SONOPANT DANDEKAR ARTS, V.S. APTE COMMERCE &
M.H. MEHTA SCIENCE COLLEGE, PALGHAR
MAHARASHTRA - 401404

DEPARTMENT OF INFORMATION TECHNOLOGY

This is to certify that Mr. / Miss. ____ of M. Sc. (I. T.) - Part 1, Semester I, Seat. No: _______________ has successfully completed the practicals in the subject of **SOFT COMPUTING TECHNIQUES** as per the requirement of the University of Mumbai in part fulfillment for the completion of Degree of Master of Science (Information Technology). It is also to certify that this is the original work of the candidate done during the academic year 2024-25.

Internal Examiner **Head of Department**

External Examiner

Date: **College Seal**

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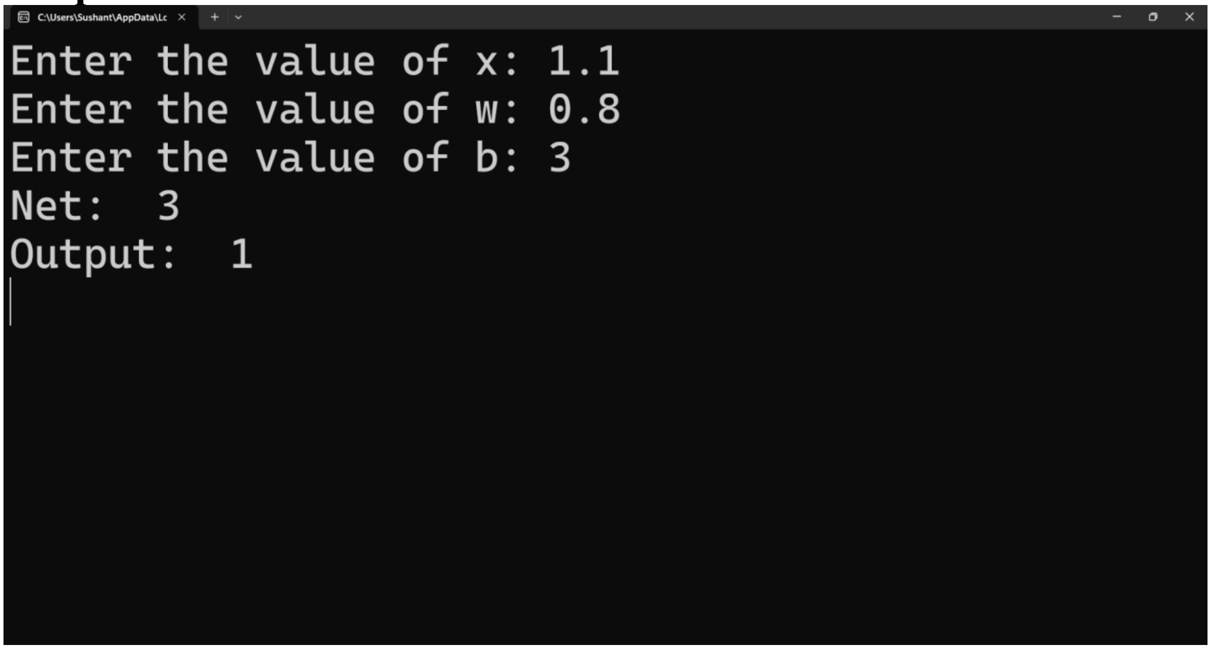
Practical 1

Practical 1A:
Aim: Design a Simple Linear Neural Network Model

Code:

```
x = float(input('Enter the value of x: '))
w = float(input('Enter the value of w: '))
b = float(input('Enter the value of b: '))
net = int(w*x+b)
if (net<0):
	out=0
elif(net>=0)&(net<=1):
	out=net
else:
	out=1
print('Net: ', net)
print('Output: ', out)
```

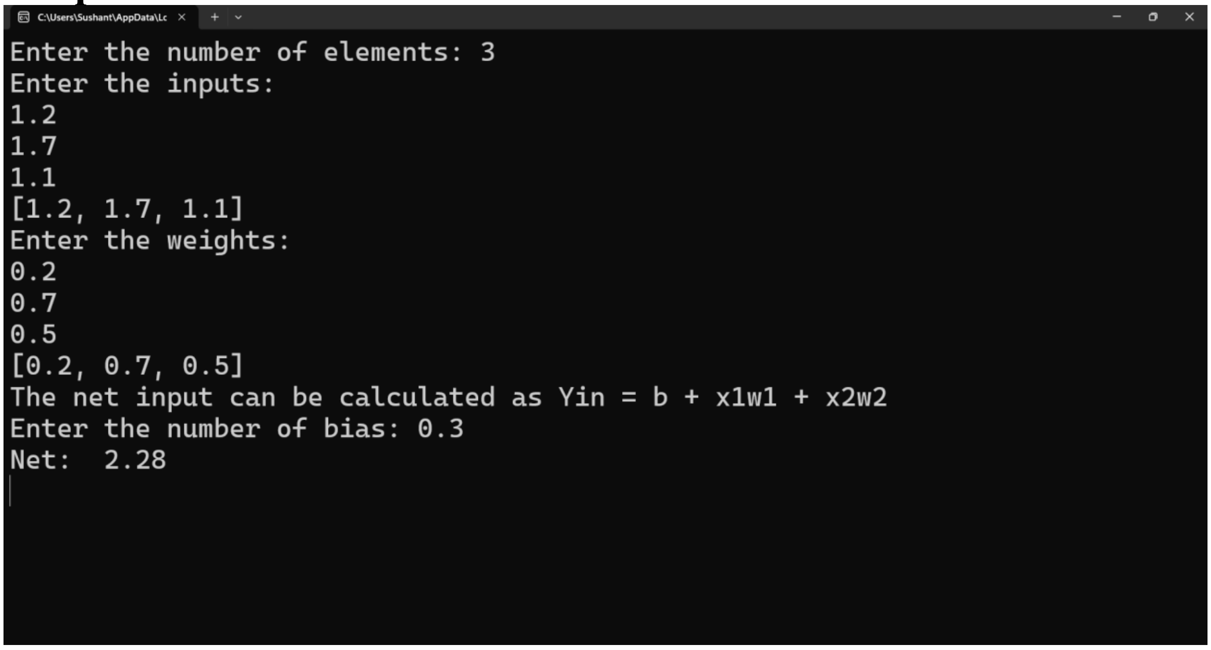
Output:



```
Enter the value of x: 1.1
Enter the value of w: 0.8
Enter the value of b: 3
Net:  3
Output:  1
```

Practical 1B:
Aim: Calculate Neural Net using both binary and bipolar sigmoidal function

Code:
```
n = int(input('Enter the number of elements: '))
print('Enter the inputs: ')
inputs = []
for i in range(0, n):
    ele = float(input())
    inputs.append(ele)
print(inputs)
print('Enter the weights: ')
weights = []
for i in range(0, n):
    ele = float(input())
    weights.append(ele)
print(weights)
print('The net input can be calculated as Yin = b + x1w1 + x2w2')
b = float(input('Enter the number of bias: '))
Yin = []
for i in range(0, n):
    Yin.append(inputs[i]*weights[i])
net = round((sum(Yin) + b), 2)
print('Net: ', net)
```

