Imports

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import math
from sklearn.model_selection import train_test_split
import random
```

Part A

In [2]:
```
def _Myinit(): #read data from file and split to series
    myData = pd.read_csv('sonar data.csv',header=None)
    #divide the information to x and y values by numbers of columns
    x=myData.iloc[:, :-1].values
    y=myData.iloc[: , -1].values
    x=np.array(x)
    y=np.array(y)

    #change R-->0 , M-->1
    for i in range(len(y)):
        if (y[i]=='R'):
            y[i]=0
        else:
            y[i]=1

    Xtrain,Xtest,Ytrain,Ytest= train_test_split(x,y, test_size=0.2, random_state=4

    return Xtrain,Xtest,Ytrain,Ytest
```

In [3]:
```
def KNN(Xtrain, Ytrain, Xtest, k): #KNN algorithm to find k nearest neighbors
    Ypredicted=[]
    for test in Xtest:
        k_closest=[]
        distances=[]
        for train in Xtrain: #runs on each row in Xtrain
            distance=np.sqrt(np.sum((test-train)**2)) #euclidean distance sqrt((x1_
            distances=np.append(distances,distance) #adding to distances array

        for j in range(k): #find the minimum k neighbors
            minimum = min(distances) #find one each run
            index = np.where(distances == minimum)[0] #get its index
            k_closest=np.append(k_closest,Ytrain[index[0]]) #adding to the k_close
            distances[index[0]] = 100000

        #check what classification to give to each element
        counter0 = 0
        counter1 = 0
        for j in k_closest:
            if (j == 1):
                counter1 = counter1 + 1
            else:
                counter0 = counter0 + 1

        if(counter1>counter0):
            Ypredicted=np.append(Ypredicted,1) #become 1
        else:
```

```
            Ypredicted=np.append(Ypredicted,0) #become 0

    return Ypredicted #return the predicted classification array
```

In [4]:
```
def ConfusionMatrix(Yreal,Ypredicted):
    # create 2x2 matrix of and crosses information between the prediction and the t
    myMatrix=np.zeros((2,2),dtype=int)

    myLen=len(Yreal)
    for i in range(myLen): # run on all the Yreal that we found and create the matr
            if (Yreal[i]==1 and Ypredicted[i]==1):
                myMatrix[0,0]+=1
            elif (Yreal[i]==1 and Ypredicted[i]==0):
                myMatrix[1,0]+=1
            elif (Yreal[i]==0 and Ypredicted[i]==1):
                myMatrix[0,1]+=1
            elif (Yreal[i]==0 and Ypredicted[i]==0):
                myMatrix[1,1]+=1

    return myMatrix #return the final matrix
```

In [5]:
```
def accuracy(MyMatrix,length): # return the accuracy in percentages
    return ((MyMatrix[0,0] + MyMatrix[1,1])/length)*100
```

Question 7

In [6]:
```
#Check KNN with all the functions we implament above

Xtrain,Xtest,Ytrain,Ytest = _Myinit()
Ypredicted = KNN(Xtrain, Ytrain, Xtest, 3)
CM = ConfusionMatrix(Ytest,Ypredicted)
acc = accuracy(CM, len(Ytest))
print("Accuracy by given Xtrain, Ytrain, Xtest: "+str(round(acc,2)) + "%") # the r


Ypredicted = KNN(Xtest, Ytest, Xtrain, 3)
CM = ConfusionMatrix(Ytrain,Ypredicted)
acc = accuracy(CM, len(Ytrain))
print("Accuracy by given Xtest, Ytest, Xtrain: "+str(round(acc,2)) + "%") # the ro
```

```
Accuracy by given Xtrain, Ytrain, Xtest: 88.1%
Accuracy by given Xtest, Ytest, Xtrain: 61.45%
```

Question 8

In [7]:
```
# Each run looks for a different amount of neighbors
temp=0
index=0
for i in range(1,len(Ytest),2):
    Ypredicted=KNN(Xtrain, Ytrain, Xtest, i) #used the KNN function
    CM=ConfusionMatrix(Ytest,Ypredicted) #create cnfusion matrix
    acc=accuracy(CM, len(Ytest));
    if (acc>=temp): #find the best accuracy
        temp=acc
        index=i
    print("k= "+str(i) +" ,accuracy: "+str(acc))

print("with k= "+str(index)+" we get the best accuracy of "+str(temp)+ "%")
```

```
k= 1 ,accuracy: 88.09523809523809
k= 3 ,accuracy: 88.09523809523809
k= 5 ,accuracy: 85.71428571428571
k= 7 ,accuracy: 80.95238095238095
k= 9 ,accuracy: 83.33333333333334
k= 11 ,accuracy: 76.19047619047619
k= 13 ,accuracy: 76.19047619047619
k= 15 ,accuracy: 76.19047619047619
k= 17 ,accuracy: 73.80952380952381
k= 19 ,accuracy: 71.42857142857143
k= 21 ,accuracy: 73.80952380952381
k= 23 ,accuracy: 71.42857142857143
k= 25 ,accuracy: 71.42857142857143
k= 27 ,accuracy: 69.04761904761905
k= 29 ,accuracy: 69.04761904761905
k= 31 ,accuracy: 64.28571428571429
k= 33 ,accuracy: 69.04761904761905
k= 35 ,accuracy: 76.19047619047619
k= 37 ,accuracy: 69.04761904761905
k= 39 ,accuracy: 73.80952380952381
k= 41 ,accuracy: 71.42857142857143
with k= 3 we get the best accuracy of 88.09523809523809%
```

Part B

Question 9

In [8]:
```python
def Probabilityclassify(X,W): #multiplies vector X by vector W
    Ypredict=X@W
    return Ypredict
```

In [9]:
```python
def Probabilityclassify2(X,W): # using when X size is smaller than W size
    Ypredict=X@W[1:] + W[0] #adding w[0] as a number
    return Ypredict
```

In [10]:
```python
def probablisticLogRegClassifier(X,W): #calculate the formula for a logistic regres
    z=-1*Probabilityclassify(X,W)
    return 1/(1+np.exp(z)) #return logistic regression classifier
```

In [11]:
```python
def probablisticLogRegClassifier2(X,W): #calls Probabilityclassify2 when X size is
    z=-1*Probabilityclassify2(X,W)
    return 1/(1+np.exp(z))
```

In [12]:
```python
def MySigma(X,Y,W): #inside calculate of gradientStep
    ans=0
    for i in range(len(X)): #for each row of X
        ans = ans + X[i]*( (probablisticLogRegClassifier(X[i],W)) - Y[i] ) #given

    return ans
```

In [13]:
```python
def gradientStep(W,a,X,Y): #the calculate for each step in gradient descent

    return W-a*MySigma(X,Y,W)
```

In [14]:
```
def FinalClassification(P,th):
    #Takes one probability each time and checks whether it is greater than the TH,
    # according to which determines the classification 0 or 1
    Ypredicted=np.zeros(len(P))

    i=0;
    for p in P:
            if (p>th):
                Ypredicted[i]=1
            else:
                Ypredicted[i]=0
            i+=1

    return Ypredicted #Returns the estimated Y
```

In [15]:
```
def calc_w_coff(x,y,a,T):
    W = np.random.rand(len(x[0])+1) #generates an array of random numbers between 0

    #adding 1's column to X .sould use only once! otherwise its crush.
    #to manipulate the algorithm that W and X in the same size
    x=np.insert(x, 0, 1, axis=1)

    mylen=T+1
    W_coff=np.zeros((mylen,len(W))) #crate array of W coefficients
    W_coff[0]=W #insert the first random W[0]
    for t in range(T):
        W=gradientStep(W,a,x,y) #with each W, with gradient descent find the next g
        W_coff[t+1]=W #insert it to the big W coefficient array

    x=x[:, 1:] #remove the 1's column from X
    return W_coff #return the W coefficients array
```

In [16]:
```
def Classification_accuracy(x,y,W,th): #check the accuracy by given W coefficients,
    P_arr=np.zeros((len(W),len(x))) #init probabilty array
    acc=np.zeros(len(W)) #specific accuracy array for each row of X
    m = np.array(range(1,len(W)+1)) #arrays of number of iteration
    print("\nAccuracy of the classifier:\n")
    for i in range(len(W)): #for each W level iteration

        P=probablisticLogRegClassifier2(x,W[i]) #calculate the probabilty for each
        P_arr[i] = P #adding it to the probabilty array
        Ypredicted=FinalClassification(P,th)
        myMatrix=ConfusionMatrix(y,Ypredicted)
        acc[i]=accuracy(myMatrix,len(x))
        print("\nAccuracy in iteration #" + str(i) +" is: "+str(acc[i])+"%") #print
    fig = plt.figure(figsize=(10, 4))
    plt.plot(m,acc)
    return P_arr
```

In [17]:
```
def cross_entropy(y,P): #The relationship between y and the probability that y came
    ans= -((y*np.log(P))+(1-y)*np.log(1-P)).sum()
    return ans
```

Question 10

D_train

In [18]:
```
# Section A
Xtrain,Xtest,Ytrain,Ytest= _Myinit()
a = 0.01
T = 400
W_coff = calc_w_coff(Xtrain,Ytrain,a,T) # run the functions we implament above and
P_arr1 = Classification_accuracy(Xtrain,Ytrain,W_coff,0.5)
```

```
Accuracy of the classifier:

Accuracy in iteration #0 is: 51.204819277108435%
Accuracy in iteration #1 is: 54.81927710843374%
Accuracy in iteration #2 is: 49.39759036144578%
Accuracy in iteration #3 is: 51.204819277108435%
Accuracy in iteration #4 is: 48.795180722891565%
Accuracy in iteration #5 is: 51.204819277108435%
Accuracy in iteration #6 is: 48.795180722891565%
Accuracy in iteration #7 is: 51.204819277108435%
Accuracy in iteration #8 is: 48.795180722891565%
Accuracy in iteration #9 is: 51.204819277108435%
Accuracy in iteration #10 is: 48.795180722891565%
Accuracy in iteration #11 is: 51.204819277108435%
Accuracy in iteration #12 is: 48.795180722891565%
Accuracy in iteration #13 is: 51.204819277108435%
Accuracy in iteration #14 is: 48.795180722891565%
Accuracy in iteration #15 is: 51.204819277108435%
Accuracy in iteration #16 is: 49.39759036144578%
Accuracy in iteration #17 is: 51.204819277108435%
Accuracy in iteration #18 is: 49.39759036144578%
Accuracy in iteration #19 is: 51.80722891566265%
Accuracy in iteration #20 is: 49.39759036144578%
Accuracy in iteration #21 is: 51.80722891566265%
Accuracy in iteration #22 is: 50.0%
Accuracy in iteration #23 is: 52.40963855421686%
Accuracy in iteration #24 is: 51.204819277108435%
Accuracy in iteration #25 is: 53.01204819277109%
Accuracy in iteration #26 is: 51.204819277108435%
Accuracy in iteration #27 is: 53.01204819277109%
Accuracy in iteration #28 is: 51.80722891566265%
Accuracy in iteration #29 is: 54.81927710843374%
Accuracy in iteration #30 is: 51.80722891566265%
```

Accuracy in iteration #31 is: 55.42168674698795%

Accuracy in iteration #32 is: 52.40963855421686%

Accuracy in iteration #33 is: 56.024096385542165%

Accuracy in iteration #34 is: 53.01204819277109%

Accuracy in iteration #35 is: 56.024096385542165%

Accuracy in iteration #36 is: 53.6144578313253%

Accuracy in iteration #37 is: 56.024096385542165%

Accuracy in iteration #38 is: 54.21686746987952%

Accuracy in iteration #39 is: 56.62650602409639%

Accuracy in iteration #40 is: 54.21686746987952%

Accuracy in iteration #41 is: 57.831325301204814%

Accuracy in iteration #42 is: 55.42168674698795%

Accuracy in iteration #43 is: 57.831325301204814%

Accuracy in iteration #44 is: 57.22891566265061%

Accuracy in iteration #45 is: 58.43373493975904%

Accuracy in iteration #46 is: 57.22891566265061%

Accuracy in iteration #47 is: 58.43373493975904%

Accuracy in iteration #48 is: 57.831325301204814%

Accuracy in iteration #49 is: 59.63855421686747%

Accuracy in iteration #50 is: 58.43373493975904%

Accuracy in iteration #51 is: 60.8433734939759%

Accuracy in iteration #52 is: 58.43373493975904%

Accuracy in iteration #53 is: 60.8433734939759%

Accuracy in iteration #54 is: 58.43373493975904%

Accuracy in iteration #55 is: 62.048192771084345%

Accuracy in iteration #56 is: 58.43373493975904%

Accuracy in iteration #57 is: 62.048192771084345%

Accuracy in iteration #58 is: 57.831325301204814%

Accuracy in iteration #59 is: 62.048192771084345%

Accuracy in iteration #60 is: 58.43373493975904%

Accuracy in iteration #61 is: 62.048192771084345%

Accuracy in iteration #62 is: 60.24096385542169%

Accuracy in iteration #63 is: 62.048192771084345%

Accuracy in iteration #64 is: 60.24096385542169%

Accuracy in iteration #65 is: 62.048192771084345%

Accuracy in iteration #66 is: 60.24096385542169%

Accuracy in iteration #67 is: 63.25301204819277%

Accuracy in iteration #68 is: 60.24096385542169%

Accuracy in iteration #69 is: 63.85542168674698%

Accuracy in iteration #70 is: 60.8433734939759%

Accuracy in iteration #71 is: 63.85542168674698%

Accuracy in iteration #72 is: 60.8433734939759%

Accuracy in iteration #73 is: 64.45783132530121%

Accuracy in iteration #74 is: 61.44578313253012%

Accuracy in iteration #75 is: 64.45783132530121%

Accuracy in iteration #76 is: 62.048192771084345%

Accuracy in iteration #77 is: 66.86746987951807%

Accuracy in iteration #78 is: 62.65060240963856%

Accuracy in iteration #79 is: 66.86746987951807%

Accuracy in iteration #80 is: 63.85542168674698%

Accuracy in iteration #81 is: 67.46987951807229%

Accuracy in iteration #82 is: 63.25301204819277%

Accuracy in iteration #83 is: 68.07228915662651%

Accuracy in iteration #84 is: 63.25301204819277%

Accuracy in iteration #85 is: 68.07228915662651%

Accuracy in iteration #86 is: 63.25301204819277%

Accuracy in iteration #87 is: 68.07228915662651%

Accuracy in iteration #88 is: 63.25301204819277%

Accuracy in iteration #89 is: 68.07228915662651%

Accuracy in iteration #90 is: 63.85542168674698%

Accuracy in iteration #91 is: 69.87951807228916%

Accuracy in iteration #92 is: 63.85542168674698%

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Accuracy in iteration #98 is: 63.85542168674698%

Accuracy in iteration #99 is: 69.27710843373494%

Accuracy in iteration #100 is: 63.85542168674698%

Accuracy in iteration #101 is: 69.87951807228916%

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Accuracy in iteration #103 is: 69.87951807228916%

Accuracy in iteration #104 is: 63.85542168674698%

Accuracy in iteration #105 is: 71.08433734939759%

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Accuracy in iteration #107 is: 71.08433734939759%

Accuracy in iteration #108 is: 64.45783132530121%

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Accuracy in iteration #118 is: 65.66265060240963%

Accuracy in iteration #119 is: 71.6867469879518%

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Accuracy in iteration #260 is: 75.30120481927712%

Accuracy in iteration #261 is: 78.3132530120482%

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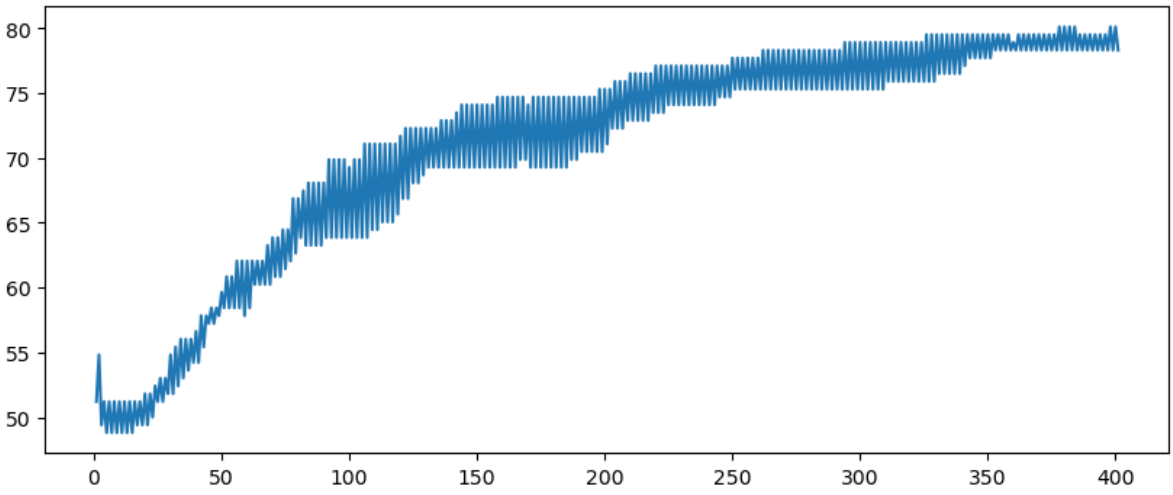

In [615…

```python
# Section B
crossEntropy=np.zeros(len(W_coff)) # use the W_coff we found above to check cross e
m = np.array(range(1,len(W_coff)+1))
for i in range(len(W_coff)):
    crossEntropy[i]= cross_entropy(Ytrain,P_arr1[i])
    print("\nCross Entropy of Train while m=" + str(m[i]) +" is: "+str(crossEntropy

fig = plt.figure(figsize=(10, 4))
plt.plot(m,crossEntropy)
```

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Cross Entropy of Train while m=1 is: 757.730369746939

Cross Entropy of Train while m=2 is: 212.1970035202889

Cross Entropy of Train while m=3 is: 266.7198099388733

Cross Entropy of Train while m=4 is: 278.8815847732376

Cross Entropy of Train while m=5 is: 235.45112550608715

Cross Entropy of Train while m=6 is: 280.40104470107786

Cross Entropy of Train while m=7 is: 226.13044363048758

Cross Entropy of Train while m=8 is: 275.8379642155096

Cross Entropy of Train while m=9 is: 220.576299377776

Cross Entropy of Train while m=10 is: 269.972887296331

Cross Entropy of Train while m=11 is: 215.82038732559963

Cross Entropy of Train while m=12 is: 263.339012077589

Cross Entropy of Train while m=13 is: 211.45707625343715

Cross Entropy of Train while m=14 is: 256.191535693428

Cross Entropy of Train while m=15 is: 207.26734149471594

Cross Entropy of Train while m=16 is: 248.7345586185516

Cross Entropy of Train while m=17 is: 203.0985085290697

Cross Entropy of Train while m=18 is: 241.1314021348216

Cross Entropy of Train while m=19 is: 198.86701574659665

Cross Entropy of Train while m=20 is: 233.51021741199077

Cross Entropy of Train while m=21 is: 194.55127738917727

Cross Entropy of Train while m=22 is: 225.9713772656966

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Cross Entropy of Train while m=26 is: 211.4432769697785

Cross Entropy of Train while m=27 is: 181.42786007908984

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Cross Entropy of Train while m=29 is: 177.159911192607

Cross Entropy of Train while m=30 is: 198.0033630395298

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Cross Entropy of Train while m=32 is: 191.77409759167455
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Cross Entropy of Train while m=37 is: 161.51098721912132

Cross Entropy of Train while m=38 is: 175.14862763747757

Cross Entropy of Train while m=39 is: 158.00332757581464

Cross Entropy of Train while m=40 is: 170.26806651825166

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Cross Entropy of Train while m=47 is: 145.48980038383328

Cross Entropy of Train while m=48 is: 153.59961821180204

Cross Entropy of Train while m=49 is: 142.70702624528838

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Cross Entropy of Train while m=249 is: 77.63912852087842

Cross Entropy of Train while m=250 is: 78.26361154809257

Cross Entropy of Train while m=251 is: 77.4908655044438

Cross Entropy of Train while m=252 is: 78.10923631734228

Cross Entropy of Train while m=253 is: 77.34423444497506

Cross Entropy of Train while m=254 is: 77.95654634452066

Cross Entropy of Train while m=255 is: 77.19919511794095

Cross Entropy of Train while m=256 is: 77.80550039058056
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Cross Entropy of Train while m=257 is: 77.05570880999538

Cross Entropy of Train while m=258 is: 77.65605878176494

Cross Entropy of Train while m=259 is: 76.91373824913364

Cross Entropy of Train while m=260 is: 77.50818333648003

Cross Entropy of Train while m=261 is: 76.77324753837476

Cross Entropy of Train while m=262 is: 77.36183729588325

Cross Entropy of Train while m=263 is: 76.63420209278446

Cross Entropy of Train while m=264 is: 77.21698525798513

Cross Entropy of Train while m=265 is: 76.49656857966063

Cross Entropy of Train while m=266 is: 77.0735931150811

Cross Entropy of Train while m=267 is: 76.36031486171638

Cross Entropy of Train while m=268 is: 76.93162799433675

Cross Entropy of Train while m=269 is: 76.22540994310147

Cross Entropy of Train while m=270 is: 76.79105820136067

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Cross Entropy of Train while m=319 is: 73.21879596880858

Cross Entropy of Train while m=320 is: 73.65643748256947
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Cross Entropy of Train while m=346 is: 72.25498761022995

Cross Entropy of Train while m=347 is: 71.77628355403401

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Cross Entropy of Train while m=399 is: 69.42381390878322

Cross Entropy of Train while m=400 is: 69.70225402705351

Cross Entropy of Train while m=401 is: 69.34036013275649
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Out[615]:
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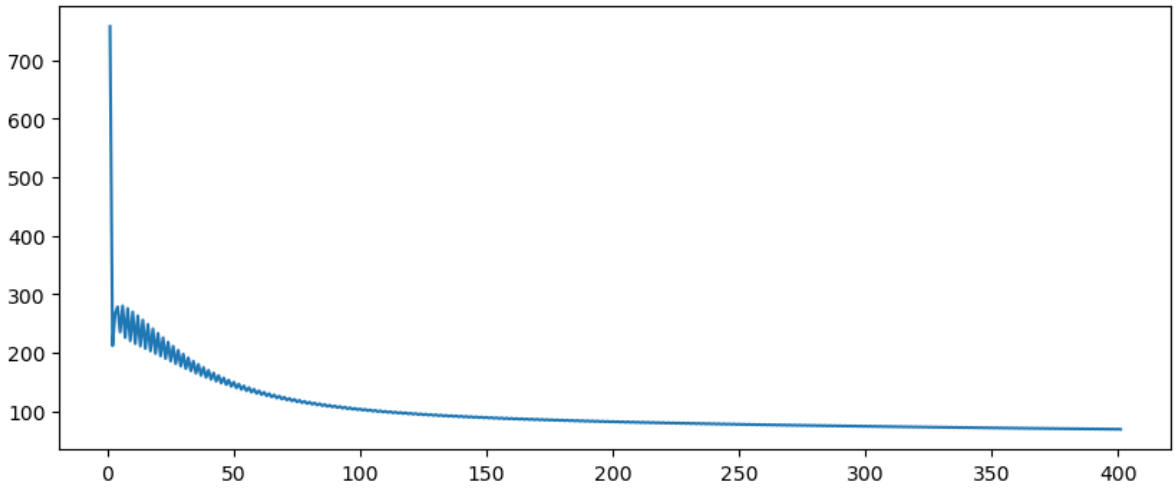
[<matplotlib.lines.Line2D at 0x25c2437f880>]
```



