VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

Artificial Intelligence (23CS5PCAIN)

Submitted by

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

B.M.S. COLLEGE OF ENGINEERING
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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Artificial Intelligence (23CS5PCAIN)" carried out by **Rohit Ramchandra Gandhi (1BM23CS417),** 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.

Prof. Sneha P Assistant Professor Department of CSE, BMSCE	Dr. Kavitha Sooda Professor & HOD Department of CSE, BMSCE

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Github Link:

https://github.com/RohitGnadhi2599/AI

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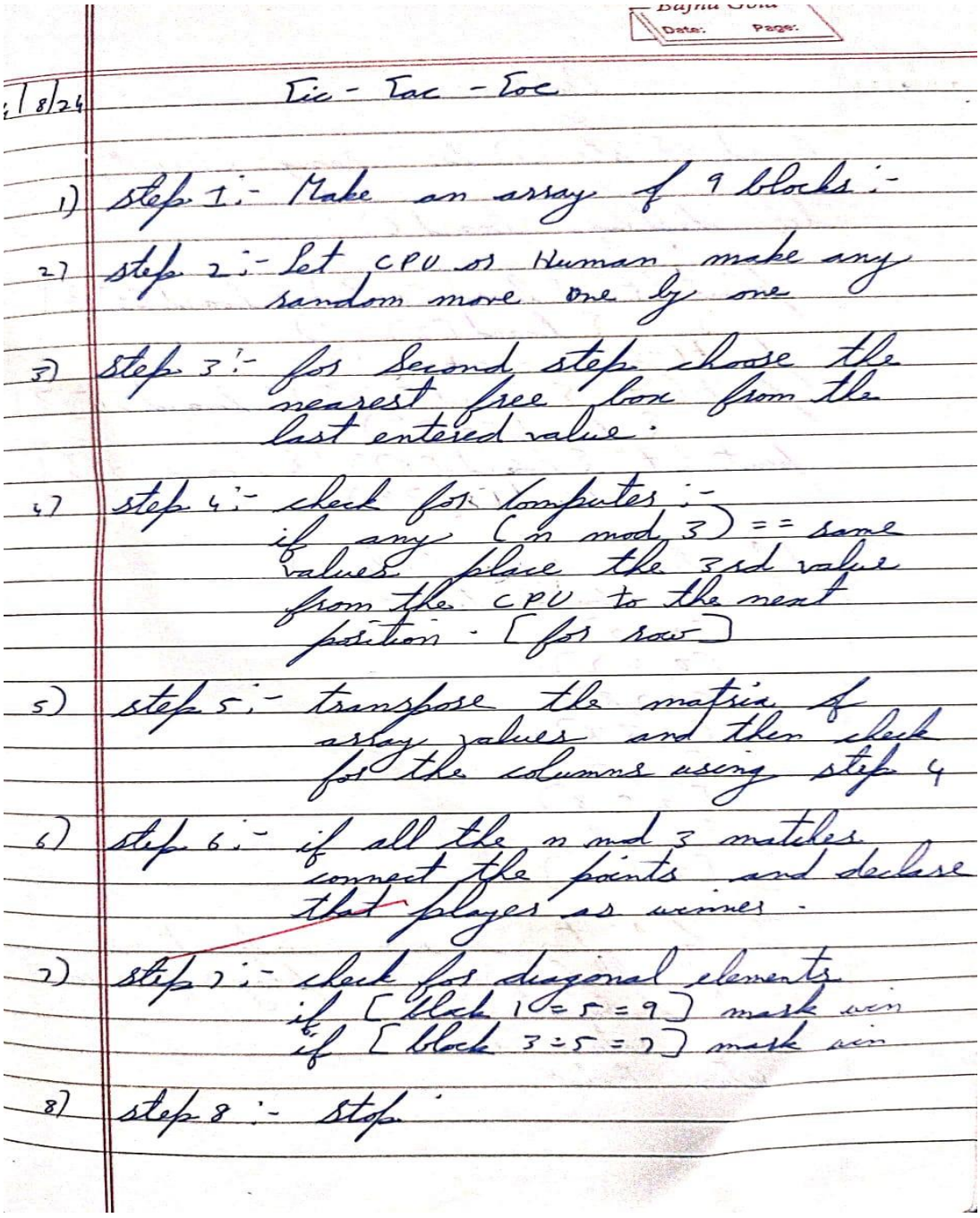
Program 1

Tic-Tac-Toe:

Algorithm:



Tic - Tac - Toe

1) step 1:- Make an array of 9 blocks:-
2) step 2:- Let CPU or Human make any random move one by one
3) step 3:- for second step choose the nearest free box from the last entered value.
4) step 4:- check for computer:-
   if any (n mod 3) == same values place the 3rd value from the CPU to the next position. [for row]
5) step 5:- transpose the matrix of array values and then check for the columns using step 4
6) step 6:- if all the n mod 3 matches connect the points and declare that player as winner.
7) step 7:- check for diagonal elements
   if [block 1 ÷ 5 = 9] mark win
   if [block 3 ÷ 5 = 7] mark win
8) step 8:- Stop.

Code:

```
import random
board = [[' ' for _ in range(3)] for _ in range(3)]
def print_board():
    for row in board:
        print(' | '.join(row))
        print('-' * 9)
def check_win(player):
    for i in range(3):
        if board[i][0] == board[i][1] == board[i][2] == player:
            return True
        if board[0][i] == board[1][i] == board[2][i] == player:
            return True
    if board[0][0] == board[1][1] == board[2][2] == player:
        return True
    if board[0][2] == board[1][1] == board[2][0] == player:
        return True
    return False
def check_draw():
    for row in board:
        if ' ' in row:
            return False
    return True
def computer():
    for row in range(3):
        for col in range(3):
            if board[row][col] == ' ':
                board[row][col] = 'O'
                if check_win('O'):
                    return
                board[row][col] = ' '
    for row in range(3):
        for col in range(3):
            if board[row][col] == ' ':
                board[row][col] = 'X'
                if check_win('X'):
                    board[row][col] = 'O'
                    return
                board[row][col] = ' '
    if board[1][1] == ' ':
```

```
            board[1][1] = 'O'
            return
        corners = [(0, 0), (0, 2), (2, 0), (2, 2)]
        random.shuffle(corners)
        for row, col in corners:
            if board[row][col] == ' ':
                board[row][col] = 'O'
                return
        sides = [(0, 1), (1, 0), (1, 2), (2, 1)]
        random.shuffle(sides)
        for row, col in sides:
            if board[row][col] == ' ':
                board[row][col] = 'O'
                return
    flag = True
    while flag:
        print_board()
        while True:
            try:
                print("Player 1's turn (X)")
                user_input = input("Enter row and column (1-3) separated by space: ")
                row, col = map(int, user_input.split())
                row -= 1
                col -= 1
                if row in range(3) and col in range(3) and board[row][col] == ' ':
                    board[row][col] = 'X'
                    break
                else:
                    print("Invalid move, cell already taken or out of bounds.")
            except (ValueError, IndexError):
                print("Invalid input, please enter two numbers between 1 and 3 separated by space.")
        if check_win('X'):
            print_board()
            print("Player 1 wins!")
            break
        if check_draw():
            print_board()
            print("Draw!")
            break
        print_board()
        print("Player 2's turn (O)")
```

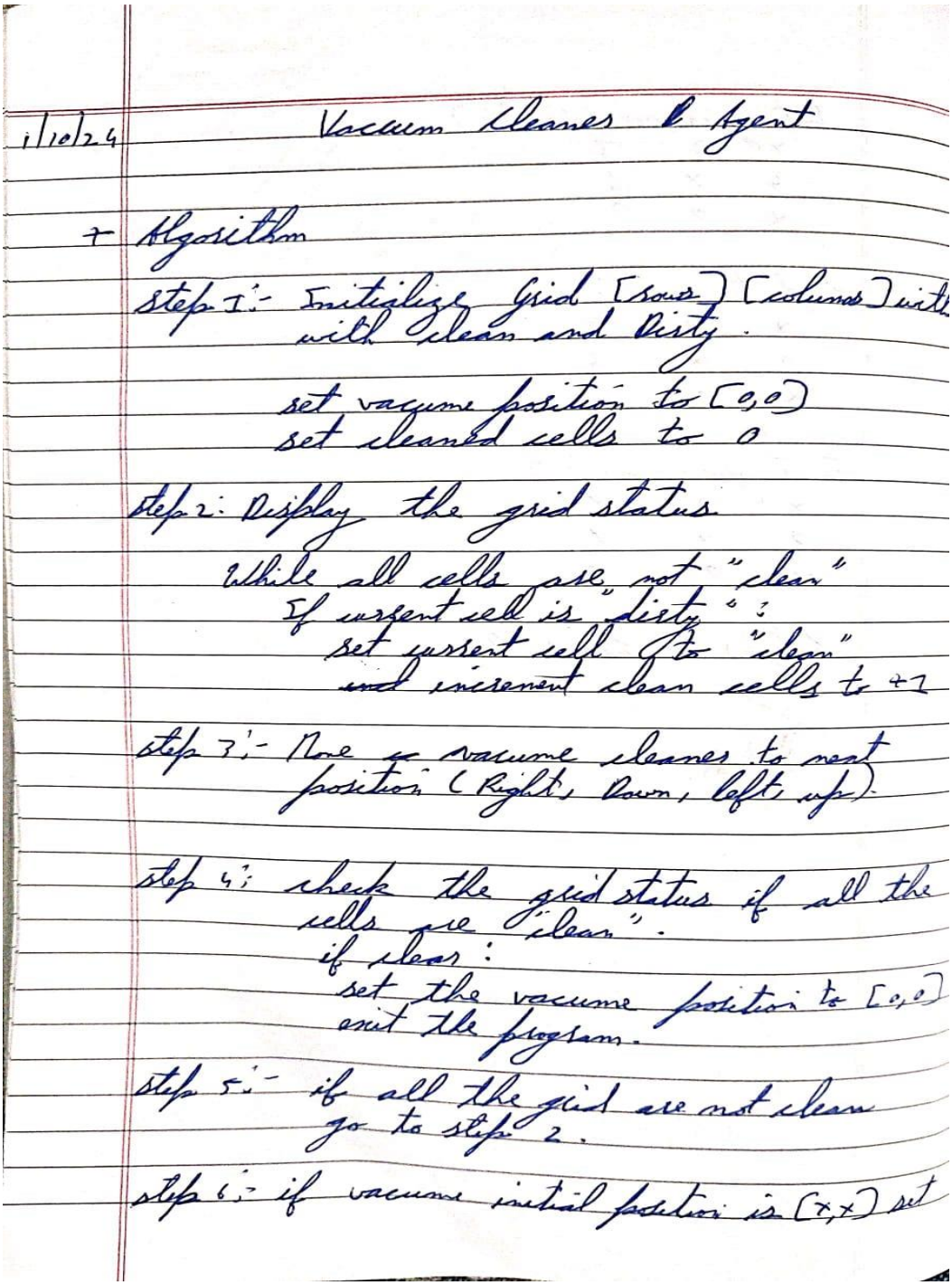
```
    computer()
    if check_win('O'):
        print_board()
        print("Player 2 wins!")
        break
    if check_draw():
        print_board()
        print("Draw!")
        break
```

Output:

```
Player 1's turn (X)
Enter row and column (1-3) separated by space: 1 2
X | X | O
---------
O | X | X
---------
  |   | O
---------
Player 2's turn (O)
X | X | O
---------
O | X | X
---------
  | O | O
---------
Player 1's turn (X)
Enter row and column (1-3) separated by space: 3 1
X | X | O
---------
O | X | X
---------
X | O | O
---------
Draw!
```

Vacuum Cleaner Agent:

Algorithm:



1/10/24 Vacuum cleaner & Agent

+ Algorithm

step 1:- Initialize Grid [rows] [columns] with with clean and Dirty.

set vacume position to [0,0]
set cleaned cells to 0

step 2: Display the grid status

While all cells are not "clean"
If urgent cell is "dirty":
set ursent cell to "clean"
and increment clean cells to +1

step 3:- Move a vacume cleaner to next position (Right, Down, left, up).

step 4: check the grid status if all the cells are "clean".
if clean:
set the vacume position to [0,0]
exit the program.

step 5:- if all the grid are not clean go to step 2.

step 6:- if vacume initial position is [x,x] set

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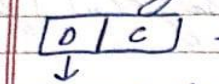
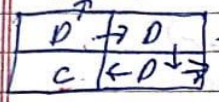
to (0,0).

+ Positioning diagram:-



→ check if: initial cell is clean is not clean and move to right. (0,2):

Vacume position



→ check if:
cell is clean & dirty:
if dirty:
set to "clean"
move at right:
check if clean or dirty
if dirty:
set to clean:
if right = NULL
go left
check: cells:
if dirty:
set to clean:
and move left:

Proceed

Code:

```
class CustomVacuumCleaner:
    def __init__(self, states, start_position):
        self.rooms = states
        self.position = start_position
        self.loc = ['A', 'B']

    def is_dirty(self):
        return self.rooms[self.position] == 1

    def clean(self):
        if self.is_dirty():
            print(f"Cleaning room {self.loc[self.position]}")
            self.rooms[self.position] = 0
        else:
            print(f"Room {self.loc[self.position]} is already clean.")

    def move(self):
        if self.position == 0:
            self.position = 1
        else:
            self.position = 0
    def run(self):
        cleaned = 0
        while cleaned <= 1:
            self.clean()
            self.move()
            cleaned += 1
        print("All rooms are clean!"
a = int(input("Enter state for room A, 0 for clean and 1 for dirty "))
b = int(input("Enter state for room B, 0 for clean and 1 for dirty "))
states = [a, b]
start_position = int(input("Enter start position, 0 for room A, 1 for room B "))
vacuum = CustomVacuumCleaner(states, start_position)
vacuum.run()
```

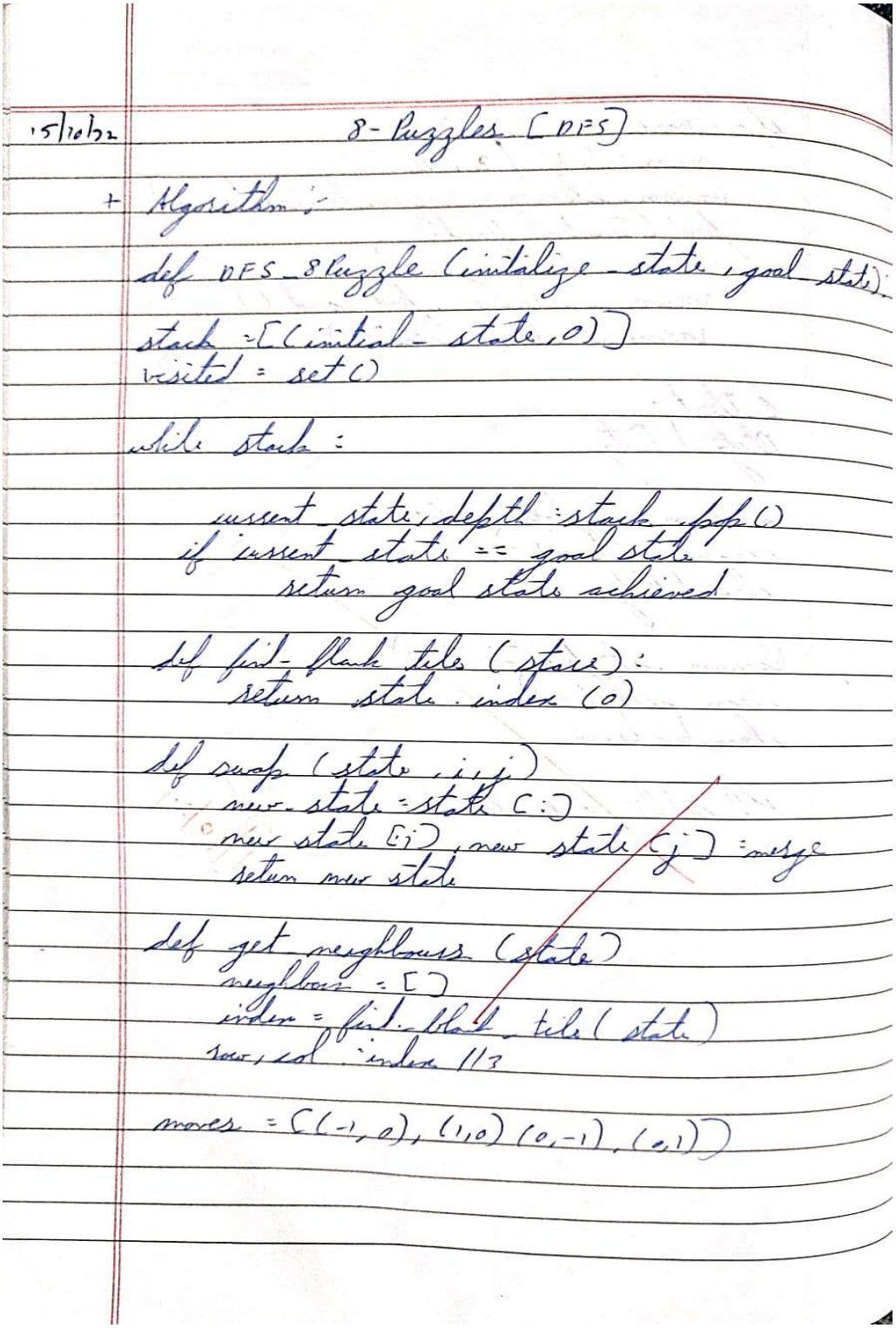
Output:

```
Enter state for room A, 0 for clean and 1 for dirty 0
Enter state for room B, 0 for clean and 1 for dirty 0
Enter start position, 0 for room A, 1 for room B 1
Room B is already clean.
Room A is already clean.
All rooms are clean!
```

Program 2

Depth First Search and Iterative Deepening Search:

Algorithm:



15/10/22 8-Puzzles [DFS]

+ Algorithm :-

```
def DFS_8puzzle (initialize_state, goal_state):
    stack = [(initial_state, 0)]
    visited = set()

    while stack :

        current_state, depth = stack.pop()
        if current_state == goal state
            return goal state achieved

    def find_blank_tile (state):
        return state.index(0)

    def swap (state, i, j)
        new_state = state [:]
        new state [i], new state [j] = new state [j], new state [i]
        return new state

    def get_neighbours (state)
        neighbours = []
        index = find_blank_tile (state)
        row, col = index // 3

    moves = [(-1, 0), (1, 0) (0, -1), (0, 1)]
```

```
in moves:
    new_row, new_col = row + move(0), col + move(1)

    if 0 <= new_row < 3 and 0 <= new_col

    new_state = swap(state, index, new_state)
    neighbours.append(new_state)
    neighbours

if current_state == goal_state
    return path + (current_state)

for neighbour in get_neighbours
    if (tuple neighbour) not in visited:
    stack.append((neighbour, path + [current]))

    if solution != No_Solution:
        print(puzzle(state))
else
    print(solution)
```

Eg:-

1	3	8
4	6	5
2	7	X

1	2	3
4	5	6
7	8	

Process:

1	3	8
4	6	5
2	X	7

→

1	3	8
4	X	5
2	6	7

→

1	3	8
X	2	5
6	7	4

→

1	2	8
3	6	5
4	7	

Code:

```
from collections import deque

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

MOVES = {
    'up': (-1, 0),
    'down': (1, 0),
    'left': (0, -1),
    'right': (0, 1)
}

def is_valid_move(board, move):
    x, y = get_zero_position(board)
    dx, dy = MOVES[move]
    new_x, new_y = x + dx, y + dy
    return 0 <= new_x < 3 and 0 <= new_y < 3

def get_zero_position(board):
    for i in range(3):
        for j in range(3):
            if board[i][j] == 0:
                return i, j

def apply_move(board, move):
    x, y = get_zero_position(board)
    dx, dy = MOVES[move]
    new_x, new_y = x + dx, y + dy
    board[x][y], board[new_x][new_y] = board[new_x][new_y], board[x][y]

def is_goal_state(board):
    return board == GOAL_STATE

def dfs(board):
    stack = deque([(board, [])])
    visited = set()
```

```
    while stack:
        current_board, moves = stack.pop()
        if tuple(map(tuple, current_board)) in visited:
            continue
        visited.add(tuple(map(tuple, current_board)))
        if is_goal_state(current_board):
            return moves
        for move in MOVES:
            new_board = [row[:] for row in current_board]
            if is_valid_move(new_board, move):
                apply_move(new_board, move)
                stack.append((new_board, moves + [move]))
    return None

def print_steps(moves):
    board = [
        [1, 2, 3],
        [4, 5, 0],
        [7, 8, 6]

    ]
    for move in moves:
        x, y = get_zero_position(board)
        dx, dy = MOVES[move]
        new_x, new_y = x + dx, y + dy
        board[x][y], board[new_x][new_y] = board[new_x][new_y], board[x][y]
        print("Move:", move)
        print("Board:")
        for row in board:
            print(row)
        print()

initial_board = [
    [1, 2, 3],
    [4, 5, 0],
    [7, 8, 6]
]
solution = dfs(initial_board)
if solution:
    print("Solution found:")
    print_steps(solution)
```

```
else:
    print("No solution found.")
```

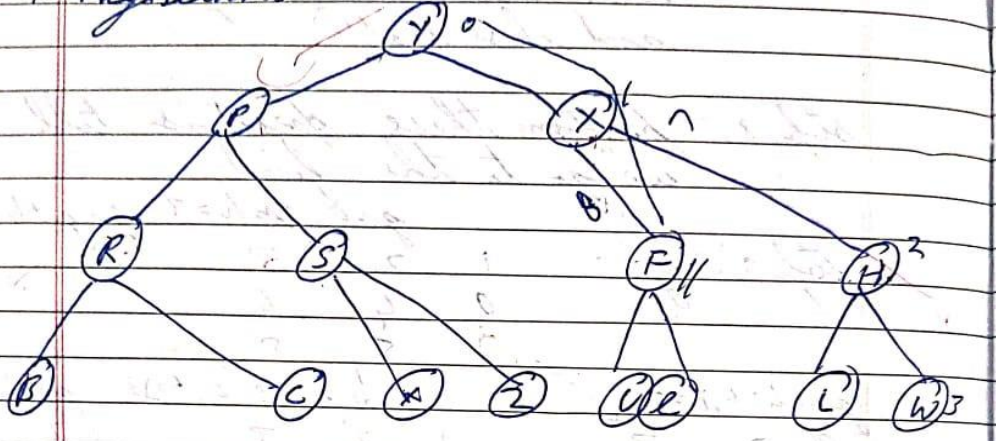
Output:

```
Move: down
Board:
[1, 2, 3]
[4, 5, 6]
[0, 7, 8]

Move: right
Board:
[1, 2, 3]
[4, 5, 6]
[7, 0, 8]

Move: right
Board:
[1, 2, 3]
[4, 5, 6]
[7, 8, 0]
```

Iterative Deepening Search:

IDS

+ Algorithm:-




```
Iterative dep( src, target, limit_max)
{
    for limit 0 to limit_max:
        if( DLS.(src, target, limit==true)
            return true.
    return false.

dept_first (src, target, limit)
    if( src == target)
        return true
    if( limit <= 0 ) // if max depth reached
        return false
    for each i adjacent of src
        if dept_first (i, target, limit-1)
    return false.
```

Proceed

Manhattan Distance

Algo:-

1) Initialize the search:

Define initial and final state.

Create a priority queue for the A* algorithm and set to track visited state.

Push the initial states into priority queue. with movement cost as 0.

2- Calculate Manhattan Distance: $[f(n) = g(n) + h(n)]$
for a given state calculate the sum of manhattan distance of all tiles.

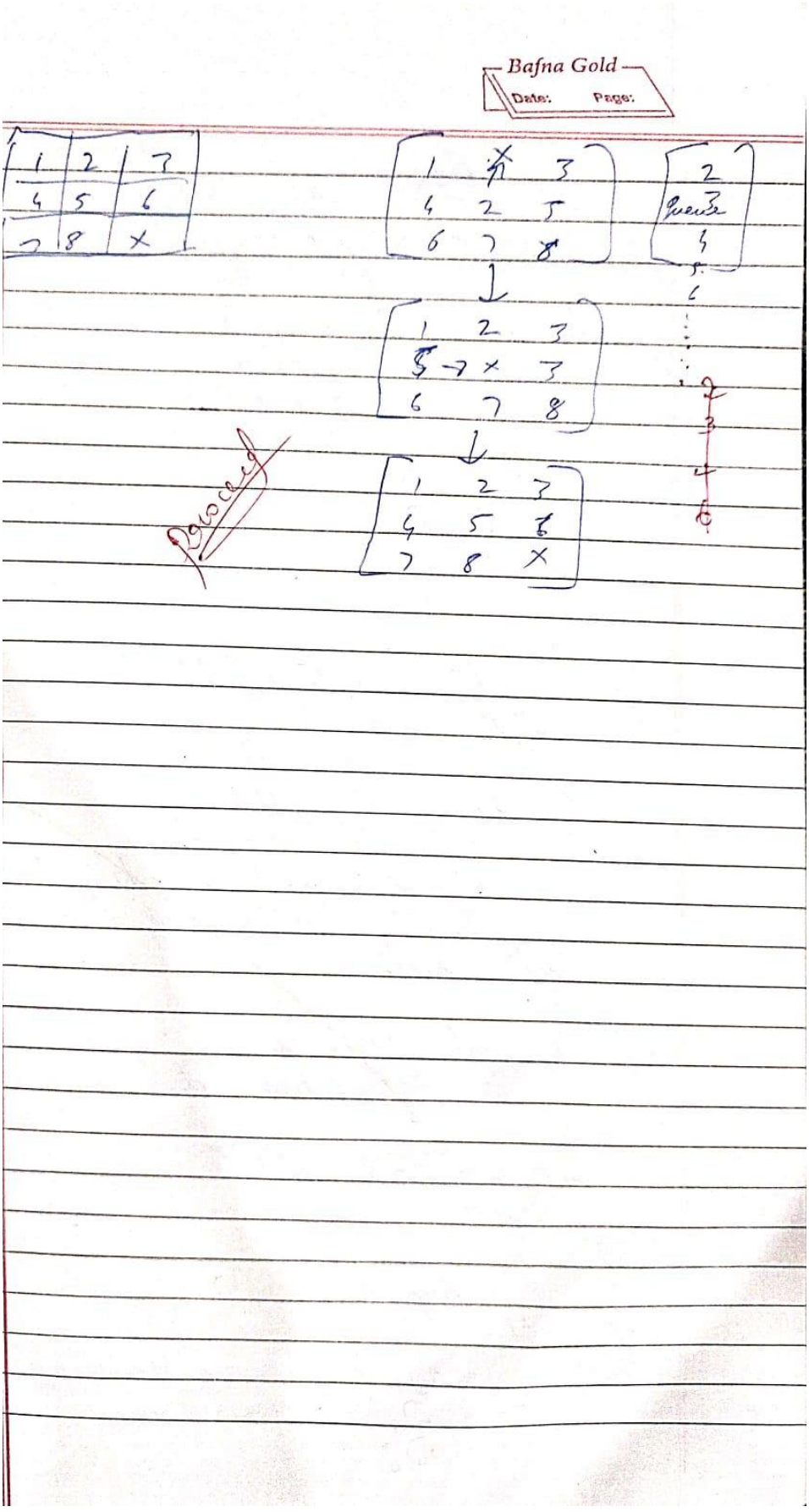
Pop the value from the lowest priority queue

If the goal pstl is reached return the solution path.

Or generate all possible valid moves.

4) Backtrack and looping loops.
Keep track of visited state to avoid cycle.

5) End condition:- If the priority queue is empty no solution is found.
If the goal is reached return solution path.


Bafna Gold
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1 2 3
4 5 6
7 8 X
1 X 3
4 2 5
6 7 8
2
Queen
4
6
1 2 3
5 → X 3
6 7 8
1 2 3
4 5 6
7 8 X
Discard

Code:

```
from collections import deque

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

MOVES = {
    'up': (-1, 0),
    'down': (1, 0),
    'left': (0, -1),
    'right': (0, 1)
}

def is_valid_move(board, move):
    x, y = get_zero_position(board)
    dx, dy = MOVES[move]
    new_x, new_y = x + dx, y + dy
    return 0 <= new_x < 3 and 0 <= new_y < 3

def get_zero_position(board):
    for i in range(3):
        for j in range(3):
            if board[i][j] == 0:
                return i, j

def apply_move(board, move):
    x, y = get_zero_position(board)
    dx, dy = MOVES[move]
    new_x, new_y = x + dx, y + dy
    board[x][y], board[new_x][new_y] = board[new_x][new_y], board[x][y]

def is_goal_state(board):
    return board == GOAL_STATE

def ids(board):
    for depth in range(1, 100):
```

```
        result = dls(board, depth)
        if result is not None:
            return result
    return None

def dls(board, depth):
    stack = deque([(board, [], 0)])
    visited = set()
    while stack:
        current_board, moves, current_depth = stack.pop()
        if tuple(map(tuple, current_board)) in visited:
            continue
        visited.add(tuple(map(tuple, current_board)))
        if is_goal_state(current_board):
            return moves
        if current_depth < depth:
            for move in MOVES:
                new_board = [row[:] for row in current_board]
                if is_valid_move(new_board, move):
                    apply_move(new_board, move)
                    stack.append((new_board, moves + [move], current_depth + 1))
    return None

def print_steps(moves):
    board = [
        [5, 4, 0],
        [6, 1, 8],
        [7, 3, 2]
    ]
    for move in moves:
        x, y = get_zero_position(board)
        dx, dy = MOVES[move]
        new_x, new_y = x + dx, y + dy
        board[x][y], board[new_x][new_y] = board[new_x][new_y], board[x][y]
        print("Move:", move)
        print("Board:")
        for row in board:
            print(row)
        print()

initial_board = [
```

```
    [5, 4, 0],
    [6, 1, 8],
    [7, 3, 2]
]
solution = ids(initial_board)
if solution:
    print("Solution found:")
    print_steps(solution)
else:
    print("No solution found.")
```

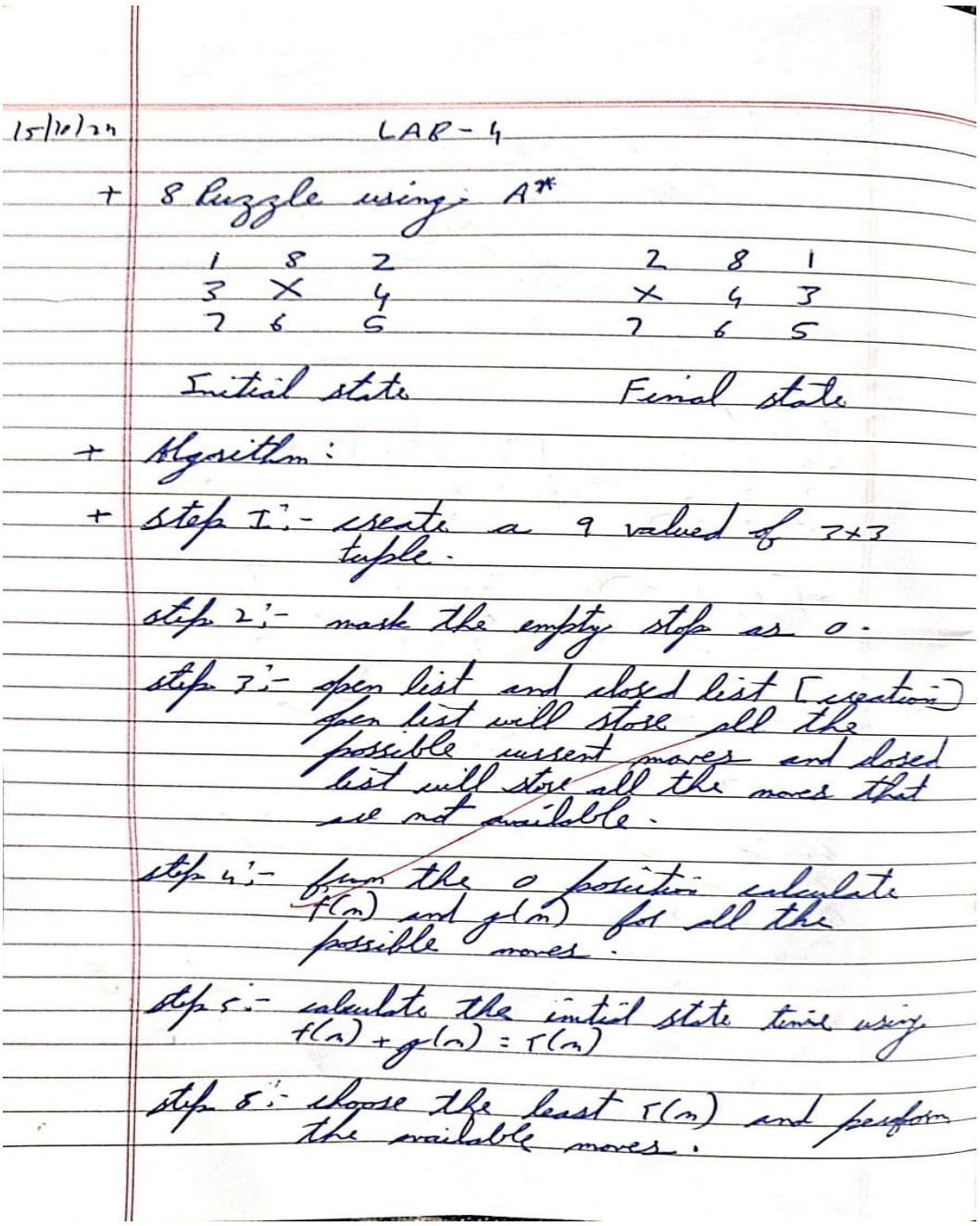
Output:

```
Move: left
Board:
[1, 4, 2]
[3, 0, 5]
[6, 7, 8]

Move: up
Board:
[1, 0, 2]
[3, 4, 5]
[6, 7, 8]

Move: left
Board:
[0, 1, 2]
[3, 4, 5]
[6, 7, 8]
```

Program 3

A* using Manhattan Distance:

Algorithm:



15/10/24

LAB - 4

+ 8 Puzzle using A*

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

Initial state — Final state

+ Algorithm:

+ step 1:- create a 9 valued of 3×3 tuple.

step 2:- mark the empty step as 0.

step 3:- open list and closed list [creation] open list will store all the possible current moves and closed list will store all the moves that are not available.

step 4:- from the 0 position calculate f(n) and g(n) for all the possible moves.

step 5:- calculate the initial state time using f(n) + g(n) = T(n)

step 6:- choose the least T(n) and perform the available moves.

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step 7:- go to step no 3 again and calculate the next position and add the data in open list() and close list()

step 8:- perform these operations till we go to the final

step 9:- Eg:- $g=0, h=3, f=g+h=3$

1 2 3
0 4 6
7 5 8

$g=1, h=4, f=5$

0 2 3
1 4 6
7 5 8

$g=1, h=2, f=3$

1 2 3
4 0 6
7 5 8

$g=1, h=1, f=5$

1 2 3
7 4 6
0 5 8

$g=2, h=1, f=3$

1 2 3
4 5 6
7 0 8

$g=2, h=3, f=5$

1 2 3
4 6 0
7 5 8

$g=2, h=3, f=5$

1 0 3
4 2 6
7 5 8

$g=7, h=2, f=5$

1 2 3
4 5 6
0 7 8

$g=3, h=6, f=3$

1 2 3
4 5 6
7 8 0

final destination

1 2 3
4 5 6
7 8 0

Code:

```
class Node:
    def __init__(self, data, level, fval):
        """ Initialize the node with the data, level of the node and the calculated fvalue """
        self.data = data
        self.level = level
        self.fval = fval
    def generate_child(self):
        """ Generate child nodes from the given node by moving the blank space
            either in the four directions {up, down, left, right} """
        x, y = self.find(self.data, '_')
        val_list = [[x, y - 1], [x, y + 1], [x - 1, y], [x + 1, y]]
        children = []
        for i in val_list:
            child = self.shuffle(self.data, x, y, i[0], i[1])
            if child is not None:
                child_node = Node(child, self.level + 1, 0)
                children.append(child_node)
        return children

    def shuffle(self, puz, x1, y1, x2, y2):
        """ Move the blank space in the given direction and if the position value are out
            of limits, return None """
        if 0 <= x2 < len(self.data) and 0 <= y2 < len(self.data):
            temp_puz = self.copy(puz)
            temp = temp_puz[x2][y2]
            temp_puz[x2][y2] = temp_puz[x1][y1]
            temp_puz[x1][y1] = temp
            return temp_puz
        else:
            return None

    def copy(self, root):
        """ Copy function to create a similar matrix of the given node"""
        return [row[:] for row in root]

    def find(self, puz, x):
        """ Specifically used to find the position of the blank space """
        for i in range(len(self.data)):
            for j in range(len(self.data)):
```

```
            if puz[i][j] == x:
                return i, j


class Puzzle:
    def __init__(self, size):
        """ Initialize the puzzle size by the specified size, open and closed lists to empty """
        self.n = size
        self.open = []
        self.closed = []

    def accept(self):
        """ Accepts the puzzle from the user """
        puz = []
        for _ in range(self.n):
            temp = input().split(" ")
            puz.append(temp)
        return puz

    def f(self, start, goal):
        """ Heuristic Function to calculate heuristic value f(x) = h(x) + g(x) """
        return self.h(start.data, goal) + start.level

    def h(self, start, goal):
        distance = 0
        for i in range(self.n):
            for j in range(self.n):
                if start[i][j] != '_' and start[i][j] != goal[i][j]:
                    # target_value = start[i][j]
                    # target_x = (int(target_value) - 1) // self.n
                    # target_y = (int(target_value) - 1) % self.n
                    # distance += abs(target_x - i) + abs(target_y - j)
                    k=0
                    l=0
                    for m in range(self.n):
                        for n in range(self.n):
                            if goal[m][n] == target_value:
                                k = m
                                l = n
                    distance += abs(k - i) + abs(l - j)
        return distance
```

```
def process(self):

  print("Enter the start state matrix (use '_' for the blank space):\n")
  start = self.accept()
  print("Enter the goal state matrix:\n")
  goal = self.accept()

  start = Node(start, 0, 0)
  start.fval = self.f(start, goal)
  self.open.append(start)
  print("\n\n")

  while True:
     cur = self.open[0]

     print("\nCurrent Node Selected:")
     for i in cur.data:
        print(" ".join(i))
     print("")

     if self.h(cur.data, goal) == 0:
        print("\nGoal reached!")
        break

     print("\nGenerating child nodes:")
     for child in cur.generate_child():
        child.fval = self.f(child, goal)
        self.open.append(child)

        print("\nChild Node:")
        for i in child.data:
           print(" ".join(i))
        print("H-value:", child.fval - child.level)
        print("Level:", child.level)
        print("F-value:", child.fval)
        print("")

     self.closed.append(cur)
     del self.open[0]
```

```
        self.open.sort(key=lambda x: x.fval)

puz = Puzzle(3)
puz.process()
```

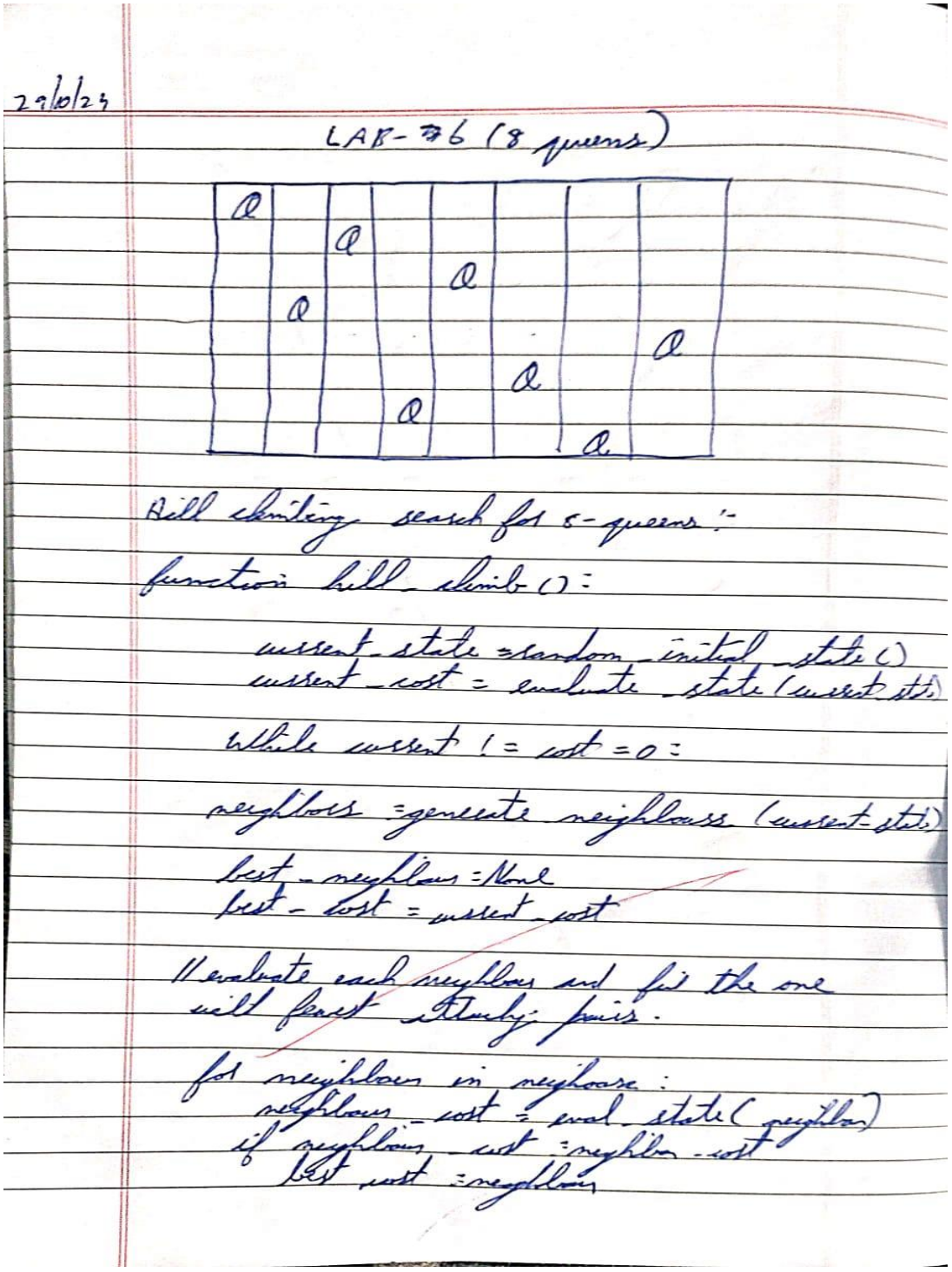
Output:

```
Generating child nodes

Child Node:
1 2 3
8 _ 4
7 6 5
H-value: 0
Level: 6
F-value: 6


Child Node:
_ 2 3
1 8 4
7 6 5
H-value: 2
Level: 6
F-value: 8


Child Node:
1 2 3
7 8 4
_ 6 5
H-value: 2
Level: 6
F-value: 8


Current Node Selected:
1 2 3
8 _ 4
7 6 5


Goal reached!
```

Program 4

Hill Climbing Search to Solve N-Queens Problem:

Algorithm:



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LAB-06 (8 queens)

Hill climbing search for 8-queens:

```
function hill_climb():

    current_state = random_initial_state()
    current_cost = evaluate_state(current_state)

    while current_cost != 0:

    neighbours = generate_neighbours(current_state)

    best_neighbour = None
    best_cost = current_cost

    Evaluate each neighbour and find the one
    with least clashing pairs.

    for neighbour in neighbours:
        neighbour_cost = eval_state(neighbour)
        if neighbour_cost < neighbour_cost
            best_cost = neighbour
```

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```
// Move to best neighbour:
current_state = best_neighbour
current_cost = best_cost

return current_state //

// Evaluate states (cost):
    attacking_pairs = 0
for i = 0 to len(state) - 1:
    for j = i+1 to len(state) - 1:
        if state[i] == state[j] or
        abs(state[i] - state[j]) == abs(i - j)
            attacking_pairs += 1
return attacking_pairs
```

A*

```
// Initialization
open_list = []
closed_list = set()

start_state = random_initial_state()
g_start = 0
h_start = eval_heuristic(start_state)
f_start = g_start + h_start
open_list.push((f_start, g_start, start_state))

// Main loop //
while open_list is not empty:
    f_current, g_current = open_list.pop()

if (eval_heuristic(current_state) == 0:
```

return current_state

// Find neighbors : [f(n) = g(n) + h(n)]

g_neighbor = g - cost(+)

h_neighbor = find_heuristic(neighbor)

f_neighbor = g_neighbor + h_neighbor

open_list.push(f_neighbor, g_neighbor, neighbor)

Outputs :- A*

@ + + + + + + +
+ + + + + + @ +
+ + + + @ + + +
+ + + + + + + @
+ @ + + + + + +
+ + + @ + + + +
+ + + + + @ + +
+ + @ + + + + +

Will change :-

+ @ + + + + + +
+ + + + + + + @
+ + + + + @ + +
+ + @ + + + + +
+ + + + + + @ +
+ + + @ + + + +
@ + + + + + + +
+ + + + @ + + +

No solution found

Code:

```
import random
def calculate_conflicts(board):
    """Calculates the number of pairs of queens attacking each other."""
    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
    return conflicts
def get_neighbors(board):
    """Generates neighboring boards by swapping two queens."""
    neighbors = []
    n = len(board)
    for i in range(n):
        for j in range(i + 1, n):
            new_board = board[:]
            new_board[i], new_board[j] = new_board[j], new_board[i]
            neighbors.append(new_board)
    return neighbors
def hill_climbing(board):
    """Solves the N-Queens problem using Hill Climbing algorithm."""
    current_conflicts = calculate_conflicts(board)
    print(f"Initial board: {board} with {current_conflicts} conflicts")

    while True:
        neighbors = get_neighbors(board)
        next_board = None
        next_conflicts = current_conflicts
        for neighbor in neighbors:
            conflicts = calculate_conflicts(neighbor)
            if conflicts < next_conflicts:
                next_conflicts = conflicts
                next_board = neighbor

        if next_conflicts >= current_conflicts:
            break

        board = next_board
```

```
            current_conflicts = next_conflicts
            print(f"Intermediate board: {board} with {current_conflicts} conflicts")

        return board, current_conflicts

try:
    n = int(input("Enter the number of queens (size of the board): "))
    if n <= 0:
        raise ValueError("The number of queens must be a positive integer.")

    board = []
    for i in range(n):
        row = int(input(f"Enter the row index for queen {i+1} (0 to {n-1}): "))
        if row < 0 or row >= n:
            raise ValueError("Invalid row index. Must be within the range 0 to n-1.")
        board.append(row)

    solution, conflicts = hill_climbing(board)
    if conflicts == 0:
        print("Solution found:")
        print(solution)
    else:
        print("No solution found, best configuration with conflicts:")
        print(solution, "with", conflicts, "conflicts.")
except ValueError as e:
    print(f"Invalid input: {e}")
```

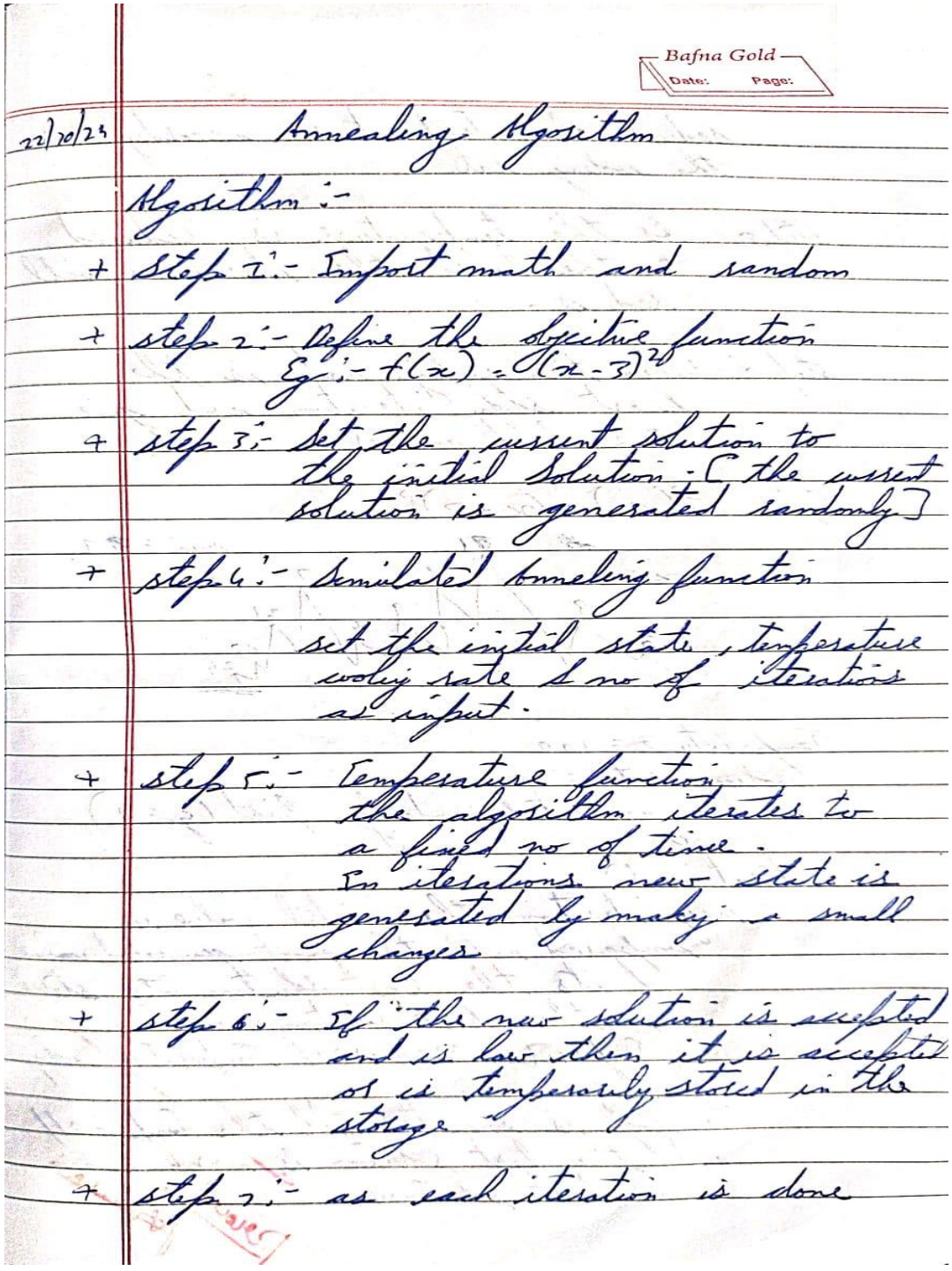
Output:

```
Enter the number of queens (size of the board): 4
Enter the row index for queen 1 (0 to 3): 3
Enter the row index for queen 2 (0 to 3): 1
Enter the row index for queen 3 (0 to 3): 2
Enter the row index for queen 4 (0 to 3): 0
Initial board: [3, 1, 2, 0] with 2 conflicts
Intermediate board: [1, 3, 2, 0] with 1 conflicts
Intermediate board: [1, 3, 0, 2] with 0 conflicts
Solution found:
[1, 3, 0, 2]
```

Program 5

Simulated Annealing to Solve 8-Queens problem:

Algorithm:



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Annealing Algorithm

Algorithm :-

+ Step 1 :- Import math and random

+ step 2 :- Define the objective function
Eg :- $f(x) = (x-3)^2$

+ step 3 :- Set the current solution to the initial solution :- [the current solution is generated randomly]

+ step 4 :- Simulated annealing function
set the initial state, temperature cooling rate & no of iterations as input.

+ step 5 :- Temperature function
the algorithm iterates to a fixed no of time.
In iterations new state is generated by making a small changes

+ step 6 :- If the new solution is accepted and is low then it is accepted as is temporarily stored in the storage

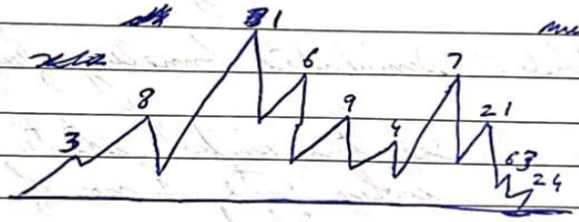
+ step 7 :- as each iteration is done

reduce the Temperature according to the cooling rate.

step 8:- As the temperature is reduced to the lowest the iterations will reduce.

step 9:- When the cooling rate is the lowest stop iteration and give the last answer.

Eg:- $f(x) = (x+3)^3$



Temperature = 100
cooling rate = 10
x is generated randomly first (y = 1)

iterations ()
every iteration the initial value is compared with the next generated value if its the best solution its stored in the best solution variable.
Temperature = 100 - 10 // (Temperature - cooling

The loop is executed till the Temp = 0 // and the last solution is considered as the best solution.

Code:

```
import random
import math
def count_attacks(queen_positions):
    attack_count = 0
    size = len(queen_positions)
    for i in range(size):
        for j in range(i + 1, size):
            if queen_positions[i] == queen_positions[j]:
                attack_count += 1
            if abs(queen_positions[i] - queen_positions[j]) == abs(i - j):
                attack_count += 1
    return attack_count
def generate_random_move(current_positions):
    new_state = current_positions[:]
    column_to_change = random.randint(0, len(current_positions) - 1)
    new_row_position = random.randint(0, len(current_positions) - 1)
    new_state[column_to_change] = new_row_position
    return new_state
def annealing_search(board_size, initial_configuration):
    current_positions = initial_configuration[:]
    current_attack_count = count_attacks(current_positions)
    temp = 1000
    min_temp = 0.0001
    cooling_factor = 0.99
    step_count = 0
    visited_states = set()
    while temp > min_temp and current_attack_count > 0:
        step_count += 1

        #if step_count % 150 == 0:
            #print("Step", step_count, ": Attacks =", current_attack_count)

        new_positions = generate_random_move(current_positions)

        new_positions_tuple = tuple(new_positions)

        if new_positions_tuple in visited_states:
            continue
```

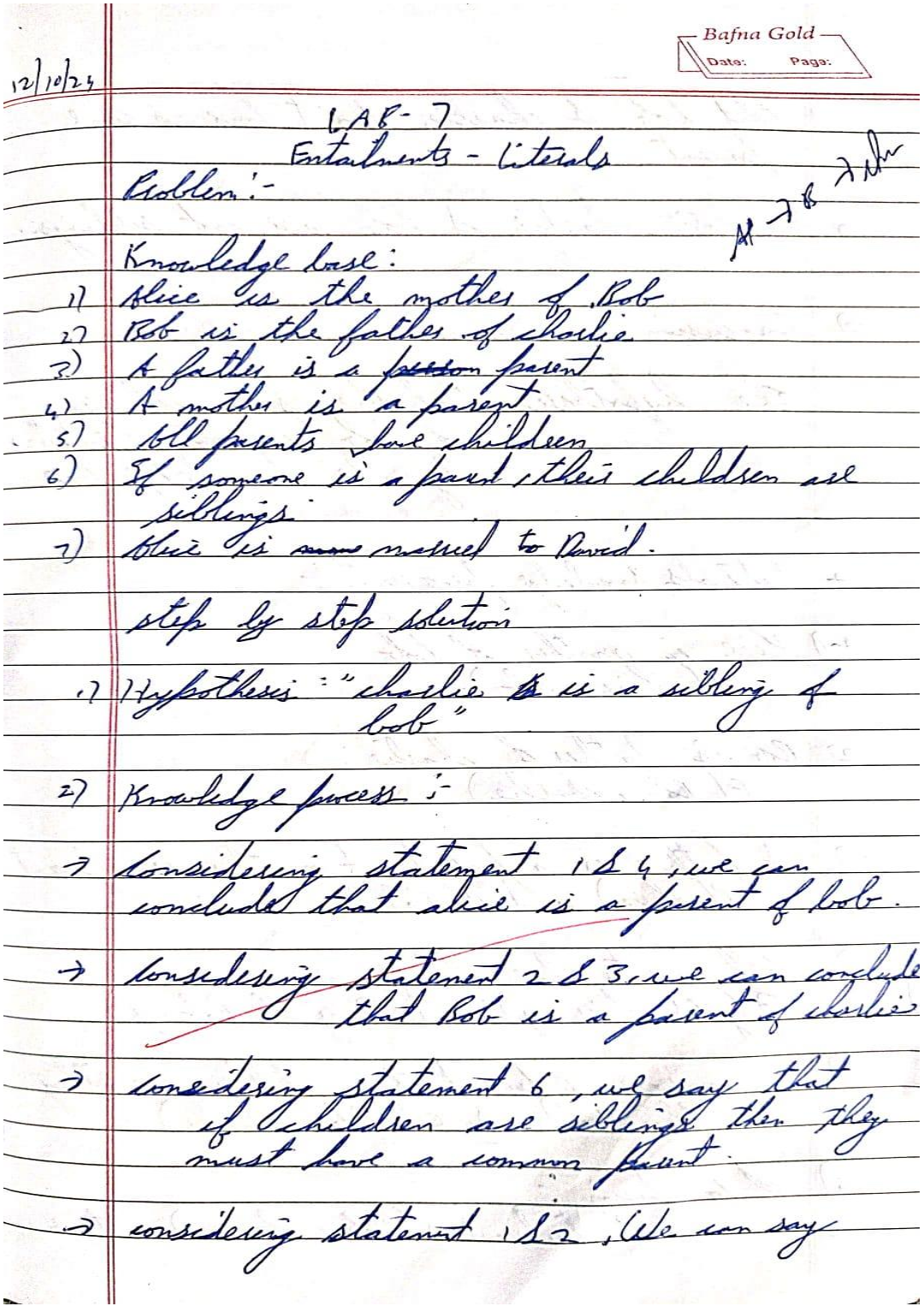
```
        visited_states.add(new_positions_tuple)

        new_attack_count = count_attacks(new_positions)

        energy_difference = new_attack_count - current_attack_count

        if energy_difference < 0 or random.random() < math.exp(-energy_difference / temp):
            current_positions, current_attack_count = new_positions, new_attack_count
        temp *= cooling_factor
        if current_attack_count == 0:
            print("Solution found after", step_count, "steps!")
            break
    return current_positions, current_attack_count
board_size = int(input("Enter the size of the board (N): "))
initial_input = input("Enter the initial configuration: ")
initial_queen_positions = [int(pos) for pos in initial_input.strip('[]').split(',')]

if len(initial_queen_positions) != board_size:
    print("Error: The initial configuration must contain exactly", board_size, "integers.")
else:
    solution, conflicts = annealing_search(board_size, initial_queen_positions)

    if conflicts == 0:
        print("Solution found!")
        print("Final board configuration:", solution)
    else:
        print("No solution found. Final conflict count:", conflicts)
```

Output:

```
Enter the size of the board (N): 8
Enter the initial configuration: 4,5,6,3,4,5,6,5
Solution found after 1093 steps!
Solution found!
Final board configuration: [5, 3, 6, 0, 2, 4, 1, 7]
```

Program 6

Knowledge Base using Propositional Logic:
Algorithm:



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LAB- 7
Entailments - Literals

Problem:-

Knowledge base:
1) Alice is the mother of Bob
2) Bob is the father of Charlie
3) A father is a person parent
4) A mother is a parent
5) All parents have children
6) If someone is a parent their children are siblings
7) Alice is married to David.

step by step solution

1) Hypothesis: "charlie is a sibling of bob"

2) Knowledge process:-

→ Considering statement 1 & 4, we can conclude that alice is a parent of bob.

→ Considering statement 2 & 3, we can conclude that Bob is a parent of charlie

→ Considering statement 6, we say that if children are siblings then they must have a common parent.

→ considering statement 1 & 2, We can say

that bob & charlie don't have a same parent

⇒ Therefore charlie & bob are not siblings.

3) Conclusion:

The hypothesis "charlie is a sibling of bob." is not entailed by the knowledge base.

→ Literals knowledge processing :-

1) Alice is mother of bob
M(Alice, bob)

2) Bob is father of charlie:
F(Bob, charlie)

3) A father is a parent, A mother is a parent
P(Alice) and P(Bob)

4) All parents has children
∃y C(Alice, y) and ∃y C(Bob, y)

5) If someone is parent their children is sibling
C(Alice, Bob) & C(Bob, charlie)

6) Conclusion :-
Entailment S(Bob, charlie) is true.

Code:

```
import  random
import itertools
import math

def eval_formula(formula, assignment):
    formula = formula.replace('and', 'and').replace('or', 'or').replace('not', 'not')
    formula = formula.replace('→', ' or not ')  # Implication A → B is equivalent to (not A or B)
    formula = formula.replace('↔', '==')  # Equivalence A ↔ B is equivalent to (A == B)

    env = {var: value for var, value in zip(assignment.keys(), assignment.values())}

    return eval(formula, {}, env)

def generate_initial_state(variables):
    return {var: random.choice([True, False]) for var in variables}

def entails(KB, alpha):
    # Find all unique variables in KB and alpha
    variables = set(''.join([ch for ch in ''.join(KB + [alpha]) if ch.isalpha()]))

    # Generate all possible truth assignments for the variables
    truth_assignments = list(itertools.product([True, False], repeat=len(variables)))
    var_list = list(variables)
    for assignment in truth_assignments:
        # Map the truth assignment to each variable
        assignment_dict = dict(zip(var_list, assignment))

        # Combine all KB formulas with AND and evaluate
        kb_combined = all(eval_formula(formula, assignment_dict) for formula in KB)
        alpha_true = eval_formula(alpha, assignment_dict)

        # If KB is true and alpha is false for any assignment, KB does not entail alpha
        if kb_combined and not alpha_true:
            return False

    # If we reach here, it means KB entails alpha
    return True

# Example Usage →
```

```
KB = ["not Q or P", "not P or (not Q)", "Q or R"]
alpha = "R"

# Check if KB entails alpha
if entails(KB, alpha):
    print("KB entails R")
else:
    print("KB does not entail R")
```

Output:

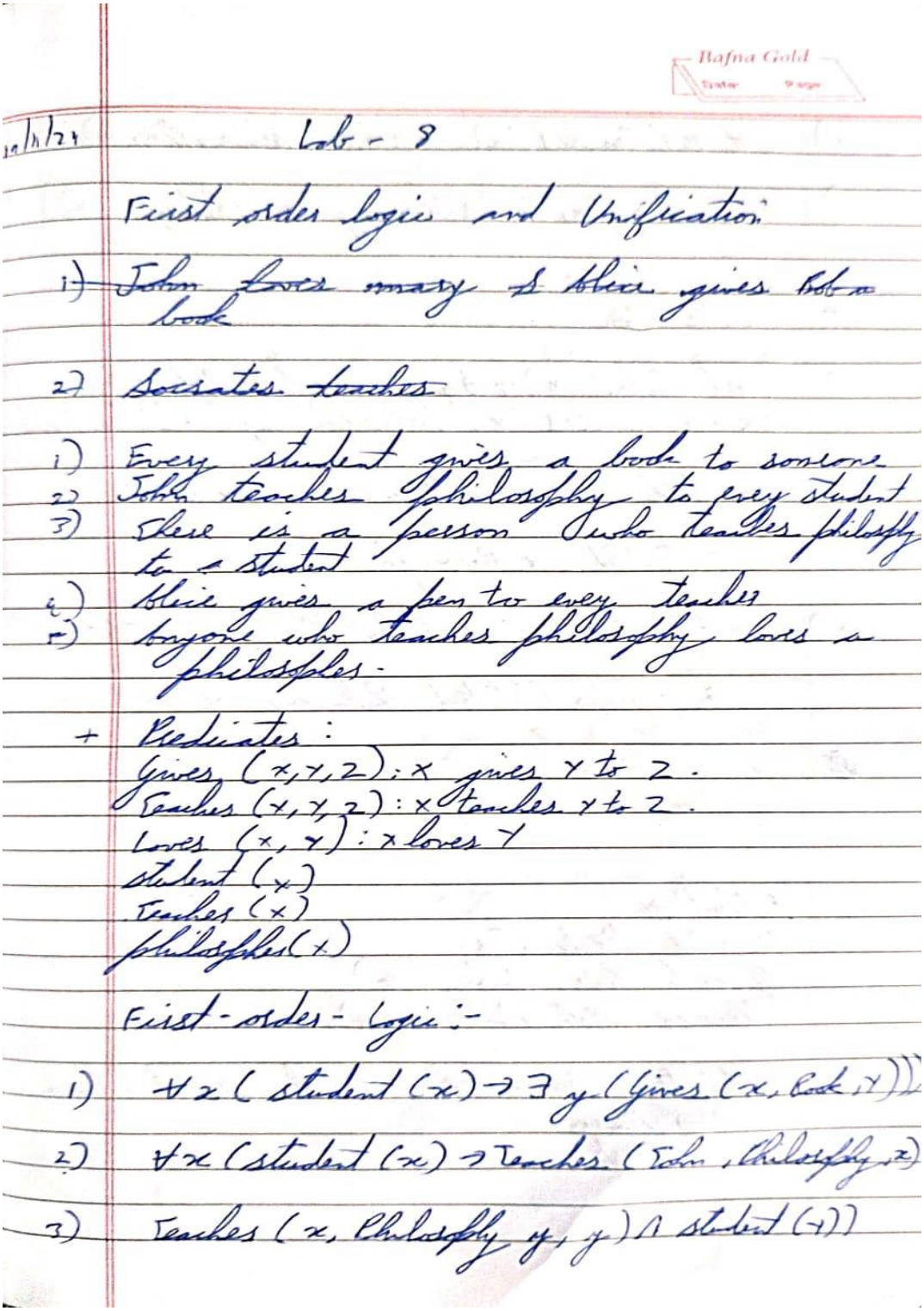
```
KB entails R
```