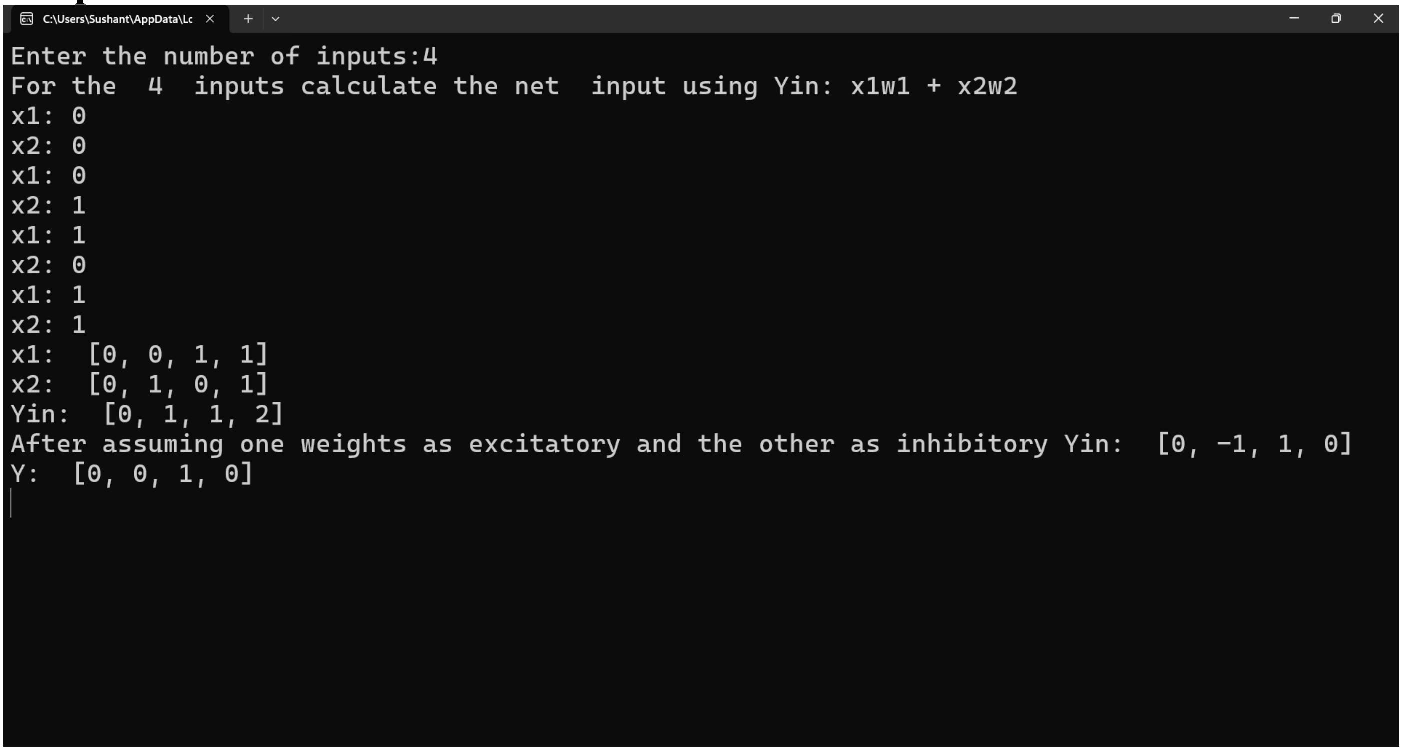
Output:

```
Enter the number of elements: 3
Enter the inputs:
1.2
1.7
1.1
[1.2, 1.7, 1.1]
Enter the weights:
0.2
0.7
0.5
[0.2, 0.7, 0.5]
The net input can be calculated as Yin = b + x1w1 + x2w2
Enter the number of bias: 0.3
Net:  2.28
```

Practical 2

Practical 2A:
Aim: Implement AND/NOT function using McCulloch-Pits neuron.

Code:
```
num_ip = int(input('Enter the number of inputs:'))
w1 = 1
w2 = 1
print('For the ', num_ip, ' inputs, calculate the net input using Yin: x1w1 + x2w2')
x1 = []
x2 = []
for j in range(0, num_ip):
   ele1 = int(input('x1: '))
   ele2 = int(input('x2: '))
   x1.append(ele1)
   x2.append(ele2)
print('x1: ', x1)
print('x2: ', x2)
n = x1 * w1
m = x2 * w2
Yin = []
for i in range (0, num_ip):
   Yin.append(n[i] + m[i])
print('Yin: ', Yin)
Yin = []
for i in range(0, num_ip):
   Yin.append(n[i] - m[i])
print('After assuming one weights as the excitatory and the other as inhibitory
Yin: ',Yin)
Y = []
for i in range(0, num_ip):
   if(Yin[i] >= 1):
      ele = 1
      Y.append(ele)
   elif(Yin[i] < 1):
      ele = 0
      Y.append(ele)
print('Y: ', Y)
```

Output:

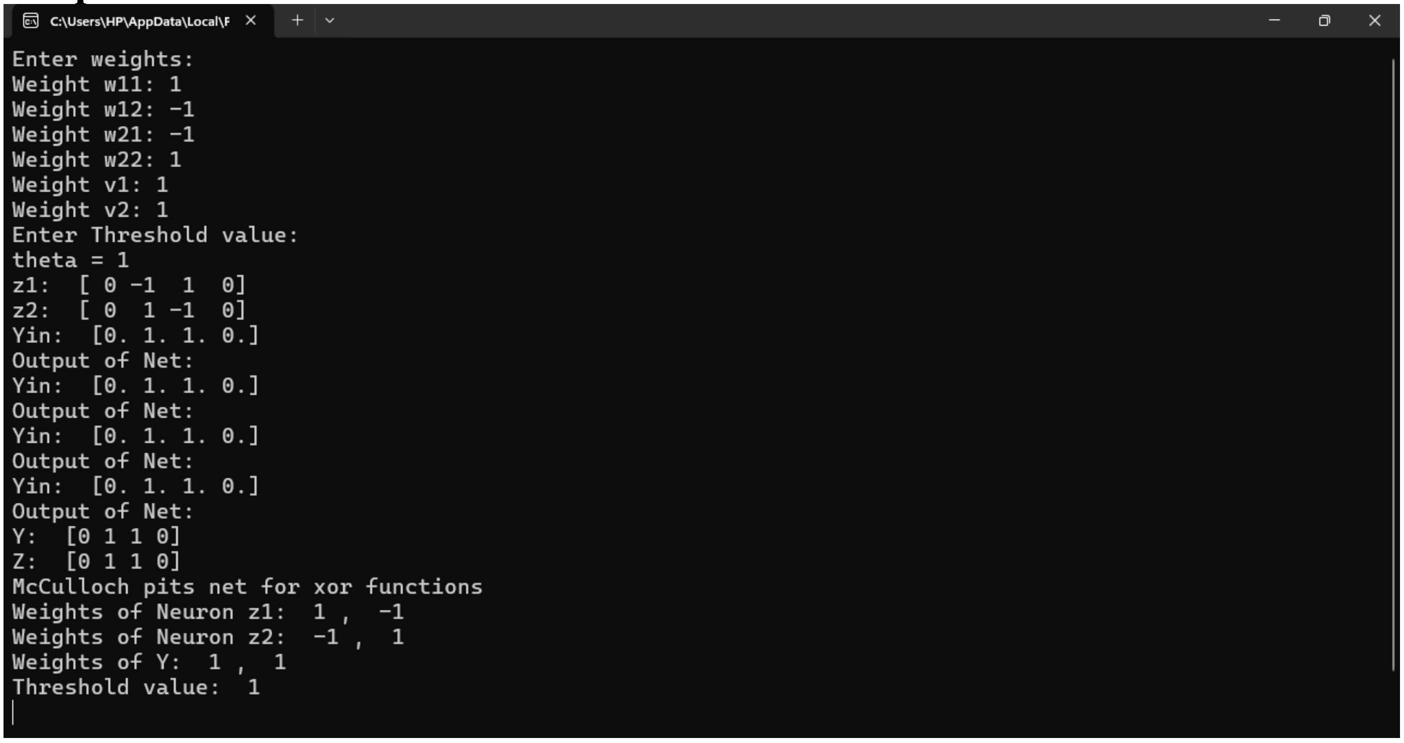


```
Enter the number of inputs:4
For the  4  inputs calculate the net  input using Yin: x1w1 + x2w2
x1: 0
x2: 0
x1: 0
x2: 1
x1: 1
x2: 0
x1: 1
x2: 1
x1:  [0, 0, 1, 1]
x2:  [0, 1, 0, 1]
Yin:  [0, 1, 1, 2]
After assuming one weights as excitatory and the other as inhibitory Yin:  [0, -1, 1, 0]
Y:  [0, 0, 1, 0]
```

Practical 2B:
Aim: Generate XOR function using McCulloch-Pits neuron net.

