# UNIVERSITY OF MUMBAI

# Teacher's Reference Manual

## Subject: Artificial Intelligence

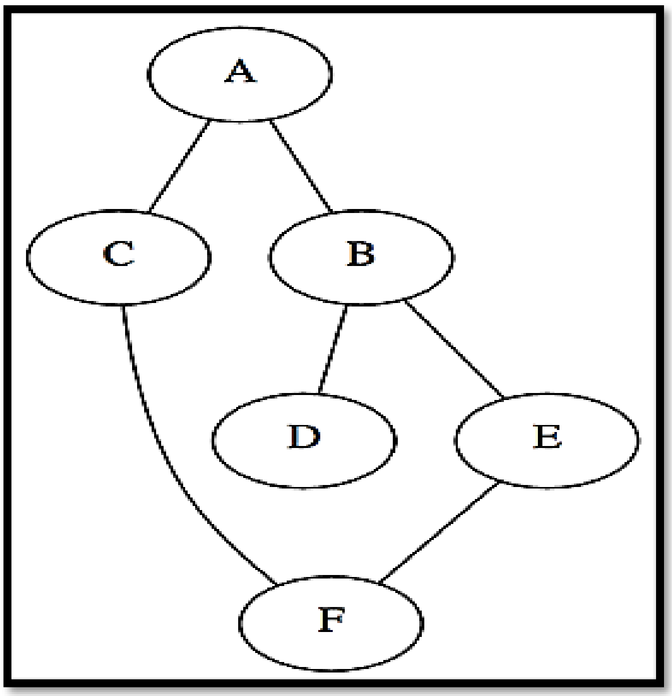
with effect from the academic year

2018 – 2019

## PRACTICAL NO-1

**A. Write a program to implement depth first search algorithm.**
**B. Write a program to implement breadth first search algorithm**

**AIM:-**
Write a program to implement depth first search algorithm.
**GRAPH:-**

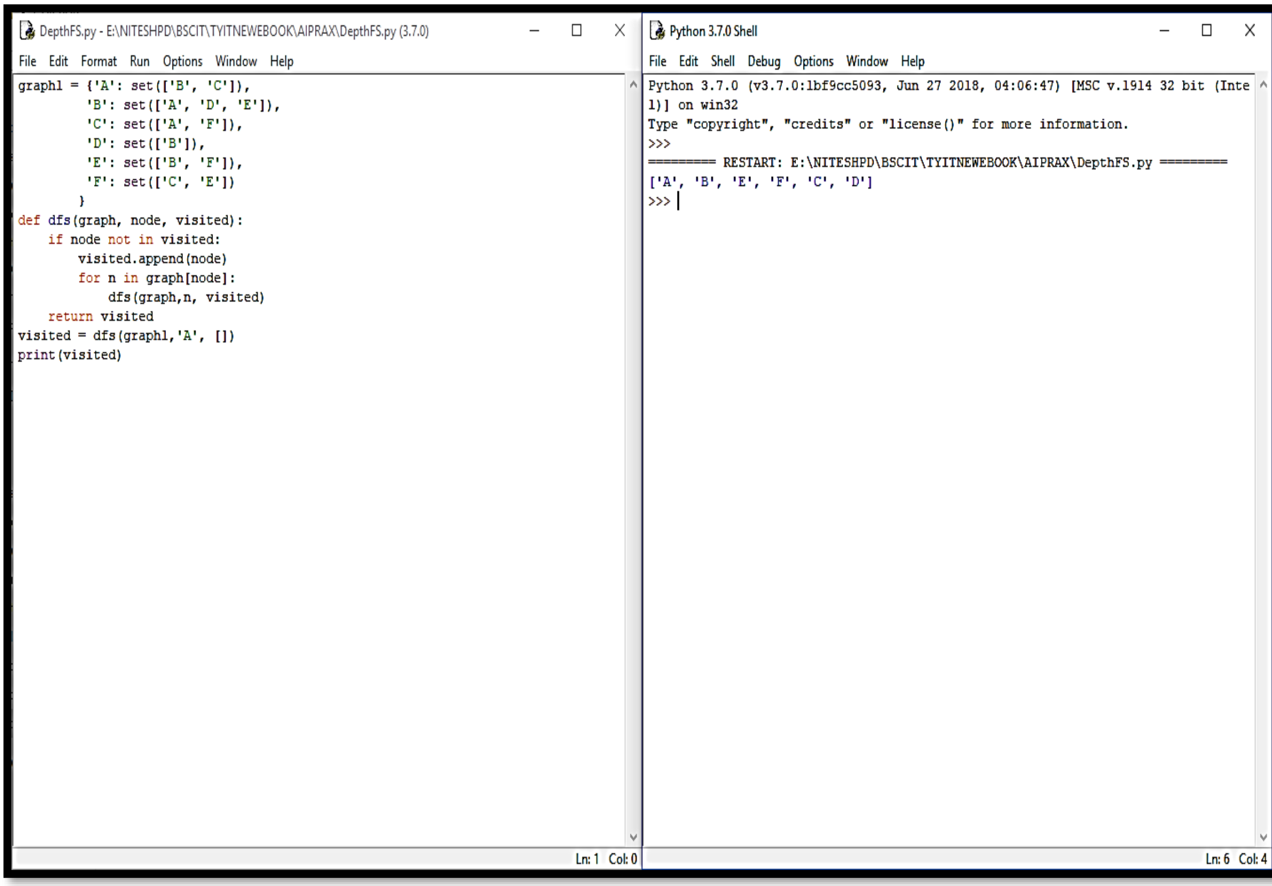



**PYTHON CODE:-**

```
graph1 = {
        'A': set(['B', 'C']),
        'B': set(['A', 'D', 'E']),
        'C': set(['A', 'F']),
        'D': set(['B']),
        'E': set(['B', 'F']),
        'F': set(['C', 'E'])
        }
def dfs(graph, node, visited):
    if node not in visited:
        visited.append(node)
        for n in graph[node]:
            dfs(graph,n, visited)
```

```
    return visited
visited = dfs(graph1,'A', [])
print(visited)
```

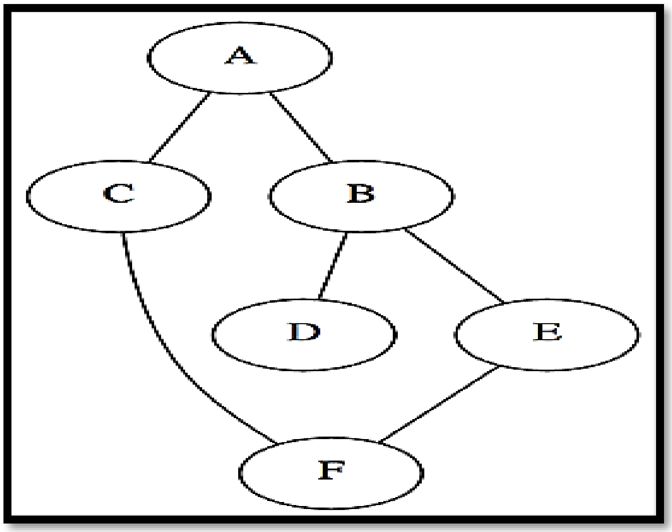
**OUTPUT:-**



**AIM:-**

Write a program to implement breadth first search algorithm.

**GRAPH:-**




**PYTHON CODE:-**

```
# sample graph implemented as a dictionary
graph = {'A': set(['B', 'C']),
         'B': set(['A', 'D', 'E']),
         'C': set(['A', 'F']),
         'D': set(['B']),
         'E': set(['B', 'F']),
         'F': set(['C', 'E'])
        }
#Implement Logic of BFS
def bfs(start):
    queue = [start]
    levels={}  #This Dict Keeps track of levels
    levels[start]=0  #Depth of start node is 0
    visited = set(start)
    while queue:
        node = queue.pop(0)
        neighbours=graph[node]
        for neighbor in neighbours:
```

```
            if neighbor not in visited:
                queue.append(neighbor)
                visited.add(neighbor)
                levels[neighbor]= levels[node]+1
    print(levels) #print graph level
    return visited
print(str(bfs('A'))) #print graph node


#For Finding Breadth First Search Path
def bfs_paths(graph, start, goal):
    queue = [(start, [start])]
    while queue:
        (vertex, path) = queue.pop(0)
        for next in graph[vertex] - set(path):
            if next == goal:
                yield path + [next]
            else:
                queue.append((next, path + [next]))
result=list(bfs_paths(graph, 'A', 'F'))
print(result)# [['A', 'C', 'F'], ['A', 'B', 'E', 'F']]

#For finding shortest path
def shortest_path(graph, start, goal):
    try:
        return next(bfs_paths(graph, start, goal))
    except StopIteration:
        return None
result1=shortest_path(graph, 'A', 'F')
print(result1)# ['A', 'C', 'F']
```

**OUTPUT:-**

BFSNew.py - E:/NITESHPD/BSCIT/AIPRAX/BFSNew.py (3.7.0)

File Edit Format Run Options Window Help

```
#For Making A Graph
graph = {'A': set(['B', 'C']),
         'B': set(['A', 'D', 'E']),
         'C': set(['A', 'F']),
         'D': set(['B']),
         'E': set(['B', 'F']),
         'F': set(['C', 'E'])
        }
#Implement Logic of BFS
def bfs(start):
    queue = [start]
    levels={}  #This Dict Keeps track of levels
    levels[start]=0  #Depth of start node is 0
    visited = set(start)
    while queue:
        node = queue.pop(0)
        neighbours=graph[node]
        for neighbor in neighbours:
            if neighbor not in visited:
                queue.append(neighbor)
                visited.add(neighbor)
                levels[neighbor]= levels[node]+1
    print(levels) #print graph Levels
    return visited
print(str(bfs('A'))) #print graph node

#For Finding Breadth First Search Path
def bfs_paths(graph, start, goal):
    queue = [(start, [start])]
    while queue:
        (vertex, path) = queue.pop(0)
        for next in graph[vertex] - set(path):
            if next == goal:
                yield path + [next]
            else:
                queue.append((next, path + [next]))
result=list(bfs_paths(graph, 'A', 'F'))
print(result)# [['A', 'C', 'F'], ['A', 'B', 'E', 'F']]
```

Ln: 20 Col: 0

```
#For finding shortest path
def shortest_path(graph, start, goal):
    try:
        return next(bfs_paths(graph, start, goal))
    except StopIteration:
        return None
result1=shortest_path(graph, 'A', 'F')
print(result1)# ['A', 'C', 'F']
```

Ln: 20 Col: 0

Python 3.7.0 Shell

File Edit Shell Debug Options Window Help

```
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Inte
l)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
================ RESTART: E:/NITESHPD/BSCIT/AIPRAX/BFSNew.py ================
{'A': 0, 'C': 1, 'B': 1, 'F': 2, 'E': 2, 'D': 2}
{'A', 'F', 'E', 'D', 'B', 'C'}
[['A', 'C', 'F'], ['A', 'B', 'E', 'F']]
['A', 'C', 'F']
>>>
```

## Practical no-2

**A. Write a program to simulate 4-Queen / N-Queen problem.**
**B. Write a program to solve tower of Hanoi problem.**

**Aim:-**
Write a program to simulate 4-Queen / N-Queen problem

**DIAGRAM:**

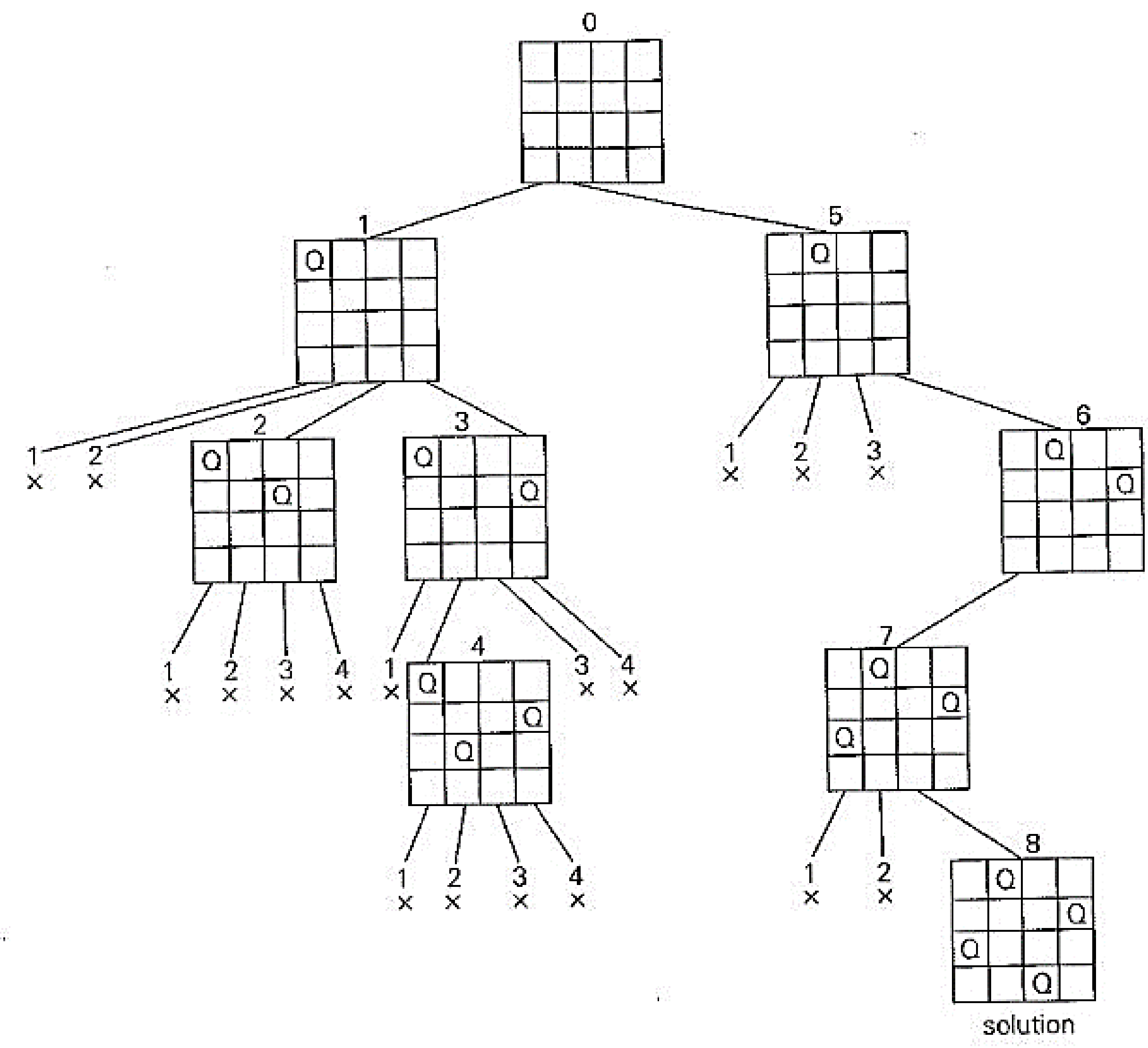



**FIGURE 12.2** State-space tree of solving the four-queens problem by backtracking. × denotes an unsuccessful attempt to place a queen in the indicated column. The numbers above the nodes indicate the order in which the nodes are generated.

**PYTHON CODE:-**

```
class QueenChessBoard:
    def __init__(self, size):
        # board has dimensions size x size
        self.size = size
        # columns[r] is a number c if a queen is placed at row r and column c.
        # columns[r] is out of range if no queen is place in row r.
        # Thus after all queens are placed, they will be at positions
        # (columns[0], 0), (columns[1], 1), ... (columns[size - 1], size - 1)
        self.columns = []
    def place_in_next_row(self, column):
        self.columns.append(column)
    def remove_in_current_row(self):
        return self.columns.pop()
    def is_this_column_safe_in_next_row(self, column):
        # index of next row
        row = len(self.columns)
        # check column
        for queen_column in self.columns:
            if column == queen_column:
                return False
        # check diagonal
        for queen_row, queen_column in enumerate(self.columns):
            if queen_column - queen_row == column - row:
                return False
        # check other diagonal
        for queen_row, queen_column in enumerate(self.columns):
            if ((self.size - queen_column) - queen_row
                == (self.size - column) - row):
                return False
        return True
    def display(self):
        for row in range(self.size):
            for column in range(self.size):
                if column == self.columns[row]:
                    print('Q', end=' ')
                else:
                    print('.', end=' ')
            print()
def solve_queen(size):
```

```
    """Display a chessboard for each possible configuration of placing n
queens on an n x n chessboard and print the number of such
configurations."""
    board = QueenChessBoard(size)
    number_of_solutions = 0

    row = 0
    column = 0
    # iterate over rows of board
    while True:
        # place queen in next row
        while column < size:
            if board.is_this_column_safe_in_next_row(column):
                board.place_in_next_row(column)
                row += 1
                column = 0
                break
            else:
                column += 1

        # if could not find column to place in or if board is full
        if (column == size or row == size):
            # if board is full, we have a solution
            if row == size:
                board.display()
                print()
                number_of_solutions += 1
                # small optimization:
                # In a board that already has queens placed in all rows except
                # the last, we know there can only be at most one position in
                # the last row where a queen can be placed. In this case, there
                # is a valid position in the last row. Thus we can backtrack two
                # times to reach the second last row.
                board.remove_in_current_row()
                row -= 1
            # now backtrack
            try:
                prev_column = board.remove_in_current_row()
            except IndexError:
                # all queens removed
```

```
                # thus no more possible configurations
                break
            # try previous row again
            row -= 1
            # start checking at column = (1 + value of column in previous row)
            column = 1 + prev_column
    print('Number of solutions:', number_of_solutions)
n = int(input('Enter n: '))
solve_queen(n)
```

**OUTPUT:-**

queenprobl.py - E:/NITESHPD/BSCIT/TYITNEWEBOOK/AIPRAX/queenprobl.py (3.7.0)

File Edit Format Run Options Window Help

```
class QueenChessBoard:
    def __init__(self, size):
        # board has dimensions size x size
        self.size = size
        # columns[r] is a number c if a queen is placed at row r and column c.
        # columns[r] is out of range if no queen is place in row r.
        # Thus after all queens are placed, they will be at positions
        # (columns[0], 0), (columns[1], 1), ... (columns[size - 1], size - 1)
        self.columns = []
    def place_in_next_row(self, column):
        self.columns.append(column)
    def remove_in_current_row(self):
        return self.columns.pop()
    def is_this_column_safe_in_next_row(self, column):
        # index of next row
        row = len(self.columns)
        # check column
        for queen_column in self.columns:
            if column == queen_column:
                return False
        # check diagonal
        for queen_row, queen_column in enumerate(self.columns):
            if queen_column - queen_row == column - row:
                return False
        # check other diagonal
        for queen_row, queen_column in enumerate(self.columns):
            if ((self.size - queen_column) - queen_row
                == (self.size - column) - row):
                return False
        return True
    def display(self):
        for row in range(self.size):
            for column in range(self.size):
                if column == self.columns[row]:
                    print('Q', end=' ')
                else:
                    print('.', end=' ')
            print()
```

Ln: 19 Col: 0

queenprobl.py - E:/NITESHPD/BSCIT/TYITNEWEBOOK/AIPRAX/queenprobl.py (3.7.0)

File Edit Format Run Options Window Help

```
def solve_queen(size):
    """Display a chessboard for each possible configuration of placing n queens
    on an n x n chessboard and print the number of such configurations."""
    board = QueenChessBoard(size)
    number_of_solutions = 0

    row = 0
    column = 0
    # iterate over rows of board
    while True:
        # place queen in next row
        while column < size:
            if board.is_this_column_safe_in_next_row(column):
                board.place_in_next_row(column)
                row += 1
                column = 0
                break
            else:
                column += 1

        # if could not find column to place in or if board is full
        if (column == size or row == size):
            # if board is full, we have a solution
            if row == size:
                board.display()
                print()
                number_of_solutions += 1
                # small optimization:
                # In a board that already has queens placed in all rows except
                # the last, we know there can only be at most one position in
                # the last row where a queen can be placed. In this case, there
                # is a valid position in the last row. Thus we can backtrack two
                # times to reach the second last row.
                board.remove_in_current_row()
                row -= 1
            # now backtrack
            try:
                prev_column = board.remove_in_current_row()
```

Ln: 19 Col: 0

```
            # now backtrack
            try:
                prev_column = board.remove_in_current_row()
            except IndexError:
                # all queens removed
                # thus no more possible configurations
                break
            # try previous row again
            row -= 1
            # start checking at column = (1 + value of column in previous row)
            column = 1 + prev_column
    print('Number of solutions:', number_of_solutions)
n = int(input('Enter n: '))
solve_queen(n)
```

Ln: 19 Col: 0

**NOTE:**

**1.** The user is prompted to enter n where n is the number of queens to place and the size of the board.

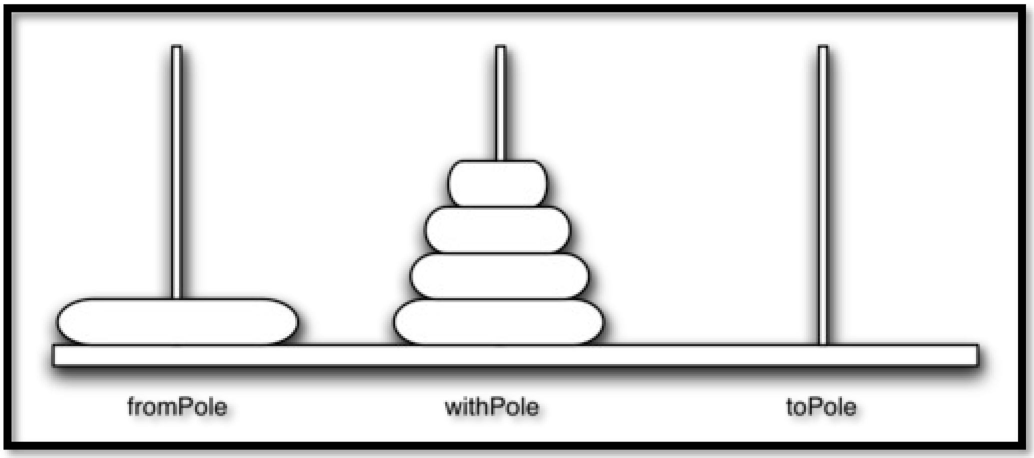
**2.** Solve queens is called on n to display all possible board configurations and the number of solutions.

```
Python 3.7.0 Shell
File Edit Shell Debug Options Window Help
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Inte
l)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
======== RESTART: E:/NITESHPD/BSCIT/TYITNEWEBOOK/AIPRAX/queenprobl.py ========
Enter n: 4
. Q . .
. . . Q
Q . . .
. . Q .

. . Q .
Q . . .
. . . Q
. Q . .

Number of solutions: 2
>>>
Ln: 17 Col: 4
```

**AIM:-**

Write a program to solve tower of Hanoi problem.

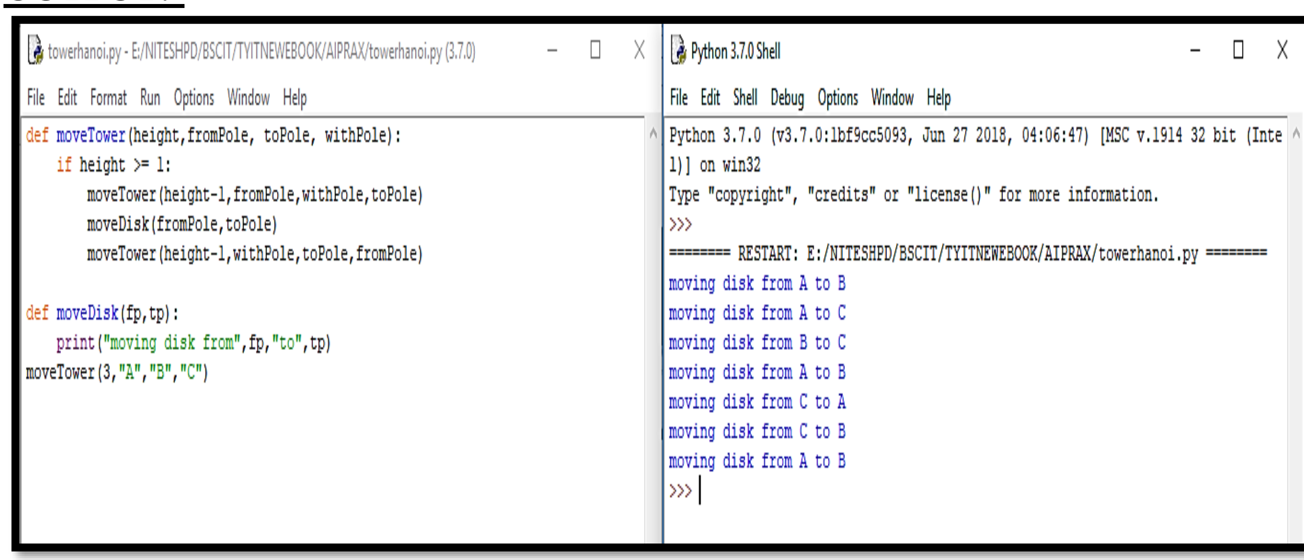
**DIAGRAM:**




**PYTHON CODE:**

```
def moveTower(height,fromPole, toPole, withPole):
    if height >= 1:
        moveTower(height-1,fromPole,withPole,toPole)
        moveDisk(fromPole,toPole)
        moveTower(height-1,withPole,toPole,fromPole)
def moveDisk(fp,tp):
    print("moving disk from",fp,"to",tp)
moveTower(3,"A","B","C")
```

**OUTPUT:-**



# PRACTICAL NO.-3

A. **Write a program to implement alpha beta search.**
B. **Write a program for Hill climbing problem.**

**AIM:-**

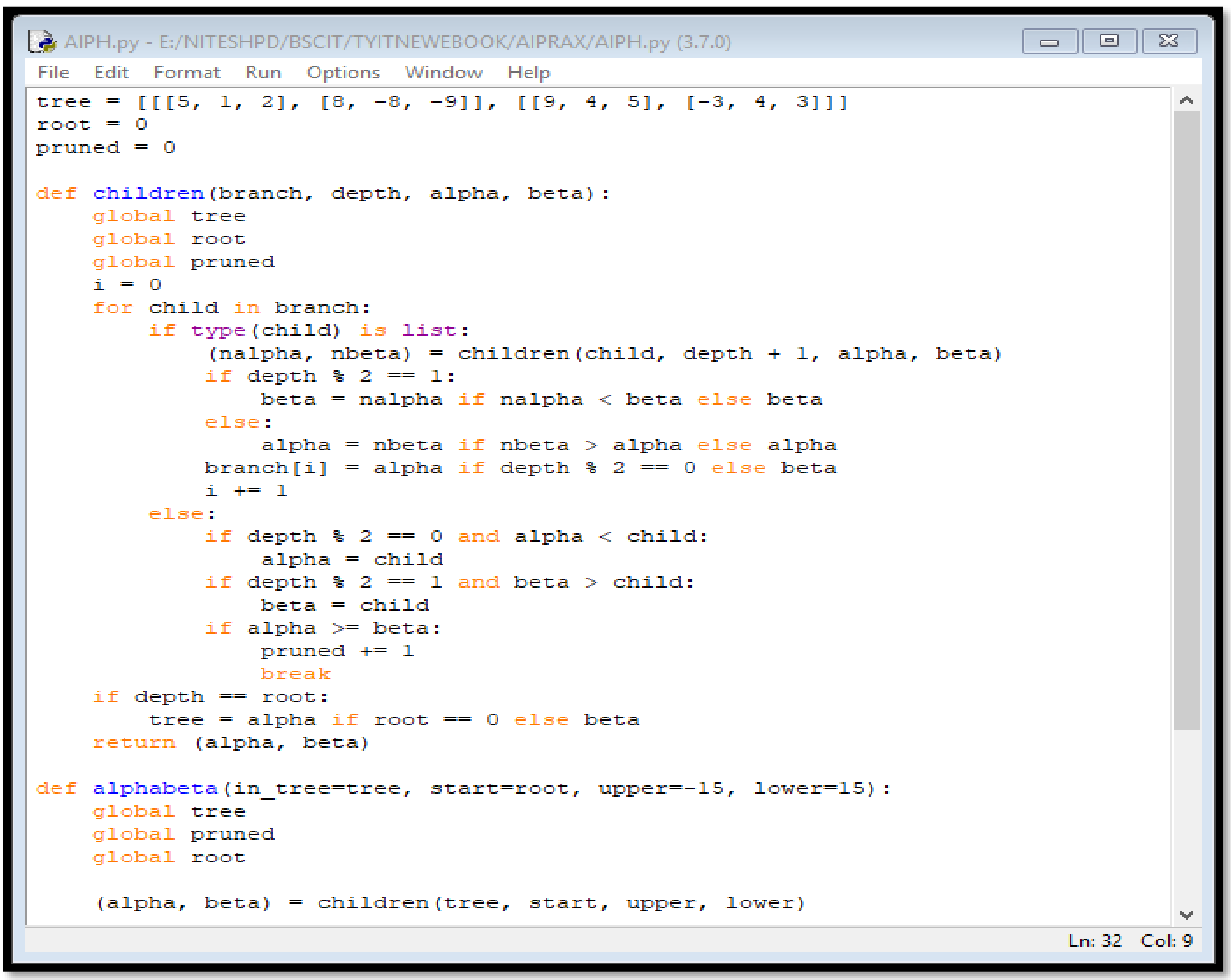
Write a program to implement alpha beta search.

**PYTHON CODE**

```
tree = [[[5, 1, 2], [8, -8, -9]], [[9, 4, 5], [-3, 4, 3]]]
root = 0
pruned = 0

def children(branch, depth, alpha, beta):
    global tree
    global root
    global pruned
    i = 0
    for child in branch:
        if type(child) is list:
            (nalpha, nbeta) = children(child, depth + 1, alpha, beta)
            if depth % 2 == 1:
                beta = nalpha if nalpha < beta else beta
            else:
                alpha = nbeta if nbeta > alpha else alpha
            branch[i] = alpha if depth % 2 == 0 else beta
            i += 1
        else:
            if depth % 2 == 0 and alpha < child:
                alpha = child
            if depth % 2 == 1 and beta > child:
                beta = child
            if alpha >= beta:
                pruned += 1
                break
    if depth == root:
        tree = alpha if root == 0 else beta
    return (alpha, beta)

def alphabeta(in_tree=tree, start=root, upper=-15, lower=15):
    global tree
```

```
    global pruned
    global root

    (alpha, beta) = children(tree, start, upper, lower)

    if __name__ == "__main__":
        print ("(alpha, beta): ", alpha, beta)
        print ("Result: ", tree)
        print ("Times pruned: ", pruned)

    return (alpha, beta, tree, pruned)

if __name__ == "__main__":
    alphabeta(None)
```

## OUTPUT



AIPH.py - E:/NITESHPD/BSCIT/TYITNEWEBOOK/AIPRAX/AIPH.py (3.7.0)

File Edit Format Run Options Window Help

```
tree = [[[5, 1, 2], [8, -8, -9]], [[9, 4, 5], [-3, 4, 3]]]
root = 0
pruned = 0

def children(branch, depth, alpha, beta):
    global tree
    global root
    global pruned
    i = 0
    for child in branch:
        if type(child) is list:
            (nalpha, nbeta) = children(child, depth + 1, alpha, beta)
            if depth % 2 == 1:
                beta = nalpha if nalpha < beta else beta
            else:
                alpha = nbeta if nbeta > alpha else alpha
            branch[i] = alpha if depth % 2 == 0 else beta
            i += 1
        else:
            if depth % 2 == 0 and alpha < child:
                alpha = child
            if depth % 2 == 1 and beta > child:
                beta = child
            if alpha >= beta:
                pruned += 1
                break
    if depth == root:
        tree = alpha if root == 0 else beta
    return (alpha, beta)

def alphabeta(in_tree=tree, start=root, upper=-15, lower=15):
    global tree
    global pruned
    global root

    (alpha, beta) = children(tree, start, upper, lower)
```

Ln: 32 Col: 9

```
    if __name__ == "__main__":
        print ("(alpha, beta): ", alpha, beta)
        print ("Result: ", tree)
        print ("Times pruned: ", pruned)

    return (alpha, beta, tree, pruned)

if __name__ == "__main__":
    alphabeta(None)
```

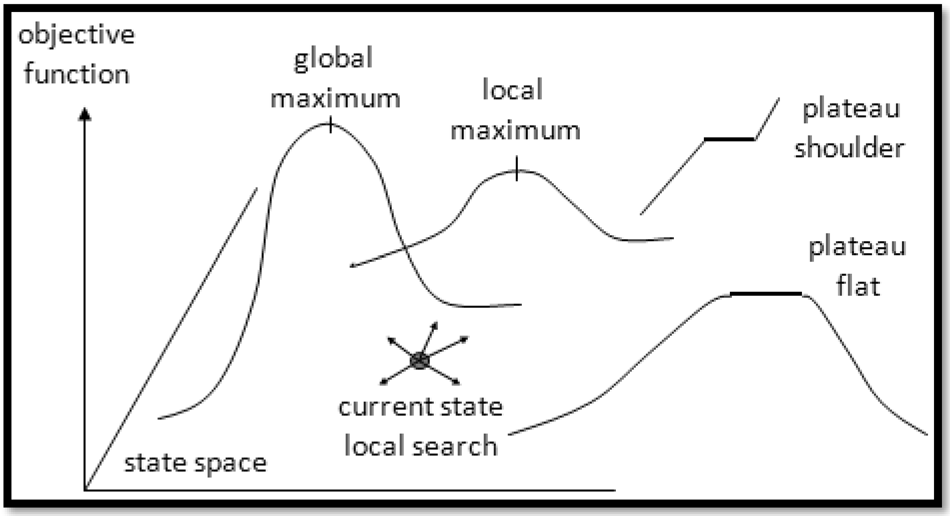
Ln: 32 Col: 9

Python 3.7.0 Shell

File Edit Shell Debug Options Window Help

```
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Inte
l)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
=========== RESTART: E:/NITESHPD/BSCIT/TYITNEWEBOOK/AIPRAX/AlPH.py ===========
(alpha, beta):  5 15
Result:  5
Times pruned:  1
>>>
```

**AIM:-**
Write a program for Hill climbing problem.
**DIAGRAM:-**




**PYTHON CODE:**

```
import math

increment = 0.1
startingPoint = [1, 1]
point1 = [1,5]
point2 = [6,4]
point3 = [5,2]
point4 = [2,1]

def distance(x1, y1, x2, y2):
    dist = math.pow(x2-x1, 2) + math.pow(y2-y1, 2)
    return dist

def sumOfDistances(x1, y1, px1, py1, px2, py2, px3, py3, px4, py4):
    d1 = distance(x1, y1, px1, py1)
    d2 = distance(x1, y1, px2, py2)
    d3 = distance(x1, y1, px3, py3)
    d4 = distance(x1, y1, px4, py4)

    return d1 + d2 + d3 + d4
```

```
def newDistance(x1, y1, point1, point2, point3, point4):
    d1 = [x1, y1]
    d1temp = sumOfDistances(x1, y1, point1[0],point1[1], point2[0],point2[1],
                            point3[0],point3[1], point4[0],point4[1] )
    d1.append(d1temp)
    return d1

minDistance = sumOfDistances(startingPoint[0], startingPoint[1],
point1[0],point1[1], point2[0],point2[1],
                            point3[0],point3[1], point4[0],point4[1] )
flag = True

def newPoints(minimum, d1, d2, d3, d4):
    if d1[2] == minimum:
        return [d1[0], d1[1]]
    elif d2[2] == minimum:
        return [d2[0], d2[1]]
    elif d3[2] == minimum:
        return [d3[0], d3[1]]
    elif d4[2] == minimum:
        return [d4[0], d4[1]]

i = 1
while flag:
    d1 = newDistance(startingPoint[0]+increment, startingPoint[1], point1, point2,
point3, point4)
    d2 = newDistance(startingPoint[0]-increment, startingPoint[1], point1, point2,
point3, point4)
    d3 = newDistance(startingPoint[0], startingPoint[1]+increment, point1, point2,
point3, point4)
    d4 = newDistance(startingPoint[0], startingPoint[1]-increment, point1, point2,
point3, point4)
    print (i,' ', round(startingPoint[0], 2), round(startingPoint[1], 2))
    minimum = min(d1[2], d2[2], d3[2], d4[2])
    if minimum < minDistance:
        startingPoint = newPoints(minimum, d1, d2, d3, d4)
        minDistance = minimum
        #print i,' ', round(startingPoint[0], 2), round(startingPoint[1], 2)
        i+=1
```

```
    else:
        flag = False
```

**OUTPUT**

hillclimb.py - E:/NITESHPD/BSCIT/TYITNEWEBOOK/AIPRAX/hillclimb.py (3.7.0)

File Edit Format Run Options Window Help

```
import math

increment = 0.1
startingPoint = [1, 1]
point1 = [1,5]
point2 = [6,4]
point3 = [5,2]
point4 = [2,1]

def distance(x1, y1, x2, y2):
    dist = math.pow(x2-x1, 2) + math.pow(y2-y1, 2)
    return dist

def sumOfDistances(x1, y1, px1, py1, px2, py2, px3, py3, px4, py4):
    d1 = distance(x1, y1, px1, py1)
    d2 = distance(x1, y1, px2, py2)
    d3 = distance(x1, y1, px3, py3)
    d4 = distance(x1, y1, px4, py4)

    return d1 + d2 + d3 + d4

def newDistance(x1, y1, point1, point2, point3, point4):
    d1 = [x1, y1]
    d1temp = sumOfDistances(x1, y1, point1[0],point1[1], point2[0],point2[1],
                                point3[0],point3[1], point4[0],point4[1] )
    d1.append(d1temp)
    return d1

minDistance = sumOfDistances(startingPoint[0], startingPoint[1], point1[0],point
                                point3[0],point3[1], point4[0],point4[1] )
flag = True

def newPoints(minimum, d1, d2, d3, d4):
    if d1[2] == minimum:
        return [d1[0], d1[1]]
    elif d2[2] == minimum:
        return [d2[0], d2[1]]
    elif d3[2] == minimum:
        return [d3[0], d3[1]]
    elif d4[2] == minimum:
```

Ln: 36 Col: 26

```
    elif d4[2] == minimum:
        return [d4[0], d4[1]]

i = 1
while flag:
    d1 = newDistance(startingPoint[0]+increment, startingPoint[1], point1, point
    d2 = newDistance(startingPoint[0]-increment, startingPoint[1], point1, point
    d3 = newDistance(startingPoint[0], startingPoint[1]+increment, point1, point
    d4 = newDistance(startingPoint[0], startingPoint[1]-increment, point1, point
    print (i,' ', round(startingPoint[0], 2), round(startingPoint[1], 2))
    minimum = min(d1[2], d2[2], d3[2], d4[2])
    if minimum < minDistance:
        startingPoint = newPoints(minimum, d1, d2, d3, d4)
        minDistance = minimum
        #print i,' ', round(startingPoint[0], 2), round(startingPoint[1], 2)
        i+=1
    else:
        flag = False
```

Python 3.7.0 Shell

File Edit Shell Debug Options Window Help

```
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Inte
l)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
======== RESTART: E:/NITESHPD/BSCIT/TYITNEWEBOOK/AIPRAX/hillclimb.py ========
1   1 1
2   1.1 1
3   1.2 1
4   1.3 1
5   1.4 1
6   1.5 1
7   1.6 1
8   1.6 1.1
9   1.7 1.1
10   1.7 1.2
11   1.7 1.3
12   1.8 1.3
13   1.8 1.4
14   1.9 1.4
15   2.0 1.4
16   2.0 1.5
17   2.1 1.5
18   2.1 1.6
19   2.2 1.6
20   2.2 1.7
21   2.3 1.7
22   2.3 1.8
23   2.3 1.9
24   2.4 1.9
25   2.5 1.9
26   2.5 2.0
27   2.6 2.0
28   2.6 2.1
29   2.7 2.1
30   2.7 2.2
31   2.8 2.2
32   2.8 2.3
33   2.9 2.3
34   2.9 2.4
35   3.0 2.4
```

Ln: 51 Col: 4

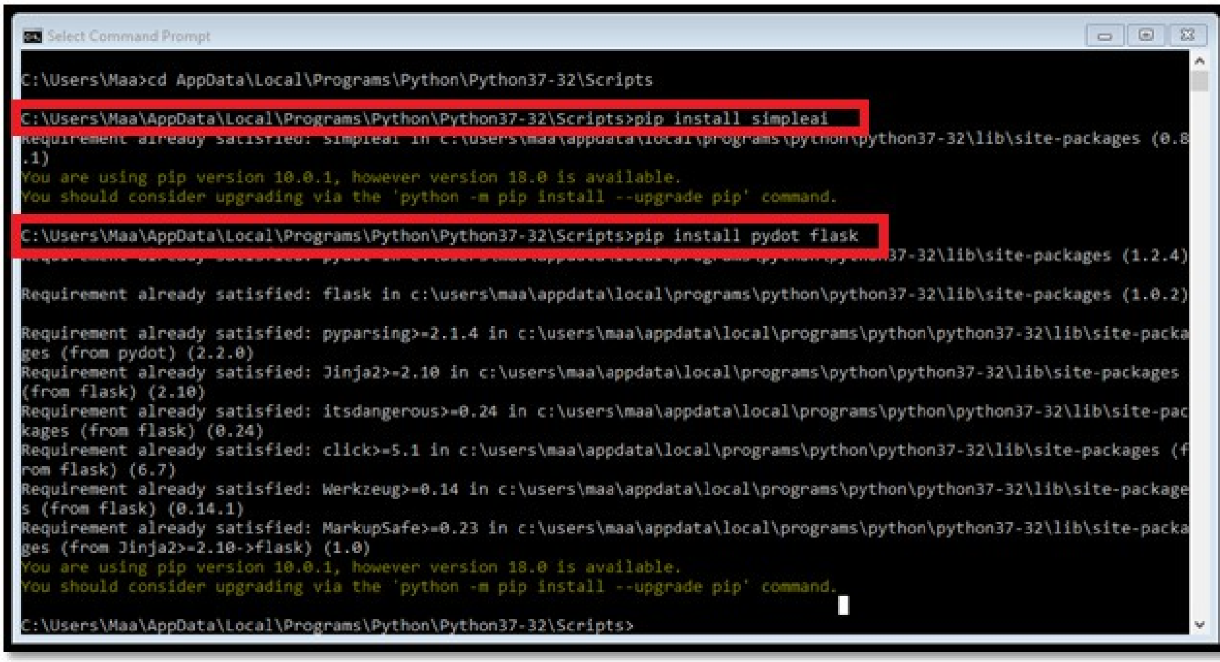
## Practical no-4

**A. Write a program to implement A* algorithm.**
**B. Write a program to implement AO* algorithm.**

**Aim:-**
Write a program to implement A* algorithm.

**Note:**
Install 2 package in python scripts directory using pip command.

**1. pip install simpleai**
**2. pip install pydot flask**

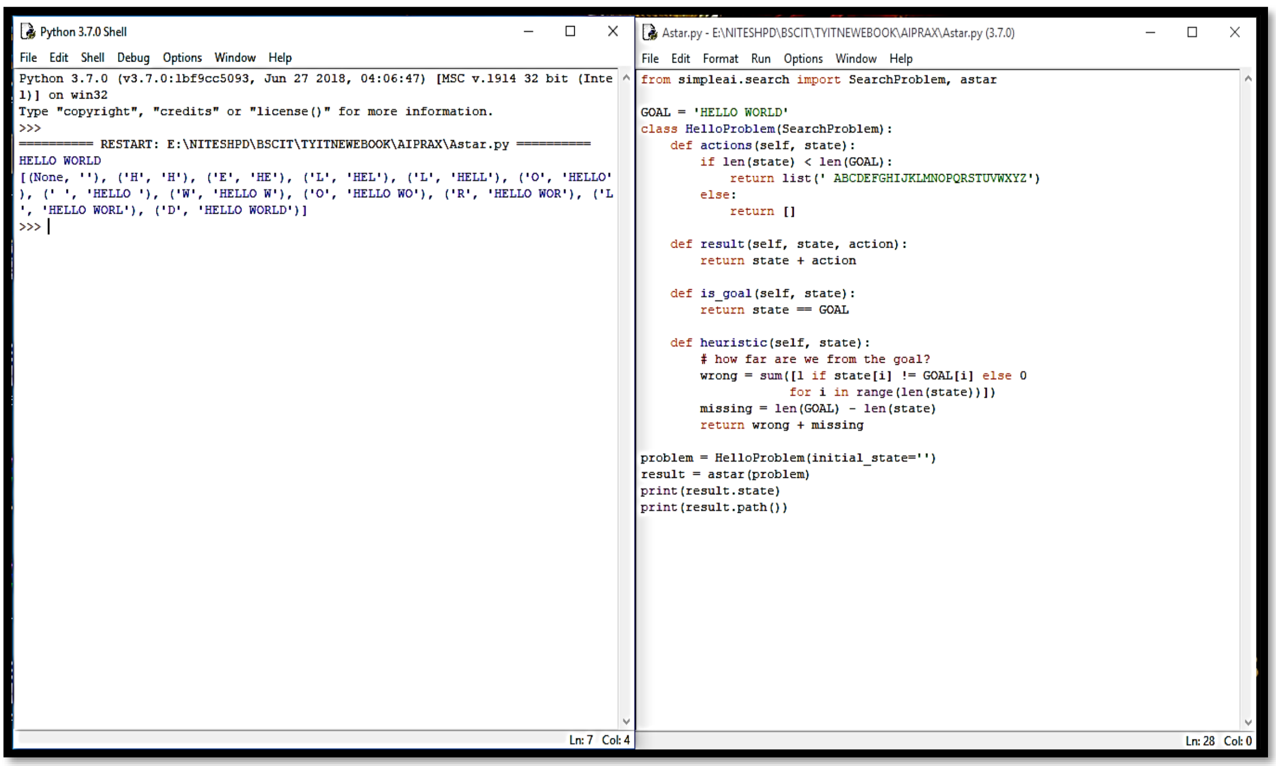



**PYTHON CODE:-**

```
from simpleai.search import SearchProblem, astar

GOAL = 'HELLO WORLD'
class HelloProblem(SearchProblem):
    def actions(self, state):
        if len(state) < len(GOAL):
            return list(' ABCDEFGHIJKLMNOPQRSTUVWXYZ')
        else:
            return []

    def result(self, state, action):
        return state + action
```

```
    def is_goal(self, state):
        return state == GOAL

    def heuristic(self, state):
        # how far are we from the goal?
        wrong = sum([1 if state[i] != GOAL[i] else 0
                    for i in range(len(state))])
        missing = len(GOAL) - len(state)
        return wrong + missing

problem = HelloProblem(initial_state='')
result = astar(problem)
print(result.state)
print(result.path())
```

**OUTPUT:-**



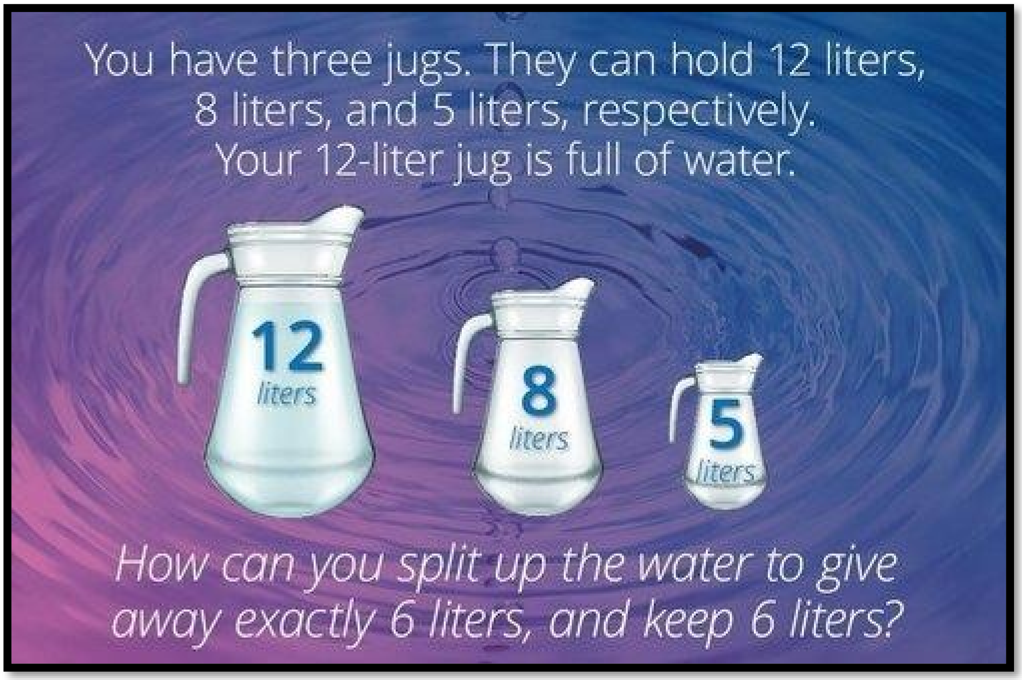
**Practical no-5**

A. **Write a program to solve water jug problem.**
B. **Design the simulation of tic – tac – toe game using min-max algorithm.**

**Aim:-**

Write a program to solve water jug problem.

**Diagram:-**




**Python Code:-**

```
# 3 water jugs capacity -> (x,y,z) where x>y>z
# initial state (12,0,0)
# final state (6,6,0)

capacity = (12,8,5)
# Maximum capacities of 3 jugs -> x,y,z
x = capacity[0]
y = capacity[1]
z = capacity[2]

# to mark visited states
memory = {}

# store solution path
ans = []
```

```
def get_all_states(state):
 # Let the 3 jugs be called a,b,c
 a = state[0]
 b = state[1]
 c = state[2]

 if(a==6 and b==6):
    ans.append(state)
    return True

 # if current state is already visited earlier
 if((a,b,c) in memory):
    return False

 memory[(a,b,c)] = 1

 #empty jug a
 if(a>0):
    #empty a into b
    if(a+b<=y):
       if( get_all_states((0,a+b,c)) ):
          ans.append(state)
          return True
    else:
       if( get_all_states((a-(y-b), y, c)) ):
          ans.append(state)
          return True
    #empty a into c
    if(a+c<=z):
       if( get_all_states((0,b,a+c)) ):
          ans.append(state)
          return True
    else:
       if( get_all_states((a-(z-c), b, z)) ):
          ans.append(state)
          return True

 #empty jug b
 if(b>0):
    #empty b into a
```

```
    if(a+b<=x):
        if( get_all_states((a+b, 0, c)) ):
            ans.append(state)
            return True
    else:
        if( get_all_states((x, b-(x-a), c)) ):
            ans.append(state)
            return True
    #empty b into c
    if(b+c<=z):
        if( get_all_states((a, 0, b+c)) ):
            ans.append(state)
            return True
    else:
        if( get_all_states((a, b-(z-c), z)) ):
            ans.append(state)
            return True

#empty jug c
if(c>0):
    #empty c into a
    if(a+c<=x):
        if( get_all_states((a+c, b, 0)) ):
            ans.append(state)
            return True
    else:
        if( get_all_states((x, b, c-(x-a))) ):
            ans.append(state)
            return True
    #empty c into b
    if(b+c<=y):
        if( get_all_states((a, b+c, 0)) ):
            ans.append(state)
            return True
    else:
        if( get_all_states((a, y, c-(y-b))) ):
            ans.append(state)
            return True

return False
```

```
initial_state = (12,0,0)
print("Starting work...\n")
get_all_states(initial_state)
ans.reverse()
for i in ans:
  print(i)
```

**Output:-**

waterjugproblem.py - E:\NITESHPD\BSCIT\TYITNEWEBOOK\AIPRAX\waterjugproblem.py (3.7.0)

File Edit Format Run Options Window Help

```
# 3 water jugs capacity -> (x,y,z) where x>y>z
# initial state (12,0,0)
# final state (6,6,0)

capacity = (12,8,5)
# Maximum capacities of 3 jugs -> x,y,z
x = capacity[0]
y = capacity[1]
z = capacity[2]

# to mark visited states
memory = {}

# store solution path
ans = []

def get_all_states(state):
    # Let the 3 jugs be called a,b,c
    a = state[0]
    b = state[1]
    c = state[2]

    if(a==6 and b==6):
        ans.append(state)
        return True

    # if current state is already visited earlier
    if((a,b,c) in memory):
        return False

    memory[(a,b,c)] = 1

    #empty jug a
    if(a>0):
        #empty a into b
        if(a+b<=y):
            if( get_all_states((0,a+b,c)) ):
                ans.append(state)
                return True
        else:
            if( get_all_states((a-(y-b), y, c)) ):
                ans.append(state)
                return True
```

Ln: 23 Col: 0

waterjugproblem.py - E:\NITESHPD\BSCIT\TYITNEWEBOOK\AIPRAX\waterjugproblem.py (3.7.0)

File Edit Format Run Options Window Help

```
        #empty a into c
        if(a+c<=z):
            if( get_all_states((0,b,a+c)) ):
                ans.append(state)
                return True
        else:
            if( get_all_states((a-(z-c), b, z)) ):
                ans.append(state)
                return True

    #empty jug b
    if(b>0):
        #empty b into a
        if(a+b<=x):
            if( get_all_states((a+b, 0, c)) ):
                ans.append(state)
                return True
        else:
            if( get_all_states((x, b-(x-a), c)) ):
                ans.append(state)
                return True
        #empty b into c
        if(b+c<=z):
            if( get_all_states((a, 0, b+c)) ):
                ans.append(state)
                return True
        else:
            if( get_all_states((a, b-(z-c), z)) ):
                ans.append(state)
                return True

    #empty jug c
    if(c>0):
        #empty c into a
        if(a+c<=x):
            if( get_all_states((a+c, b, 0)) ):
                ans.append(state)
                return True
        else:
            if( get_all_states((x, b, c-(x-a))) ):
                ans.append(state)
                return True
        #empty c into b
```

Ln: 23 Col: 0

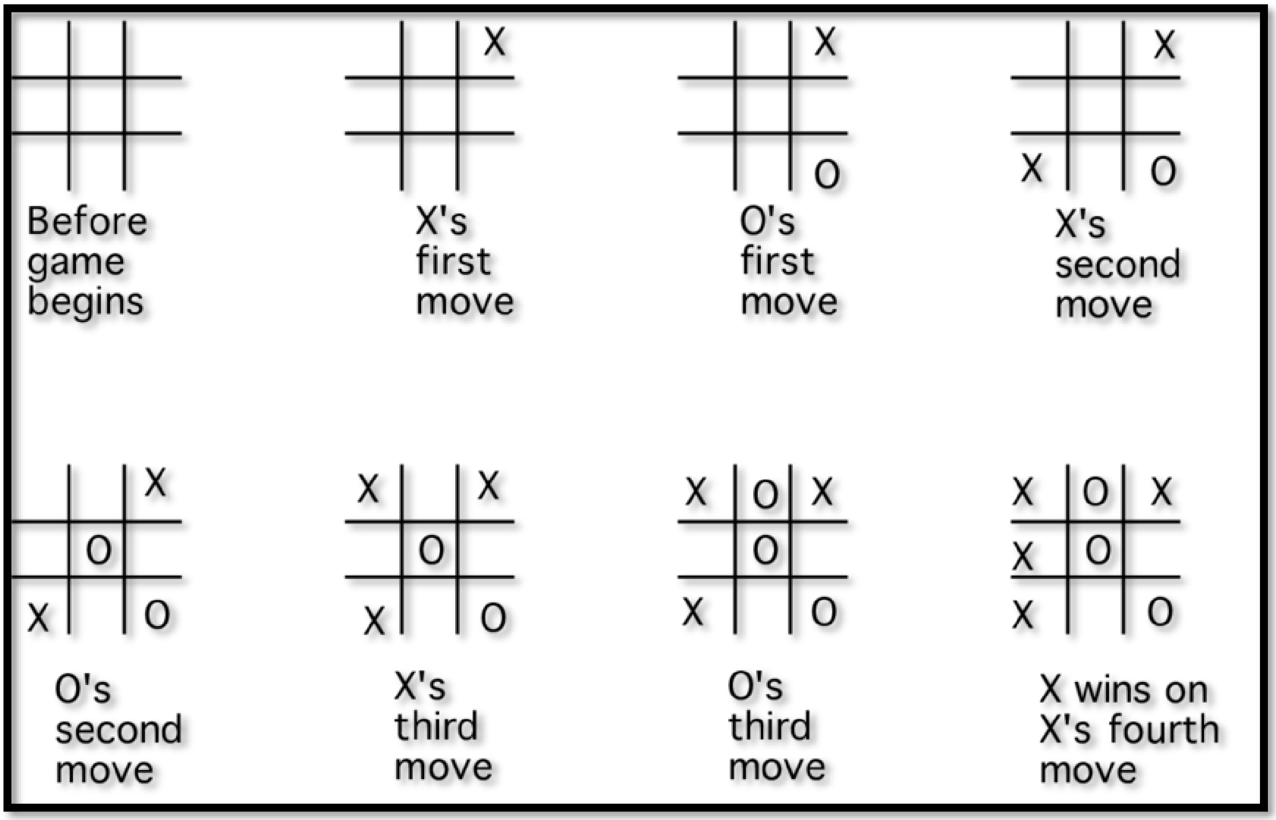
```
        #empty c into b
        if(b+c<=y):
            if( get_all_states((a, b+c, 0)) ):
                ans.append(state)
                return True
        else:
            if( get_all_states((a, y, c-(y-b))) ):
                ans.append(state)
                return True

    return False

initial_state = (12,0,0)
print("Starting work...\n")
get_all_states(initial_state)
ans.reverse()
for i in ans:
    print(i)
```

```
Python 3.7.0 Shell
File Edit Shell Debug Options Window Help
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Inte
l)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:\NITESHPD\BSCIT\TYITNEWEBOOK\AIPRAX\waterjugproblem.py =====
Starting work...

(12, 0, 0)
(4, 8, 0)
(0, 8, 4)
(8, 0, 4)
(8, 4, 0)
(3, 4, 5)
(3, 8, 1)
(11, 0, 1)
(11, 1, 0)
(6, 1, 5)
(6, 6, 0)
>>>
Ln: 18 Col: 4
```

**Aim:-**

Design the simulation of TIC – TAC –TOE game using min-max algorithm

**Diagram:-**




**Python Code:**

```
import os
import time

board = [' ',' ',' ',' ',' ',' ',' ',' ',' ',' ']
player = 1

########win Flags##########
Win = 1
Draw = -1
Running = 0
Stop = 1
############################
Game = Running
Mark = 'X'

#This Function Draws Game Board
```

```
def DrawBoard():
    print(" %c | %c | %c " % (board[1],board[2],board[3]))
    print("___|___|___")
    print(" %c | %c | %c " % (board[4],board[5],board[6]))
    print("___|___|___")
    print(" %c | %c | %c " % (board[7],board[8],board[9]))
    print("   |   |   ")

#This Function Checks position is empty or not
def CheckPosition(x):
    if(board[x] == ' '):
        return True
    else:
        return False

#This Function Checks player has won or not
def CheckWin():
    global Game
    #Horizontal winning condition
    if(board[1] == board[2] and board[2] == board[3] and board[1] != ' '):
        Game = Win
    elif(board[4] == board[5] and board[5] == board[6] and board[4] != ' '):
        Game = Win
    elif(board[7] == board[8] and board[8] == board[9] and board[7] != ' '):
        Game = Win
    #Vertical Winning Condition
    elif(board[1] == board[4] and board[4] == board[7] and board[1] != ' '):
        Game = Win
    elif(board[2] == board[5] and board[5] == board[8] and board[2] != ' '):
        Game = Win
    elif(board[3] == board[6] and board[6] == board[9] and board[3] != ' '):
        Game=Win
    #Diagonal Winning Condition
    elif(board[1] == board[5] and board[5] == board[9] and board[5] != ' '):
        Game = Win
    elif(board[3] == board[5] and board[5] == board[7] and board[5] != ' '):
        Game=Win
    #Match Tie or Draw Condition
    elif(board[1]!=' ' and board[2]!=' ' and board[3]!=' ' and board[4]!=' ' and
board[5]!=' ' and board[6]!=' ' and board[7]!=' ' and board[8]!=' ' and board[9]!=' '):
```

```
        Game=Draw
    else:
        Game=Running

print("Tic-Tac-Toe Game")
print("Player 1 [X] --- Player 2 [O]\n")
print()
print()
print("Please Wait...")
time.sleep(1)
while(Game == Running):
    os.system('cls')
    DrawBoard()
    if(player % 2 != 0):
        print("Player 1's chance")
        Mark = 'X'
    else:
        print("Player 2's chance")
        Mark = 'O'
    choice = int(input("Enter the position between [1-9] where you want to mark :
"))
    if(CheckPosition(choice)):
        board[choice] = Mark
        player+=1
        CheckWin()

os.system('cls')
DrawBoard()
if(Game==Draw):
    print("Game Draw")
elif(Game==Win):
    player-=1
    if(player%2!=0):
        print("Player 1 Won")
    else:
        print("Player 2 Won")
```

**NOTE:-**
**Game Rules**

1. Traditionally the first player plays with "X". So you can decide who wants to go with "X" and who wants go with "O".
2. Only one player can play at a time.
3. If any of the players have filled a square then the other player and the same player cannot override that square.
4. There are only two conditions that may match will be draw or may win.
5. The player that succeeds in placing three respective marks (X or O) in a horizontal, vertical or diagonal row wins the game.

## OUTPUT:-

TICTOE.py - E:/NITESHPD/BSCIT/TYITNEWEBOOK/AIPRAX/TICTOE.py (3.7.0)

File Edit Format Run Options Window Help

```
import os
import time

board = [' ',' ',' ',' ',' ',' ',' ',' ',' ',' ']
player = 1

########win Flags##########
Win = 1
Draw = -1
Running = 0
Stop = 1
###########################
Game = Running
Mark = 'X'

#This Function Draws Game Board
def DrawBoard():
    print(" %c | %c | %c " % (board[1],board[2],board[3]))
    print("___|___|___")
    print(" %c | %c | %c " % (board[4],board[5],board[6]))
    print("___|___|___")
    print(" %c | %c | %c " % (board[7],board[8],board[9]))
    print("   |   |   ")

#This Function Checks position is empty or not
def CheckPosition(x):
    if(board[x] == ' '):
        return True
    else:
        return False

#This Function Checks player has won or not
def CheckWin():
    global Game
    #Horizontal winning condition
    if(board[1] == board[2] and board[2] == board[3] and board[1] != ' '):
        Game = Win
    elif(board[4] == board[5] and board[5] == board[6] and board[4] != ' '):
        Game = Win
    elif(board[7] == board[8] and board[8] == board[9] and board[7] != ' '):
```

Ln: 33 Col: 19

TICTOE.py - E:/NITESHPD/BSCIT/TYITNEWEBOOK/AIPRAX/TICTOE.py (3.7.0)

File Edit Format Run Options Window Help

```
        Game = Win
    #Vertical Winning Condition
    elif(board[1] == board[4] and board[4] == board[7] and board[1] != ' '):
        Game = Win
    elif(board[2] == board[5] and board[5] == board[8] and board[2] != ' '):
        Game = Win
    elif(board[3] == board[6] and board[6] == board[9] and board[3] != ' '):
        Game=Win
    #Diagonal Winning Condition
    elif(board[1] == board[5] and board[5] == board[9] and board[5] != ' '):
        Game = Win
    elif(board[3] == board[5] and board[5] == board[7] and board[5] != ' '):
        Game=Win
    #Match Tie or Draw Condition
    elif(board[1]!=' ' and board[2]!=' ' and board[3]!=' ' and board[4]!=' ' and
        Game=Draw
    else:
        Game=Running

print("Tic-Tac-Toe Game")
print("Player 1 [X] --- Player 2 [O]\n")
print()
print("Please Wait...")
time.sleep(1)
while(Game == Running):
    os.system('cls')
    DrawBoard()
    if(player % 2 != 0):
        print("Player 1's chance")
        Mark = 'X'
    else:
        print("Player 2's chance")
        Mark = 'O'
    choice = int(input("Enter the position between [1-9] where you want to mark
    if(CheckPosition(choice)):
        board[choice] = Mark
        player+=1
        CheckWin()

os.system('cls')
```

Ln: 33 Col: 19

```
os.system('cls')
DrawBoard()
if(Game==Draw):
    print("Game Draw")
elif(Game==Win):
    player-=1
    if(player%2!=0):
        print("Player 1 Won")
    else:
        print("Player 2 Won")
```

Ln: 33 Col: 19

Python 3.7.0 Shell

File Edit Shell Debug Options Window Help

```
Please Wait...
    |   |
____|___|___
    |   |
____|___|___
    |   |
    |   |
Player 1's chance
Enter the position between [1-9] where you want to mark : 1
 X  |   |
____|___|___
    |   |
____|___|___
    |   |
    |   |
Player 2's chance
Enter the position between [1-9] where you want to mark : 2
 X  | O |
____|___|___
    |   |
____|___|___
    |   |
    |   |
Player 1's chance
Enter the position between [1-9] where you want to mark : 3
 X  | O | X
____|___|___
    |   |
____|___|___
    |   |
    |   |
Player 2's chance
Enter the position between [1-9] where you want to mark : 4
 X  | O | X
____|___|___
 O  |   |
____|___|___
    |   |
    |   |
Player 1's chance
```

Ln: 73 Col: 4

```
Enter the position between [1-9] where you want to mark : 5
 X | O | X
___|___|___
 O | X |
___|___|___
   |   |
   |   |
Player 2's chance
Enter the position between [1-9] where you want to mark : 6
 X | O | X
___|___|___
 O | X | O
___|___|___
   |   |
   |   |
Player 1's chance
Enter the position between [1-9] where you want to mark : 7
 X | O | X
___|___|___
 O | X | O
___|___|___
 X |   |
   |   |
Player 1 Won
>>>
```

## PRACTICAL No.-6

**A. Write a program to solve Missionaries and Cannibals problem.**
**B. Design an application to simulate number puzzle problem.**

**Aim:-**
Write a program to solve Missionaries and Cannibals problem.
**Diagram:-**

**Python Code:-**

```
import math
# Missionaries and Cannibals Problem
class State():
	def __init__(self, cannibalLeft, missionaryLeft, boat, cannibalRight,
missionaryRight):
		self.cannibalLeft = cannibalLeft
		self.missionaryLeft = missionaryLeft
		self.boat = boat
		self.cannibalRight = cannibalRight
		self.missionaryRight = missionaryRight
		self.parent = None

	def is_goal(self):
		if self.cannibalLeft == 0 and self.missionaryLeft == 0:
			return True
		else:
			return False

	def is_valid(self):
		if self.missionaryLeft >= 0 and self.missionaryRight >= 0 \
		and self.cannibalLeft >= 0 and self.cannibalRight >= 0 \
		and (self.missionaryLeft == 0 or self.missionaryLeft >=
self.cannibalLeft) \
		and (self.missionaryRight == 0 or self.missionaryRight >=
self.cannibalRight):
```

```
            return True
        else:
            return False

    def __eq__(self, other):
        return self.cannibalLeft == other.cannibalLeft and self.missionaryLeft
== other.missionaryLeft \
           and self.boat == other.boat and self.cannibalRight ==
other.cannibalRight \
           and self.missionaryRight == other.missionaryRight

    def __hash__(self):
        return hash((self.cannibalLeft, self.missionaryLeft, self.boat,
self.cannibalRight, self.missionaryRight))

def successors(cur_state):
    children = [];
    if cur_state.boat == 'left':
        new_state = State(cur_state.cannibalLeft, cur_state.missionaryLeft -
2, 'right',
                cur_state.cannibalRight, cur_state.missionaryRight + 2)
        ## Two missionaries cross left to right.
        if new_state.is_valid():
            new_state.parent = cur_state
            children.append(new_state)
        new_state = State(cur_state.cannibalLeft - 2,
cur_state.missionaryLeft, 'right',
                cur_state.cannibalRight + 2, cur_state.missionaryRight)
        ## Two cannibals cross left to right.
        if new_state.is_valid():
            new_state.parent = cur_state
            children.append(new_state)
        new_state = State(cur_state.cannibalLeft - 1, cur_state.missionaryLeft
- 1, 'right',
                cur_state.cannibalRight + 1, cur_state.missionaryRight + 1)
        ## One missionary and one cannibal cross left to right.
        if new_state.is_valid():
            new_state.parent = cur_state
            children.append(new_state)
```

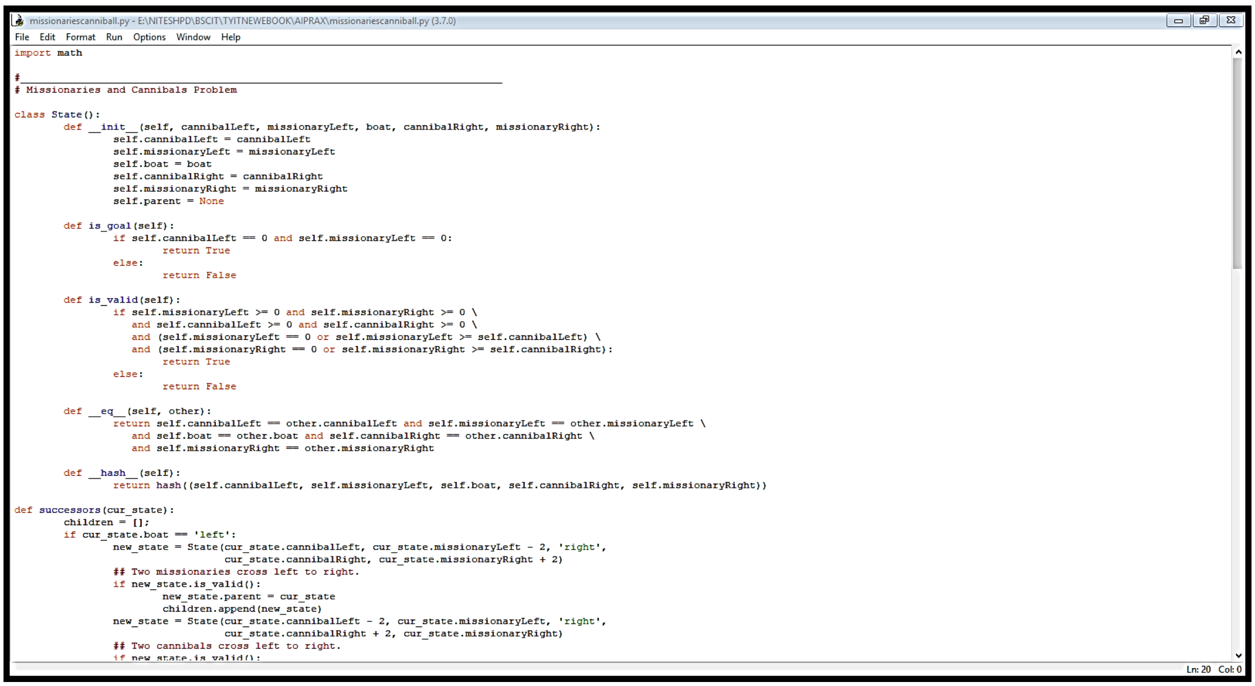
```
            new_state = State(cur_state.cannibalLeft, cur_state.missionaryLeft -
1, 'right',
                              cur_state.cannibalRight, cur_state.missionaryRight + 1)
            ## One missionary crosses left to right.
            if new_state.is_valid():
                new_state.parent = cur_state
                children.append(new_state)
            new_state = State(cur_state.cannibalLeft - 1,
cur_state.missionaryLeft, 'right',
                              cur_state.cannibalRight + 1, cur_state.missionaryRight)
            ## One cannibal crosses left to right.
            if new_state.is_valid():
                new_state.parent = cur_state
                children.append(new_state)
        else:
            new_state = State(cur_state.cannibalLeft, cur_state.missionaryLeft +
2, 'left',
                              cur_state.cannibalRight, cur_state.missionaryRight - 2)
            ## Two missionaries cross right to left.
            if new_state.is_valid():
                new_state.parent = cur_state
                children.append(new_state)
            new_state = State(cur_state.cannibalLeft + 2,
cur_state.missionaryLeft, 'left',
                              cur_state.cannibalRight - 2, cur_state.missionaryRight)
            ## Two cannibals cross right to left.
            if new_state.is_valid():
                new_state.parent = cur_state
                children.append(new_state)
            new_state = State(cur_state.cannibalLeft + 1, cur_state.missionaryLeft
+ 1, 'left',
                              cur_state.cannibalRight - 1, cur_state.missionaryRight - 1)
            ## One missionary and one cannibal cross right to left.
            if new_state.is_valid():
                new_state.parent = cur_state
                children.append(new_state)
            new_state = State(cur_state.cannibalLeft, cur_state.missionaryLeft +
1, 'left',
                              cur_state.cannibalRight, cur_state.missionaryRight - 1)
            ## One missionary crosses right to left.
```

```
        if new_state.is_valid():
            new_state.parent = cur_state
            children.append(new_state)
        new_state = State(cur_state.cannibalLeft + 1,
cur_state.missionaryLeft, 'left',
             cur_state.cannibalRight - 1, cur_state.missionaryRight)
        ## One cannibal crosses right to left.
        if new_state.is_valid():
            new_state.parent = cur_state
            children.append(new_state)
    return children

def breadth_first_search():
    initial_state = State(3,3,'left',0,0)
    if initial_state.is_goal():
        return initial_state
    frontier = list()
    explored = set()
    frontier.append(initial_state)
    while frontier:
        state = frontier.pop(0)
        if state.is_goal():
            return state
        explored.add(state)
        children = successors(state)
        for child in children:
            if (child not in explored) or (child not in frontier):
                frontier.append(child)
    return None

def print_solution(solution):
        path = []
        path.append(solution)
        parent = solution.parent
        while parent:
            path.append(parent)
            parent = parent.parent

        for t in range(len(path)):
            state = path[len(path) - t - 1]
```

```
                print ("(" + str(state.cannibalLeft) + "," + str(state.missionaryLeft) \
                       + "," + state.boat + "," + str(state.cannibalRight) + "," + \
                       str(state.missionaryRight) + ")")

def main():
        solution = breadth_first_search()
        print ("Missionaries and Cannibals solution:")
        print ("(cannibalLeft,missionaryLeft,boat,cannibalRight,missionaryRight)")
        print_solution(solution)
```

**# if called from the command line, call main()**

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


missionariescanniball.py - E:\NITESHPD\BSCIT\TYITNEWEBOOK\AIPRAX\missionariescanniball.py (3.7.0)

File Edit Format Run Options Window Help

```
import math

#__________________________________________________________________
# Missionaries and Cannibals Problem

class State():
        def __init__(self, cannibalLeft, missionaryLeft, boat, cannibalRight, missionaryRight):
                self.cannibalLeft = cannibalLeft
                self.missionaryLeft = missionaryLeft
                self.boat = boat
                self.cannibalRight = cannibalRight
                self.missionaryRight = missionaryRight
                self.parent = None

        def is_goal(self):
                if self.cannibalLeft == 0 and self.missionaryLeft == 0:
                        return True
                else:
                        return False

        def is_valid(self):
                if self.missionaryLeft >= 0 and self.missionaryRight >= 0 \
                   and self.cannibalLeft >= 0 and self.cannibalRight >= 0 \
                   and (self.missionaryLeft == 0 or self.missionaryLeft >= self.cannibalLeft) \
                   and (self.missionaryRight == 0 or self.missionaryRight >= self.cannibalRight):
                        return True
                else:
                        return False

        def __eq__(self, other):
                return self.cannibalLeft == other.cannibalLeft and self.missionaryLeft == other.missionaryLeft \
                   and self.boat == other.boat and self.cannibalRight == other.cannibalRight \
                   and self.missionaryRight == other.missionaryRight

        def __hash__(self):
                return hash((self.cannibalLeft, self.missionaryLeft, self.boat, self.cannibalRight, self.missionaryRight))

def successors(cur_state):
        children = [];
        if cur_state.boat == 'left':
                new_state = State(cur_state.cannibalLeft, cur_state.missionaryLeft - 2, 'right',
                                  cur_state.cannibalRight, cur_state.missionaryRight + 2)
                ## Two missionaries cross left to right.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
                new_state = State(cur_state.cannibalLeft - 2, cur_state.missionaryLeft, 'right',
                                  cur_state.cannibalRight + 2, cur_state.missionaryRight)
                ## Two cannibals cross left to right.
                if new_state.is_valid():
```

Ln: 20 Col: 0

missionariescanniball.py - E:\NITESHPD\BSCIT\TYITNEWEBOOK\AIPRAX\missionariescanniball.py (3.7.0)

File Edit Format Run Options Window Help

```
                ## Two cannibals cross left to right.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
                new_state = State(cur_state.cannibalLeft - 1, cur_state.missionaryLeft - 1, 'right',
                                  cur_state.cannibalRight + 1, cur_state.missionaryRight + 1)
                ## One missionary and one cannibal cross left to right.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
                new_state = State(cur_state.cannibalLeft, cur_state.missionaryLeft - 1, 'right',
                                  cur_state.cannibalRight, cur_state.missionaryRight + 1)
                ## One missionary crosses left to right.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
                new_state = State(cur_state.cannibalLeft - 1, cur_state.missionaryLeft, 'right',
                                  cur_state.cannibalRight + 1, cur_state.missionaryRight)
                ## One cannibal crosses left to right.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
        else:
                new_state = State(cur_state.cannibalLeft, cur_state.missionaryLeft + 2, 'left',
                                  cur_state.cannibalRight, cur_state.missionaryRight - 2)
                ## Two missionaries cross right to left.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
                new_state = State(cur_state.cannibalLeft + 2, cur_state.missionaryLeft, 'left',
                                  cur_state.cannibalRight - 2, cur_state.missionaryRight)
                ## Two cannibals cross right to left.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
                new_state = State(cur_state.cannibalLeft + 1, cur_state.missionaryLeft + 1, 'left',
                                  cur_state.cannibalRight - 1, cur_state.missionaryRight - 1)
                ## One missionary and one cannibal cross right to left.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
                new_state = State(cur_state.cannibalLeft, cur_state.missionaryLeft + 1, 'left',
                                  cur_state.cannibalRight, cur_state.missionaryRight - 1)
                ## One missionary crosses right to left.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
                new_state = State(cur_state.cannibalLeft + 1, cur_state.missionaryLeft, 'left',
                                  cur_state.cannibalRight - 1, cur_state.missionaryRight)
                ## One cannibal crosses right to left.
```

Ln: 20 Col: 0

missionariescanniball.py - E:\NITESHPD\BSCIT\TYITNEWEBOOK\AIPRAX\missionariescanniball.py (3.7.0)

File Edit Format Run Options Window Help

```
                new_state = State(cur_state.cannibalLeft + 1, cur_state.missionaryLeft, 'left',
                                  cur_state.cannibalRight - 1, cur_state.missionaryRight)
                ## One cannibal crosses right to left.
                if new_state.is_valid():
                        new_state.parent = cur_state
                        children.append(new_state)
        return children

def breadth_first_search():
        initial_state = State(3,3,'left',0,0)
        if initial_state.is_goal():
                return initial_state
        frontier = list()
        explored = set()
        frontier.append(initial_state)
        while frontier:
                state = frontier.pop(0)
                if state.is_goal():
                        return state
                explored.add(state)
                children = successors(state)
                for child in children:
                        if (child not in explored) or (child not in frontier):
                                frontier.append(child)
        return None

def print_solution(solution):
                path = []
                path.append(solution)
                parent = solution.parent
                while parent:
                        path.append(parent)
                        parent = parent.parent

                for t in range(len(path)):
                        state = path[len(path) - t - 1]
                        print ("(" + str(state.cannibalLeft) + "," + str(state.missionaryLeft) \
                              + "," + state.boat + "," + str(state.cannibalRight) + "," + \
                              str(state.missionaryRight) + ")")

def main():
        solution = breadth_first_search()
        print ("Missionaries and Cannibals solution:")
        print ("(cannibalLeft,missionaryLeft,boat,cannibalRight,missionaryRight)")
        print_solution(solution)

# if called from the command line, call main()
if __name__ == "__main__":
    main()
```

Ln: 20 Col: 0

```
Python 3.7.0 Shell
File  Edit  Shell  Debug  Options  Window  Help
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Inte
l)] on win32
Type "copyright", "credits" or "license()" for more information.
>>> 
== RESTART: E:\NITESHPD\BSCIT\TYITNEWEBOOK\AIPRAX\missionariescanniball.py ==
Missionaries and Cannibals solution:
(cannibalLeft,missionaryLeft,boat,cannibalRight,missionaryRight)
(3,3,left,0,0)
(1,3,right,2,0)
(2,3,left,1,0)
(0,3,right,3,0)
(1,3,left,2,0)
(1,1,right,2,2)
(2,2,left,1,1)
(2,0,right,1,3)
(3,0,left,0,3)
(1,0,right,2,3)
(1,1,left,2,2)
(0,0,right,3,3)
>>> 
Ln: 18  Col: 0
```

**AIM:-**

Design an application to simulate number puzzle problem.

**PYHTON CODE:-**

```
'''
8 puzzle problem, a smaller version of the fifteen puzzle:
States are defined as string representations of the pieces on the puzzle.
Actions denote what piece will be moved to the empty space.
States must allways be inmutable. We will use strings, but internally most of
the time we will convert those strings to lists, which are easier to handle.
For example, the state (string):
'1-2-3
 4-5-6
 7-8-e'
will become (in lists):
[['1', '2', '3'],
 ['4', '5', '6'],
 ['7', '8', 'e']]

'''

from __future__ import print_function
from simpleai.search import astar, SearchProblem
from simpleai.search.viewers import WebViewer

GOAL = '''1-2-3
4-5-6
7-8-e'''

INITIAL = '''4-1-2
7-e-3
8-5-6'''



def list_to_string(list_):
    return '\n'.join(['-'.join(row) for row in list_])


def string_to_list(string_):
    return [row.split('-') for row in string_.split('\n')]
```

```
def find_location(rows, element_to_find):
    '''Find the location of a piece in the puzzle.
       Returns a tuple: row, column'''
    for ir, row in enumerate(rows):
        for ic, element in enumerate(row):
            if element == element_to_find:
                return ir, ic


# we create a cache for the goal position of each piece, so we don't have to
# recalculate them every time
goal_positions = {}
rows_goal = string_to_list(GOAL)
for number in '12345678e':
    goal_positions[number] = find_location(rows_goal, number)


class EigthPuzzleProblem(SearchProblem):
    def actions(self, state):
        '''Returns a list of the pieces we can move to the empty space.'''
        rows = string_to_list(state)
        row_e, col_e = find_location(rows, 'e')

        actions = []
        if row_e > 0:
            actions.append(rows[row_e - 1][col_e])
        if row_e < 2:
            actions.append(rows[row_e + 1][col_e])
        if col_e > 0:
            actions.append(rows[row_e][col_e - 1])
        if col_e < 2:
            actions.append(rows[row_e][col_e + 1])

        return actions

    def result(self, state, action):
        '''Return the resulting state after moving a piece to the empty space.
          (the "action" parameter contains the piece to move)
        '''
```

```
        rows = string_to_list(state)
        row_e, col_e = find_location(rows, 'e')
        row_n, col_n = find_location(rows, action)

        rows[row_e][col_e], rows[row_n][col_n] = rows[row_n][col_n],
rows[row_e][col_e]

        return list_to_string(rows)

    def is_goal(self, state):
        '''Returns true if a state is the goal state.'''
        return state == GOAL

    def cost(self, state1, action, state2):
        '''Returns the cost of performing an action. No useful on this problem, i
          but needed.
        '''
        return 1

    def heuristic(self, state):
        '''Returns an *estimation* of the distance from a state to the goal.
          We are using the manhattan distance.
        '''
        rows = string_to_list(state)
        distance = 0
        for number in '12345678e':
            row_n, col_n = find_location(rows, number)
            row_n_goal, col_n_goal = goal_positions[number]
            distance += abs(row_n - row_n_goal) + abs(col_n - col_n_goal)
        return distance
result = astar(EigthPuzzleProblem(INITIAL))
for action, state in result.path():
    print('Move number', action)
    print(state)
```

**OUTPUT:**

*eight_puzzle.py - E:\NITESHPD\BSCIT\TYITNEWEBOOK\JAVAEE\simpleai-master\simpleai-m...

File Edit Format Run Options Window Help

```python
'''
8 puzzle problem, a smaller version of the fifteen puzzle:
States are defined as string representations of the pieces on the puzzle.
Actions denote what piece will be moved to the empty space.
States must allways be inmutable. We will use strings, but internally most of
the time we will convert those strings to lists, which are easier to handle.
For example, the state (string):
'1-2-3
 4-5-6
 7-8-e'
will become (in lists):
[['1', '2', '3'],
 ['4', '5', '6'],
 ['7', '8', 'e']]
'''

from __future__ import print_function
from simpleai.search import astar, SearchProblem
from simpleai.search.viewers import WebViewer

GOAL = '''1-2-3
4-5-6
7-8-e'''

INITIAL = '''4-1-2
7-e-3
8-5-6'''

def list_to_string(list_):
    return '\n'.join(['-'.join(row) for row in list_])
def string_to_list(string_):
    return [row.split('-') for row in string_.split('\n')]
def find_location(rows, element_to_find):
    '''Find the location of a piece in the puzzle.
       Returns a tuple: row, column'''
    for ir, row in enumerate(rows):
        for ic, element in enumerate(row):
            if element == element_to_find:
                return ir, ic
# we create a cache for the goal position of each piece, so we don't have to
```

Ln: 92 Col: 65

*eight_puzzle.py - E:\NITESHPD\BSCIT\TYITNEWEBOOK\JAVAEE\simpleai-master\simpleai-master\sa...

File Edit Format Run Options Window Help

```python
# recalculate them every time
goal_positions = {}
rows_goal = string_to_list(GOAL)
for number in '12345678e':
    goal_positions[number] = find_location(rows_goal, number)
class EigthPuzzleProblem(SearchProblem):
    def actions(self, state):
        '''Returns a list of the pieces we can move to the empty space.'''
        rows = string_to_list(state)
        row_e, col_e = find_location(rows, 'e')

        actions = []
        if row_e > 0:
            actions.append(rows[row_e - 1][col_e])
        if row_e < 2:
            actions.append(rows[row_e + 1][col_e])
        if col_e > 0:
            actions.append(rows[row_e][col_e - 1])
        if col_e < 2:
            actions.append(rows[row_e][col_e + 1])
        return actions
    def result(self, state, action):
        '''Return the resulting state after moving a piece to the empty space.
           (the "action" parameter contains the piece to move)
        '''
        rows = string_to_list(state)
        row_e, col_e = find_location(rows, 'e')
        row_n, col_n = find_location(rows, action)
        rows[row_e][col_e], rows[row_n][col_n] = rows[row_n][col_n], rows[row_e]
        return list_to_string(rows)
    def is_goal(self, state):
        '''Returns true if a state is the goal state.'''
        return state == GOAL
    def cost(self, state1, action, state2):
        '''Returns the cost of performing an action. No useful on this problem,
           but needed.
        '''
        return 1
    def heuristic(self, state):
        '''Returns an *estimation* of the distance from a state to the goal.
```

Ln: 92 Col: 65

```
        '''Returns an *estimation* of the distance from a state to the goal.
           We are using the manhattan distance.
        '''
        rows = string_to_list(state)
        distance = 0
        for number in '12345678e':
            row_n, col_n = find_location(rows, number)
            row_n_goal, col_n_goal = goal_positions[number]
            distance += abs(row_n - row_n_goal) + abs(col_n - col_n_goal)
        return distance
result = astar(EigthPuzzleProblem(INITIAL))
# if you want to use the visual debugger, use this instead:
# result = astar(EigthPuzzleProblem(INITIAL), viewer=WebViewer())
for action, state in result.path():
    print('Move number', action)
    print(state)
```

Ln: 92 Col: 65

Python 3.7.0 Shell

File Edit Shell Debug Options Window Help

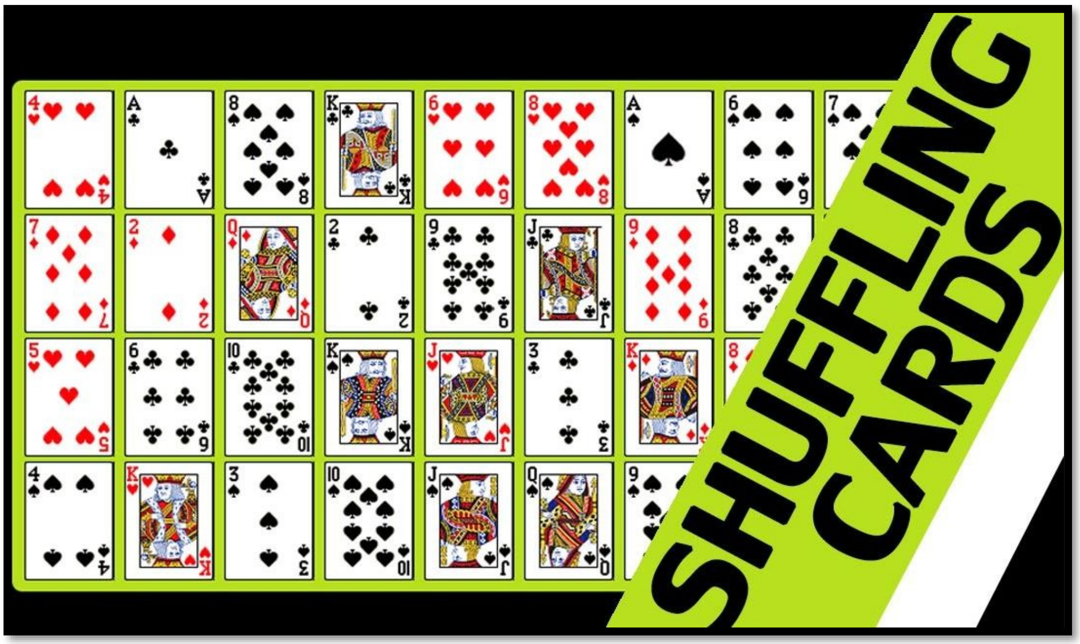
```
>>>
 RESTART: E:\NITESHPD\BSCIT\TYITNEWEBOOK\JAVAEE\simpleai-master\simpleai-master\
samples\search\eight_puzzle.py
Move number None
4-1-2
7-e-3
8-5-6
Move number 5
4-1-2
7-5-3
8-e-6
Move number 8
4-1-2
7-5-3
e-8-6
Move number 7
4-1-2
e-5-3
7-8-6
Move number 4
e-1-2
4-5-3
7-8-6
Move number 1
1-e-2
4-5-3
7-8-6
Move number 2
1-2-e
4-5-3
7-8-6
Move number 3
1-2-3
4-5-e
7-8-6
Move number 6
1-2-3
4-5-6
7-8-e
>>>
```

Ln: 41 Col: 4

## PRACTICAL No.-7

**A. Write a program to shuffle Deck of cards.**
**B. Solve traveling salesman problem using artificial intelligence technique.**

**Aim:-**
Write a program to shuffle Deck of cards.
**Diagram:-**




**Python Code:-**

```
#first let's import random procedures since we will be shuffling
import random

#next, let's start building list holders so we can place our cards in there:
cardfaces = []
suits = ["Hearts", "Diamonds", "Clubs", "Spades"]
royals = ["J", "Q", "K", "A"]
deck = []

#now, let's start using loops to add our content:
for i in range(2,11):
   cardfaces.append(str(i)) #this adds numbers 2-10 and converts them to string
data

for j in range(4):
```

```
    cardfaces.append(royals[j]) #this will add the royal faces to the cardbase

for k in range(4):
    for l in range(13):
        card = (cardfaces[l] + " of " + suits[k])
        #this makes each card, cycling through suits, but first through faces
        deck.append(card)
        #this adds the information to the "full deck" we want to make
#now let's shuffle our deck!
random.shuffle(deck)

#now let's see the cards!
for m in range(52):
    print(deck[m])
```

**OR**

```
# Python program to shuffle a deck of card using the module random and
draw 5 cards
# import modules
import itertools, random
# make a deck of cards
deck = list(itertools.product(range(1,14),['Spade','Heart','Diamond','Club']))
# shuffle the cards
random.shuffle(deck)
# draw five cards
print("You got:")
for i in range(5):
   print(deck[i][0], "of", deck[i][1])
```

**Output:-**

suffledeckcard.py - E:/NITESHPD/BSCIT/AIPRAX/suffledeckcard.py (3.7.0)

```
# Python program to shuffle a deck of card using the module random and draw 5 ca

# import modules
import itertools, random

# make a deck of cards
deck = list(itertools.product(range(1,14),['Spade','Heart','Diamond','Club']))

# shuffle the cards
random.shuffle(deck)

# draw five cards
print("You got:")
for i in range(5):
   print(deck[i][0], "of", deck[i][1])
```

suffledeckcards2.py - E:/NITESHPD/BSCIT/AIPRAX/suffledeckcards2.py (3.7.0)

```
#first let's import random procedures since we will be shuffling
import random

#next, let's start building list holders so we can place our cards in there:
cardfaces = []
suits = ["Hearts", "Diamonds", "Clubs", "Spades"]
royals = ["J", "Q", "K", "A"]
deck = []

#now, let's start using loops to add our content:
for i in range(2,11):
    cardfaces.append(str(i)) #this adds numbers 2-10 and converts them to string

for j in range(4):
    cardfaces.append(royals[j]) #this will add the royal faces to the cardbase

for k in range(4):
    for l in range(13):
        card = (cardfaces[l] + " of " + suits[k])
        #this makes each card, cycling through suits, but first through faces
        deck.append(card)
        #this adds the information to the "full deck" we want to make
#now let's shuffle our deck!
random.shuffle(deck)

#now let's see the cards!
for m in range(52):
    print(deck[m])
```

```
Python 3.7.0 Shell
File Edit Shell Debug Options Window Help
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Inte
l)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
=========== RESTART: E:/NITESHPD/BSCIT/AIPRAX/suffledeckcards2.py ===========
3 of Spades
6 of Diamonds
10 of Clubs
8 of Diamonds
J of Spades
10 of Diamonds
9 of Spades
Q of Hearts
6 of Clubs
A of Spades
Q of Diamonds
K of Spades
J of Clubs
K of Diamonds
A of Diamonds
4 of Diamonds
9 of Hearts
Q of Spades
6 of Spades
5 of Spades
8 of Spades
4 of Hearts
3 of Clubs
5 of Clubs
4 of Spades
2 of Spades
3 of Diamonds
7 of Spades
7 of Clubs
9 of Clubs
8 of Hearts
10 of Spades
5 of Hearts
A of Clubs
J of Hearts
Ln: 25 Col: 11
```

**OR**

```
Python 3.7.0 Shell
File Edit Shell Debug Options Window Help
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Inte
l)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
============ RESTART: E:/NITESHPD/BSCIT/AIPRAX/suffledeckcard.py ============
You got:
7 of Club
6 of Club
1 of Spade
2 of Spade
6 of Heart
>>>
```

## PRACTICAL No.-8

A. **Solve the block of World problem.**
B. **Solve constraint satisfaction problem**

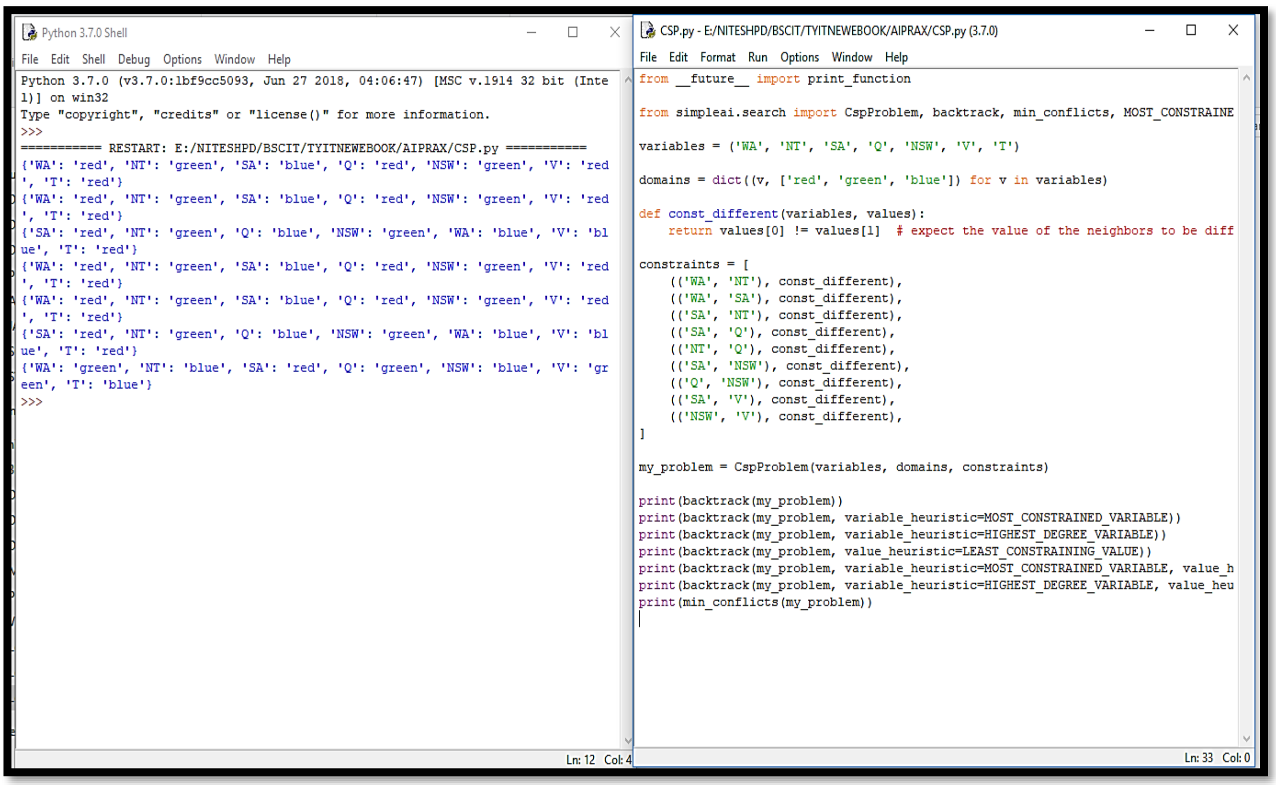
**Aim:-**
Implementation Of Constraints Satisfactions Problem

**PYTHON CODE:**

```
from __future__ import print_function

from simpleai.search import CspProblem, backtrack, min_conflicts,
MOST_CONSTRAINED_VARIABLE, HIGHEST_DEGREE_VARIABLE,
LEAST_CONSTRAINING_VALUE

variables = ('WA', 'NT', 'SA', 'Q', 'NSW', 'V', 'T')

domains = dict((v, ['red', 'green', 'blue']) for v in variables)

def const_different(variables, values):
    return values[0] != values[1]  # expect the value of the neighbors to be different

constraints = [
    (('WA', 'NT'), const_different),
    (('WA', 'SA'), const_different),
    (('SA', 'NT'), const_different),
    (('SA', 'Q'), const_different),
    (('NT', 'Q'), const_different),
    (('SA', 'NSW'), const_different),
    (('Q', 'NSW'), const_different),
    (('SA', 'V'), const_different),
    (('NSW', 'V'), const_different),
]

my_problem = CspProblem(variables, domains, constraints)

print(backtrack(my_problem))
print(backtrack(my_problem,
variable_heuristic=MOST_CONSTRAINED_VARIABLE))
print(backtrack(my_problem,
variable_heuristic=HIGHEST_DEGREE_VARIABLE))
```

print(backtrack(my_problem,
value_heuristic=LEAST_CONSTRAINING_VALUE))
print(backtrack(my_problem,
variable_heuristic=MOST_CONSTRAINED_VARIABLE,
value_heuristic=LEAST_CONSTRAINING_VALUE))
print(backtrack(my_problem,
variable_heuristic=HIGHEST_DEGREE_VARIABLE,
value_heuristic=LEAST_CONSTRAINING_VALUE))
print(min_conflicts(my_problem))

## OUTPUT:-




## Note:

Following practical will be update soon:

- Practical No-4-B
- Practical No.-8-A
- Practical No-9
- Practical No.10.