D_test

In [616…
```
# Section B
P_arr2 = Classification_accuracy(Xtest,Ytest,W_coff,0.5) #use the W_coff we found
```

```
Accuracy of the classifier:

Accuracy in iteration #0 is: 61.904761904761905%
Accuracy in iteration #1 is: 61.904761904761905%
Accuracy in iteration #2 is: 38.095238095238095%
Accuracy in iteration #3 is: 61.904761904761905%
Accuracy in iteration #4 is: 38.095238095238095%
Accuracy in iteration #5 is: 61.904761904761905%
Accuracy in iteration #6 is: 38.095238095238095%
Accuracy in iteration #7 is: 61.904761904761905%
Accuracy in iteration #8 is: 38.095238095238095%
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Accuracy in iteration #10 is: 38.095238095238095%
Accuracy in iteration #11 is: 61.904761904761905%
Accuracy in iteration #12 is: 38.095238095238095%
Accuracy in iteration #13 is: 61.904761904761905%
Accuracy in iteration #14 is: 38.095238095238095%
Accuracy in iteration #15 is: 61.904761904761905%
Accuracy in iteration #16 is: 38.095238095238095%
Accuracy in iteration #17 is: 61.904761904761905%
Accuracy in iteration #18 is: 40.476190476190474%
Accuracy in iteration #19 is: 61.904761904761905%
Accuracy in iteration #20 is: 42.857142857142854%
Accuracy in iteration #21 is: 61.904761904761905%
Accuracy in iteration #22 is: 45.23809523809524%
Accuracy in iteration #23 is: 64.28571428571429%
Accuracy in iteration #24 is: 45.23809523809524%
Accuracy in iteration #25 is: 69.04761904761905%
Accuracy in iteration #26 is: 45.23809523809524%
Accuracy in iteration #27 is: 69.04761904761905%
Accuracy in iteration #28 is: 47.61904761904761%
Accuracy in iteration #29 is: 69.04761904761905%
Accuracy in iteration #30 is: 47.61904761904761%
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Accuracy in iteration #31 is: 69.04761904761905%

Accuracy in iteration #32 is: 47.61904761904761%

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Accuracy in iteration #40 is: 47.61904761904761%

Accuracy in iteration #41 is: 71.42857142857143%

Accuracy in iteration #42 is: 47.61904761904761%

Accuracy in iteration #43 is: 73.80952380952381%

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Accuracy in iteration #50 is: 47.61904761904761%

Accuracy in iteration #51 is: 76.19047619047619%

Accuracy in iteration #52 is: 52.38095238095239%

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Accuracy in iteration #59 is: 78.57142857142857%

Accuracy in iteration #60 is: 54.761904761904766%

Accuracy in iteration #61 is: 78.57142857142857%

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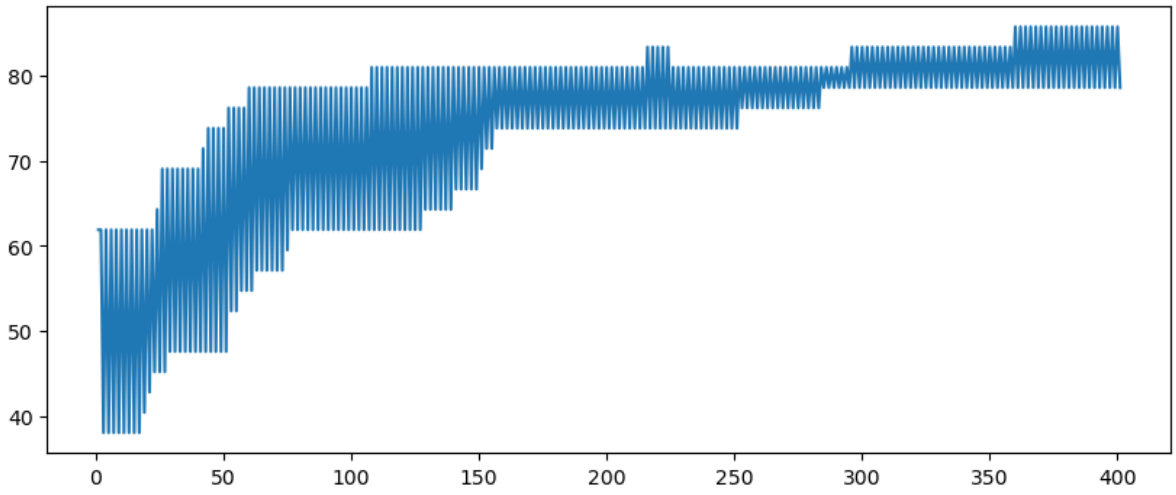

In [617…

```
# Section B
crossEntropy=np.zeros(len(W_coff)) # use the W_coff we found above to check cross e
m = np.array(range(1,len(W_coff)+1))
for i in range(len(W_coff)):
    crossEntropy[i]= cross_entropy(Ytest,P_arr2[i])
    print("\nCross Entropy of Test while m=" + str(m[i]) +" is: "+str(crossEntropy
plt.plot(m,crossEntropy)
```

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Cross Entropy of Test while m=1 is: 144.6705076010668

Cross Entropy of Test while m=2 is: 41.32274145337364

Cross Entropy of Test while m=3 is: 75.21440017162026

Cross Entropy of Test while m=4 is: 52.60882644333814

Cross Entropy of Test while m=5 is: 65.88531331968532

Cross Entropy of Test while m=6 is: 51.925395212685245

Cross Entropy of Test while m=7 is: 63.228806298942246

Cross Entropy of Test while m=8 is: 50.189506731801444

Cross Entropy of Test while m=9 is: 61.703874643283754

Cross Entropy of Test while m=10 is: 48.29313019001726

Cross Entropy of Test while m=11 is: 60.40744633951634

Cross Entropy of Test while m=12 is: 46.33702051620691

Cross Entropy of Test while m=13 is: 59.21796511163833

Cross Entropy of Test while m=14 is: 44.37166329191187

Cross Entropy of Test while m=15 is: 58.07028134858896

Cross Entropy of Test while m=16 is: 42.4380642296085

Cross Entropy of Test while m=17 is: 56.918905791058386

Cross Entropy of Test while m=18 is: 40.56810132457004

Cross Entropy of Test while m=19 is: 55.73877371838236

Cross Entropy of Test while m=20 is: 38.78433164501106

Cross Entropy of Test while m=21 is: 54.52308037882233

Cross Entropy of Test while m=22 is: 37.10083681166521

Cross Entropy of Test while m=23 is: 53.27804589651233

Cross Entropy of Test while m=24 is: 35.52483359194058

Cross Entropy of Test while m=25 is: 52.01687097338135

Cross Entropy of Test while m=26 is: 34.05847137883987

Cross Entropy of Test while m=27 is: 50.75475111923416

Cross Entropy of Test while m=28 is: 32.700353384903686

Cross Entropy of Test while m=29 is: 49.50563086905431

Cross Entropy of Test while m=30 is: 31.446623787017735

Cross Entropy of Test while m=31 is: 48.28054938615421

Cross Entropy of Test while m=32 is: 30.291704823607855
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Cross Entropy of Test while m=33 is: 47.08717757681135

Cross Entropy of Test while m=34 is: 29.228851170904303

Cross Entropy of Test while m=35 is: 45.93013317062743

Cross Entropy of Test while m=36 is: 28.25064192452961

Cross Entropy of Test while m=37 is: 44.811687969228984

Cross Entropy of Test while m=38 is: 27.349438762810873

Cross Entropy of Test while m=39 is: 43.732552354220324

Cross Entropy of Test while m=40 is: 26.517778957639955

Cross Entropy of Test while m=41 is: 42.69253979599293

Cross Entropy of Test while m=42 is: 25.748665494293746

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Cross Entropy of Test while m=45 is: 40.72727530997126

Cross Entropy of Test while m=46 is: 24.37335926181713

Cross Entropy of Test while m=47 is: 39.80048706058737

Cross Entropy of Test while m=48 is: 23.756579613123748

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Cross Entropy of Test while m=65 is: 33.00545486210497

Cross Entropy of Test while m=66 is: 19.706583874501817

Cross Entropy of Test while m=67 is: 32.408039907993604

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Cross Entropy of Test while m=214 is: 13.83233535615789

Cross Entropy of Test while m=215 is: 20.07880619298344

Cross Entropy of Test while m=216 is: 13.824691851034522

Cross Entropy of Test while m=217 is: 20.043665524272036

Cross Entropy of Test while m=218 is: 13.817415073297788

Cross Entropy of Test while m=219 is: 20.009304719983252

Cross Entropy of Test while m=220 is: 13.810491491413687

Cross Entropy of Test while m=221 is: 19.97569574039899

Cross Entropy of Test while m=222 is: 13.803908226257711

Cross Entropy of Test while m=223 is: 19.94281179513

Cross Entropy of Test while m=224 is: 13.797653015346294

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Cross Entropy of Test while m=225 is: 19.910627279908503

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Cross Entropy of Test while m=251 is: 19.546052295054963

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Cross Entropy of Test while m=257 is: 19.473687329170474

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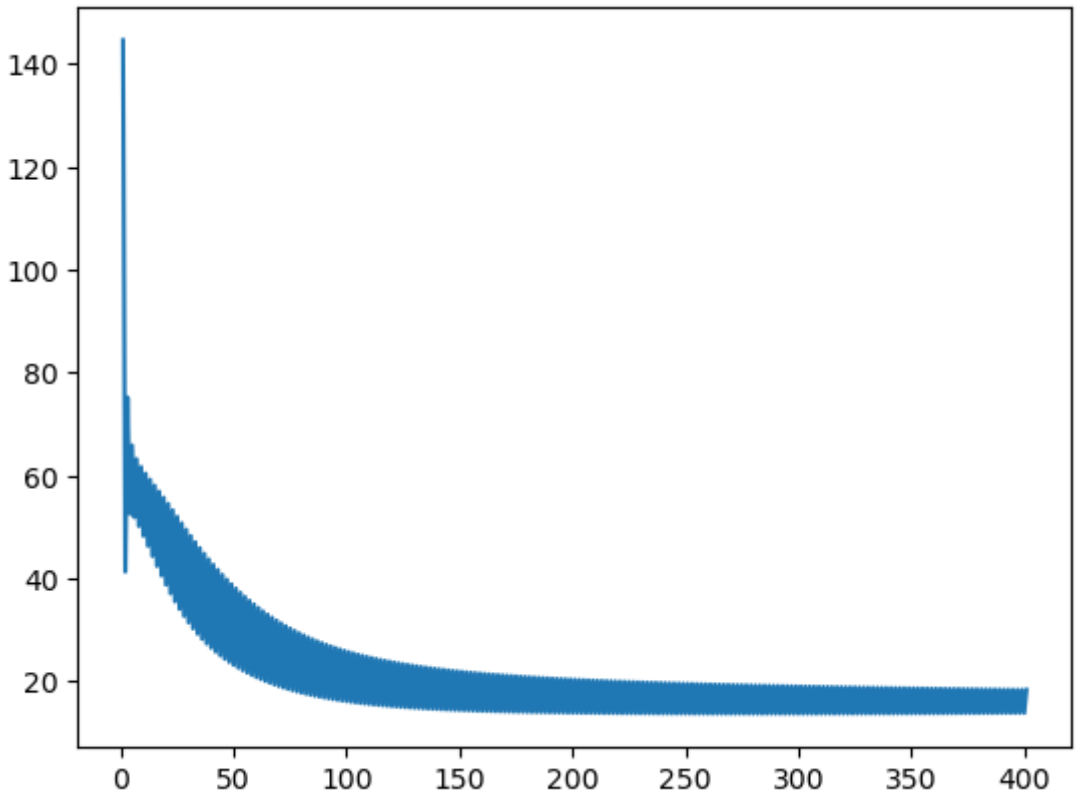
Cross Entropy of Test while m=398 is: 13.861713184943627

Cross Entropy of Test while m=399 is: 18.381021077191797

Cross Entropy of Test while m=400 is: 13.865950356236283

Cross Entropy of Test while m=401 is: 18.370198865014153
```

Out[617]: `[<matplotlib.lines.Line2D at 0x25c250ebdc0>]`



ROC

In [35]:
```
def rocMatrix(P,Yreal,length):

    thValues=np.linspace(0.01,1,100) # give values for th between 0 to 1
    myMatrix=np.zeros((3,100)) # create matrix 3x100
    acc=np.zeros(100) #specific accuracy array for each value of y
    for i in range(100):
            Ypredicted=FinalClassification(P,thValues[i]) # find the y with the fu
            CM=ConfusionMatrix(Yreal,Ypredicted) # find the confusion matrix betwe
            acc[i]=accuracy(CM, length);
            myMatrix[0,i]=thValues[i] # implament to formula to create roc matrix
            myMatrix[1,i]=CM[0,0]/(CM[0,0]+CM[1,0])
            myMatrix[2,i]=CM[0,1]/(CM[0,1]+CM[1,1])

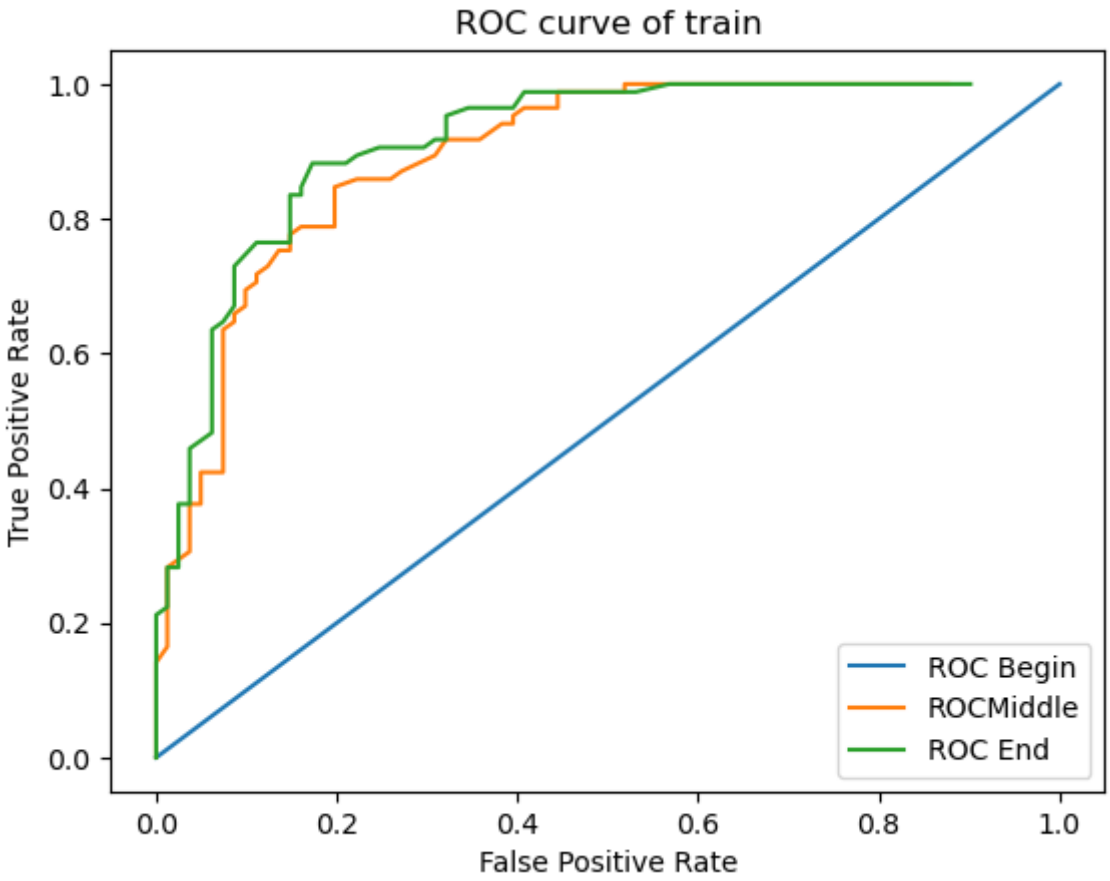
    print("max accuracy of roc matrix is " + str(acc.max())+"%")
    return myMatrix
```

In [628…
```
# Q10 - Section C
print("Train:")
print("Begin:")
roc_train_begin=rocMatrix(P_arr1[0],Ytrain,len(Xtrain)) # find the roc for the firs
print("Middle:")
mid=round(T/2)
roc_train_middle=rocMatrix(P_arr1[mid],Ytrain,len(Xtrain)) # find the roc for the r
print("End:")
roc_train_end=rocMatrix(P_arr1[T],Ytrain,len(Xtrain))# find the roc for the last w

index_vlues = ["th", "TPR", "FPR"]
df1 = pd.DataFrame(data = roc_train_begin, O = index_vlues) # plot every roc we fou
df2 = pd.DataFrame(data = roc_train_middle, index = index_vlues)
df3 = pd.DataFrame(data = roc_train_end, index = index_vlues)
plt.plot(df1.loc["FPR"].values, df1.loc["TPR"].values)
plt.plot(df2.loc["FPR"].values, df2.loc["TPR"].values)
plt.plot(df3.loc["FPR"].values, df3.loc["TPR"].values)
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.legend(['ROC Begin', 'ROCMiddle','ROC End'])
plt.title('ROC curve of train')
```

```
Train:
Begin:
max accuracy of roc matrix is 51.204819277108435%
Middle:
max accuracy of roc matrix is 82.53012048192771%
End:
max accuracy of roc matrix is 85.54216867469879%
```

Out[628]:
```
Text(0.5, 1.0, 'ROC curve of train')
```



In [629…

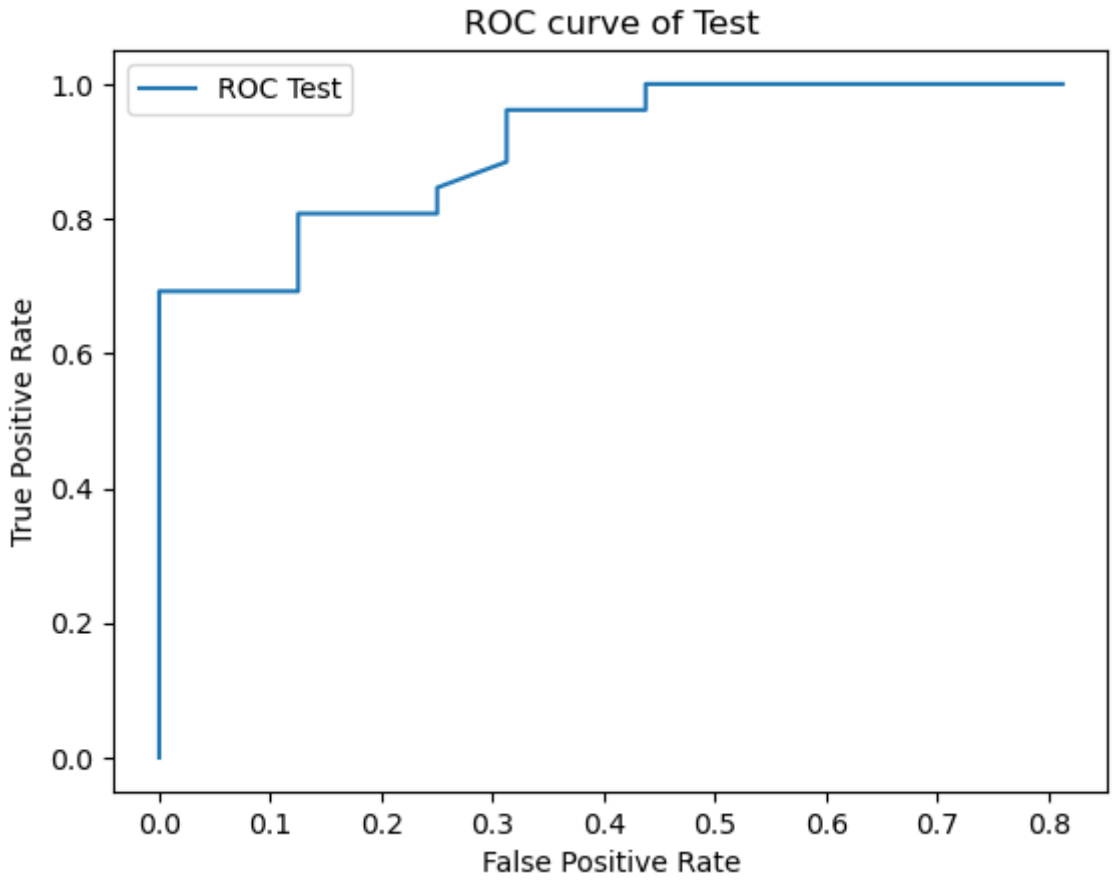
```
# Q10 - Section D

print("Test:")
roc_test=rocMatrix(P_arr2[T],Ytest,len(Xtest)) # find the roc for the last w
index_vlues = ["th", "TPR", "FPR"]
df1 = pd.DataFrame(data = roc_test, index = index_vlues) # plot the roc we found f
plt.plot(df1.loc["FPR"].values, df1.loc["TPR"].values)
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.legend(['ROC Test'])
plt.title('ROC curve of Test')
```

```
Test:
max accuracy of roc matrix is 85.71428571428571%
```

Out[629]:

```
Text(0.5, 1.0, 'ROC curve of Test')
```



Question 11

In [630…

```
def Impact_Test (a,myType):
    #Running a test on the data to find the behavior and effect of the variables
    #myType=0 mean train, myType=1 mean test
    Xtrain,Xtest,Ytrain,Ytest= _Myinit() #read data from file and split to series
    T=[1,10,100,400,800] #array of differents 'T' values
    if (myType==0): #if we cheak train type
        for t in T:
            print("\n\033[1;34mIn this stage , a= "+str(a)+" , T= "+str(t)+"\033[0
            W_coff = calc_w_coff(Xtrain,Ytrain,a,t)
            P_arr = Classification_accuracy(Xtrain,Ytrain,W_coff,0.5)
            print("\n\033[1;33mThe first value of W[0] in this stage: \n" +str(W_c
            print("\n\033[1;32mThe final value of W in this stage: \n" +str(W_coff
    else:
        for t in T:
            print("\n\033[1;34mIn this stage , a= "+str(a)+" , T= "+str(t)+"\033[0
            W_coff = calc_w_coff(Xtrain,Ytrain,a,t)
            P_arr = Classification_accuracy(Xtest,Ytest,W_coff,0.5)
            print("\n\033[1;33mThe first value of W[0] in this stage: \n" +str(W_c
            print("\n\033[1;32mThe final value of W in this stage: \n" +str(W_coff
```

In [19]:

```
# #Running a test on the data, at each step a different 'a' value is sent to the In
# #check train
# a=[0.01,0.05,0.1,0.3,0.5,1] #array of differents 'a' values
# for i in range(len(a)):
#     Impact_Test(a[i],0)
```

In [20]:

```
# # #check test
# #the same as above
# a=[0.01,0.05,0.1,0.3,0.5,1]
```

```
# for i in range(len(a)):
#     Impact_Test(a[i],1)
```

Question 12

In [41]:
```
def Normalization(): #normalized all the data and return its separated
    Xtrain,Xtest,Ytrain,Ytest= _Myinit() #read data from file and split to series

    #normalizes the information
    avrages=np.mean(Xtrain,axis=0) #get the mean of each column
    Xtrain=Xtrain-avrages #remove the mean from X
    variances = np.var(Xtrain, axis=0) #get the variance of each column
    Xtrain = Xtrain / np.sqrt(variances) #remove the variance from X

    #same calc for the test
    avrages=np.mean(Xtest,axis=0)
    Xtest=Xtest-avrages
    variances = np.var(Xtest, axis=0)
    Xtest = Xtest / np.sqrt(variances)

    return Xtrain,Xtest,Ytrain,Ytest
```

In [42]:
```
def calc_w_coff_Normalized(x,y,a,T):
#same explanation and operation as this function above, but now starting with zeros

    W = np.zeros(len(x[0])+1) #starting with zeros at W[0]
    x=np.insert(x, 0, 1, axis=1)

    mylen=T+1
    W_coff=np.zeros((mylen,len(W)))
    W_coff[0]=W
    for t in range(T):
        W=gradientStep(W,a,x,y)
        W_coff[t+1]=W

    x=x[:, 1:]
    return W_coff
```

In [43]:
```
#Check KNN
#same explanation and operation as this part above, but now with normalization init

#init the normalization function and get the starting normalized elemets
Xtrain,Xtest,Ytrain,Ytest=Normalization()



Ypredicted=KNN(Xtrain, Ytrain, Xtest, 3)
CM=ConfusionMatrix(Ytest,Ypredicted)
acc=accuracy(CM, len(Ytest));
print("Accuracy of Test: "+str(round(acc,2)) + "%")
```

```
Accuracy of Test: 90.48%
```

In [29]:
```
#question 8
#same explanation and operation as this part above

temp=0
index=0
for i in range(1,len(Ytest),2):
    Ypredicted=KNN(Xtrain, Ytrain, Xtest, i)
    CM=ConfusionMatrix(Ytest,Ypredicted)
```

```
    acc=accuracy(CM, len(Ytest));
    if (acc>=temp):
        temp=acc
        index=i
    print("k= "+str(i) +" ,accuracy: "+str(acc))

print("with k= "+str(index)+" we get the best accuracy of "+str(temp)+ "%")
```

```
k= 1 ,accuracy: 88.09523809523809
k= 3 ,accuracy: 90.47619047619048
k= 5 ,accuracy: 85.71428571428571
k= 7 ,accuracy: 85.71428571428571
k= 9 ,accuracy: 88.09523809523809
k= 11 ,accuracy: 83.33333333333334
k= 13 ,accuracy: 80.95238095238095
k= 15 ,accuracy: 78.57142857142857
k= 17 ,accuracy: 80.95238095238095
k= 19 ,accuracy: 78.57142857142857
k= 21 ,accuracy: 80.95238095238095
k= 23 ,accuracy: 83.33333333333334
k= 25 ,accuracy: 80.95238095238095
k= 27 ,accuracy: 80.95238095238095
k= 29 ,accuracy: 80.95238095238095
k= 31 ,accuracy: 80.95238095238095
k= 33 ,accuracy: 78.57142857142857
k= 35 ,accuracy: 78.57142857142857
k= 37 ,accuracy: 78.57142857142857
k= 39 ,accuracy: 78.57142857142857
k= 41 ,accuracy: 78.57142857142857
with k= 3 we get the best accuracy of 90.47619047619048%
```

In [30]:

```
Xtrain,Xtest,Ytrain,Ytest=Normalization() #init the normalization function and get

#at this part, we choose better a and number of iteration T after normalization
a=0.001
T=250

#runs the function to calculate the W vector
W_coff = calc_w_coff_Normalized(Xtrain,Ytrain,a,T)

#calculates the percentage of accuracy for each iteration for test
print("\nTrain:")
P_arr1 = Classification_accuracy(Xtrain,Ytrain,W_coff,0.5)
```

Train:

Accuracy of the classifier:

Accuracy in iteration #0 is: 48.795180722891565%

Accuracy in iteration #1 is: 72.28915662650603%

Accuracy in iteration #2 is: 75.90361445783132%

Accuracy in iteration #3 is: 77.71084337349397%

Accuracy in iteration #4 is: 79.51807228915662%

Accuracy in iteration #5 is: 79.51807228915662%

Accuracy in iteration #6 is: 80.72289156626506%

Accuracy in iteration #7 is: 80.12048192771084%

Accuracy in iteration #8 is: 80.12048192771084%

Accuracy in iteration #9 is: 80.72289156626506%

Accuracy in iteration #10 is: 81.32530120481928%

Accuracy in iteration #11 is: 81.92771084337349%

Accuracy in iteration #12 is: 81.92771084337349%

Accuracy in iteration #13 is: 81.92771084337349%

Accuracy in iteration #14 is: 81.92771084337349%

Accuracy in iteration #15 is: 81.92771084337349%

Accuracy in iteration #16 is: 81.92771084337349%

Accuracy in iteration #17 is: 81.92771084337349%

Accuracy in iteration #18 is: 81.92771084337349%

Accuracy in iteration #19 is: 81.92771084337349%

Accuracy in iteration #20 is: 81.92771084337349%

Accuracy in iteration #21 is: 82.53012048192771%

Accuracy in iteration #22 is: 82.53012048192771%

Accuracy in iteration #23 is: 83.13253012048193%

Accuracy in iteration #24 is: 83.13253012048193%

Accuracy in iteration #25 is: 83.73493975903614%

Accuracy in iteration #26 is: 83.73493975903614%

Accuracy in iteration #27 is: 83.73493975903614%

Accuracy in iteration #28 is: 83.73493975903614%

Accuracy in iteration #29 is: 83.73493975903614%

Accuracy in iteration #30 is: 83.73493975903614%

Accuracy in iteration #31 is: 84.33734939759037%

Accuracy in iteration #32 is: 84.33734939759037%

Accuracy in iteration #33 is: 84.33734939759037%

Accuracy in iteration #34 is: 84.33734939759037%

Accuracy in iteration #35 is: 84.33734939759037%

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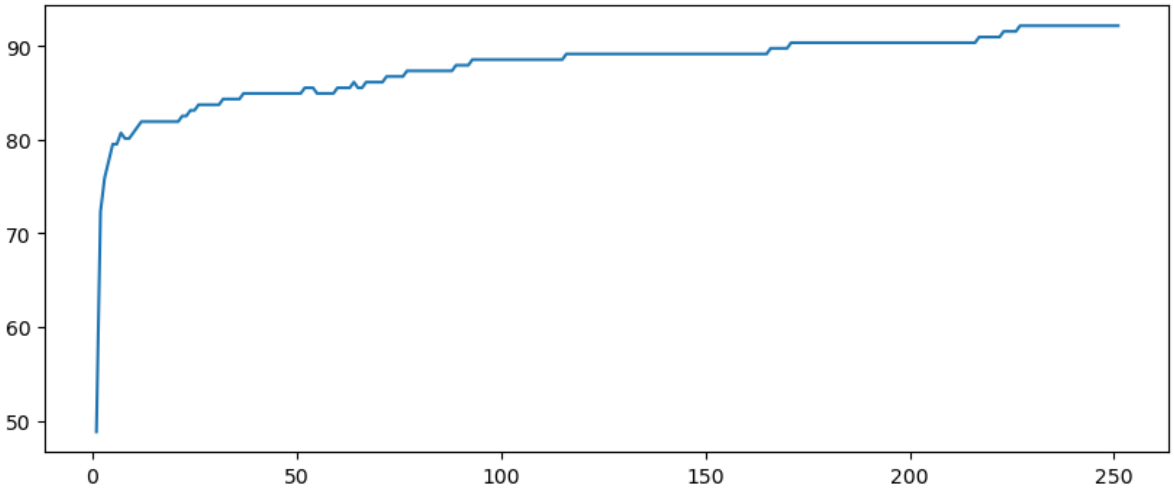

