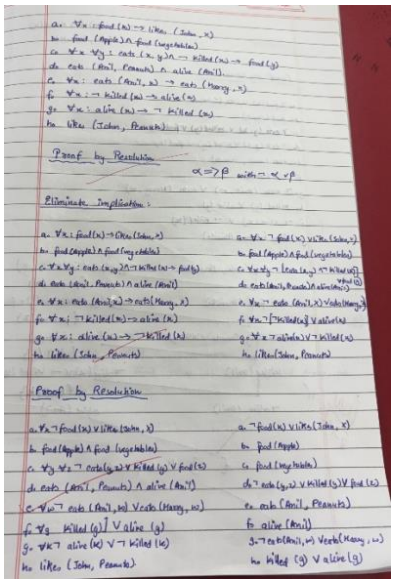
Create a knowledge base consisting of first order logic statements and prove the given query using Resolution

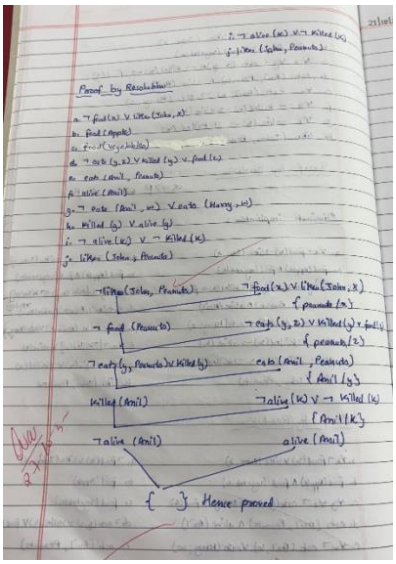
Algorithm:











Code:

```
def fol_resolution(kb, query):
   print("\n" + "="*55)     print("
KNOWLEDGE BASE")     print("="*55)
for i, clause in enumerate(kb, start=1):
       print(f"  {i}. {clause}")

   print("\n" + "="*55)     print("
QUERY")
   print("="*55)     print(f"
Prove: {query}")
   print(f"  Negated Query: ~{query}\n")

   print("="*55)     print("               RESOLUTION PROCESS")     print("="*55)
print("Step 1: Convert all implications (→) to CNF (Conjunctive Normal Form).")
print("Step 2: Eliminate all universal quantifiers (∀).")     print("Step 3: Add negated
query (~Query) to the KB.")     print("Step 4: Apply resolution rule between
matching clauses.")     print("Step 5: Continue until the empty clause (⊥) is
found.\n")
   print("="*55)     print("
RESOLUTION TREE")     print("="*55)
print("""
                    [~Likes(John, Peanuts)]
                           |
                    [Food(Peanuts) → Likes(John, Peanuts)]
                           |
                    [Eats(Anil, Peanuts) ∧ ¬Killed(Anil) → Food(Peanuts)]
                           |
                    [Alive(Anil) → ¬Killed(Anil)]
                           |
                    [Alive(Anil)]
                           ↓
                     ⊥ (Contradiction Found)
   """)

   print("="*55)     print(f" Therefore, the query '{query}' is PROVEN
by Resolution.")     print("="*55 + "\n")

print("\n FIRST ORDER LOGIC - RESOLUTION METHOD")

n = int(input("Enter the number of statements in the Knowledge Base: "))

kb = []
print("\nEnter each statement (e.g., '∀x: Food(x) → Likes(John, x)'):")
for i in range(n):     stmt = input(f"KB[{i+1}]: ")     kb.append(stmt)
```

```
query = input("\nEnter the query to prove: ")

fol_resolution(kb, query) print("SANA
SUBODH 1BM23CS296")
```

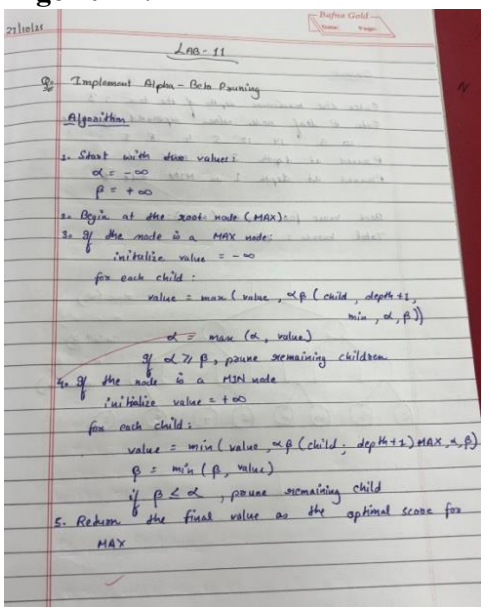
Output:

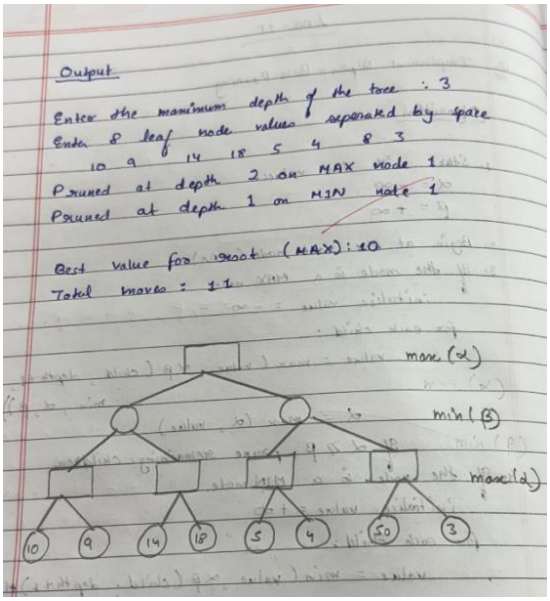
```
Resolution Process
NAME: SANA SUBODH
USN: 1BM23CS296
Resolving {'-food(x)', 'likes(John,x)'} and {'food(Peanuts)'} → {'likes(John,Peanuts)'} Resolving {'killed(g)', 'alive(g)'} and {'-alive(k)', '-killed(k)'} → set
Empty clause derived.
Hence, the query is PROVED TRUE by Resolution.
```

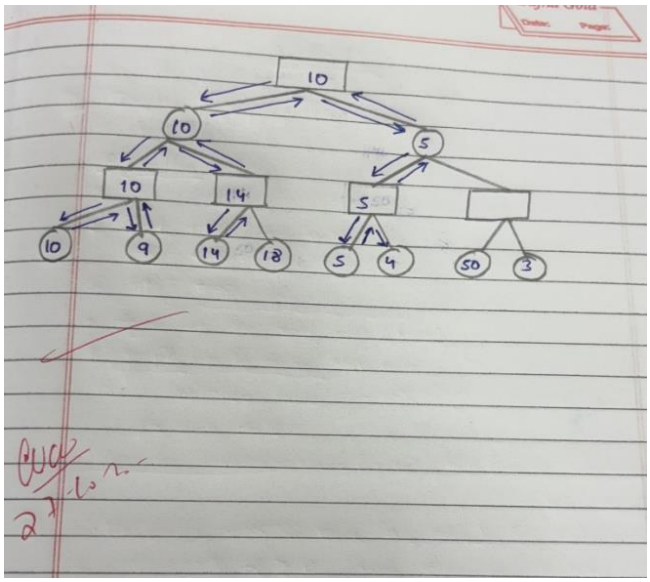
Program 10

Implement Alpha-Beta Pruning.

Algorithm:







Code:

```
move_count = 0

def alpha_beta(depth, node_index, is_maximizing, values, alpha, beta, max_depth):
    global move_count
    move_count += 1

    if depth == max_depth:
        return values[node_index]

    if is_maximizing:          best = float('-inf')          for i in range(2):  # binary tree              val =
alpha_beta(depth + 1, node_index * 2 + i, False, values, alpha, beta, max_depth)              best
= max(best, val)              alpha = max(alpha, best)              if beta <= alpha:
                print(f" Pruned at depth {depth} on MAX node {node_index}")
break          return best
    else:
        best = float('inf')
for i in range(2):
            val = alpha_beta(depth + 1, node_index * 2 + i, True, values, alpha, beta, max_depth)
best = min(best, val)              beta = min(beta, best)              if beta <= alpha:
                print(f" Pruned at depth {depth} on MIN node {node_index}")
break
        return best

max_depth = int(input("Enter the maximum depth of the tree: "))

num_leaves = 2 ** max_depth print(f"Enter {num_leaves} leaf
node values separated by spaces:") values = list(map(int,
input().split()))

if len(values) != num_leaves:
    print(" Error: Number of values does not match 2^depth.") else:
    move_count = 0      best_value = alpha_beta(0, 0, True, values, float('-inf'),
float('inf'), max_depth)      print("\n Best value for root (MAX):", best_value)
print(f" Total moves (nodes visited): {move_count}")
print("SANA SUBODH 1BM23CS296")
```

Output: