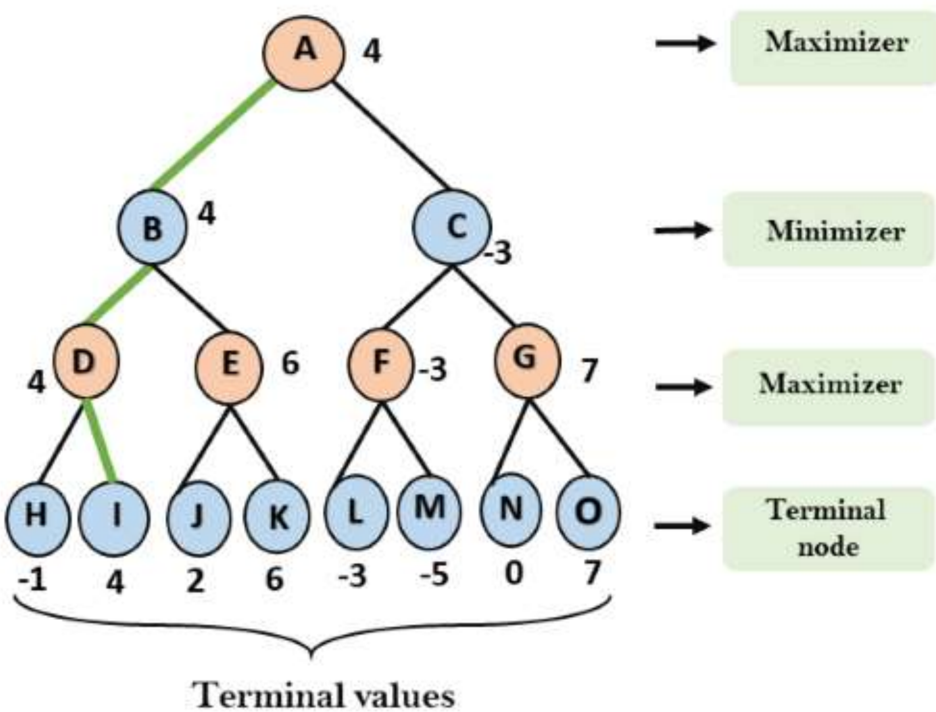
RESULT : Thus the python program to implement water jug problem have been implemented successfully.

EX.NO: 04
:

MINIMAX ALGORITHM

- A simple example can be used to explain how the minimax algorithm works. We've included an example of a game-tree below, which represents a two-player game.
- There are two players in this scenario, one named Maximizer and the other named Minimizer.
- Maximizer will strive for the highest possible score, while Minimizer will strive for the lowest possible score.
- Because this algorithm uses DFS, we must go all the way through the leaves to reach the terminal nodes in this game-tree.
- The terminal values are given at the terminal node, so we'll compare them and retrace the tree till we reach the original state.



AIM :
To implement MINIMAX Algorithm problem using Python.

SOURCE CODE :

```
from math import inf as infinity
from random import choice
import platform
import time
from os import system
HUMAN = -1
COMP = +1
board = [
   [0, 0, 0],
   [0, 0, 0],
   [0, 0, 0],
]
def evaluate(state):
  if wins(state, COMP):
      score = +1
   elif wins(state, HUMAN):
      score = -1
   else:
      score = 0
return score

def wins(state, player):

   win_state = [
      [state[0][0], state[0][1], state[0][2]],
      [state[1][0], state[1][1], state[1][2]],
      [state[2][0], state[2][1], state[2][2]],
      [state[0][0], state[1][0], state[2][0]],
      [state[0][1], state[1][1], state[2][1]],
      [state[0][2], state[1][2], state[2][2]],
      [state[0][0], state[1][1], state[2][2]],
      [state[2][0], state[1][1], state[0][2]],
   ]
   if [player, player, player] in win_state:
      return True
   else:
      return False
def game_over(state):
        return wins(state, HUMAN) or wins(state, COMP)
def empty_cells(state):
   cells = []
   for x, row in enumerate(state):
      for y, cell in enumerate(row):
```

```
            if cell == 0:
                cells.append([x, y])

  return cells
def valid_move(x, y):

    if [x, y] in empty_cells(board):
        return True
    else:
        return False
def set_move(x, y, player):

    if valid_move(x, y):
        board[x][y] = player
        return True
    else:
        return False
def minimax(state, depth, player):
    if player == COMP:
        best = [-1, -1, -infinity]
    else:
        best = [-1, -1, +infinity]

    if depth == 0 or game_over(state):
        score = evaluate(state)
        return [-1, -1, score]
    for cell in empty_cells(state):
        x, y = cell[0], cell[1]
        state[x][y] = player
        score = minimax(state, depth - 1, -player)
        state[x][y] = 0
        score[0], score[1] = x, y

        if player == COMP:
            if score[2] > best[2]:
                best = score  # max value
        else:
            if score[2] < best[2]:
                best = score  # min value

    return best

def clean():
```

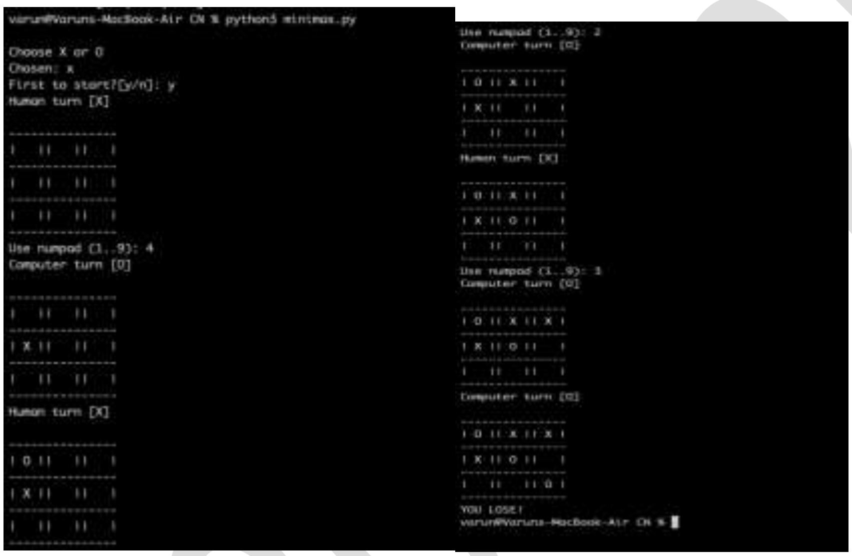
```
    os_name = platform.system().lower()
    if 'windows' in os_name:
        system('cls')
    else:
        system('clear')

def render(state, c_choice, h_choice):

    chars = {
        -1: h_choice,
        +1: c_choice,
        0: ' '
    }
    str_line = '---------------'

    print('\n' + str_line)
    for row in state:
        for cell in row:
            symbol = chars[cell]
            print(f'| {symbol} |', end='')
        print('\n' + str_line)

def ai_turn(c_choice, h_choice):

    depth = len(empty_cells(board))
    if depth == 0 or game_over(board):
        return

    clean()
    print(f'Computer turn [{c_choice}]')
    render(board, c_choice, h_choice)

    if depth == 9:
        x = choice([0, 1, 2])
        y = choice([0, 1, 2])
    else:
        move = minimax(board, depth, COMP)
        x, y = move[0], move[1]

    set_move(x, y, COMP)
    time.sleep(1)
```

```
def human_turn(c_choice, h_choice):

    depth = len(empty_cells(board))
    if depth == 0 or game_over(board):
        return

    # Dictionary of valid moves
    move = -1
    moves = {
        1: [0, 0], 2: [0, 1], 3: [0, 2],
        4: [1, 0], 5: [1, 1], 6: [1, 2],
        7: [2, 0], 8: [2, 1], 9: [2, 2],
    }

    clean()
    print(f'Human turn [{h_choice}]')
    render(board, c_choice, h_choice)

    while move < 1 or move > 9:
        try:
            move = int(input('Use numpad (1..9): '))
            coord = moves[move]
            can_move = set_move(coord[0], coord[1], HUMAN)

            if not can_move:
                print('Bad move')
                move = -1
        except (EOFError, KeyboardInterrupt):
            print('Bye')
            exit()
        except (KeyError, ValueError):
            print('Bad choice')

def main():

    clean()
    h_choice = ''  # X or O
    c_choice = ''  # X or O
    first = ''  # if human is the first

    # Human chooses X or O to play
    while h_choice != 'O' and h_choice != 'X':
        try:
```

```
        print('')
        h_choice = input('Choose X or O\nChosen: ').upper()
    except (EOFError, KeyboardInterrupt):
        print('Bye')
        exit()
    except (KeyError, ValueError):
        print('Bad choice')

# Setting computer's choice
if h_choice == 'X':
    c_choice = 'O'
else:
    c_choice = 'X'

# Human may starts first
clean()
while first != 'Y' and first != 'N':
    try:
        first = input('First to start?[y/n]: ').upper()
    except (EOFError, KeyboardInterrupt):
        print('Bye')
        exit()
    except (KeyError, ValueError):
        print('Bad choice')

# Main loop of this game
while len(empty_cells(board)) > 0 and not game_over(board):
    if first == 'N':
        ai_turn(c_choice, h_choice)
        first = ''

    human_turn(c_choice, h_choice)
    ai_turn(c_choice, h_choice)

if wins(board, HUMAN):
    clean()
    print(f'Human turn [{h_choice}]')
    render(board, c_choice, h_choice)
    print('YOU WIN!')
elif wins(board, COMP):
    clean()
    print(f'Computer turn [{c_choice}]')
    render(board, c_choice, h_choice)
```

```
            print('YOU LOSE!')
        else:
            clean()
            render(board, c_choice, h_choice)
            print('DRAW!')

        exit()
if __name__ == '__main__':
    main()
```

<u>OUTPUT:</u>



<u>RESULT :Thus the above execution of the algorithm has been successfully executed.</u>