

UNIVERSITY OF MUMBAI



Teacher's Reference Manual

Subject: Artificial Intelligence

with effect from the academic year
2018 – 2019

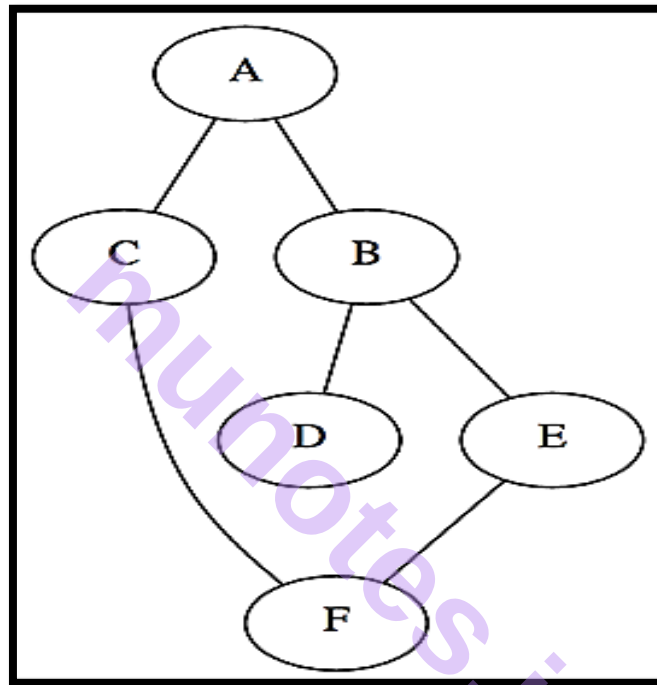
PRACTICAL NO-1

- 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.

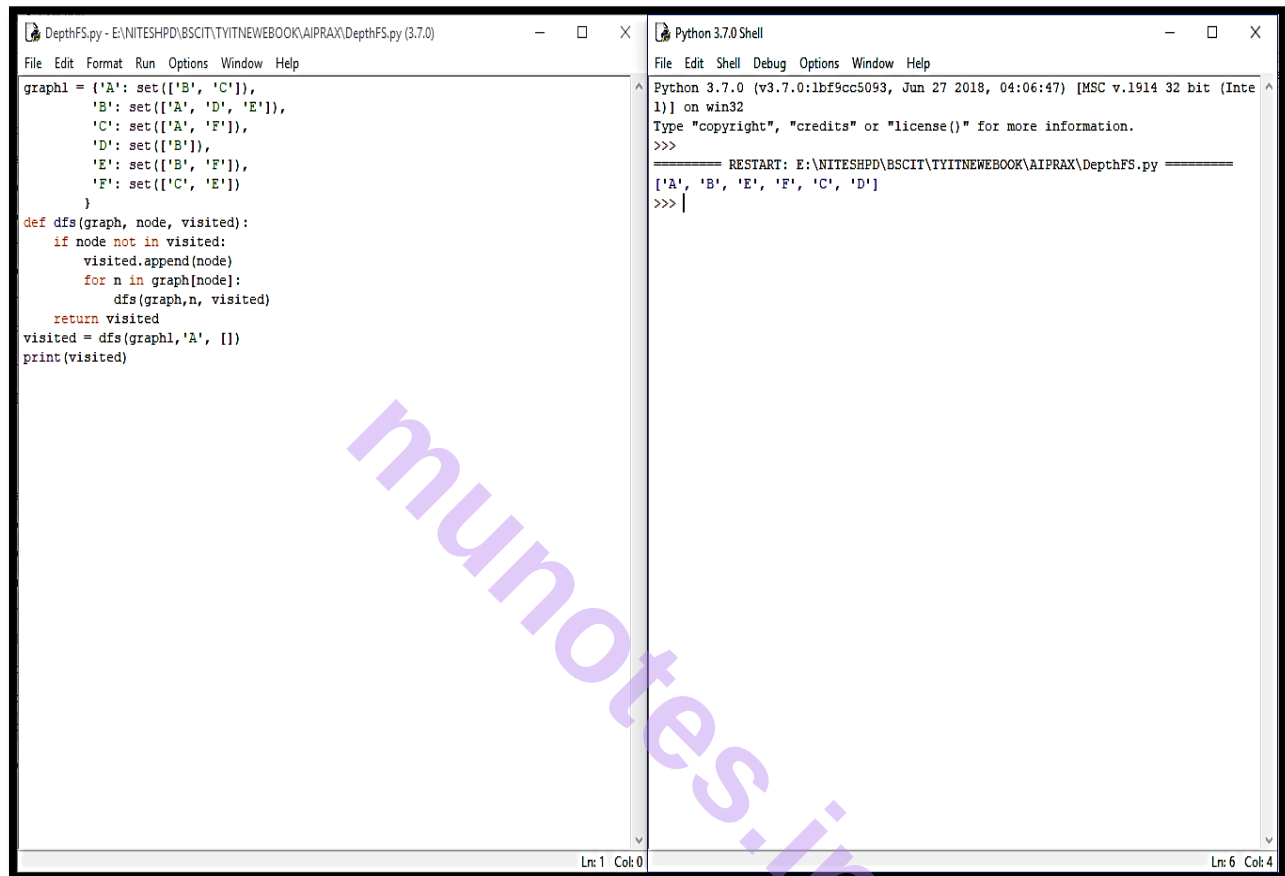
GRAPH:-



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)
```

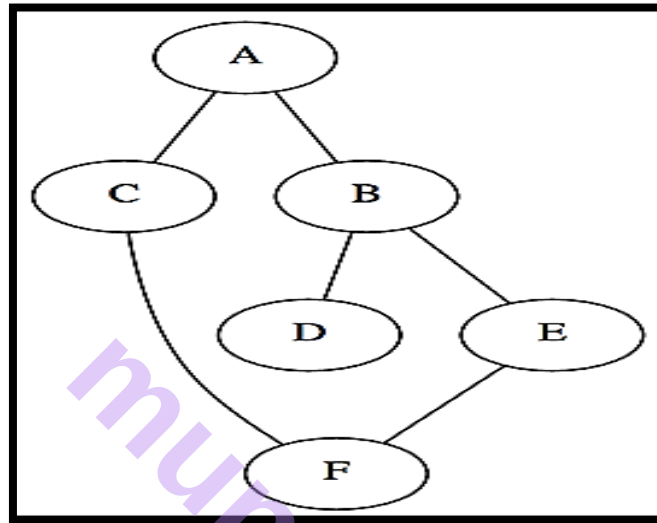
OUTPUT:-

```
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)
```

```
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:\NITESHPD\BSCIT\TYITNEWBOOK\AI\PRAX\DepthFS.py =====
['A', 'B', 'E', 'F', 'C', 'D']
>>> |
```

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:
```

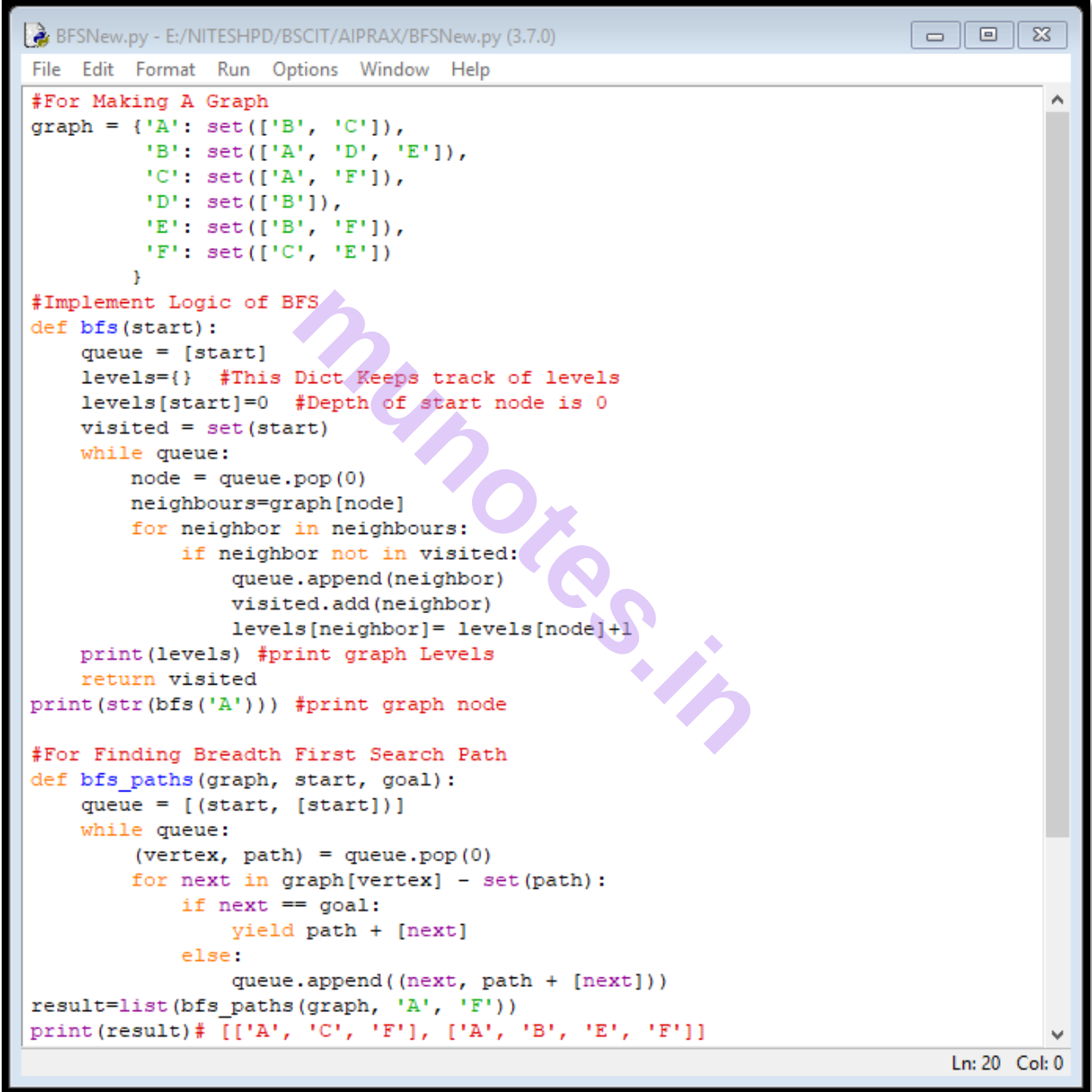
```
        if neighbor not in visited:
            queue.append(neighbor)
            visited.add(neighbor)
            levels[neighbor]= levels[node]+1
    print(levels) #print graph level
    return visited
print(str(bfs('A')) #print graph node
```

#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:-A screenshot of a Python IDE window titled 'BFSNew.py - E:/NITESHDPD/BSCIT/AIPRAX/BFSNew.py (3.7.0)'. The window contains Python code for a Breadth-First Search (BFS) algorithm. The code defines a graph, a BFS function, and a function to find the search path. The output of the code is printed at the bottom of the window.

```
#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'])
        }

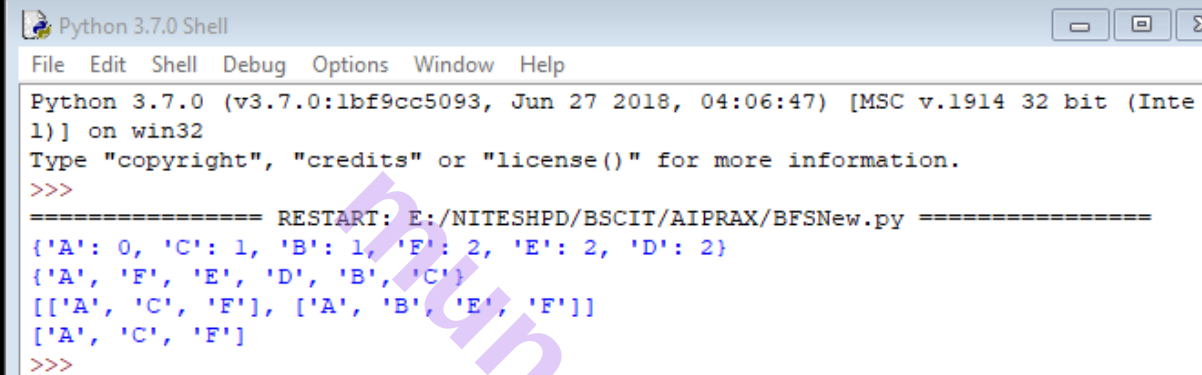
#Implement Logic of BFS
def bfs(start):
    queue = [start]
    levels={} #This Dict Keeps track of levels
    levels[start]=0 #Depth of start node is 0
    visited = set(start)
    while queue:
        node = queue.pop(0)
        neighbours=graph[node]
        for neighbor in neighbours:
            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

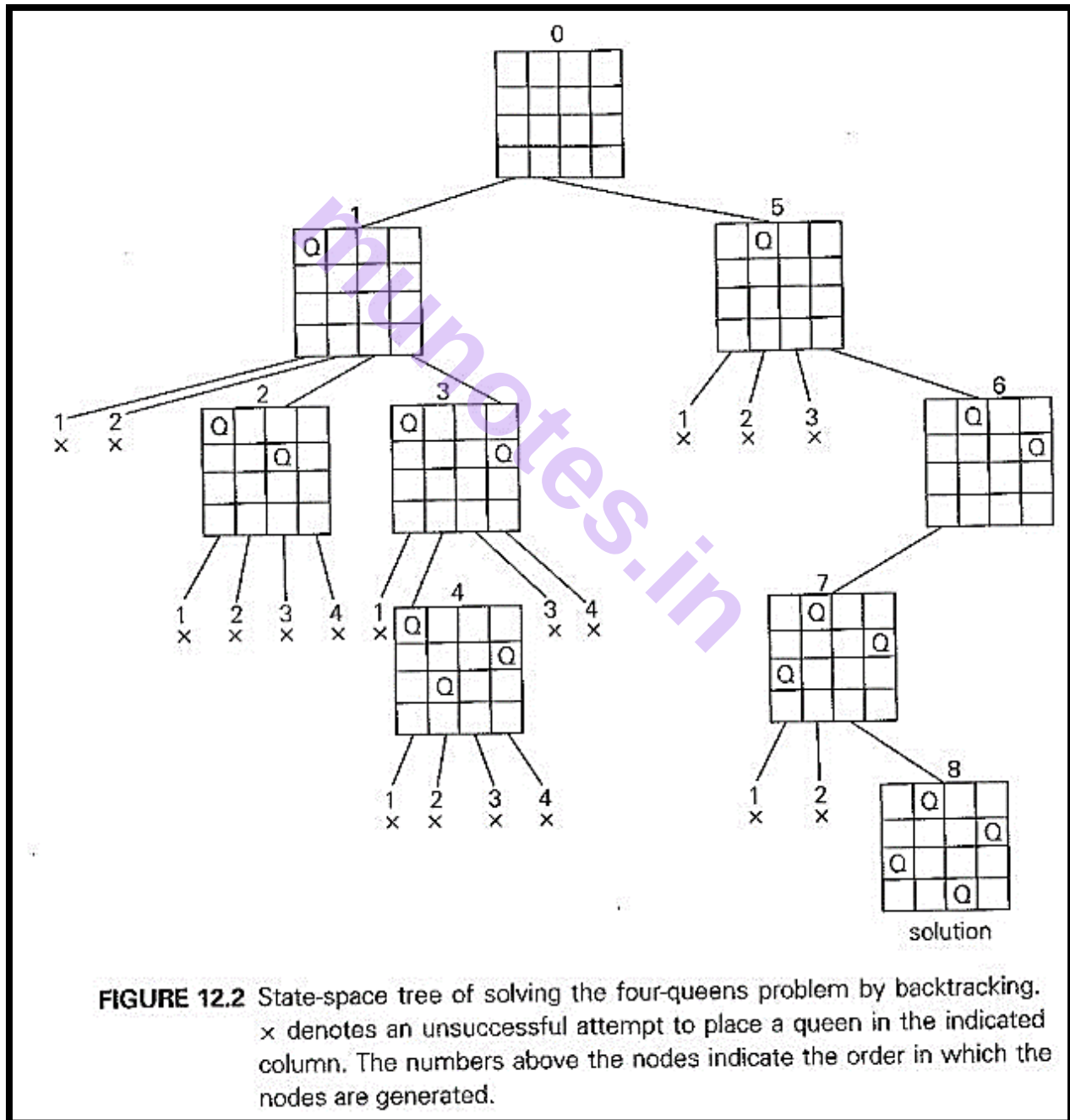
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:/NITESHDPD/BSCIT/AIPRAX/BFSNew.py =====
{'A': 0, 'C': 1, 'B': 1, 'F': 2, 'E': 2, 'D': 2}
{'A', 'F', 'E', 'D', 'B', 'C'}
[['A',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

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:
```

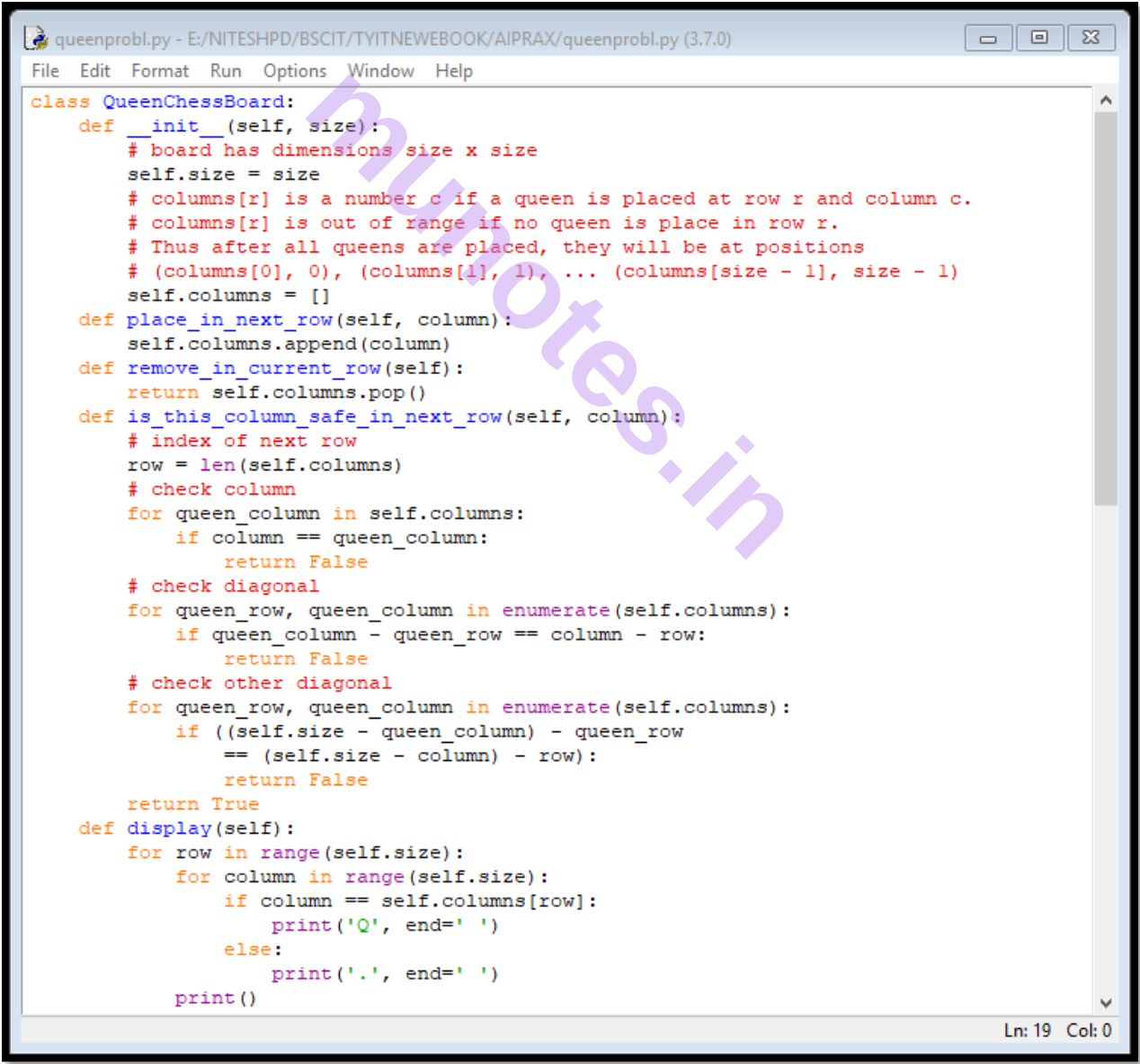
```
    prev_column = board.remove_in_current_row()
```

```
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:-

A screenshot of a Python IDE window titled 'queenprobl.py - E:/NITESHDPD/BSCIT/TYITNEWBOOK/AIPRAX/queenprobl.py (3.7.0)'. The window contains a Python class named 'QueenChessBoard' with several methods. The methods include: 'init' for setting board size and columns; 'place_in_next_row' for adding a column; 'remove_in_current_row' for removing a column; 'is_this_column_safe_in_next_row' for checking if a column is safe in the next row; and 'display' for printing the board state. The code uses comments to explain the logic. A large 'munotes.in' watermark is visible diagonally across the code. The status bar at the bottom right shows 'Ln: 19 Col: 0'.

```
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()
```

```

queenprobl.py - E:/NITESHDPD/BSCIT/TYITNEWBOOK/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

```

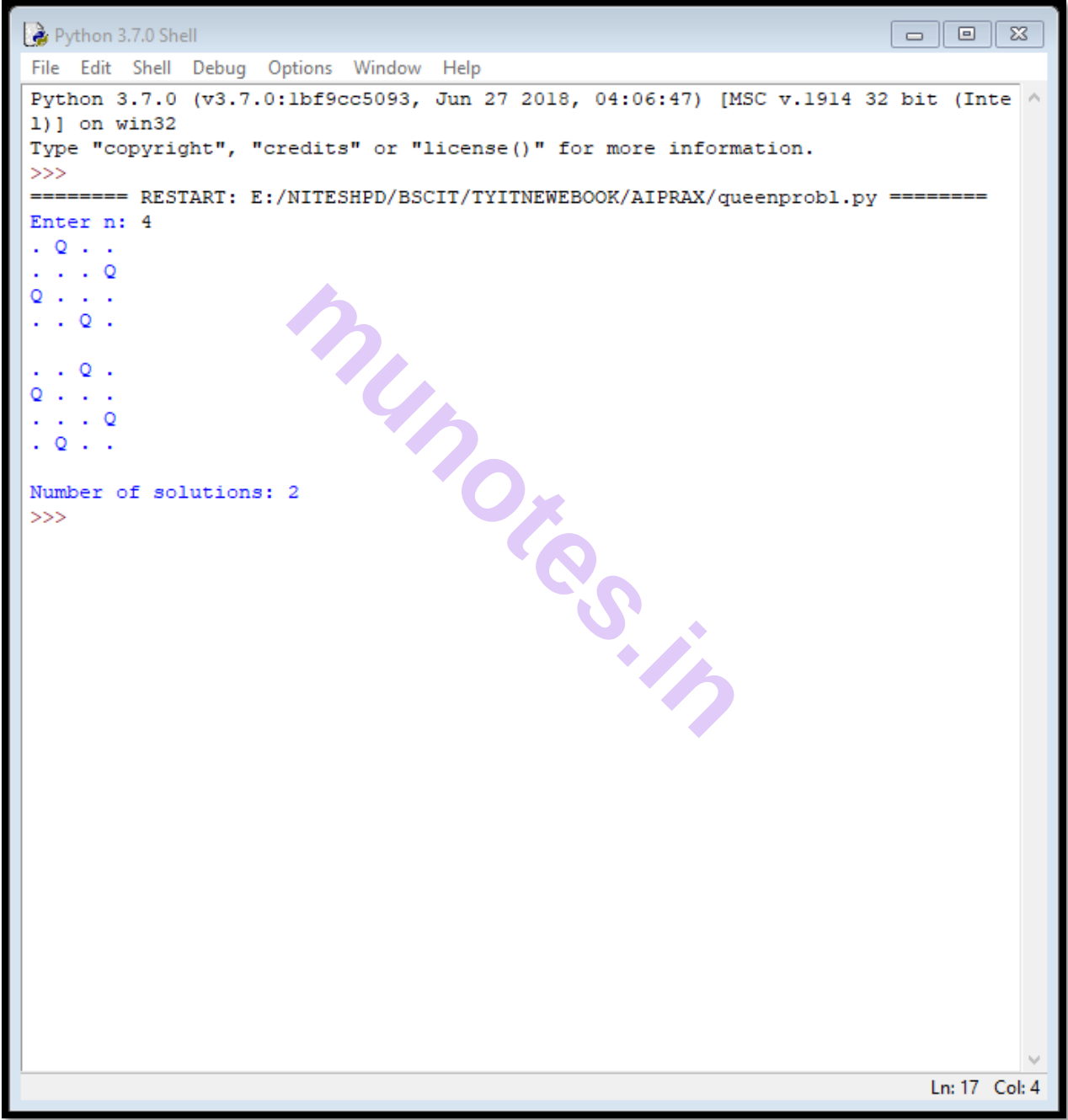
        # now backtrack
        try:
            prev_column = board.remove_in_current_row()
        except IndexError:
            # all queens removed
            # thus no more possible configurations
            break
        # try previous row again
        row -= 1
        # start checking at column = (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 (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:/NITESHDPD/BSCIT/TYITNEWEBOOK/AIPRAX/queenprobl.py =====
Enter n: 4
. Q . .
. . . Q
Q . . .
. . Q .

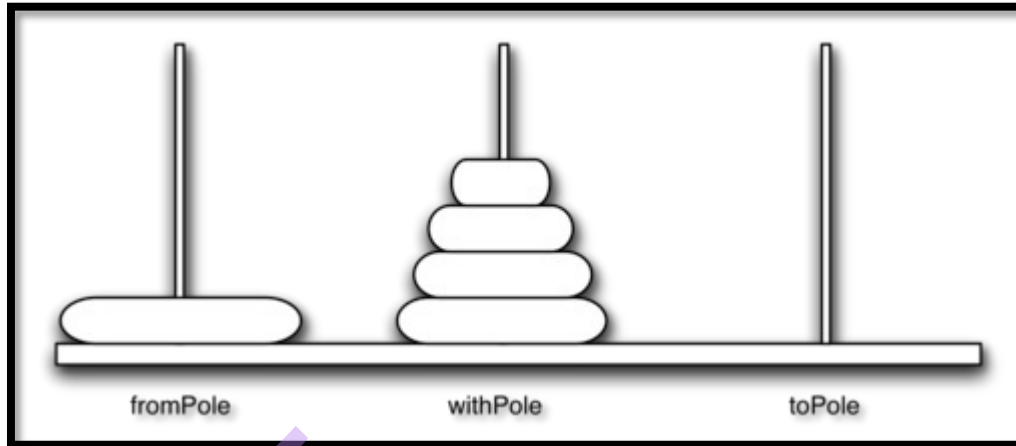
. . Q .
Q . . .
. . . Q
. Q . .

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:-

<pre> towerhanoi.py - E:/NITESHDPD/BSCIT/TYITNEWEBOOK/AIPRAX/towerhanoi.py (3.7.0) File Edit Format Run Options Window Help 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") </pre>	<pre> 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 (Intel)] on win32 Type "copyright", "credits" or "license()" for more information. >>> ===== RESTART: E:/NITESHDPD/BSCIT/TYITNEWEBOOK/AIPRAX/towerhanoi.py ===== moving disk from A to B moving disk from A to C moving disk from B to C moving disk from A to B moving disk from C to A moving disk from C to B moving disk from A to B >>> </pre>
--	---

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

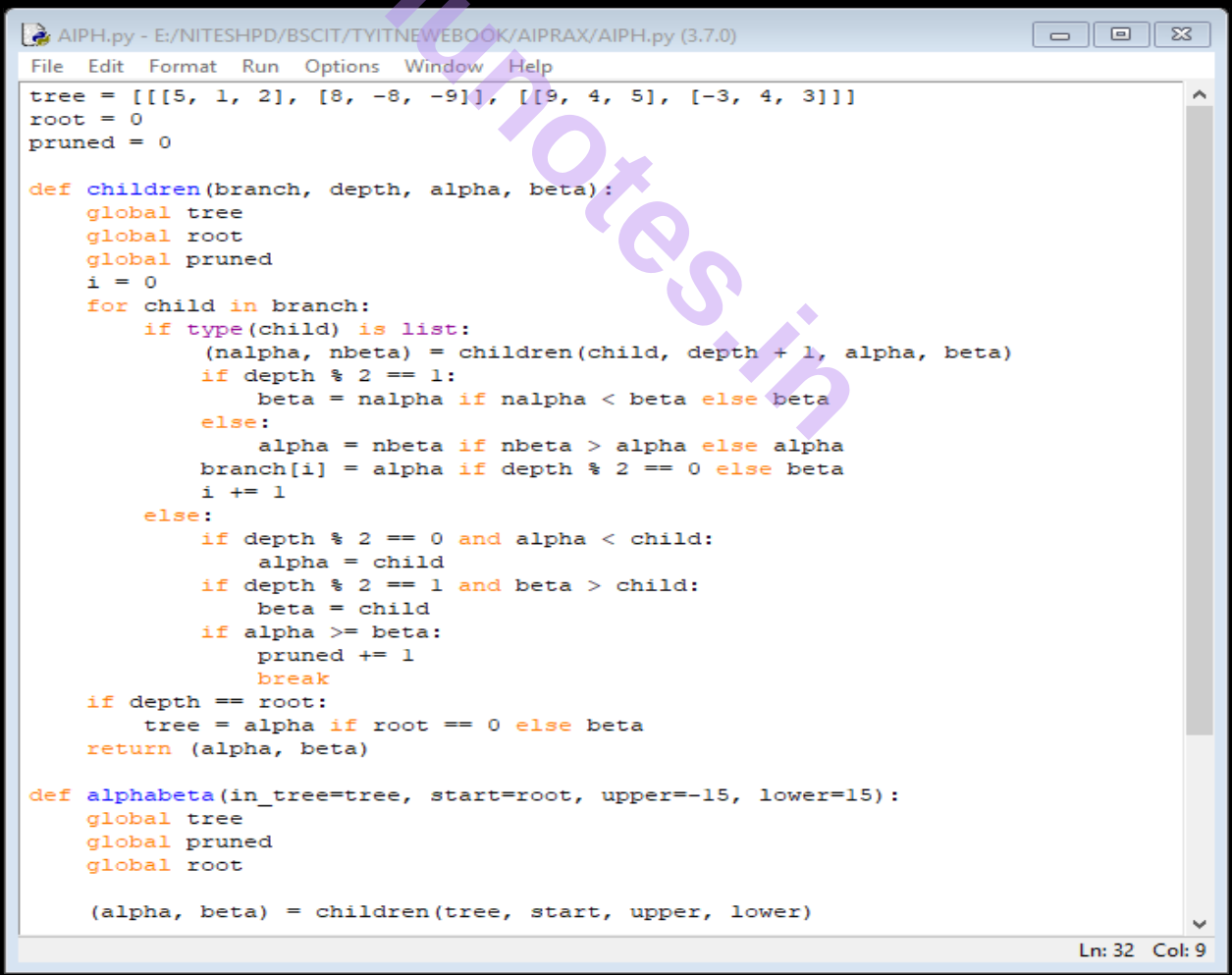
(alpha, beta) = children(tree, start, upper, lower)

```
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:/NITESHDPD/BSCIT/TYITNEWBOOK/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)

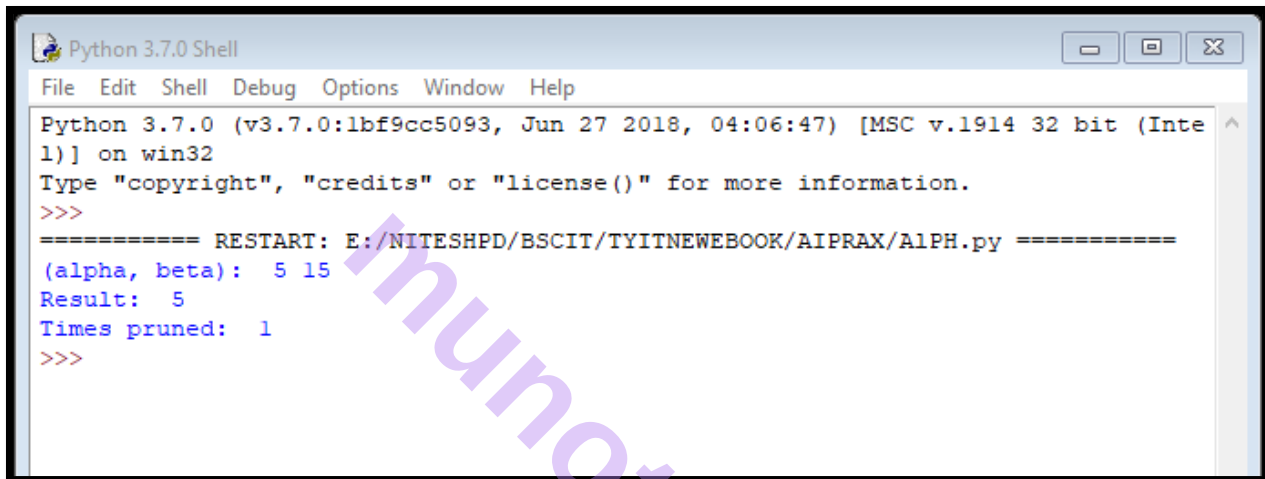
def alphabeta(in_tree=tree, start=root, upper=-15, lower=15):
    global tree
    global pruned
    global root

    (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



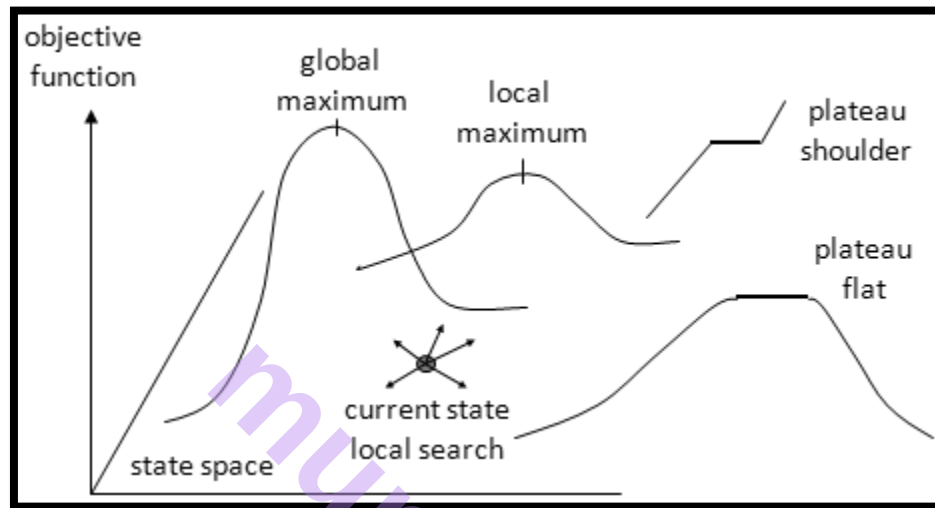
Python 3.7.0 Shell

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 (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:/NITESH/DPD/BSCIT/TYIT/NEWBOOK/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

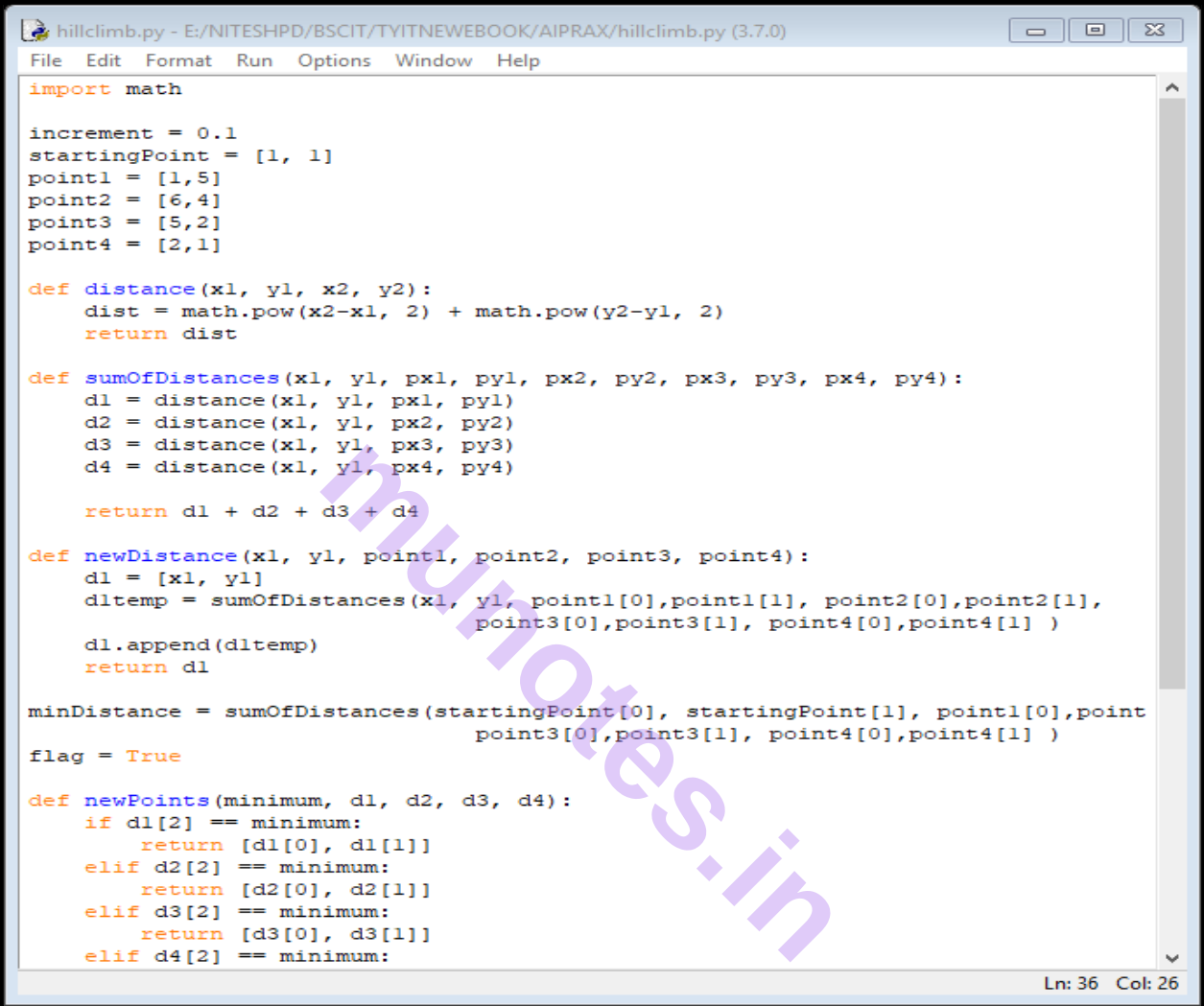
def newPoints(minimum, d1, d2, d3, d4):
    if d1[2] == minimum:
        return [d1[0], d1[1]]
    elif d2[2] == minimum:
        return [d2[0], d2[1]]
    elif d3[2] == minimum:
        return [d3[0], d3[1]]
    elif d4[2] == minimum:
        return [d4[0], d4[1]]

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:/NITESHDPD/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]
    dltemp = sumOfDistances(x1, y1, point1[0],point1[1], point2[0],point2[1],
        point3[0],point3[1], point4[0],point4[1] )

    d1.append(dltemp)
    return d1

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

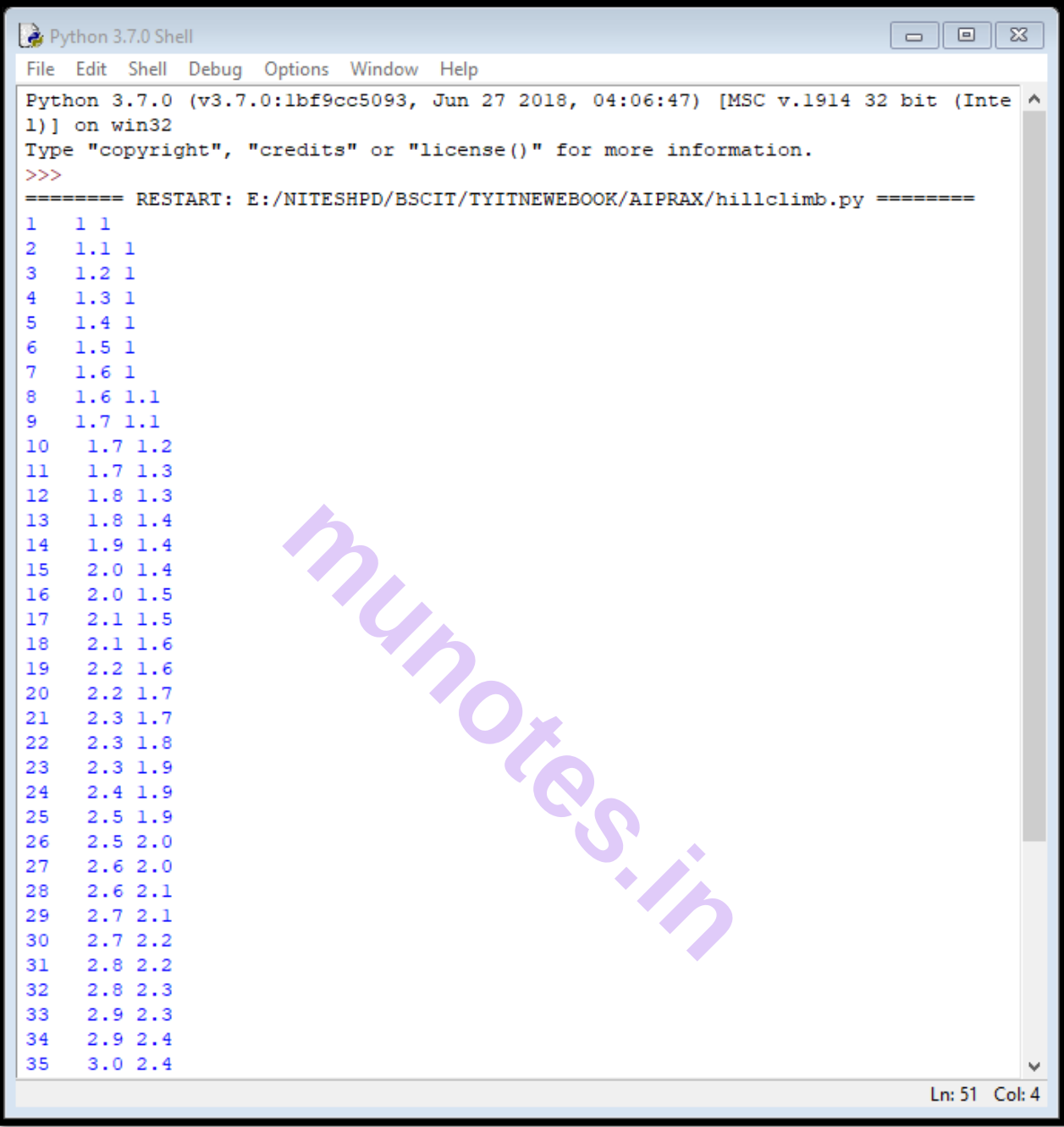
flag = True

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

```
    return [d4[0], d4[1]]

i = 1
while flag:
    d1 = newDistance(startingPoint[0]+increment, startingPoint[1], point1, point2)
    d2 = newDistance(startingPoint[0]-increment, startingPoint[1], point1, point2)
    d3 = newDistance(startingPoint[0], startingPoint[1]+increment, point1, point2)
    d4 = newDistance(startingPoint[0], startingPoint[1]-increment, point1, point2)
    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 (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:/NITESHDPD/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

```

C:\Users\Maa>cd AppData\Local\Programs\Python\Python37-32\Scripts
C:\Users\Maa\AppData\Local\Programs\Python\Python37-32\Scripts>pip install simpleai
Requirement already satisfied: simpleai in c:\users\maa\appdata\local\programs\python\python37-32\lib\site-packages (0.8.1)
You are using pip version 10.0.1, however version 18.0 is available.
You should consider upgrading via the 'python -m pip install --upgrade pip' command.
C:\Users\Maa\AppData\Local\Programs\Python\Python37-32\Scripts>pip install pydot flask
Requirement already satisfied: pydot in c:\users\maa\appdata\local\programs\python\python37-32\lib\site-packages (1.2.4)
Requirement already satisfied: flask in c:\users\maa\appdata\local\programs\python\python37-32\lib\site-packages (1.0.2)
Requirement already satisfied: pyparsing>=2.1.4 in c:\users\maa\appdata\local\programs\python\python37-32\lib\site-packages (from pydot) (2.2.0)
Requirement already satisfied: Jinja2>=2.10 in c:\users\maa\appdata\local\programs\python\python37-32\lib\site-packages (from flask) (2.10)
Requirement already satisfied: itsdangerous>=0.24 in c:\users\maa\appdata\local\programs\python\python37-32\lib\site-packages (from flask) (0.24)
Requirement already satisfied: click>=5.1 in c:\users\maa\appdata\local\programs\python\python37-32\lib\site-packages (from flask) (6.7)
Requirement already satisfied: Werkzeug>=0.14 in c:\users\maa\appdata\local\programs\python\python37-32\lib\site-packages (from flask) (0.14.1)
Requirement already satisfied: MarkupSafe>=0.23 in c:\users\maa\appdata\local\programs\python\python37-32\lib\site-packages (from Jinja2>=2.10->flask) (1.0)
You are using pip version 10.0.1, however version 18.0 is available.
You should consider upgrading via the 'python -m pip install --upgrade pip' command.
C:\Users\Maa\AppData\Local\Programs\Python\Python37-32\Scripts>

```

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):
```

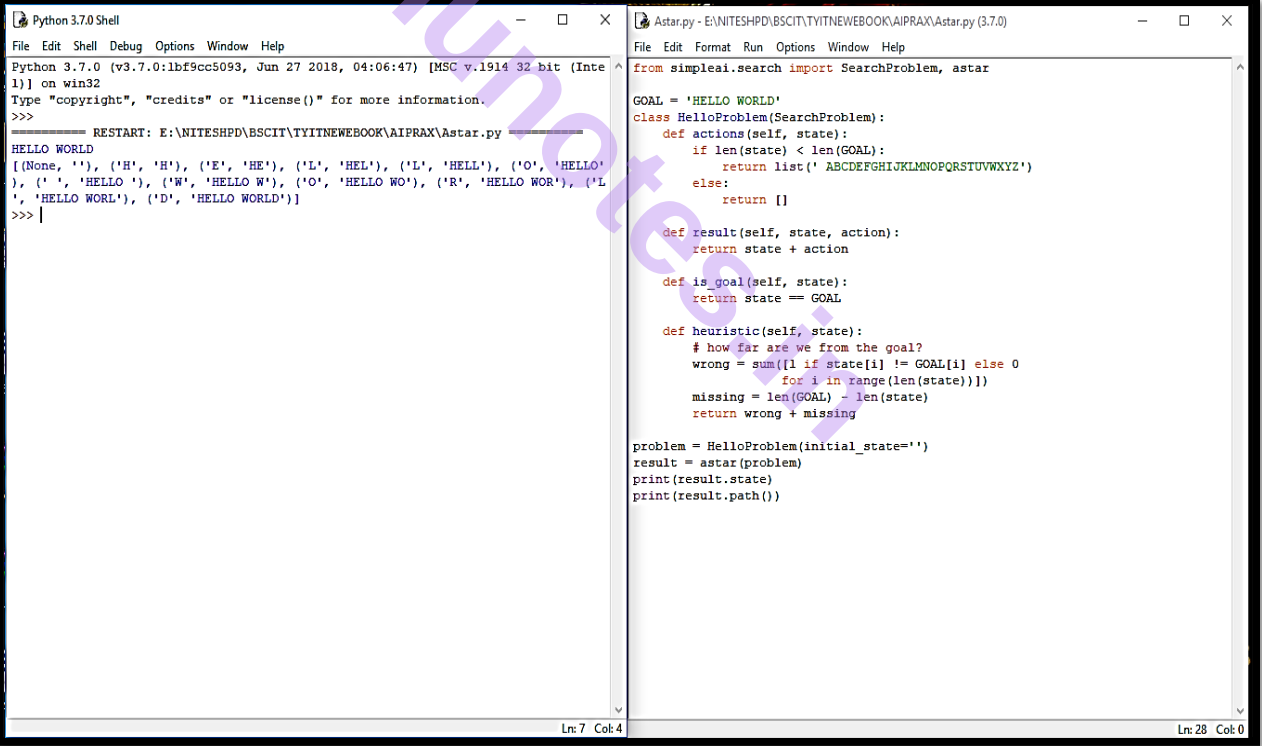
```
        return state + action
```

```
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:-



The screenshot shows two windows. The left window is a Python 3.7.0 Shell with the following output:

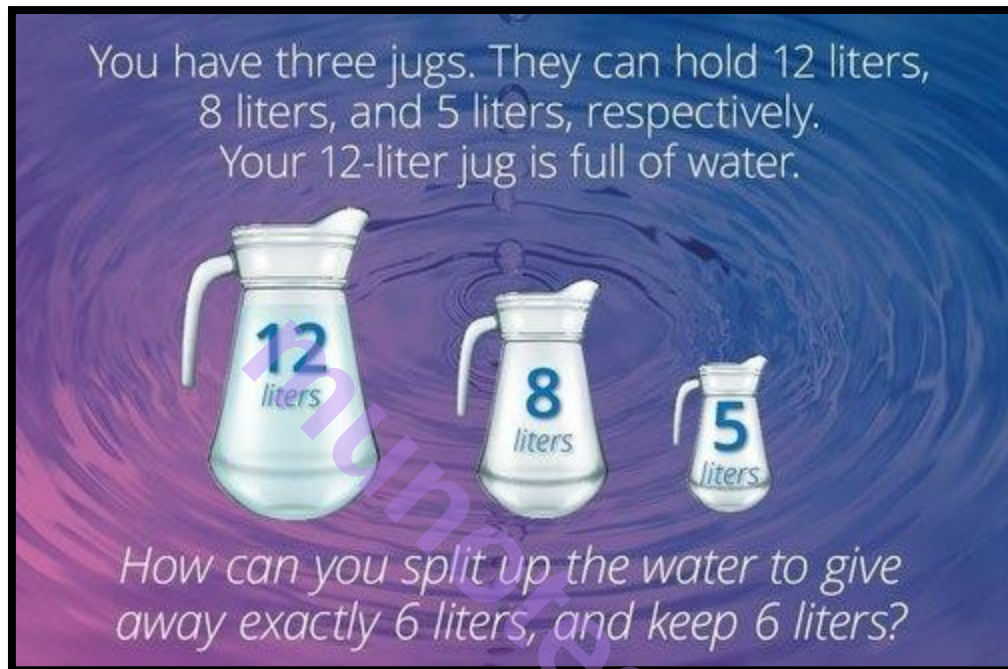
```
Python 3.7.0 Shell  
File Edit Shell Debug Options Window Help  
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Intel)] on win32  
Type "copyright", "credits" or "license()" for more information.  
>>>  
----- RESTART: E:\NITESH\PD\BSCIT\TYIT\NEWBOOK\AI\PRAX\Astar.py -----  
HELLO WORLD  
[(None, ''), ('H', 'H'), ('E', 'HE'), ('L', 'HEL'), ('L', 'HELL'), ('O', 'HELLO'), (' ', 'HELLO '), ('W', 'HELLO W'), ('O', 'HELLO WO'), ('R', 'HELLO WOR'), ('L', 'HELLO WORL'), ('D', 'HELLO WORLD')]  
>>>|
```

The right window is an Astar.py script with the following code:

```
Astar.py - E:\NITESH\PD\BSCIT\TYIT\NEWBOOK\AI\PRAX\Astar.py (3.7.0)  
File Edit Format Run Options Window Help  
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())
```

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
```

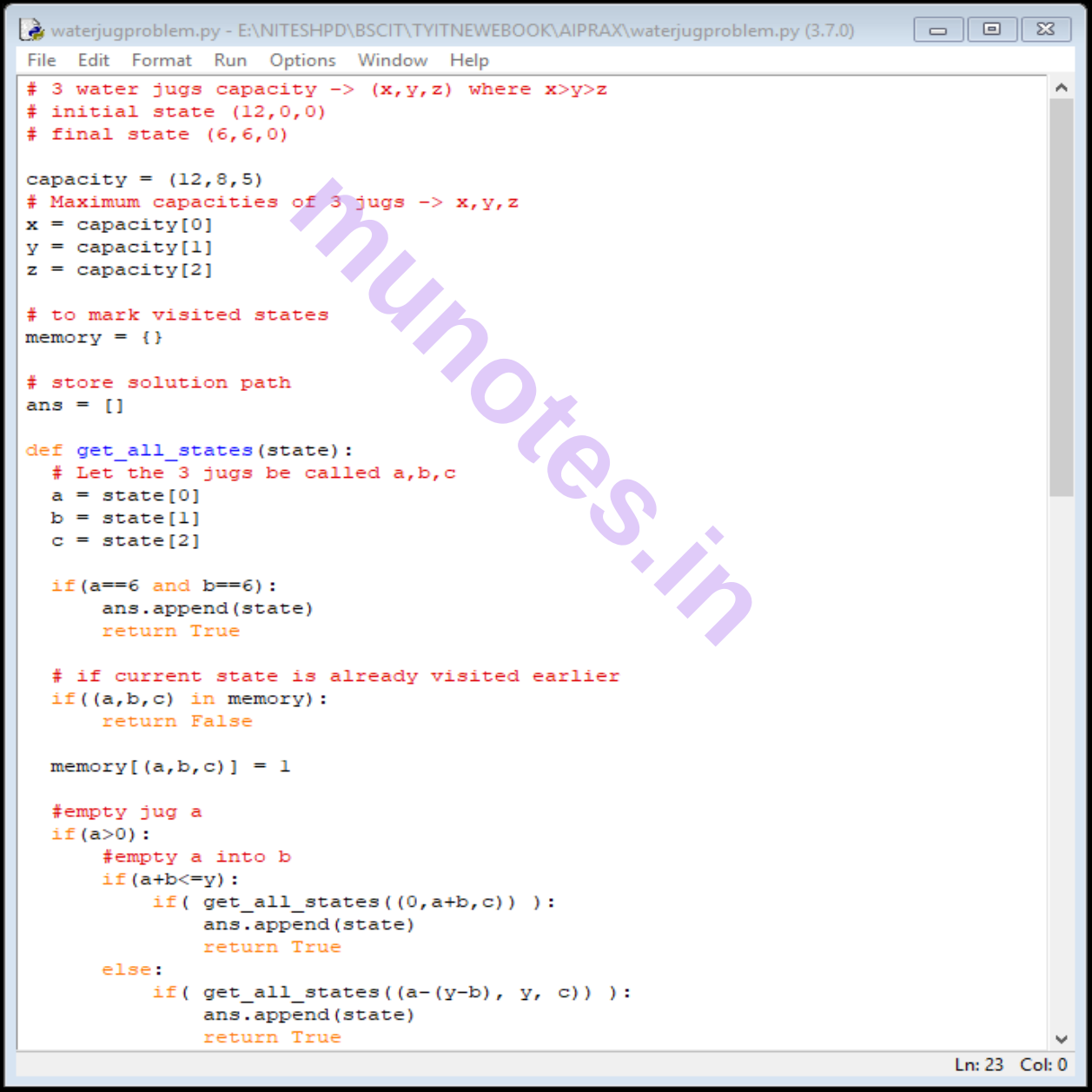
```
if(a+b<=x):
    if( get_all_states((a+b, 0, c)) ):
        ans.append(state)
        return True
else:
    if( get_all_states((x, b-(x-a), c)) ):
        ans.append(state)
        return True
#empty b into c
if(b+c<=z):
    if( get_all_states((a, 0, b+c)) ):
        ans.append(state)
        return 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:\NITESH\PD\BSCIT\TYITNEWBOOK\AI\PRAX\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:\NITESH\PD\BSCIT\TYITNEWBOOK\AI\PRAX\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

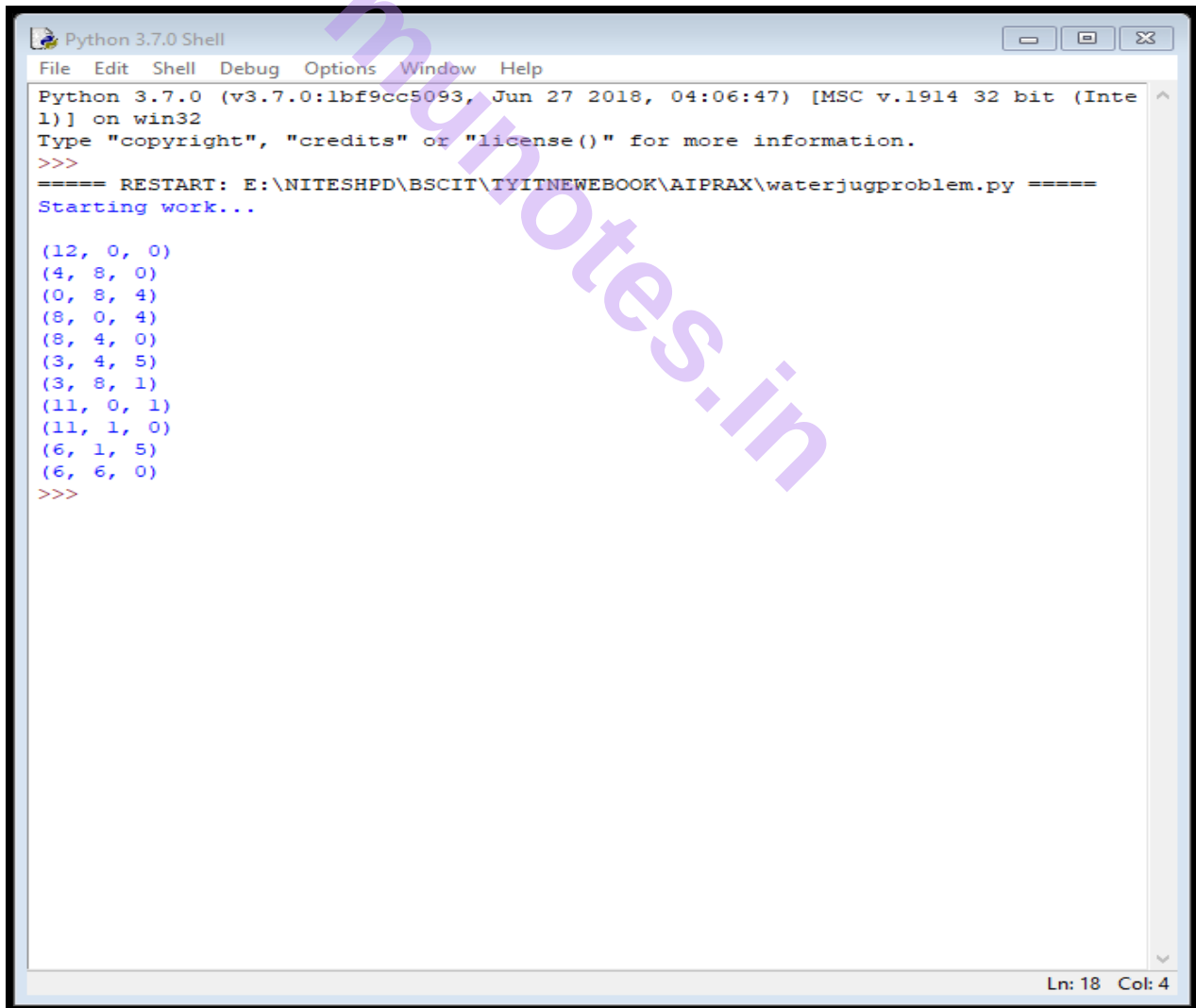
#empty jug c
if(c>0):
    #empty c into a
    if(a+c<=x):
        if( get_all_states((a+c, b, 0)) ):
            ans.append(state)
            return True
        else:
            if( get_all_states((x, b, c-(x-a))) ):
                ans.append(state)
                return True
    #empty c into b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

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)
```



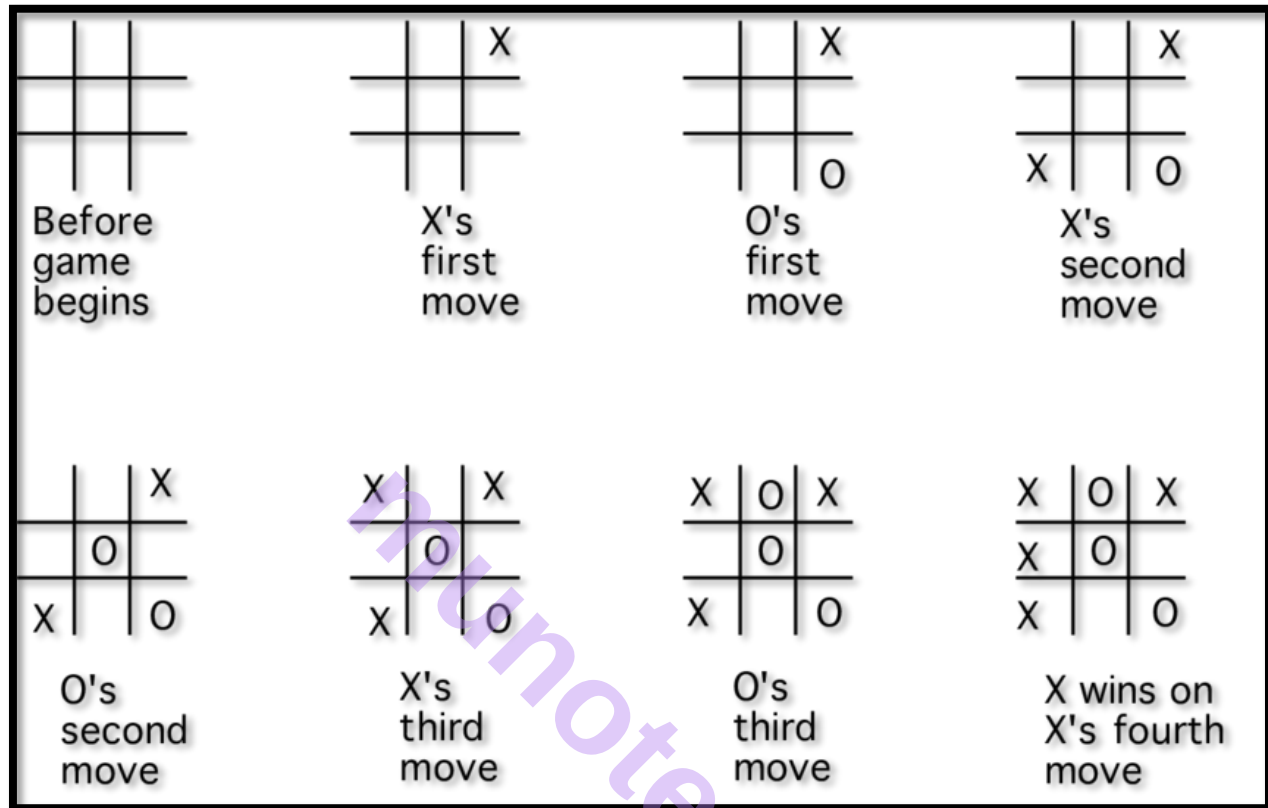
```
Python 3.7.0 Shell
File Edit Shell Debug Options Window Help
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:06:47) [MSC v.1914 32 bit (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:\NITESH\PD\BSCIT\TYITNEWBOOK\AIPRAX\waterjugproblem.py =====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

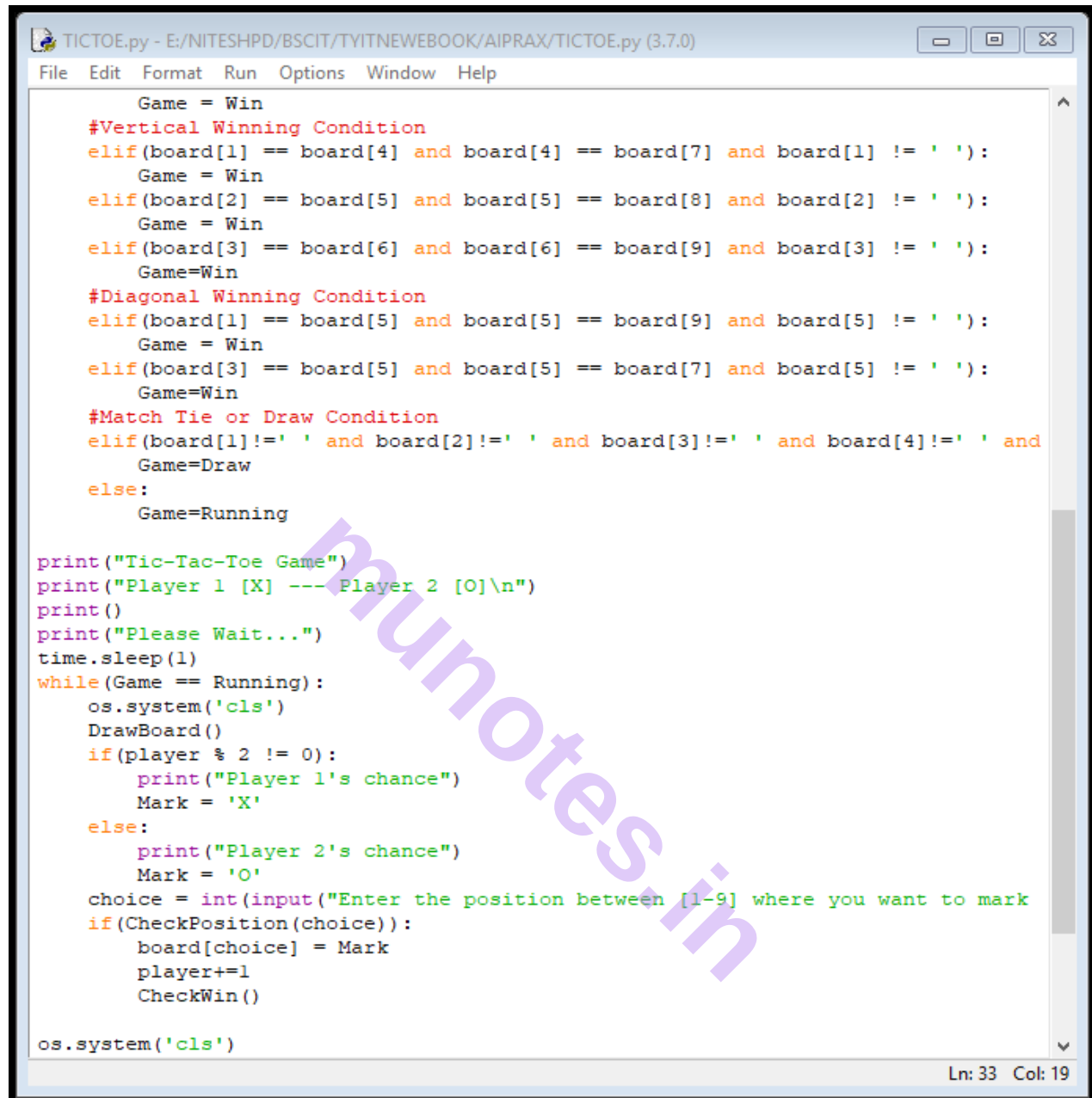
```
def CheckWin():
    global Game
    #Horizontal winning condition
    if(board[1] == board[2] and board[2] == board[3] and board[1] != ' '):
        Game = Win
    elif(board[4] == board[5] and board[5] == board[6] and board[4] != ' '):
        Game = Win
    elif(board[7] == board[8] and board[8] == 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



```

TICTOE.py - E:/NITESH/DPD/BSCIT/TYITNEWBOOK/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
```

```
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)

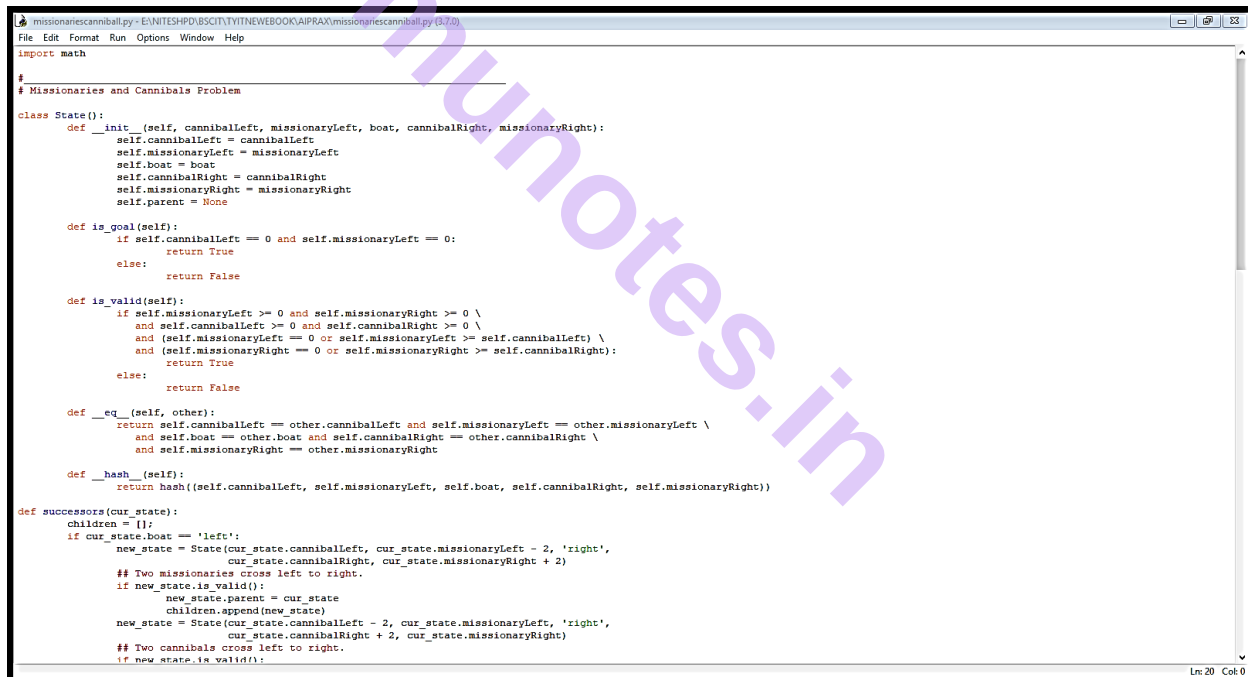
```

if called from the command line, call main()

```

if __name__ == "__main__":
    main()

```



```

missionariescannibal.py - EN:\NITESHPD\BSC\IT\YI\NEWBOOK\APRA\missionariescannibal.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():

```

```

missionariescannibals.py - E:\NITESHP\DSCT\TYIT\NEWBOOK\APRAX\missionariescannibals.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.

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

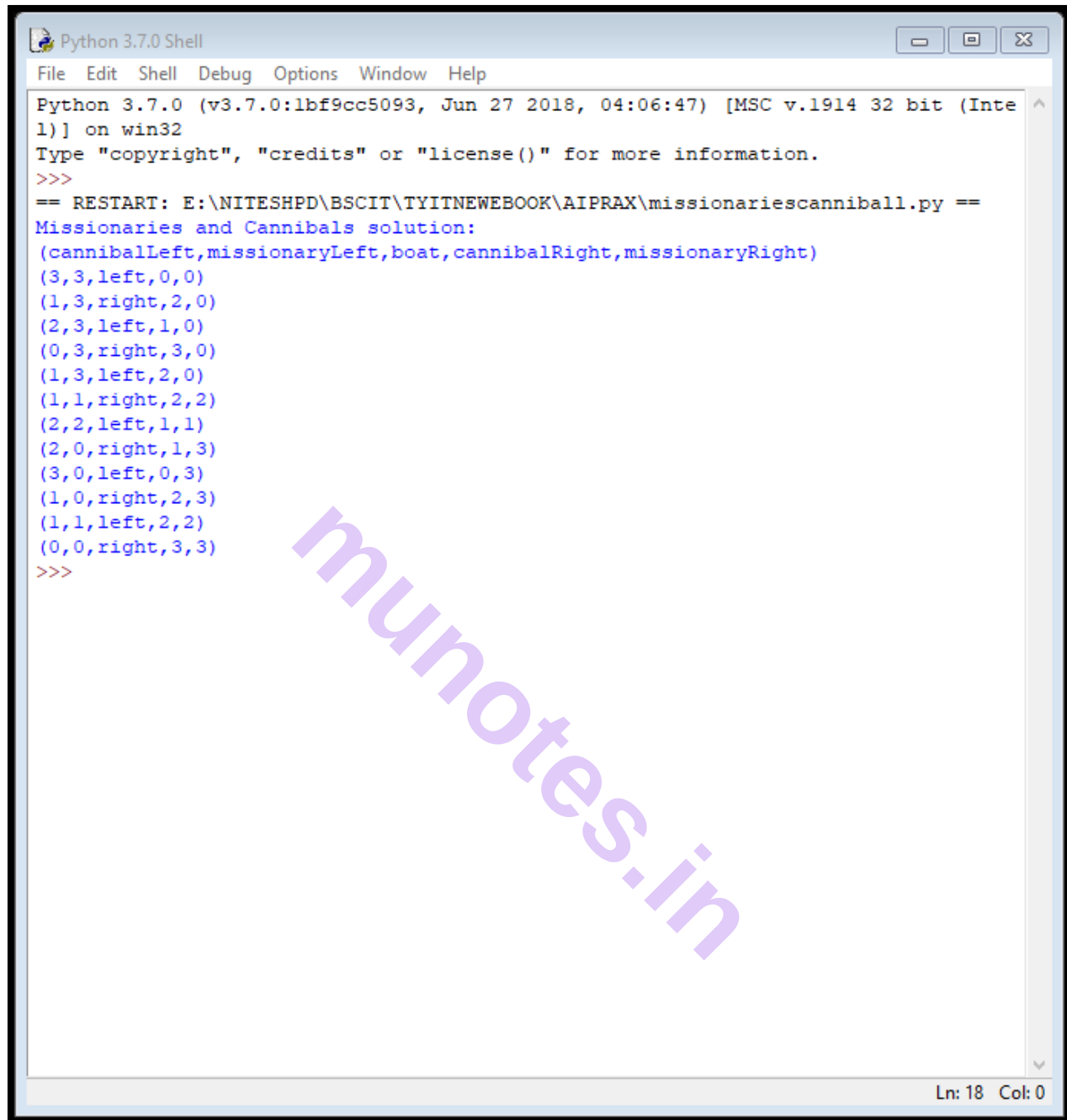
def print_solution(solution):
    path = []
    path.append(solution)
    parent = solution.parent
    while parent:
        path.append(parent)
        parent = parent.parent

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

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

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

```



```
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 (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
== RESTART: E:\NITESH\PD\BSCIT\TYITNEWEBOOK\AI\PRAX\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 immutable. 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 EighthPuzzleProblem(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:\NITESH\PD\BSCIT\TYIT\NEWBOOK\JAVAAEE\simpleai-master\simpleai-m...
File Edit Format Run Options Window Help

'''
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 always be immutable. 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']]
'''

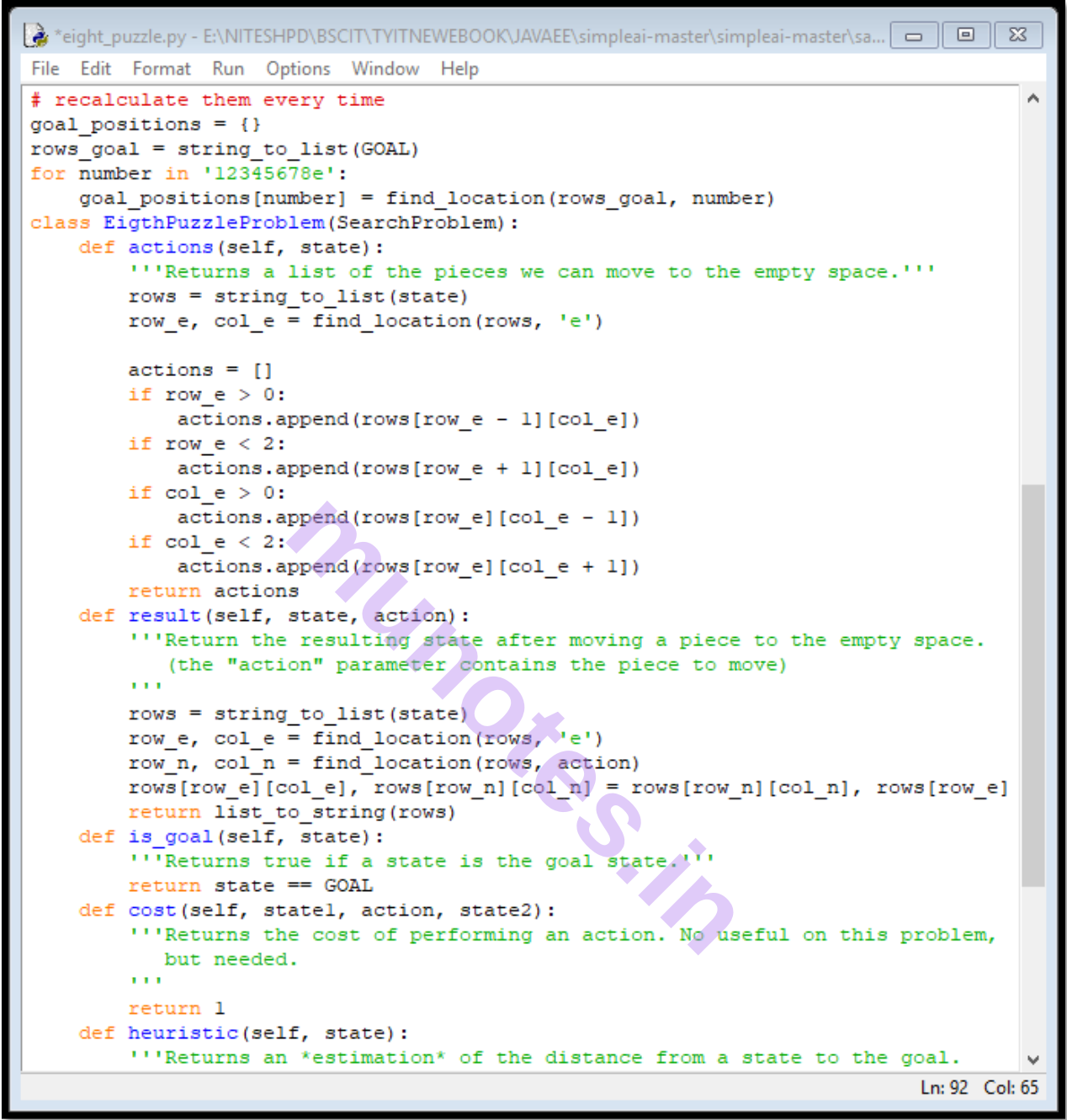
from __future__ import print_function
from simpleai.search import astar, SearchProblem
from simpleai.search.viewers import WebViewer

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:\NITESH\PD\BSCIT\TYITNEW\BOOK\JAVAEE\simpleai-master\simpleai-master\sa...
File Edit Format Run Options Window Help

# 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 EighthPuzzleProblem(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(EighthPuzzleProblem(INITIAL))
# if you want to use the visual debugger, use this instead:
# result = astar(EighthPuzzleProblem(INITIAL), viewer=WebView())
for action, state in result.path():
    print('Move number', action)
    print(state)
```

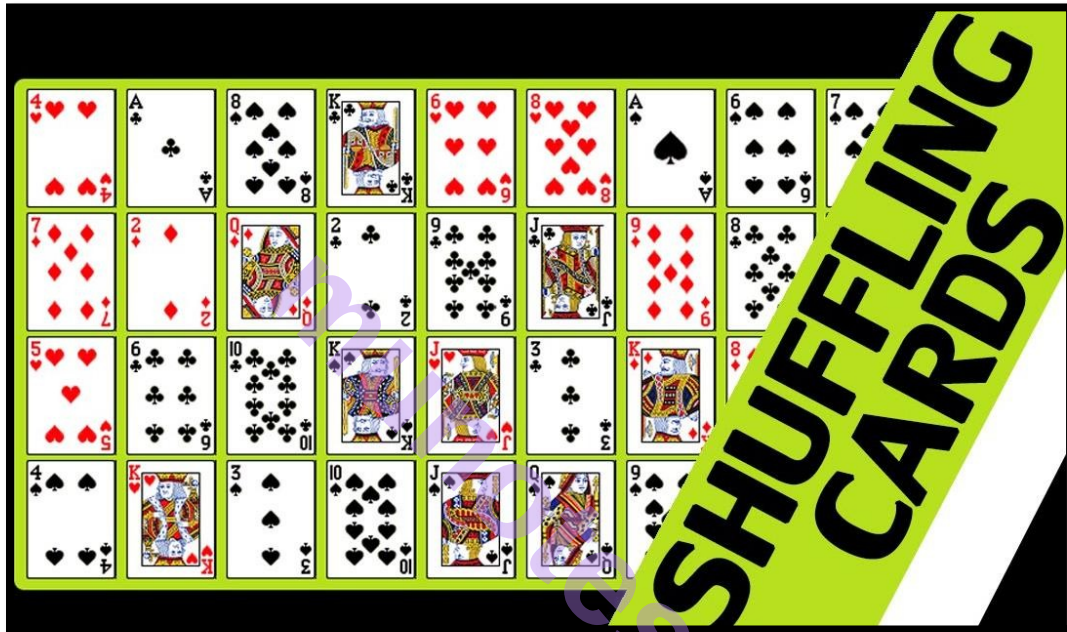
Ln: 92 Col: 65

```
Python 3.7.0 Shell
File Edit Shell Debug Options Window Help
>>>
RESTART: E:\NITESH\PD\BSCIT\TYIT\NEWBOOK\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

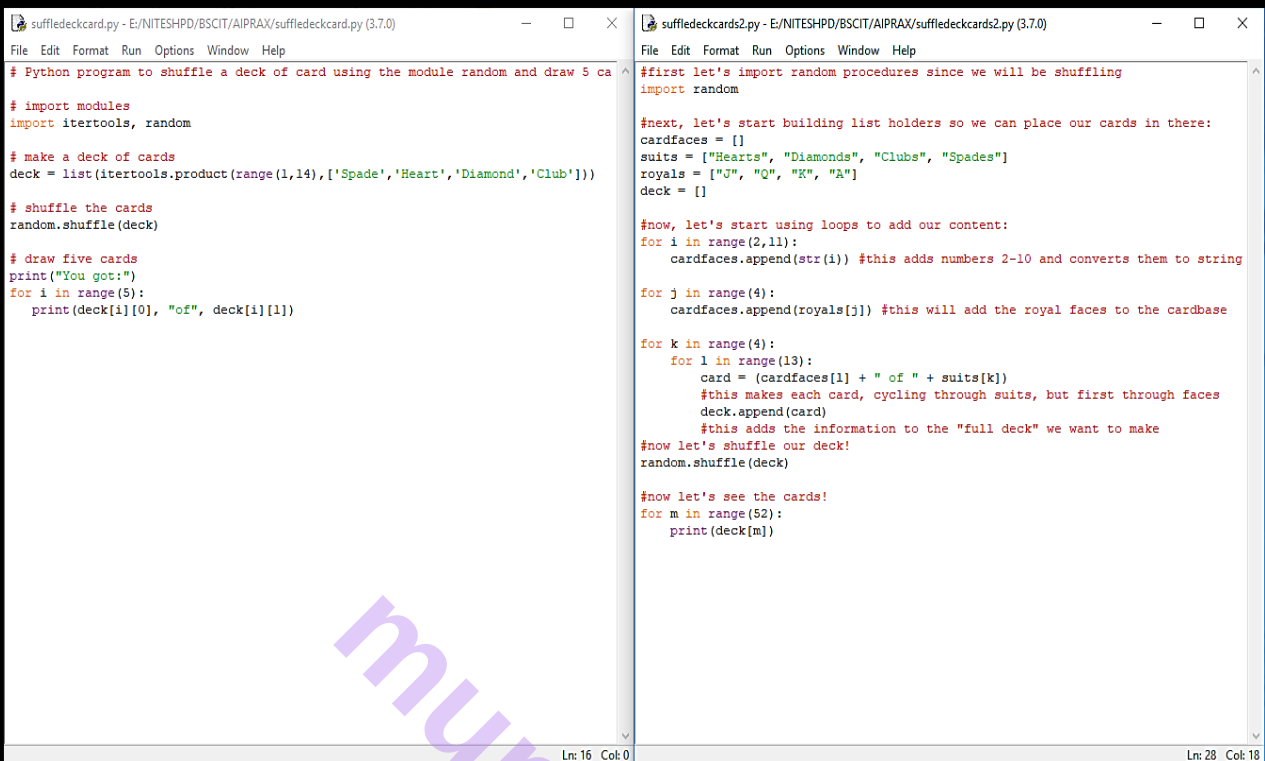
for k in range(4):
    for l in range(13):
        card = (cardfaces[l] + " of " + suits[k])
        #this makes each card, cycling through suits, but first through faces
        deck.append(card)
        #this adds the information to the "full deck" we want to make
#now let's shuffle our deck!
random.shuffle(deck)

#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:-



```
# 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])
```

```
#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 = []

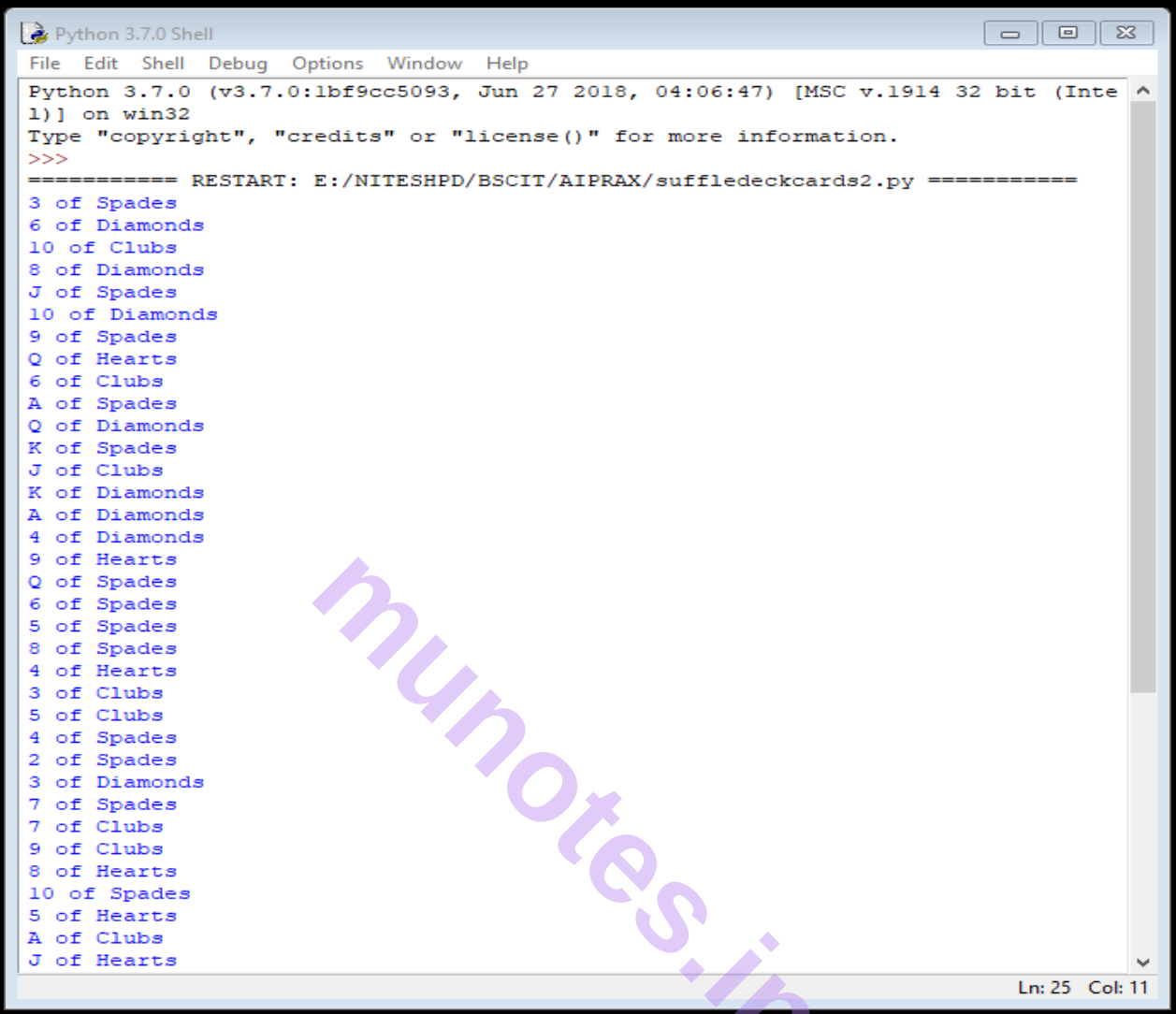
#now, let's start using loops to add our content:
for i in range(2,11):
    cardfaces.append(str(i)) #this adds numbers 2-10 and converts them to string

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

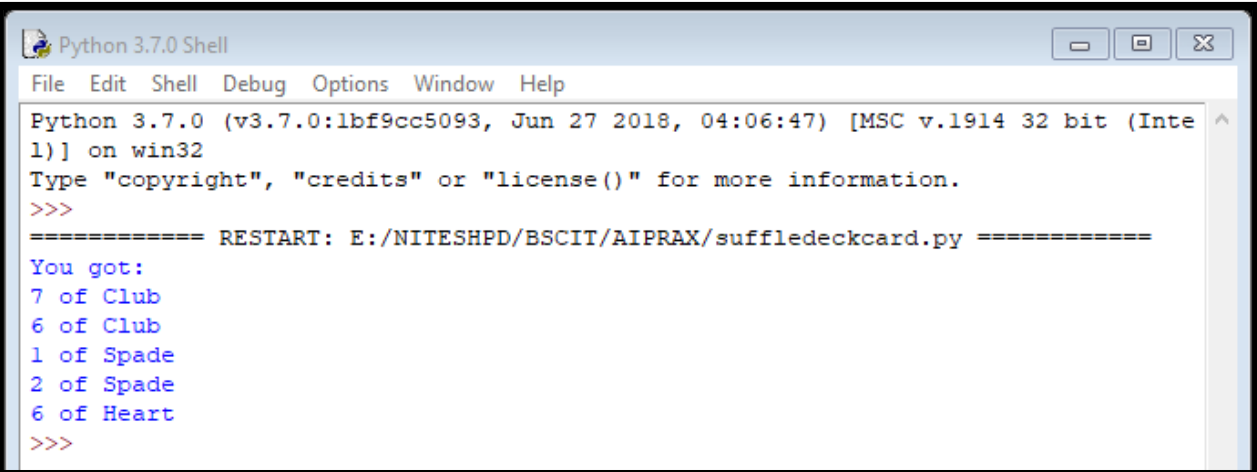
#now let's shuffle our deck!
random.shuffle(deck)

#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 (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:/NITESHDPD/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 (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:/NITESHDPD/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:-

The screenshot shows two side-by-side Python 3.7.0 Shell windows. The left window displays the initial state of the CSP solver, including the variables, domains, and constraints. The right window shows the search process, including the constraints and the search process.

```

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 (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: E:/NITESH/DPD/BSCIT/TYITNEWBOOK/AIPRAX/CSP.py =====
{'WA': 'red', 'NT': 'green', 'SA': 'blue', 'Q': 'red', 'NSW': 'green', 'V': 'red', 'T': 'red'}
{'WA': 'red', 'NT': 'green', 'SA': 'blue', 'Q': 'red', 'NSW': 'green', 'V': 'red', 'T': 'red'}
{'SA': 'red', 'NT': 'green', 'Q': 'blue', 'NSW': 'green', 'WA': 'blue', 'V': 'blue', 'T': 'red'}
{'WA': 'red', 'NT': 'green', 'SA': 'blue', 'Q': 'red', 'NSW': 'green', 'V': 'red', 'T': 'red'}
{'WA': 'red', 'NT': 'green', 'SA': 'blue', 'Q': 'red', 'NSW': 'green', 'V': 'red', 'T': 'red'}
{'SA': 'red', 'NT': 'green', 'Q': 'blue', 'NSW': 'green', 'WA': 'blue', 'V': 'blue', 'T': 'red'}
{'WA': 'green', 'NT': 'blue', 'SA': 'red', 'Q': 'green', 'NSW': 'blue', 'V': 'green', 'T': 'blue'}
>>>

CSP.py - E:/NITESH/DPD/BSCIT/TYITNEWBOOK/AIPRAX/CSP.py (3.7.0)
File Edit Format Run Options Window Help
from _future_ import print_function
from simpleai.search import CspProblem, backtrack, min_conflicts, MOST_CONSTRAINED_VARIABLE, HIGHEST_DEGREE_VARIABLE, LEAST_CONSTRAINING_VALUE

variables = {'WA': 'red', 'NT': 'green', 'SA': 'blue', 'Q': 'red', 'NSW': 'green', 'V': 'red', 'T': 'red'}
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))

```

Note:

Following practical will be update soon:

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

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