Code:
```
import numpy as np
print('Enter weights:')
w11 = int(input('Weight w11: '))
w12 = int(input('Weight w12: '))
w21 = int(input('Weight w21: '))
w22 = int(input('Weight w22: '))
v1 = int(input('Weight v1: '))
v2 = int(input('Weight v2: '))
print('Enter Threshold value:')
theta = int(input('theta = '))
x1 = np.array([0,0,1,1])
x2 = np.array([0,1,0,1])
z = np.array([0,1,1,0])
con = 1
y1 = np.zeros((4, ))
y2 = np.zeros((4, ))
y = np.zeros((4, ))
while con == 1:
    zin1 = np.zeros((4, ))
    zin2 = np.zeros((4, ))
    zin1 = x1 * w11 + x2 * w21
    zin2 = x1 * w21 + x2 * w22
    print('z1: ', zin1)
    print('z2: ', zin2)
    for i in range(0, 4):
        if zin1[i] >= theta:
            y1[i] = 1
        else:
            y1[i] = 0
        if zin2[i] >= theta:
            y2[i] = 1
        else:
            y2[i] = 0
        yin = np.array([])
        yin = y1 * v1 + y2 * v2
    for i in range(0, 4):
        if yin[i] >= theta:
            y[i] = 1
        else:
            y[i] = 0
        print('Yin: ', yin)
        print('Output of Net: ')
    y = y.astype(int)
    print('Y: ', y)
    print('Z: ', z)
    if np.array_equal(y, z):
        con = 0
    else:
        print('Net isn\'t learning enter another set of weights and threshold value')
        w11 = input('Weights w11: ')
        w12 = input('Weight w12: ')
        w21 = input('Weight w21: ')
        w22 = input('Weight w22: ')
        v1 = input('Weiht v1: ')
        v2 = input('Weight v2: ')
        theta = input('theta: ')
print('McCulloch pits net for xor functions')
print('Weights of Neuron z1: ', w11, ', ', w21)
print('Weights of Neuron z2: ', w12, ', ', w22)
print('Weights of Y: ', v1, ', ', v2)
print('Threshold value: ', theta)
```

Output:



```
Enter weights:
Weight w11: 1
Weight w12: -1
Weight w21: -1
Weight w22: 1
Weight v1: 1
Weight v2: 1
Enter Threshold value:
theta = 1
z1:  [ 0 -1  1  0]
z2:  [ 0  1 -1  0]
Yin:  [0. 1. 1. 0.]
Output of Net:
Yin:  [0. 1. 1. 0.]
Output of Net:
Yin:  [0. 1. 1. 0.]
Output of Net:
Yin:  [0. 1. 1. 0.]
Output of Net:
Y:  [0 1 1 0]
Z:  [0 1 1 0]
McCulloch pits net for xor functions
Weights of Neuron z1:  1 ,  -1
Weights of Neuron z2:  -1 ,  1
Weights of Y:  1 ,  1
Threshold value:  1
```

Practical 3

Practical 3A:
Aim: Program to implement Hebb's Rule

Code:
```
pip install numpy
import numpy as np
x1 = np.array([1, 1, 1, -1, 1, -1, 1, 1, 1])
x2 = np.array([1, 1, 1, 1, -1, 1, 1, 1, 1])
b = 0
y = np.array([1, -1])
wtold = np.zeros((9, ))
wtnew = np.zeros((9, ))
bias = 0
print('First input with target: 1')
for i in range(0, 9):
    wtold[i] = wtold[i] + x1[i] * y[0]
    wtnew = wtold
    b = b+ y[0]
print('New wt: ', wtnew)
print('Bias Value: ', b)
print('Second input with target = -1')
for i in range(0, 9):
    wtnew[i] = wtold[i] + x2[i] * y[1]
    b = b+ y[1]
print('New wt: ', wtnew)
print('Bias Value: ', b)
```

Output:
```
First input with target: 1
New wt: [ 1. 1. 1. -1. 1. -1. 1. 1. 1.]
Bias Value: 9
Second input with target = -1
New wt: [ 0. 0. 0. -2. 2. -2. 0. 0. 0.]
Bias Value: 0
```

Practical 3B:
Aim: Implement Delta Rule

Code:
```
import math
print('Using 3 inputs, 3 weights, 1 output')
x1 = [0.3, 0.5, 0.8]
w1 = [0.1, 0.1, 0.1]
t = 1
a = 0.1
diff = 1
yin = 0
while(diff > 0.4):
    for i in range(0, 3):
        yin = yin + (x1[i] * w1[i])
    yin = yin + 0.25
    yin = round(yin, 3)
    print('Yin: ', yin)
    print('Target: ', t)
    diff = t - yin
    diff = round(diff, 3)
    diff = math.fabs(diff)
print('Error: ', diff)
new1 = []
for i in range(0, 3):
    wnew1 = w1[i] + a * diff * x1[i]
    wnew1 = round(wnew1, 2)
    new1.append(wnew1)
w1 = new1
print('w1new=', w1)
```

Output:
```
Using 3 inputs, 3 weights, 1 output
Yin: 0.41
Target: 1
Yin: 0.82
Target: 1
Error: 0.18
w1new = [0.11, 0.11, 0.11]
```

Practical 4

Practical 4A:
Aim: Back Propagation Algorithm

Code:

```
import numpy as np
x = np.array(([2, 9], [1, 5], [3, 6]), dtype = float)
y = np.array(([92], [86], [89]), dtype = float)
x = x/np.amax(x, axis = 0)
y = y/100
class NN(object):
    def __init__(self):
        self.inputsize = 2
        self.outputsize = 1
        self.hiddensize = 3
        self.w1 = np.random.randn(self.inputsize, self.hiddensize)
        self.w2 = np.random.randn(self.hiddensize, self.outputsize)
    def forward(self, x):
        self.z1 = np.dot(x, self.w1)
        self.z2 = self.sigmoidal(self.z1)
        self.z3 = np.dot(self.z2, self.w2)
        op = self.sigmoidal(self.z3)
        return op
    def sigmoidal(self, s):
        return 1/(1/np.exp(-s))
obj = NN()
op = obj.forward(x)
print('Actual Output: ', str(op))
print('Target Output: ', str(y))
```

Output:

```
Actual Output: [[11.44977396] [ 3.39433893] [ 5.98908991]]
Target Output: [[0.92] [0.86] [0.89]]
```

Practical 4B:
Aim: Error Back Propagation Algorithm Learning

Code:
```
import math
a0 = -1
t = -1
w10 = float(input(‘Enter weight of first network: ‘))
b10 = float(input(‘Enter base of first network: ‘))
w20 = float(input(‘Enter weight of second network: ‘))
b20 = float(input(‘Enter base of second network: ‘))
c = float(input(‘Enter learning coefficient: ‘))
n1 = float(w10 * c + b10)
a1 = math.tanh(n1)
n2 = float(w20 * c + b20)
a2 = math.tanh(float(n2))
e = t - a2
s2 = 2 * (1 - a2 * a2) * e
s1 = (1 - a2 * a2) * w20 * s2
w21 = w20 - (c * s2 * a1)
w11 = w10 - (c * s1 * a0)
b21 = b20 - (c * s2)
b11 = b10 - (c * s1)
print(‘Updated weight of first n/w w11: ’, w11)
print(‘Updated base of first n/w b10: ’, b10)
print(‘Updated weight of first n/w w21: ’, w21)
print(‘Updated base of first n/w b20: ’, b20)
```

Output:
```
Enter weight of first network: 12
Enter base of first network: 35
Enter weight of second network: 23
Enter base of second network: 45
Enter learning coefficient: 11
Updated weight of first n/w w11: 12.0
Updated base of first n/w b10: 35.0
Updated weight of first n/w w21: 23.0
Updated base of first n/w b20: 45.0
```

Practical 5

Practical 5A:
Aim: Hopfield Network

Code:
```
#include "hop.h"
#include <iostream>
using namespace std;
neuron::neuron(int *j)
{
   int i;
   for (i = 0; i < 4; i++)
   {
      weightv[i] = *(j + i);
   }
}
int neuron::act(int m, int *x)
{
   int i;
   int a = 0;
   for (i = 0; i < m; i++)
   {
      a += x[i] * weightv[i];
   }
   return a;
}
int network::threshld(int k)
{
   if (k >= 0)
      return (1);
   else
      return (0);
}
network::network(int a[4], int b[4], int c[4], int d[4])
{
   nrn[0] = neuron(a);
   nrn[1] = neuron(b);
   nrn[2] = neuron(c);
   nrn[3] = neuron(d);
}
```

```
void network::activation(int *patrn)
{
   int i, j;
   for (i = 0; i < 4; i++)
   {
      for (j = 0; j < 4; j++)
      {
         cout << "\n nrn[" << i << "].weightv[" << j << "] is " <<
nrn[i].weightv[j];
      }
      nrn[i].activation = nrn[i].act(4, patrn);
      cout << "\nActivation is " << nrn[i].activation;
      output[i] = threshld(nrn[i].activation);
      cout << "\nOutput value is " << output[i] << "\n";
   }
}
int main()
{
   int patrn1[] = {1, 0, 1, 0}, i;
   int wt1[] = {0, -3, 3, -3};
   int wt2[] = {-3, 0, -3, 3};
   int wt3[] = {3, -3, 0, -3};
   int wt4[] = {-3, 3, -3, 0};
   cout << "THIS PROGRAM IS FOR A HOPFIELD NETWORK WITH A
SINGLE LAYER OF 4 FULLY INTERCONNECTED NEURONS. NETWORK
SHOULD RECALL THE PATTERNS 1010 AND 0101 CORRECTLY.\n";
   network h1(wt1, wt2, wt3, wt4);
   h1.activation(patrn1);
   for (i = 0; i < 4; i++)
   {
      if (h1.output[i] == patrn1[i])
      {
         cout << "\n pattern = " << patrn1[i] << " output = " << h1.output[i] << "
component matches";
      }
      else
      {
         cout << "\n pattern = " << patrn1[i] << " output = " << h1.output[i] << "
discrepancy occurred";
      }
   }
```

```
    cout << "\n\n";
    int patrn2[] = {0, 1, 0, 1};
    h1.activation(patrn2);
    for (i = 0; i < 4; i++)
    {
        if (h1.output[i] == patrn2[i])
        {
            cout << "\n pattern = " << patrn2[i] << " output = " << h1.output[i] << "
component matches";
        }
        else
        {
            cout << "\n pattern = " << patrn2[i] << " output = " << h1.output[i] << "
discrepancy occurred";
        }
    }
}
```

Code for hop.h:

```
#include <stdio.h>
#include <iostream>
#include <math.h>
class neuron
{
protected:
    int activation;
    friend class network;
public:
    int weightv[4];
    neuron() {};
    neuron(int *j);
    int act(int, int *);
};
class network
{
public:
    neuron nrn[4];
    int output[4];
    int threshld(int);
    void activation(int j[4]);
    network(int *, int *, int *, int *);
};
```

Output:

```
THIS PROGRAM IS FOR A HOPFIELD NETWORK WITH A SINGLE
LAYER OF 4 FULLY INTERCONNECTED NEURONS. NETWORK
SHOULD RECALL THE PATTERNS 1010 AND 0101 CORRECTLY.

nrn[0].weightv[0] is 0
nrn[0].weightv[1] is -3
nrn[0].weightv[2] is 3
nrn[0].weightv[3] is -3
Activation is 3
Output value is 1

nrn[1].weightv[0] is -3
nrn[1].weightv[1] is 0
nrn[1].weightv[2] is -3
nrn[1].weightv[3] is 3
Activation is -3
Output value is 0

nrn[2].weightv[0] is 3
nrn[2].weightv[1] is -3
nrn[2].weightv[2] is 0
nrn[2].weightv[3] is -3
Activation is 3
Output value is 1

nrn[3].weightv[0] is -3
nrn[3].weightv[1] is 3
nrn[3].weightv[2] is -3
nrn[3].weightv[3] is 0
Activation is -3
Output value is 0

pattern = 1 output = 1 component matches
pattern = 0 output = 0 component matches
pattern = 1 output = 1 component matches
pattern = 0 output = 0 component matches

nrn[0].weightv[0] is 0
```

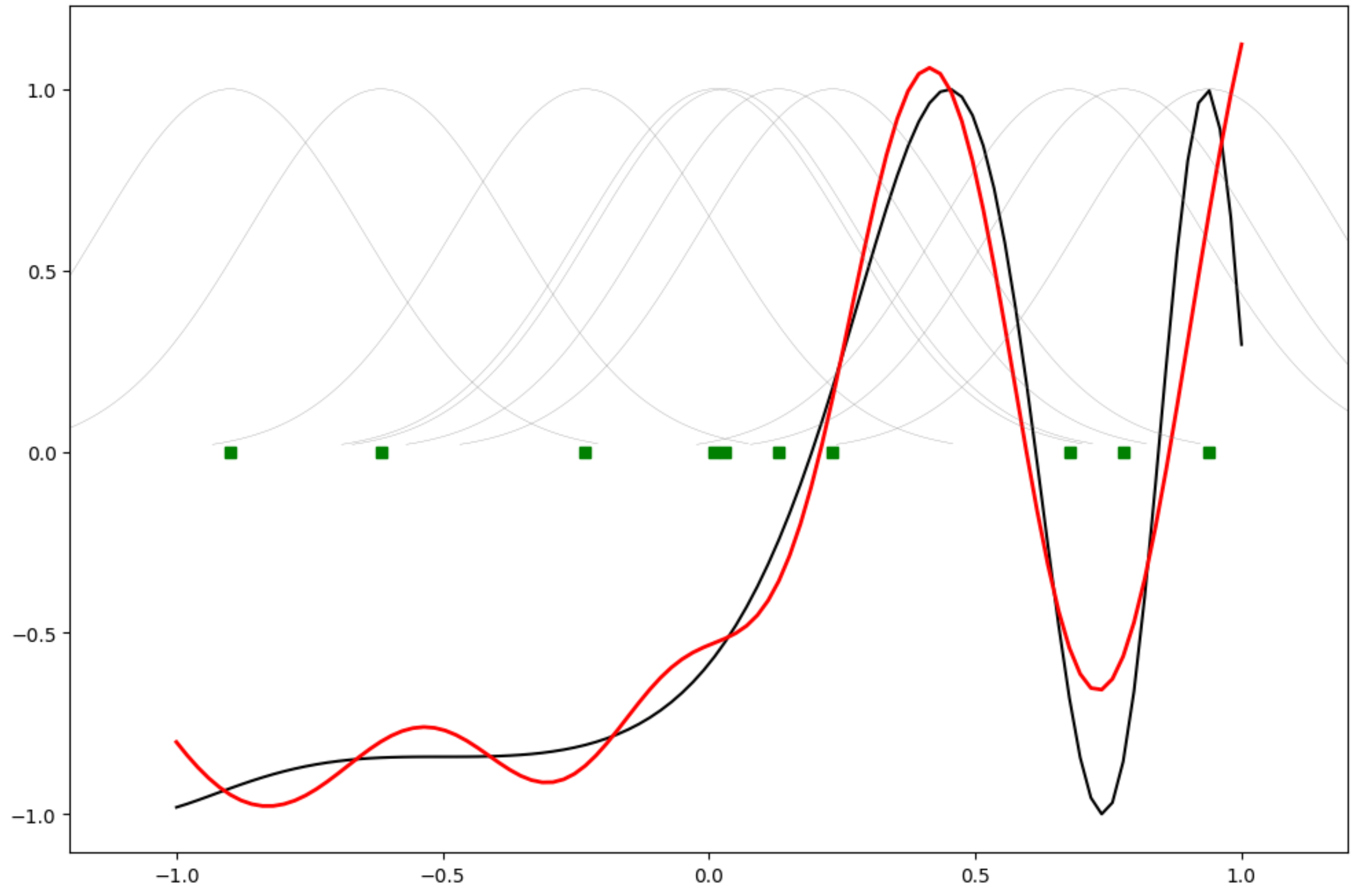
```
nrn[0].weightv[1] is -3
nrn[0].weightv[2] is 3
nrn[0].weightv[3] is -3
Activation is -3
Output value is 0

nrn[1].weightv[0] is -3
nrn[1].weightv[1] is 0
nrn[1].weightv[2] is -3
nrn[1].weightv[3] is 3
Activation is 3
Output value is 1

nrn[2].weightv[0] is 3
nrn[2].weightv[1] is -3
nrn[2].weightv[2] is 0
nrn[2].weightv[3] is -3
Activation is -3
Output value is 0

nrn[3].weightv[0] is -3
nrn[3].weightv[1] is 3
nrn[3].weightv[2] is -3
nrn[3].weightv[3] is 0
Activation is 3
Output value is 1

pattern = 0 output = 0 component matches
pattern = 1 output = 1 component matches
pattern = 0 output = 0 component matches
pattern = 1 output = 1 component matches
```

Practical 5B:
Aim: Radial Basis Function

Code:
```
import numpy as np
from scipy.linalg import norm, pinv
from matplotlib import pyplot as plt
from numpy import random, exp, zeros, dot, array, sin, arange
class RBF:
  def __init__(self, indim, numCenters, outdim):
    self.indim = indim
    self.outdim = outdim
    self.numCenters = numCenters
    self.centers = [random.uniform(-1, 1, indim) for i in range(numCenters)]
    self.beta = 8
    self.W = random.random((self.numCenters, self.outdim))
  def _basisfunc(self, c, d):
    assert len(d) == self.indim
    return exp(-self.beta * norm(c - d) ** 2)
  def _calcAct(self, X):
    G = zeros((X.shape[0], self.numCenters), float)
    for ci, c in enumerate(self.centers):
      for xi, x in enumerate(X):
        G[xi, ci] = self._basisfunc(c, x)
    return G
  def train(self, X, Y):
    rnd_idx = random.permutation(X.shape[0])[:self.numCenters]
    self.centers = [X[i, :] for i in rnd_idx]
    G = self._calcAct(X)
    self.W = dot(pinv(G), Y)
  def test(self, X):
    G = self._calcAct(X)
    Y = dot(G, self.W)
    return Y
if __name__ == '__main__':
  n = 100
  x = np.mgrid[-1:1:complex(0, n)].reshape(n, 1)
  y = sin(3 * (x + 0.5) ** 3 - 1)
  rbf = RBF(1, 10, 1)
  rbf.train(x, y)
  z = rbf.test(x)
```

```
plt.figure(figsize=(12, 8))
plt.plot(x, y, 'k-')
plt.plot(x, z, 'r-', linewidth=2)
plt.plot(rbf.centers, zeros(rbf.numCenters), 'gs')
for c in rbf.centers:
    cx = arange(c - 0.7, c + 0.7, 0.01)
    cy = [rbf._basisfunc(array([cx_]), array([c])) for cx_ in cx]
    plt.plot(cx, cy, '-', color='gray', linewidth=0.2)
plt.xlim(-1.2, 1.2)
plt.show()
```

Output:



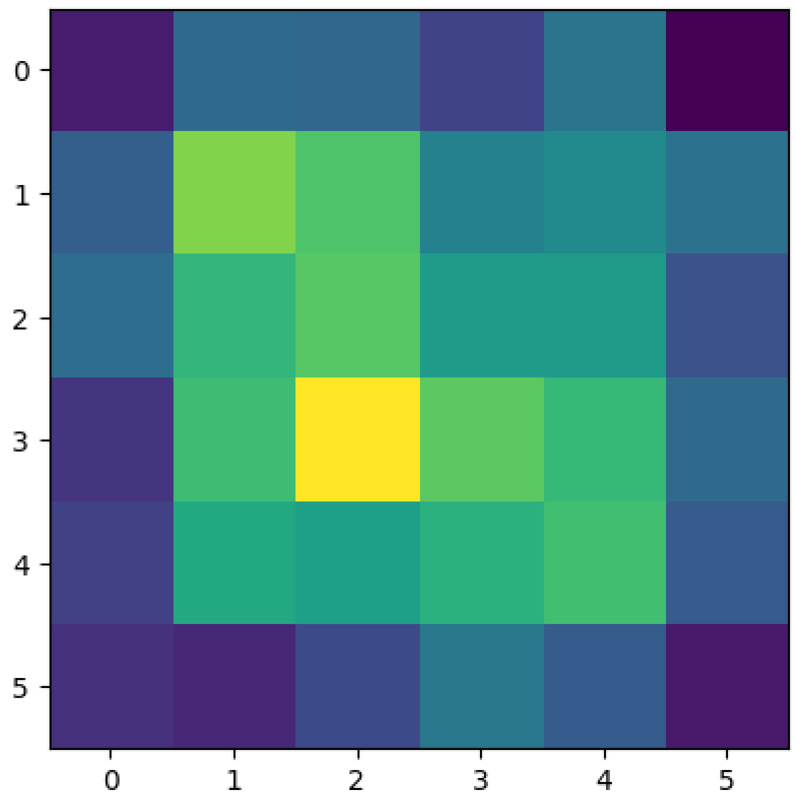
Practical 6

Practical 6A:
Aim: Kohonen Self Organizing Map

Code:

```
pip install minisom
pip install matplotlib
from minisom import MiniSom
import matplotlib.pyplot as plt
data = [[0.8, 0.55, 0.22, 0.03], [0.82, 0.5, 0.23, 0.03], [0.8, 0.54, 0.22, 0.03], [0.8,
0.53, 0.26, 0.03], [0.79, 0.56, 0.22, 0.03], [0.75, 0.6, 0.25, 0.03], [0.77, 0.59,
0.22, 0.03]]
som = MiniSom(6, 6, 4, sigma = 0.4, learning_rate = 0.5)
som.train_random(data, 100)
plt.imshow(som.distance_map())
plt.show()
```

Output:



Practical 6B:
Aim: Adaptive Response Theory

Code:
```
from __future__ import print_function, division
import numpy as np
class ART:
    def _init_(self, n=5, m=10, rho=0.5):
        self.F1 = np.ones(n)
        self.F2 = np.ones(m)
        self.Wf = np.random.random((m, n))
        self.Wb = np.random.random((n, m))
        self.rho = rho
        self.active = 0
    def learn(self, X):
        ''' Learn input X '''
        self.F2[...] = np.dot(self.Wf, X)
        I = np.argsort(self.F2[:self.active].ravel())[::-1]
        for i in I:
            d = (self.Wb[:, i] * X).sum() / X.sum()
            if d >= self.rho:
                self.Wb[:, i] *= X
                self.Wf[i, :] = self.Wb[:, i] / (0.5 + self.Wb[:, i].sum())
                return self.Wb[:, i], i
        if self.active < self.F2.size:
            i = self.active
            self.Wb[:, i] *= X
            self.Wf[i, :] = self.Wb[:, i] / (0.5 + self.Wb[:, i].sum())
            self.active += 1
            return self.Wb[:, i], i
        return None, None
def letter_to_array(letter):
    ''' Convert a letter to a numpy array '''
    shape = len(letter), len(letter[0])
    Z = np.zeros(shape, dtype=int)
    for row in range(Z.shape[0]):
        for column in range(Z.shape[1]):
            if letter[row][column] == '#':
                Z[row][column] = 1
    return Z
def print_letter(Z):
    ''' Print an array as if it was a letter '''
    for row in range(Z.shape[0]):
        for col in range(Z.shape[1]):
            if Z[row, col]:
                print('#', end="")
            else:
                print(' ', end="")
        print()
if __name__ == '__main__':
    np.random.seed(1)
    network = ART(5, 10, rho=0.5)
    data = ["  O  ", " O O ", "  O  ", " O O ", "  O  ", " O O ", "  O  ", " OO O", "
OO  ", " OO O", " OO  ", "OOO  ", "OO   ", "O    ", "OO   ", "OOO  ", "OOOO ",
"OOOOO"]
    X = np.zeros(len(data[0]))
    for i in range(len(data)):
        for j in range(len(data[i])):
            X[j] = (data[i][j] == 'O')
        Z, k = network.learn(X)
        print("|%s|" % data[i], "-> class", k)
    A = letter_to_array([' #### ', '#    #', '#    #', '######', '#    #', '#    #', '#    #'])
    B = letter_to_array(['##### ', '#    #', '#    #', '##### ', '#    #', '#    #', '##### '])
    C = letter_to_array([' #### ', '#    #', '#     ', '#     ', '#     ', '#    #', ' #### '])
    D = letter_to_array(['##### ', '#    #', '#    #', '#    #', '#    #', '#    #', '##### '])
    E = letter_to_array(['######', '#     ', '#     ', '####  ', '#     ', '#     ', '######'])
    F = letter_to_array(['######', '#     ', '#     ', '####  ', '#     ', '#     ', '#     '])
    samples = [A, B, C, D, E, F]
    network = ART(6 * 7, 10, rho=0.15)
    for i in range(len(samples)):
        Z, k = network.learn(samples[i].ravel())
        print("%c" % (ord('A') + i), "-> class", k)
        print_letter(Z.reshape(7, 6))
```

Output:

```
| O   | -> class 0
| O O | -> class 1
|  O  | -> class 2
| O O | -> class 1
|  O  | -> class 3
| O O | -> class 1
|  O  | -> class 3
| OO O| -> class 4
| OO  | -> class 5
| OO O| -> class 6
| OO  | -> class 6
|OOO  | -> class 6
|OO   | -> class 7
|O    | -> class 8
|OO   | -> class 9
|OOO  | -> class 6
|OOOO | -> class None
|OOOOO| -> class None
A -> class 0
 ####
#    #
#    #
######
#    #
#    #
#    #
B -> class 0
 ####
#    #
#    #
#####
#    #
#    #
#
C -> class 0
 ####
#    #
#
#
#
```

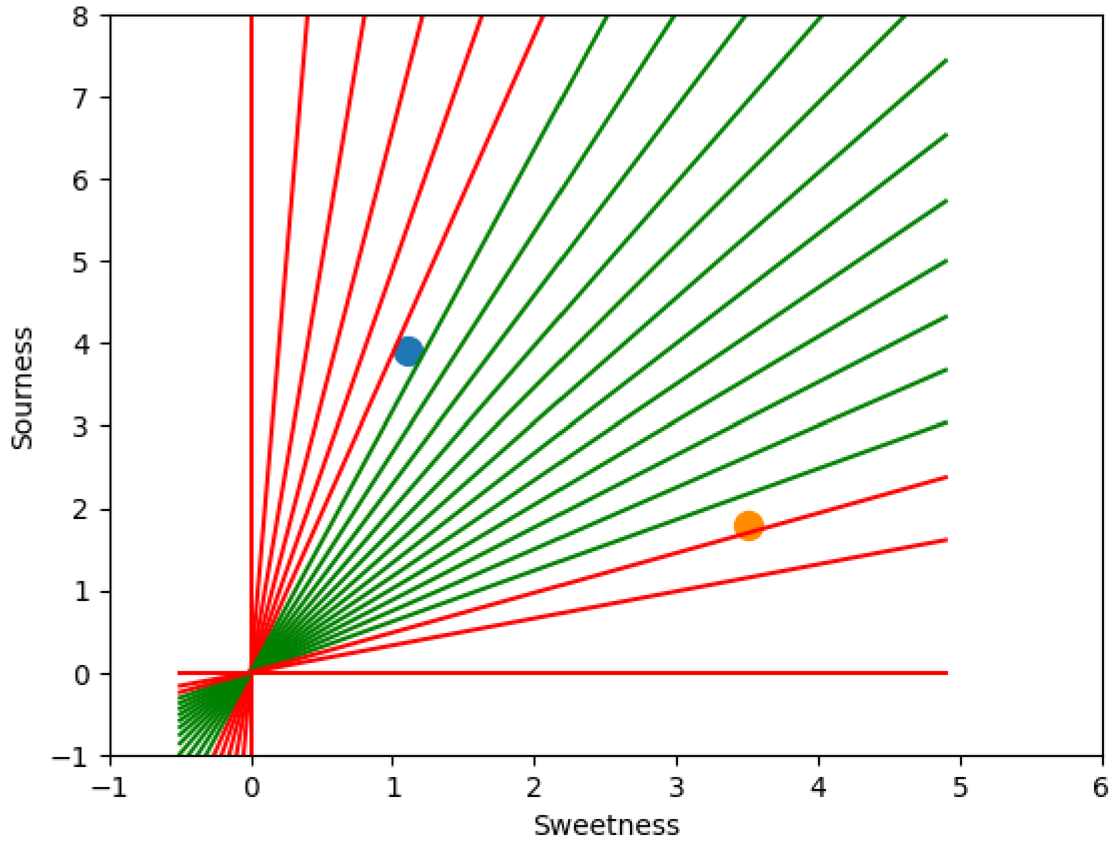
```
#    #

D -> class 0
 ####
#    #
#
#
#
#    #

E -> class 0
 ####
#
#
#
#
#

F -> class 0
 ####
#
#
#
#
#
```

Practical 7

Practical 7A:
Aim: Line Separation

Code:
```
import numpy as np
import matplotlib.pyplot as plt
def create_distance_function(a, b, c):
    def distance(x, y):
        nom = a * x + b * y + c
        if nom == 0:
            pos = 0
        elif (nom < 0 and b < 0) or (nom > 0 and b > 0):
            pos = -1
        else:
            pos = 1
        return (np.absolute(nom) / np.sqrt(a ** 2 + b ** 2), pos)
    return distance
points = [(3.5, 1.8), (1.1, 3.9)]
fig, ax = plt.subplots()
ax.set_xlabel("Sweetness")
ax.set_ylabel("Sourness")
ax.set_xlim([-1, 6])
ax.set_ylim([-1, 8])
X = np.arange(-0.5, 5, 0.1)
colors = ["r", ""]
size = 10
for (index, (x, y)) in enumerate(points):
    if index == 0:
        ax.plot(x, y, "o", color = "darkorange", markersize = size)
    else:
        ax.plot(x, y, "o", markersize = size)
        step = 0.05
for x in np.arange(0, 1 + step, step):
    slope = np.tan(np.arccos(x))
    dist4line1 = create_distance_function(slope, -1, 0)
    Y = slope * X
    results = []
    for point in points:
        results.append(dist4line1(*point))
    if (results[0][1] != results[1][1]):
        ax.plot(X, Y, 'g-')
    else:
        ax.plot(X, Y, 'r-')
plt.show()
```

Output:



Practical 8

Practical 8A:
Aim: Membership and Identity operators in, not in

Code:
```
list1 = []
print("Enter 5 numbers: ")
for i in range(0, 5):
   v = input()
   list1.append(v)
   list2 = []
print("Enter 5 numbers: ")
for i in range(0, 5):
   v = input()
   list2.append(v)
   flag = []
for i in list1:
   if i in list2:
      flag = 1
   if(flag == 1):
      print("Lists Overlap")
   else:
      print("Lists don't Overlap")
```

Output:
```
Enter 5 numbers: 1, 2, 3, 4, 5
Enter 5 numbers: 6, 7, 8, 9, 0
Lists don’t Overlap
Lists don’t Overlap
Lists don’t Overlap
Lists don’t Overlap
Lists don’t Overlap
```

Practical 8B:
Aim: Membership and Identity operators is, is not

Code:
```
x = 5
if(type(x) is not int):
   print(‘True’)
else:
   print(‘False’)
```
Output:
```
False
```

Code:
```
x = 5
if(type(x) is int):
   print(‘True’)
else:
   print(‘False’)
```
Output:
```
True
```

Code:
```
x = int(input(‘Enter value of x: ’))
if(type(x) is int):
   print(‘True’)
else:
   print(‘False’)
```
Output:
```
Enter value of x: 0.01
False
```

Code:
```
x = int(input(‘Enter value of x: ’))
if(type(x) is int):
   print(‘True’)
else:
   print(‘False’)
```
Output:
```
Enter value of x: 1
False
```

Practical 9

Practical 9A:
Aim: Ratios using Fuzzy Logic

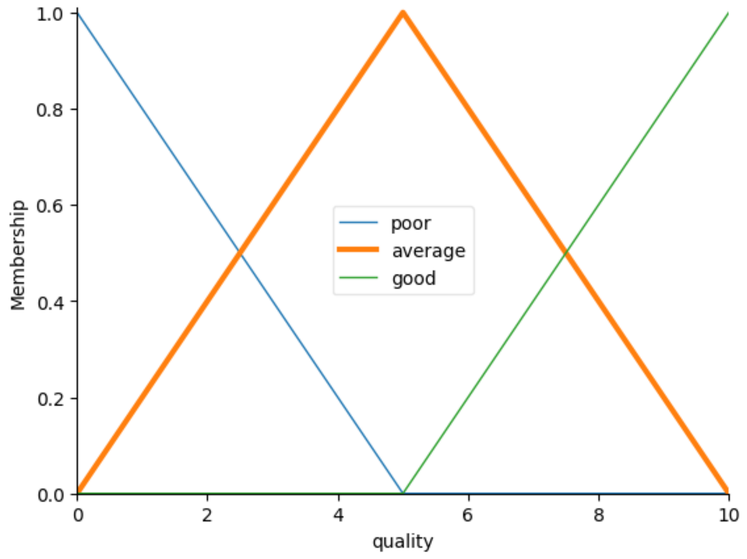
Code:
```
from fuzzywuzzy import fuzz
from fuzzywuzzy import process
s1 = "I love fuzzysforfuzzys"
s2 = "I am loving fuzzysforfuzzys"
print ("FuzzyWuzzy Ratio:", fuzz.ratio(s1, s2))
print ("FuzzyWuzzy Partial Ratio: ", fuzz.partial_ratio(s1, s2))
print ("FuzzyWuzzy Token Sort Ratio: ", fuzz.token_sort_ratio(s1, s2))
print ("FuzzyWuzzy Token Set Ratio: ", fuzz.token_set_ratio(s1, s2))
print ("FuzzyWuzzy W Ratio: ", fuzz.WRatio(s1, s2), '\n')
query = 'fuzzys for fuzzys'
choices = ['fuzzy for fuzzy', 'fuzzy fuzzy', 'g. for fuzzys']
print ("List of ratios: ", process.extract(query, choices), '\n')
print ("Best among the above list: ", process.extractOne(query, choices))
```