```
KB does not entail R
```

Program 7

Unification in First Order Logic:

Algorithm:



4) $\forall x (Teaches(x) \rightarrow Gives(Alice, Ben, x))$

5) $\forall x (Teaches(x, Philosophy, y) \rightarrow (Philosopher(x))$

+ Unification

1) $\forall x (student(x) \rightarrow \exists y (Gives(x, Rob, y))$
$\exists x \exists y (Teaches(x, Philosophy, y) \wedge Student(y))$

$\forall x (student(x) \rightarrow \exists y (Gives(x, Rob, y)))$

$= student(x, Rob, y)$

2) $\exists x \exists y (Teaches(x, philosophy, y) \wedge student(y))$
$\rightarrow Teaches(student, Philosophy, y)$

Output :-
Original Predicates:
Gives(Alice, Rob, Rob)
Received(Rob, Rob, Alice)

Unification successful with substitutions
$y \rightarrow Rob$

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Code:

```
def occurs_check(var, term):
    """Checks if a variable occurs in a term."""
    if isinstance(term, str):  # Term is a constant
        return False
    elif isinstance(term, tuple):  # Term is a function (represented as a tuple)
        # Recursively check the function arguments
        if term[0] == var:
            return True
        return any(occurs_check(var, arg) for arg in term[1:])
    return False

def unify(psi1, psi2, subst=None):
    """Unify two terms psi1 and psi2 with the current substitution."""
    if subst is None:
        subst = {}

    # Step 1: If either term is a variable or constant
    if isinstance(psi1, str):  # psi1 is a variable
        if psi1 == psi2:  # Identical variables
            return subst
        elif psi1 in subst:  # psi1 already has a substitution
            return unify(subst[psi1], psi2, subst)
        elif occurs_check(psi1, psi2):  # Occurs check
            return "FAILURE"
        else:
            subst[psi1] = psi2  # Create a new substitution
            return subst

    elif isinstance(psi2, str):  # psi2 is a variable
        if psi2 == psi1:  # Identical variables
            return subst
        elif psi2 in subst:  # psi2 already has a substitution
            return unify(psi1, subst[psi2], subst)
        elif occurs_check(psi2, psi1):  # Occurs check
            return "FAILURE"
        else:
            subst[psi2] = psi1  # Create a new substitution
            return subst
```

```
    # Step 2: Check if the initial predicate symbols match
    if isinstance(psi1, tuple) and isinstance(psi2, tuple):
        if psi1[0] != psi2[0]:  # Predicate symbols don't match
            return "FAILURE"

    # Step 3: Check if they have the same number of arguments
    if isinstance(psi1, tuple) and isinstance(psi2, tuple):
        if len(psi1) != len(psi2):  # Different number of arguments
            return "FAILURE"

    # Step 4: Initialize the substitution set (already initialized as `subst`)

    # Step 5: Iterate through the arguments of psi1 and psi2
    if isinstance(psi1, tuple) and isinstance(psi2, tuple):
        for arg1, arg2 in zip(psi1[1:], psi2[1:]):
            # Recursively unify the arguments
            result = unify(arg1, arg2, subst)
            if result == "FAILURE":
                return "FAILURE"
            elif result != subst:
                subst = result  # Update the substitution set

    # Step 6: Return the final substitution set
    return subst

# Helper function to display the substitution in a readable format
def print_substitution(subst):
    if subst == "FAILURE":
        print("FAILURE")
    else:
        for var, val in subst.items():
            print(f"{var} -> {val}")

# Helper function to parse the user input into the required format
def parse_input(input_str):
    """Parse the input string into a tuple representing the term."""
    input_str = input_str.strip()
    if '(' in input_str and ')' in input_str:
        # Extract the predicate and arguments
        predicate, args = input_str.split('(', 1)
        args = args.rstrip(')').split(',')
```

```
        args = [parse_input(arg.strip()) if '(' in arg else arg.strip() for arg in args]
        return (predicate.strip(), *args)
    else:
        # Single term, assume it's a constant or a variable
        return input_str.strip()

# Main function to handle user input and unification
def main():
    print("Please enter the first term (e.g., f(X, g(Y))):")
    term1 = input().strip()

    print("Please enter the second term (e.g., f(a, g(b))):")
    term2 = input().strip()

    # Parse the user input into structured terms
    psi1 = parse_input(term1)
    psi2 = parse_input(term2)

    # Unify the terms and print the result
    substitution = unify(psi1, psi2)
    print_substitution(substitution)

# Run the main function
if __name___== "__main__":
    main()
```

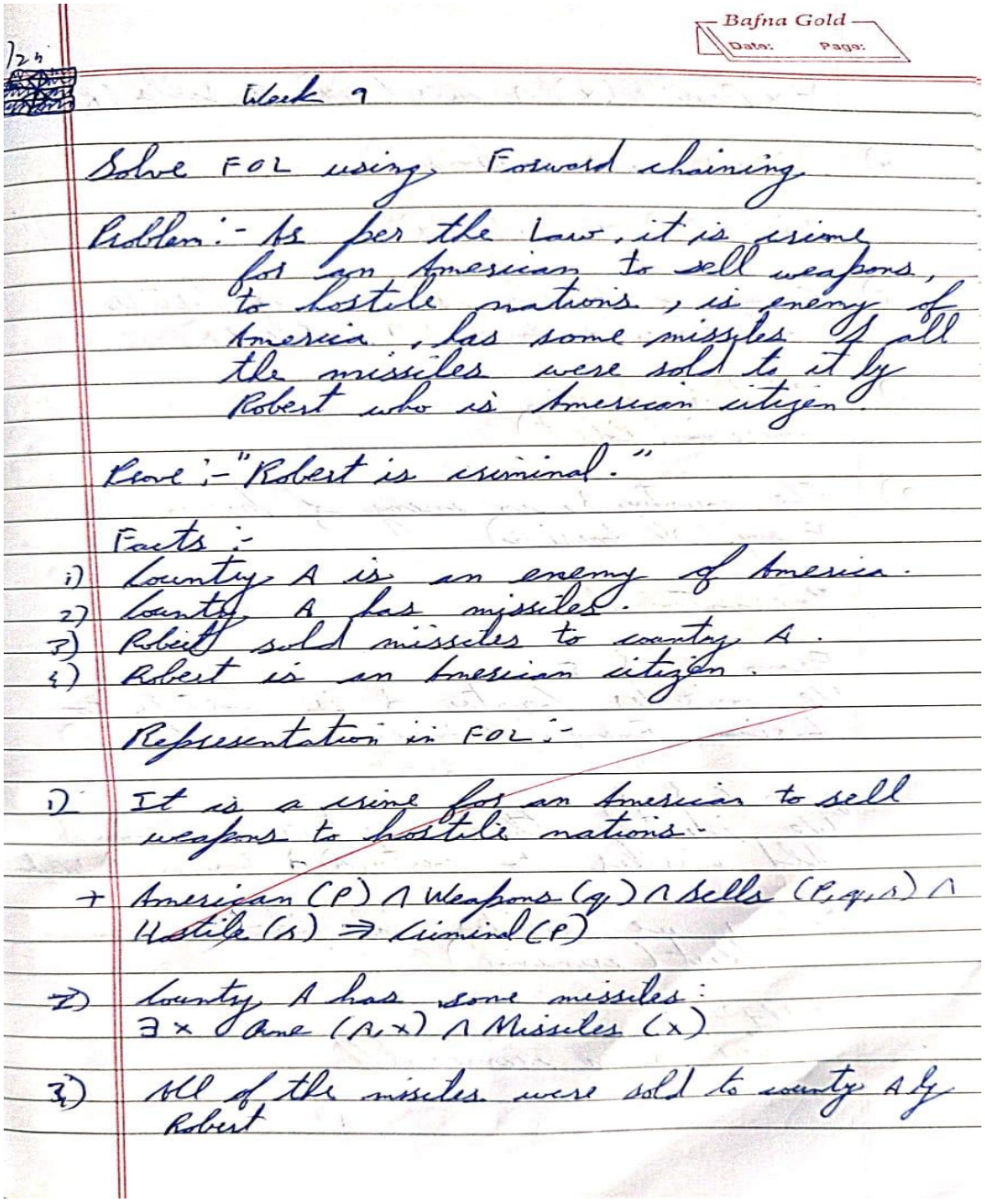
Output:

```
Please enter the first term (e.g., f(X, g(Y))):
American(robert,x)
Please enter the second term (e.g., f(a, g(b))):
American(y,enemy)
robert -> y
x -> enemy
```

Program 8

Knowledge Base consisting of First Order Logic Statements and proof using Forward Reasoning:

Algorithm:



Week 9

Solve FOL using Forward chaining

Problem :- As per the law, it is crime for an American to sell weapons, to hostile nations, is enemy of America, has some missiles & all the missiles were sold to it by Robert who is American citizen.

Prove :- "Robert is criminal."

Facts :-

1) Country A is an enemy of America.
2) Country A has missiles.
3) Robert sold missiles to country A.
4) Robert is an American citizen.

Representation in FOL :-

1) It is a crime for an American to sell weapons to hostile nations.

+ American (P) ∧ Weapons (q) ∧ Sells (P, q, r) ∧ Hostile (r) ⇒ Criminal (P)

2) Country A has some missiles:
∃ x Owns (A, x) ∧ Missiles (x)

3) All of the missiles were sold to country A by Robert

$\forall x$ Missile $(x) \wedge$ owns $(A, x) \Rightarrow$ Sells (Robert, x, A)

4) Missiles are weapons

Missile $(x) \Rightarrow$ weapon (x)

5) Enemy of America is known as hostile
$\forall x$ Enemy $(x,$ America$) \Rightarrow$ Hostile (x)

6) Robert is american
American (Robert)

7) The country A, an enemy of America
Enemy (A, America)

Observation :-

From 7 & 5
We consider country A is hostile to America Enemy (A, America) $\Rightarrow$ Hostile (A)

from 6 & 3
We identify that robert is american & sold missiles to country (A) & American (R)

$\therefore$ for 1 we consider Robert is criminal
Robert (criminal)

Output :-
Robert is a criminal //

Code:

```
class ForwardChaining:
    def __init__(self, facts, rules):
        """
        Initialize the Forward Chaining algorithm with facts and rules.
        :param facts: Set of known facts (initial facts).
        :param rules: List of rules where each rule is a tuple (premise, conclusion).
        """
        self.facts = set(facts)
        self.rules = rules
        self.inferred_facts = set(facts)  # Set of facts derived during the process

    def apply_rule(self, rule):
        """
        Applies a rule to derive new facts from existing facts.
        :param rule: A rule represented as (premise, conclusion).
        :return: True if a new fact is derived, False otherwise.
        """
        premise, conclusion = rule
        premise_facts = set(premise.split(','))  # Split the premise into individual facts
        # Check if the premise of the rule is fully satisfied by current facts
        if premise_facts.issubset(self.facts):  # Ensure all premises are in facts
            if conclusion not in self.facts:
                print(f"Inferred new fact: {conclusion}")
                self.facts.add(conclusion)  # Add the conclusion to the set of facts
                return True
        return False

    def forward_chaining(self):
        """
        Applies forward chaining to derive new facts until no more facts can be derived.
        """
        new_inference = True
        while new_inference:
            new_inference = False
            # Go through all the rules and try to apply them
            for rule in self.rules:
                if self.apply_rule(rule):
                    new_inference = True
            if new_inference:
```

```
            print(f"Current facts: {self.facts}")
        print("Forward Chaining completed.")

    def is_goal_reached(self, goal):
        """
        Checks if the goal has been reached (i.e., if the goal is in the facts).
        :param goal: The goal fact to check for.
        :return: True if the goal is in the facts, otherwise False.
        """
        return goal in self.facts


def main():
    print("Forward Chaining System")

    # Define the initial facts
    facts = {
        "american(p)",
        "weapon(q)",
        "sells(p,q,r)",
        "hostile(r)",
        "american(robert)",
        "enemy(a, america)"
    }

    # Define the rules (premise -> conclusion)
    rules = [
        ("american(p),weapon(q),sells(p,q,r),hostile(r)", "criminal(p)"),  # Rule 1
        ("owns(a,x),missile(x)", "sells(robert,x,a)"),  # Rule 2
        ("missile(x)", "weapon(x)"),  # Rule 3
        ("enemy(a,america)", "hostile(a)")  # Rule 4
    ]

    # Create an instance of ForwardChaining with the facts and rules
    fc = ForwardChaining(facts, rules)

    # Perform forward chaining to infer new facts
    fc.forward_chaining()

    # Define the goal (fact you want to check)
    goal = "criminal(robert)"
```

```
    # Check if the goal is reached
    if fc.is_goal_reached(goal):
        print(f"The goal '{goal}' is reached!")
    else:
        print(f"The goal '{goal}' is reached.")

# Run the main function
if __name__ == "__main__":
    main()
```

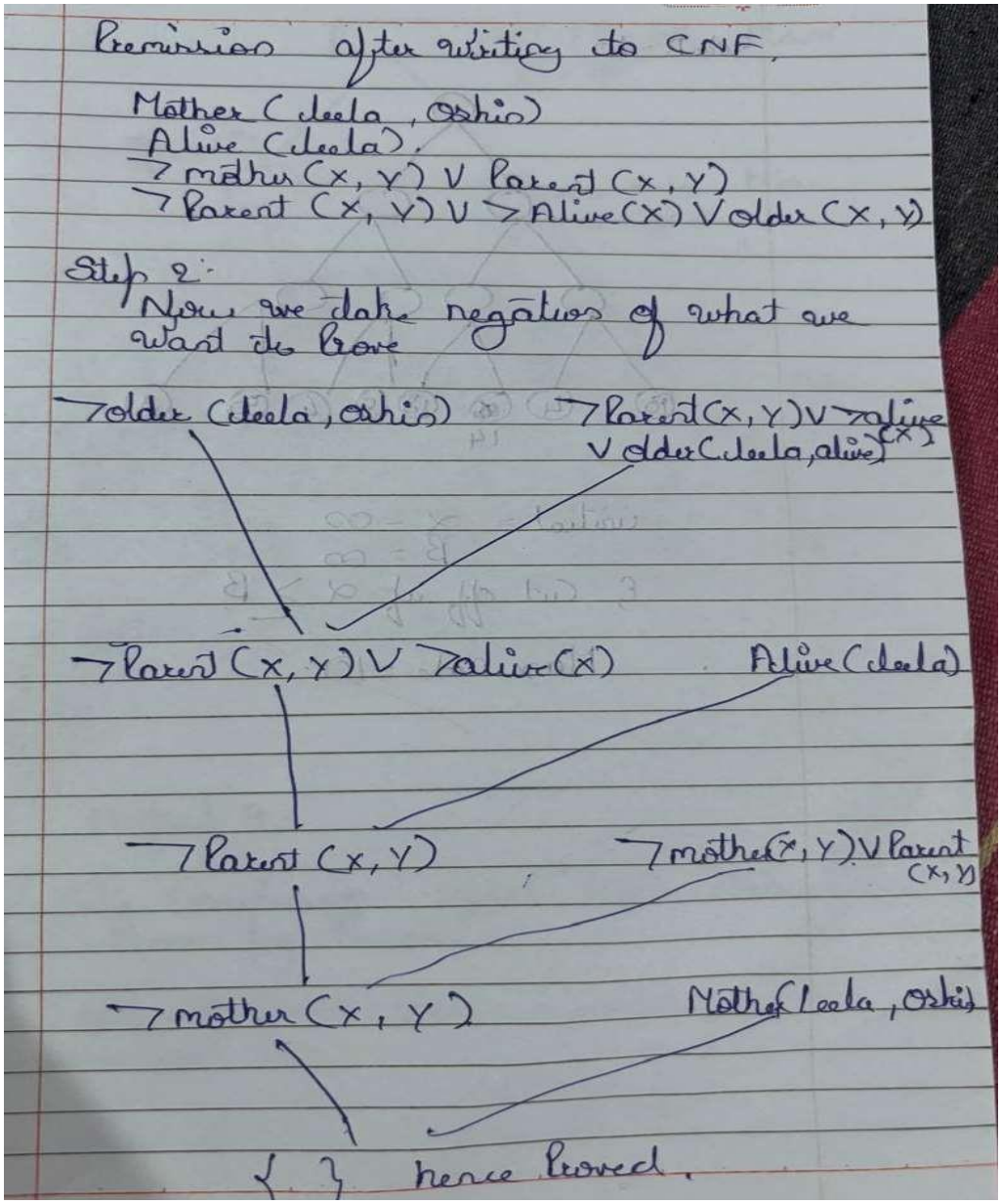
Output:

```
Forward Chaining System
Forward Chaining completed.
The goal 'criminal(robert)' is reached.
```

Program 9

Knowledge Base consisting of First Order Logic Statements and proof using Resolution:

Algorithm:



Code:

```
import time
start_time = time.time()
import re
import itertools
import collections
import copy
import queue

p=open("input.txt","r")
data=list()
data1= p.readlines()
count=0

n=int(data1[0])
queries=list()
for i in range(1,n+1):
    queries.append(data1[i].rstrip())
k=int(data1[n+1])
kbbefore=list()

def CNF(sentence):
    temp=re.split("=>",sentence)
    temp1=temp[0].split('&')
    for i in range(0,len(temp1)):
        if temp1[i][0]=='~':
            temp1[i]=temp1[i][1:]
        else:
            temp1[i]='~'+temp1[i]
    temp2='|'.join(temp1)
    temp2=temp2+'|'+temp[1]
    return temp2
variableArray = list("abcdefghijklmnopqrstuvwxyz")
variableArray2 = []
variableArray3 = []
variableArray5 = []
variableArray6 = []
for eachCombination in itertools.permutations(variableArray, 2):
    variableArray2.append(eachCombination[0] + eachCombination[1])
for eachCombination in itertools.permutations(variableArray, 3):
```

```
    variableArray3.append(eachCombination[0] + eachCombination[1] + eachCombination[2])
for eachCombination in itertools.permutations(variableArray, 4):
    variableArray5.append(eachCombination[0] + eachCombination[1] + eachCombination[2]+
eachCombination[3])
for eachCombination in itertools.permutations(variableArray, 5):
    variableArray6.append(eachCombination[0] + eachCombination[1] + eachCombination[2] +
eachCombination[3] + eachCombination[4])
variableArray = variableArray + variableArray2 + variableArray3 + variableArray5 + variableArray6
capitalVariables = "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
number=0

def standardizationnew(sentence):
    newsentence=list(sentence)
    i=0
    global number
    variables=collections.OrderedDict()
    positionsofvariable=collections.OrderedDict()
    lengthofsentence=len(sentence)
    for i in range(0,lengthofsentence-1):
        if(newsentence[i]==',' or newsentence[i]=='('):
            if newsentence[i+1] not in capitalVariables:
                substitution=variables.get(newsentence[i+1])
                positionsofvariable[i+1]=i+1
                if not substitution :
                    variables[newsentence[i+1]]=variableArray[number]
                    newsentence[i+1]=variableArray[number]
                    number+=1
                else:
                    newsentence[i+1]=substitution
    return  "".join(newsentence)

def insidestandardizationnew(sentence):
    lengthofsentence=len(sentence)
    newsentence=sentence
    variables=collections.OrderedDict()
    positionsofvariable=collections.OrderedDict()
    global number
    i=0
    while i <=len(newsentence)-1 :
        if(newsentence[i]==',' or newsentence[i]=='('):
            if newsentence[i+1] not in capitalVariables:
```

```
            j=i+1
            while(newsentence[j]!=',' and newsentence[j]!=')' ):
                j+=1
            substitution=variables.get(newsentence[i+1:j])
            if not substitution :
                variables[newsentence[i+1:j]]=variableArray[number]
                newsentence=newsentence[:i+1]+variableArray[number]+newsentence[j:]
                i=i+len(variableArray[number])
                number+=1
            else:
                newsentence=newsentence[:i+1]+substitution+newsentence[j:]
                i=i+len(substitution)
        i+=1
    return newsentence

def replace(sentence,theta):
    lengthofsentence=len(sentence)
    newsentence=sentence
    i=0
    while i <=len(newsentence)-1 :
        if(newsentence[i]==',' or newsentence[i]=='('):
            if newsentence[i+1] not in capitalVariables:
                j=i+1
                while(newsentence[j]!=',' and newsentence[j]!=')' ):
                    j+=1
                nstemp=newsentence[i+1:j]
                substitution=theta.get(nstemp)
                if substitution :
                    newsentence=newsentence[:i+1]+substitution+newsentence[j:]
                    i=i+len(substitution)
        i+=1
    return newsentence
repeatedsentencecheck=collections.OrderedDict()

def insidekbcheck(sentence):
    lengthofsentence=len(sentence)
    newsentence=pattern.split(sentence)
    newsentence.sort()
    newsentence="|".join(newsentence)
    global repeatedsentencecheck
    i=0
```

```
    while i <=len(newsentence)-1 :
        if(newsentence[i]==',' or newsentence[i]=='('):
            if newsentence[i+1] not in capitalVariables:
                j=i+1
                while(newsentence[j]!=',' and newsentence[j]!=')' ):
                    j+=1
                newsentence=newsentence[:i+1]+'x'+newsentence[j:]
        i+=1
    repeatflag=repeatedsentencecheck.get(newsentence)
    if repeatflag :
        return True
    repeatedsentencecheck[newsentence]=1
    return False

for i in range(n+2,n+2+k):
     data1[i]=data1[i].replace(" ","")
     if "=>" in data1[i]:
        data1[i]=data1[i].replace(" ","")
        sentencetemp=CNF(data1[i].rstrip())
        kbbefore.append(sentencetemp)
     else:
        kbbefore.append(data1[i].rstrip())
for i in range(0,k):
    kbbefore[i]=kbbefore[i].replace("  ","")

kb={}
pattern=re.compile("\||&|=>") #we can remove the '\|" to speed up as 'OR' doesnt come in the KB
pattern1=re.compile("[(,]")
for i in range(0,k):
    kbbefore[i]=standardizationnew(kbbefore[i])
    temp=pattern.split(kbbefore[i])
    lenoftemp=len(temp)
    for j in range(0,lenoftemp):
        clause=temp[j]
        clause=clause[:-1]
        predicate=pattern1.split(clause)
        argumentlist=predicate[1:]
        lengthofpredicate=len(predicate)-1
        if predicate[0] in kb:
            if lengthofpredicate in kb[predicate[0]]:
                kb[predicate[0]][lengthofpredicate].append([kbbefore[i],temp,j,predicate[1:]])
```

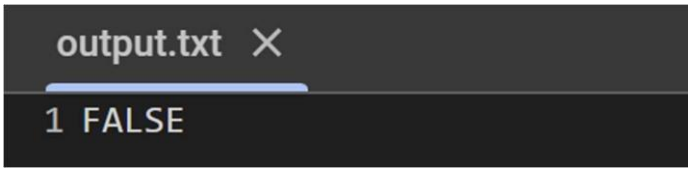
```
            else:
                kb[predicate[0]][lengthofpredicate]=[kbbefore[i],temp,j,predicate[1:]]
        else:
            kb[predicate[0]]={lengthofpredicate:[[kbbefore[i],temp,j,predicate[1:]]]}

for qi in range(0,n):
    queries[qi]=standardizationnew(queries[qi])

def substituevalue(paramArray, x, y):
    for index, eachVal in enumerate(paramArray):
        if eachVal == x:
            paramArray[index] = y
    return paramArray

def unificiation(arglist1,arglist2):
    theta = collections.OrderedDict()
    for i in range(len(arglist1)):
        if arglist1[i] != arglist2[i] and (arglist1[i][0] in capitalVariables) and (arglist2[i][0] in
capitalVariables):
            return []
        elif arglist1[i] == arglist2[i] and (arglist1[i][0] in capitalVariables) and (arglist2[i][0] in
capitalVariables):
            if arglist1[i] not in theta.keys():
                theta[arglist1[i]] = arglist2[i]
        elif (arglist1[i][0] in capitalVariables) and not (arglist2[i][0] in capitalVariables):
            if arglist2[i] not in theta.keys():
                theta[arglist2[i]] = arglist1[i]
                arglist2 = substituevalue(arglist2, arglist2[i], arglist1[i])
        elif not (arglist1[i][0] in capitalVariables) and (arglist2[i][0] in capitalVariables):
            if arglist1[i] not in theta.keys():
                theta[arglist1[i]] = arglist2[i]
                arglist1 = substituevalue(arglist1, arglist1[i], arglist2[i])
        elif not (arglist1[i][0] in capitalVariables) and not (arglist2[i][0] in capitalVariables):
            if arglist1[i] not in theta.keys():
                theta[arglist1[i]] = arglist2[i]
                arglist1 = substituevalue(arglist1, arglist1[i], arglist2[i])
            else:
                argval=theta[arglist1[i]]
                theta[arglist2[i]]=argval
                arglist2 = substituevalue(arglist2, arglist2[i], argval)
    return [arglist1,arglist2,theta]
```

```
def resolution():
    global repeatedsentencecheck
    answer=list()
    qrno=0
    for qr in queries:
        qrno+=1
        repeatedsentencecheck.clear()
        q=queue.Queue()
        query_start=time.time()
        kbquery=copy.deepcopy(kb)
        ans=qr
        if qr[0]=='~':
            ans=qr[1:]
        else:
            ans='~'+qr
        q.put(ans)
        label:outerloop
        currentanswer="FALSE"
        counter=0
        while True:
            counter+=1
            if q.empty():
                break
            ans=q.get()
            label:outerloop1
            ansclauses=pattern.split(ans)
            lenansclauses=len(ansclauses)
            flagmatchedwithkb=0
            innermostflag=0
            for ac in range(0,lenansclauses):
                insidekbflag=0
                ansclausestruncated=ansclauses[ac][:-1]
                ansclausespredicate=pattern1.split(ansclausestruncated)
                lenansclausespredicate=len(ansclausespredicate)-1
                if ansclausespredicate[0][0]=='~':
                    anspredicatenegated=ansclausespredicate[0][1:]
                else:
                    anspredicatenegated="~"+ansclausespredicate[0]
                x=kbquery.get(anspredicatenegated,{}).get(lenansclausespredicate)
                if not x:
```

```
            continue
        else:
            lenofx=len(x)
            for numofpred in range(0,lenofx):
                insidekbflag=0
                putinsideq=0
                sentenceselected=x[numofpred]

thetalist=unificiation(copy.deepcopy(sentenceselected[3]),copy.deepcopy(ansclausespredicate[1:]))
                if(len(thetalist)!=0):
                    for key in thetalist[2]:
                        tl=thetalist[2][key]
                        tl2=thetalist[2].get(tl)
                        if tl2:
                            thetalist[2][key]=tl2
                    flagmatchedwithkb=1
                    notincludedindex=sentenceselected[2]
                    senclause=copy.deepcopy(sentenceselected[1])
                    mergepart1=""
                    del senclause[notincludedindex]
                    ansclauseleft=copy.deepcopy(ansclauses)
                    del ansclauseleft[ac]
                    for am in range(0,len(senclause)):
                        senclause[am]=replace(senclause[am],thetalist[2])
                        mergepart1=mergepart1+senclause[am]+'|'
                    for remain in range(0,len(ansclauseleft)):
                        listansclauseleft=ansclauseleft[remain]
                        ansclauseleft[remain]=replace(listansclauseleft,thetalist[2])
                        if ansclauseleft[remain] not in senclause:
                            mergepart1=mergepart1+ansclauseleft[remain]+'|'
                    mergepart1=mergepart1[:-1]
                    if mergepart1=="":
                      currentanswer="TRUE"
                      break
                    ckbflag=insidekbcheck(mergepart1)
                    if not ckbflag:
                            mergepart1=insidestandardizationnew(mergepart1)
                            ans=mergepart1
                            temp=pattern.split(ans)
                            lenoftemp=len(temp)
                            for j in range(0,lenoftemp):
```

```
                                clause=temp[j]
                                clause=clause[:-1]
                                predicate=pattern1.split(clause)
                                argumentlist=predicate[1:]
                                lengthofpredicate=len(predicate)-1
                                if predicate[0] in kbquery:
                                    if lengthofpredicate in kbquery[predicate[0]]:

kbquery[predicate[0]][lengthofpredicate].append([mergepart1,temp,j,argumentlist])
                                    else:

kbquery[predicate[0]][lengthofpredicate]=[[mergepart1,temp,j,argumentlist]]
                                else:

kbquery[predicate[0]]={lengthofpredicate:[[mergepart1,temp,j,argumentlist]]}
                                q.put(ans)
                        if(currentanswer=="TRUE"):
                            break
                    if(currentanswer=="TRUE"):
                        break
                    if(counter==2000 or (time.time()-query_start)>20):
                        break
                answer.append(currentanswer)
            return answer

if __name___== '__main__':
    finalanswer=resolution()
    o=open("output.txt","w+")
    wc=0
    while(wc < n-1):
        o.write(finalanswer[wc]+"\n")
        wc+=1
    o.write(finalanswer[wc])
    o.close()
```

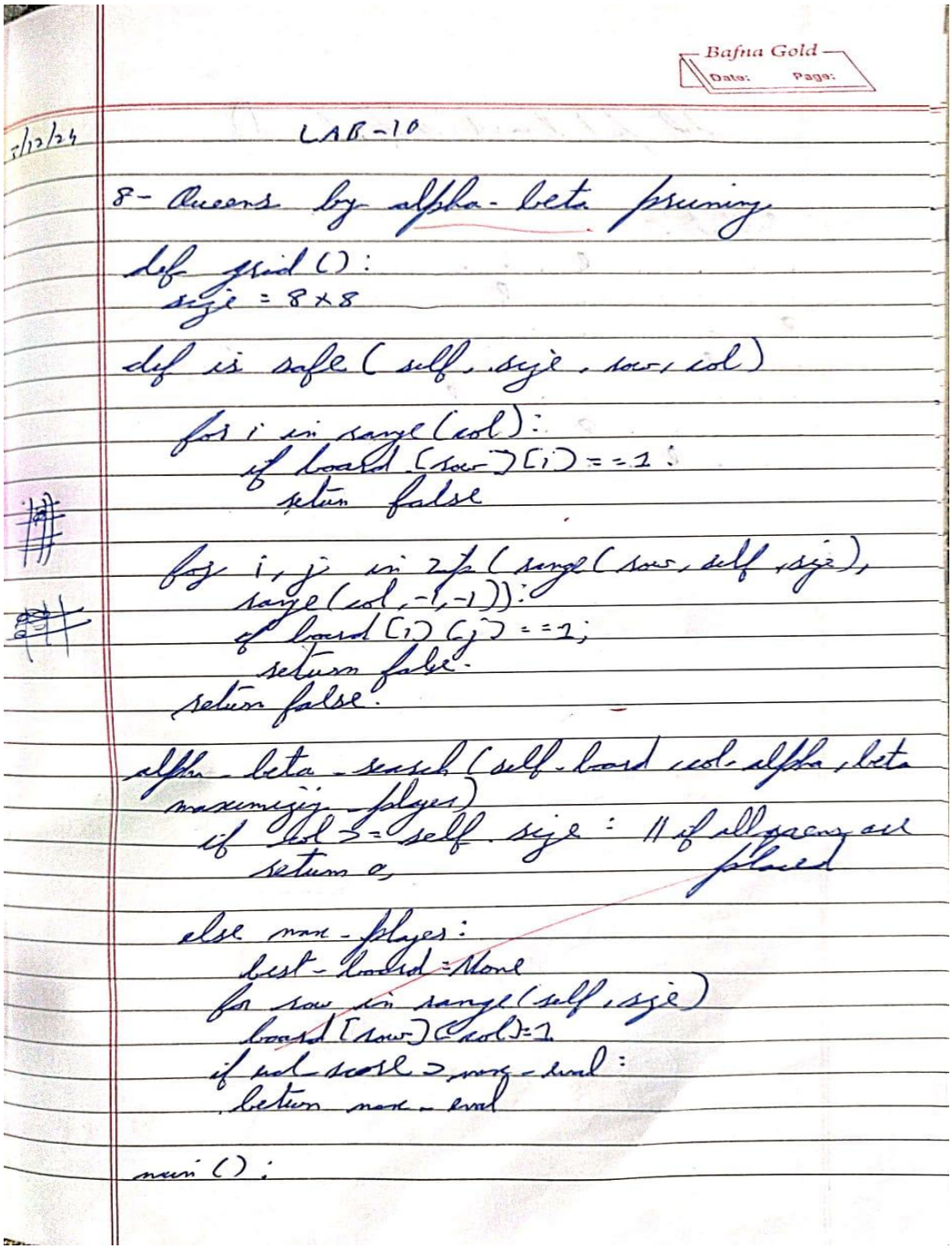
Output:



Program 10

Alpha-Beta Pruning

Algorithm:



```
Bafna Gold
Date:  Page:

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8- Queens by alpha-beta pruning

def grid():
    size = 8*8

def is safe(self, size, row, col)

    for i in range(col):
        if board[row][i] == 1:
            return false

    for i, j in zip(range(row, self, size),
        range(col, -1, -1)):
        if board[i][j] == 1;
            return false.
    return false.

alpha_beta_search(self, board, col, alpha, beta
    maximizing_player)
    if col >= self.size: # if all queens are
        return a,                    placed

    else max_player:
        best_board = None
        for row in range(self, size)
        board[row][col] = 1
        if val_score > max_eval:
            return max_eval

main():
```

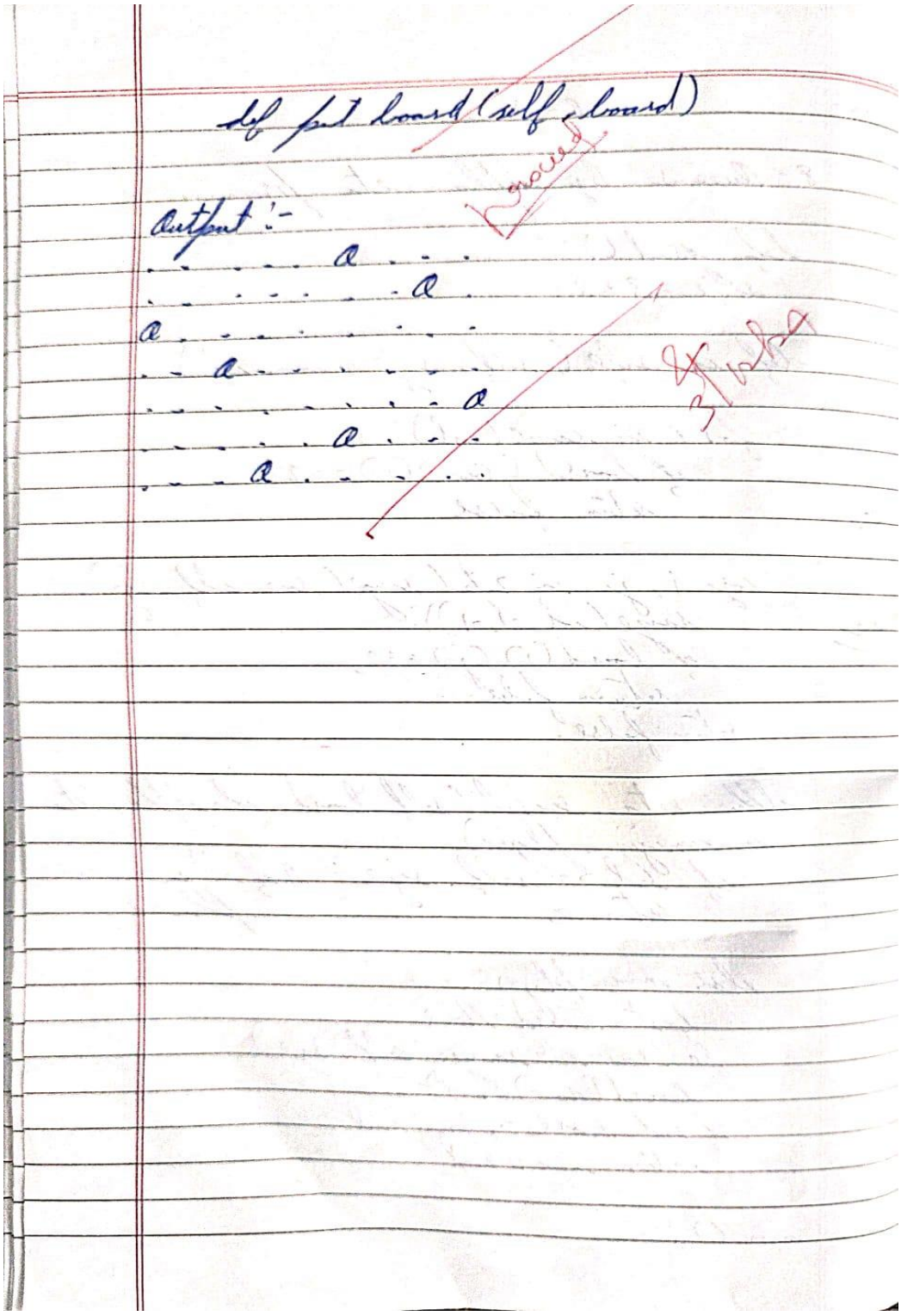
def put board (self, board)
output :-

Code:

```
def alpha_beta(depth, node_index, maximizing_player, values, alpha, beta):
    # Base case: If the depth is 0, return the value at this node
    if depth == 0:
        return values[node_index]
    if maximizing_player:
        max_eval = -math.inf  # Start with a very small value
        for i in range(2):  # Assuming binary tree structure with two children
            eval_value = alpha_beta(depth - 1, node_index * 2 + i, False, values, alpha, beta)
            max_eval = max(max_eval, eval_value)
            alpha = max(alpha, eval_value)
            if beta <= alpha:
                break  # Beta cut-off
        return max_eval
    else:
        min_eval = math.inf  # Start with a very large value
        for i in range(2):  # Assuming binary tree structure with two children
            eval_value = alpha_beta(depth - 1, node_index * 2 + i, True, values, alpha, beta)
            min_eval = min(min_eval, eval_value)
            beta = min(beta, eval_value)
            if beta <= alpha:
                break  # Alpha cut-off
        return min_eval
def main():
    depth = int(input("Enter the depth of the tree: "))
    num_nodes = 2 ** (depth + 1) - 1  # Number of nodes in a binary tree
    values = []

    print(f"Enter the leaf node values for depth {depth}:")
    for i in range(2 ** depth):  # Leaf nodes are at the last level
        value = int(input(f"Enter value for leaf node {i+1}: "))
        values.append(value)
    alpha = -math.inf
    beta = math.inf
    result = alpha_beta(depth, 0, True, values, alpha, beta)
    print(f"Optimal value (using Alpha-Beta Pruning): {result}")

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

Output:

```
Enter the depth of the tree: 3
Enter the leaf node values for depth 3:
Enter value for leaf node 1: 10
Enter value for leaf node 2: 9
Enter value for leaf node 3: 14
Enter value for leaf node 4: 18
Enter value for leaf node 5: 5
Enter value for leaf node 6: 4
Enter value for leaf node 7: 50
Enter value for leaf node 8: 3
Optimal value (using Alpha-Beta Pruning): 10
```