Output:
```
FuzzyWuzzy Ratio: 86
FuzzyWuzzy Partial Ratio:  86
FuzzyWuzzy Token Sort Ratio:  86
FuzzyWuzzy Token Set Ratio:  87
FuzzyWuzzy W Ratio:  86

List of ratios: [('g. for fuzzys', 95), ('fuzzy for fuzzy', 94), ('fuzzy fuzzy', 86)]

Best among the above list: ('g. for fuzzys', 95)
```

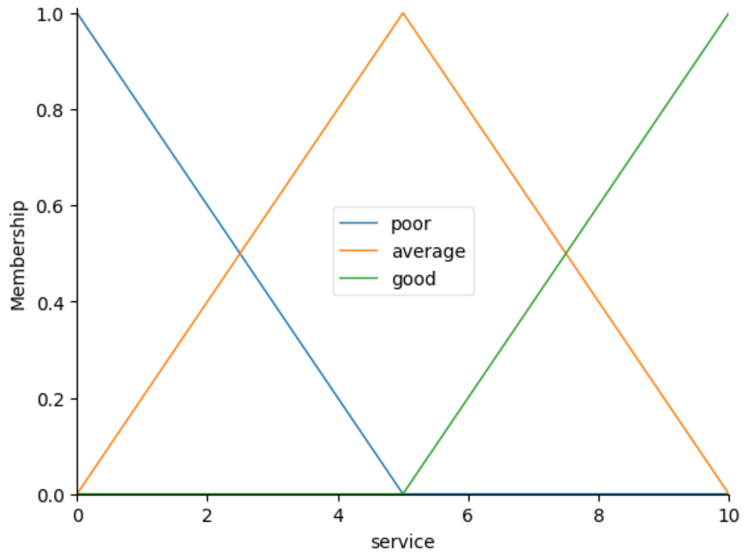
Practical 9B:
Aim: Tipping Problem using Fuzzy Logic

Code:
```
import numpy as np
import skfuzzy as fuzz
from skfuzzy import control as ctrl
quality = ctrl.Antecedent(np.arange(0, 11, 1), 'quality')
service = ctrl.Antecedent(np.arange(0, 11, 1), 'service')
tip = ctrl.Consequent(np.arange(0, 26, 1), 'tip')
quality.automf(3)
service.automf(3)
tip['low'] = fuzz.trimf(tip.universe, [0, 0, 13])
tip['medium'] = fuzz.trimf(tip.universe, [0, 13, 25])
tip['high'] = fuzz.trimf(tip.universe, [13, 25, 25])
quality['average'].view()
service.view()
tip.view()
```

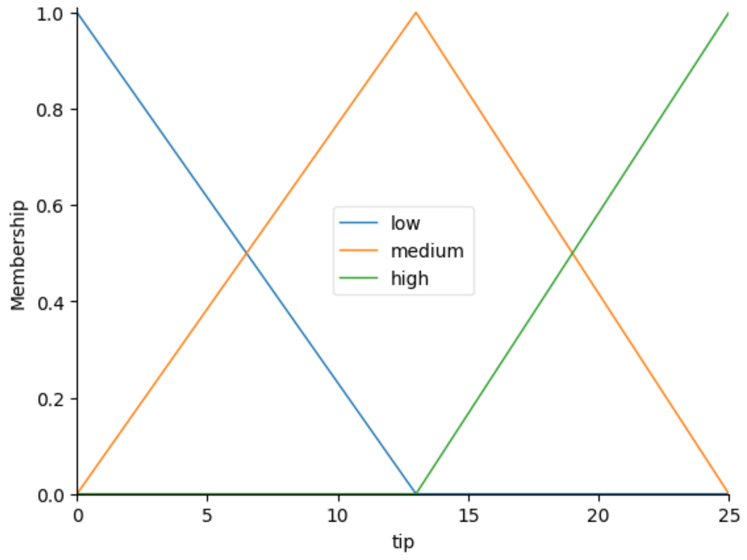
Output:



1.0
0.8
0.6
0.4
0.2
0.0
Membership
0
2
4
6
8
10
quality
poor
average
good



1.0
0.8
0.6
0.4
0.2
0.0
Membership
0
2
4
6
8
10
service
poor
average
good



1.0
0.8
0.6
0.4
0.2
0.0
Membership
0
5
10
15
20
25
tip
low
medium
high

Practical 10

Practical 10A:
Aim: Simple Genetic Algorithm

Code:

```
import random
POPULATION_SIZE = 100
GENES =
'''abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
1234567890, .-;:_!"#%&/()=?@${[]}'''
TARGET = "I love Coding"
class Individual(object):
    def __init__(self, chromosome):
        self.chromosome = chromosome
        self.fitness = self.cal_fitness()
    @classmethod
    def mutated_genes(cls):
        global GENES
        gene = random.choice(GENES)
        return gene
    @classmethod
    def create_gnome(cls):
        global TARGET
        gnome_len = len(TARGET)
        return [cls.mutated_genes() for _ in range(gnome_len)]
    def mate(self, par2):
        child_chromosome = []
        for gp1, gp2 in zip(self.chromosome, par2.chromosome):
            prob = random.random()
            if prob < 0.45:
                child_chromosome.append(gp1)
            elif prob < 0.90:
                child_chromosome.append(gp2)
            else:
                child_chromosome.append(self.mutated_genes())
        return Individual(child_chromosome)
    def cal_fitness(self):
        global TARGET
        fitness = 0
        for gs, gt in zip(self.chromosome, TARGET):
            if gs != gt:
                fitness += 1
        return fitness
def main():
    global POPULATION_SIZE
    generation = 1
    found = False
    population = []
    for _ in range(POPULATION_SIZE):
        gnome = Individual.create_gnome()
        population.append(Individual(gnome))
    while not found:
        population = sorted(population, key=lambda x: x.fitness)
        if population[0].fitness <= 0:
            found = True
            break
        new_generation = []
        s = int((10 * POPULATION_SIZE) / 100)
        new_generation.extend(population[:s])
        s = int((90 * POPULATION_SIZE) / 100)
        for _ in range(s):
            parent1 = random.choice(population[:50])
            parent2 = random.choice(population[:50])
            child = parent1.mate(parent2)
            new_generation.append(child)
        population = new_generation
        print("Generation: {}\tString: {}\tFitness: {}".format(generation,
"".join(population[0].chromosome), population[0].fitness))
        generation += 1
    print("Generation: {}\tString: {}\tFitness: {}".format(generation,
"".join(population[0].chromosome), population[0].fitness))
if __name__ == '__main__':
    main()
```

Output:

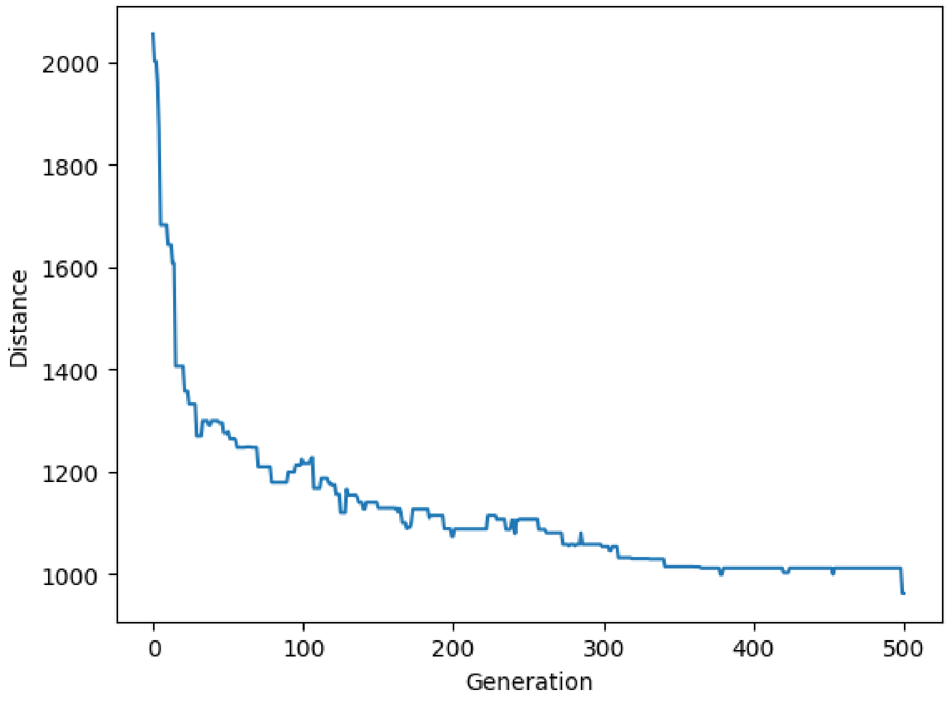
```
Generation: 1    String: Y 3,v3Zg#K@Em    Fitness: 11
Generation: 2    String: Y 3,v3Zg#K@Em    Fitness: 11
Generation: 3    String: I}S/8P p@ui?w    Fitness: 10
Generation: 4    String: I}S/8P p@ui?w    Fitness: 10
Generation: 5    String: zZ#ovshCZuXLg    Fitness: 9
Generation: 6    String: zZ#ovshCZuXLg    Fitness: 9
```

```
Generation: 7    String: IjlCFe C@&i?g    Fitness: 6
Generation: 8    String: IjlCFe C@&i?g    Fitness: 6
Generation: 9    String: I lVLe C_&i:g    Fitness: 5
Generation: 10    String: I lVve C@&i:g    Fitness: 4
Generation: 11    String: I lVve C@&i:g    Fitness: 4
Generation: 12    String: I lVve C@&i:g    Fitness: 4
Generation: 13    String: I love CIGi?g    Fitness: 3
Generation: 14    String: I love CIGi?g    Fitness: 3
Generation: 15    String: I love CGdirg    Fitness: 2
Generation: 16    String: I love CGdirg    Fitness: 2
Generation: 17    String: I love CGdirg    Fitness: 2
Generation: 18    String: I love CGdirg    Fitness: 2
Generation: 19    String: I love CGdirg    Fitness: 2
Generation: 20    String: I love CGdirg    Fitness: 2
Generation: 21    String: I love CGdirg    Fitness: 2
Generation: 22    String: I love CGdirg    Fitness: 2
Generation: 23    String: I love CGdirg    Fitness: 2
Generation: 24    String: I love CGdirg    Fitness: 2
Generation: 25    String: I love CGdirg    Fitness: 2
Generation: 26    String: I love CGdirg    Fitness: 2
Generation: 27    String: I love CGdirg    Fitness: 2
Generation: 28    String: I love CGdirg    Fitness: 2
Generation: 29    String: I love CGdirg    Fitness: 2
Generation: 30    String: I love CGdirg    Fitness: 2
Generation: 31    String: I love CGdirg    Fitness: 2
Generation: 32    String: I love CGdirg    Fitness: 2
Generation: 33    String: I love CGdirg    Fitness: 2
Generation: 34    String: I love CGdirg    Fitness: 2
Generation: 35    String: I love CGdirg    Fitness: 2
Generation: 36    String: I love CGding    Fitness: 1
Generation: 37    String: I love CGding    Fitness: 1
Generation: 38    String: I love CGding    Fitness: 1
Generation: 39    String: I love CGding    Fitness: 1
Generation: 40    String: I love CGding    Fitness: 1
Generation: 41    String: I love Coding    Fitness: 0
```

Practical 10B:
Aim: Classes creation using Genetic Algorithm

Code:
```
import numpy as np, random, operator, pandas as pd, matplotlib.pyplot as plt
from tkinter import Tk, Canvas, Frame, BOTH, Text
import math
class City:
    def __init__(self, x, y):
        self.x = x
        self.y = y
    def distance(self, city):
        xDis = abs(self.x - city.x)
        yDis = abs(self.y - city.y)
        distance = np.sqrt((xDis ** 2) + (yDis ** 2))
        return distance
    def __repr__(self):
        return "(" + str(self.x) + "," + str(self.y) + ")"
class Fitness:
    def __init__(self, route):
        self.route = route
        self.distance = 0
        self.fitness = 0.0
    def routeDistance(self):
        if self.distance == 0:
            pathDistance = 0
            for i in range(0, len(self.route)):
                fromCity = self.route[i]
                toCity = None
                if i + 1 < len(self.route):
                    toCity = self.route[i + 1]
                else:
                    toCity = self.route[0]
                pathDistance += fromCity.distance(toCity)
            self.distance = pathDistance
        return self.distance
    def routeFitness(self):
        if self.fitness == 0:
            self.fitness = 1 / float(self.routeDistance())
        return self.fitness
def createRoute(cityList):
    route = random.sample(cityList, len(cityList))
    return route
def initialPopulation(popSize, cityList):
    population = []
    for i in range(0, popSize):
        population.append(createRoute(cityList))
    return population
def rankRoutes(population):
    fitnessResults = {}
    for i in range(0, len(population)):
        fitnessResults[i] = Fitness(population[i]).routeFitness()
    return sorted(fitnessResults.items(), key=operator.itemgetter(1), reverse=True)
def selection(popRanked, eliteSize):
    selectionResults = []
    df = pd.DataFrame(np.array(popRanked), columns=["Index", "Fitness"])
    df['cum_sum'] = df.Fitness.cumsum()
    df['cum_perc'] = 100 * df.cum_sum / df.Fitness.sum()
    for i in range(0, eliteSize):
        selectionResults.append(popRanked[i][0])
    for i in range(0, len(popRanked) - eliteSize):
        pick = 100 * random.random()
        for i in range(0, len(popRanked)):
            if pick <= df.iat[i, 3]:
                selectionResults.append(popRanked[i][0])
                break
    return selectionResults
def matingPool(population, selectionResults):
    matingpool = []
    for i in range(0, len(selectionResults)):
        index = selectionResults[i]
        matingpool.append(population[index])
    return matingpool
def breed(parent1, parent2):
    child = []
    childP1 = []
    childP2 = []
    geneA = int(random.random() * len(parent1))
    geneB = int(random.random() * len(parent1))
    startGene = min(geneA, geneB)
    endGene = max(geneA, geneB)
    for i in range(startGene, endGene):
        childP1.append(parent1[i])
    childP2 = [item for item in parent2 if item not in childP1]
    child = childP1 + childP2
    return child
def breedPopulation(matingpool, eliteSize):
    children = []
    length = len(matingpool) - eliteSize
    pool = random.sample(matingpool, len(matingpool))
    for i in range(0, eliteSize):
        children.append(matingpool[i])
    for i in range(0, length):
        child = breed(pool[i], pool[len(matingpool) - i - 1])
        children.append(child)
    return children
def mutate(individual, mutationRate):
    for swapped in range(len(individual)):
        if random.random() < mutationRate:
            swapWith = int(random.random() * len(individual))
            city1 = individual[swapped]
            city2 = individual[swapWith]
            individual[swapped] = city2
            individual[swapWith] = city1
    return individual
def mutatePopulation(population, mutationRate):
    mutatedPop = []
    for ind in range(0, len(population)):
        mutatedInd = mutate(population[ind], mutationRate)
        mutatedPop.append(mutatedInd)
    return mutatedPop
def nextGeneration(currentGen, eliteSize, mutationRate):
    popRanked = rankRoutes(currentGen)
    selectionResults = selection(popRanked, eliteSize)
    matingpool = matingPool(currentGen, selectionResults)
    children = breedPopulation(matingpool, eliteSize)
    nextGeneration = mutatePopulation(children, mutationRate)
    return nextGeneration
def geneticAlgorithm(population, popSize, eliteSize, mutationRate, generations):
    pop = initialPopulation(popSize, population)
    print("Initial distance: " + str(1 / rankRoutes(pop)[0][1]))
    for i in range(0, generations):
        pop = nextGeneration(pop, eliteSize, mutationRate)
    print("Final distance: " + str(1 / rankRoutes(pop)[0][1]))
    bestRouteIndex = rankRoutes(pop)[0][0]
    bestRoute = pop[bestRouteIndex]
    return bestRoute
def geneticAlgorithmPlot(population, popSize, eliteSize, mutationRate,
generations):
    pop = initialPopulation(popSize, population)
    progress = []
    progress.append(1 / rankRoutes(pop)[0][1])
    for i in range(0, generations):
        pop = nextGeneration(pop, eliteSize, mutationRate)
        progress.append(1 / rankRoutes(pop)[0][1])
    plt.plot(progress)
    plt.ylabel('Distance')
    plt.xlabel('Generation')
    plt.show()
def main():
    cityList = []
    for i in range(0, 25):
        cityList.append(City(x=int(random.random() * 200), y =
int(random.random() * 200)))
    geneticAlgorithmPlot(population=cityList, popSize=100, eliteSize=20,
mutationRate=0.01, generations=500)
if __name__ == '__main__':
    main()
```

Output:


Distance
Generation