In [31]:
```
#calculates the percentage of accuracy for each iteration for test
print("\n\nTest:")
P_arr2 = Classification_accuracy(Xtest,Ytest,W_coff,0.5) #runs the classification_
```

Test:

Accuracy of the classifier:

Accuracy in iteration #0 is: 38.095238095238095%

Accuracy in iteration #1 is: 76.19047619047619%

Accuracy in iteration #2 is: 73.80952380952381%

Accuracy in iteration #3 is: 76.19047619047619%

Accuracy in iteration #4 is: 78.57142857142857%

Accuracy in iteration #5 is: 78.57142857142857%

Accuracy in iteration #6 is: 78.57142857142857%

Accuracy in iteration #7 is: 80.95238095238095%

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Accuracy in iteration #201 is: 85.71428571428571%

Accuracy in iteration #202 is: 85.71428571428571%

Accuracy in iteration #203 is: 85.71428571428571%

Accuracy in iteration #204 is: 85.71428571428571%

Accuracy in iteration #205 is: 85.71428571428571%

Accuracy in iteration #206 is: 85.71428571428571%

Accuracy in iteration #207 is: 85.71428571428571%

Accuracy in iteration #208 is: 85.71428571428571%

Accuracy in iteration #209 is: 85.71428571428571%

Accuracy in iteration #210 is: 85.71428571428571%

Accuracy in iteration #211 is: 85.71428571428571%

Accuracy in iteration #212 is: 85.71428571428571%

Accuracy in iteration #213 is: 85.71428571428571%

Accuracy in iteration #214 is: 85.71428571428571%

Accuracy in iteration #215 is: 85.71428571428571%

Accuracy in iteration #216 is: 85.71428571428571%

Accuracy in iteration #217 is: 85.71428571428571%

Accuracy in iteration #218 is: 85.71428571428571%

Accuracy in iteration #219 is: 85.71428571428571%

Accuracy in iteration #220 is: 85.71428571428571%
```

```
Accuracy in iteration #221 is: 85.71428571428571%

Accuracy in iteration #222 is: 85.71428571428571%

Accuracy in iteration #223 is: 85.71428571428571%

Accuracy in iteration #224 is: 85.71428571428571%

Accuracy in iteration #225 is: 85.71428571428571%

Accuracy in iteration #226 is: 85.71428571428571%

Accuracy in iteration #227 is: 85.71428571428571%

Accuracy in iteration #228 is: 85.71428571428571%

Accuracy in iteration #229 is: 85.71428571428571%

Accuracy in iteration #230 is: 85.71428571428571%

Accuracy in iteration #231 is: 85.71428571428571%

Accuracy in iteration #232 is: 85.71428571428571%

Accuracy in iteration #233 is: 85.71428571428571%

Accuracy in iteration #234 is: 85.71428571428571%

Accuracy in iteration #235 is: 85.71428571428571%

Accuracy in iteration #236 is: 83.33333333333334%

Accuracy in iteration #237 is: 83.33333333333334%

Accuracy in iteration #238 is: 83.33333333333334%

Accuracy in iteration #239 is: 83.33333333333334%

Accuracy in iteration #240 is: 83.33333333333334%

Accuracy in iteration #241 is: 83.33333333333334%

Accuracy in iteration #242 is: 83.33333333333334%

Accuracy in iteration #243 is: 83.33333333333334%

Accuracy in iteration #244 is: 83.33333333333334%

Accuracy in iteration #245 is: 83.33333333333334%

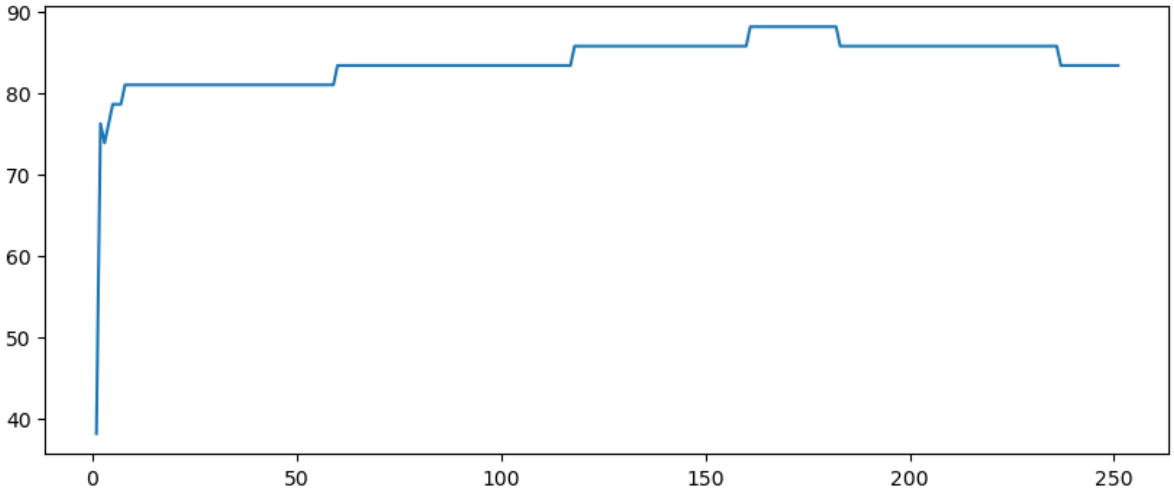
Accuracy in iteration #246 is: 83.33333333333334%

Accuracy in iteration #247 is: 83.33333333333334%

Accuracy in iteration #248 is: 83.33333333333334%

Accuracy in iteration #249 is: 83.33333333333334%

Accuracy in iteration #250 is: 83.33333333333334%
```



In [32]:
```
# Cross Entropy of Train
#same explanation and operation as this part above
crossEntropy=np.zeros(len(W_coff))
m = np.array(range(1,len(W_coff)+1))
for i in range(len(W_coff)):
    crossEntropy[i]= cross_entropy(Ytrain,P_arr1[i])
    print("\nCross Entropy of Train while m=" + str(m[i]) +" is: "+str(crossEntropy
plt.plot(m,crossEntropy)
```

```
Cross Entropy of Train while m=1 is: 115.0624319729511

Cross Entropy of Train while m=2 is: 102.13454511821507

Cross Entropy of Train while m=3 is: 94.86537431982869

Cross Entropy of Train while m=4 is: 89.96121901441012

Cross Entropy of Train while m=5 is: 86.31302598401648

Cross Entropy of Train while m=6 is: 83.4420546824922

Cross Entropy of Train while m=7 is: 81.09693982621198

Cross Entropy of Train while m=8 is: 79.12847914315807

Cross Entropy of Train while m=9 is: 77.44096828314373

Cross Entropy of Train while m=10 is: 75.96968194592968

Cross Entropy of Train while m=11 is: 74.66908723997574

Cross Entropy of Train while m=12 is: 73.50612984385202

Cross Entropy of Train while m=13 is: 72.45617554661979

Cross Entropy of Train while m=14 is: 71.50044643542654

Cross Entropy of Train while m=15 is: 70.6243440832193

Cross Entropy of Train while m=16 is: 69.81632082333164

Cross Entropy of Train while m=17 is: 69.06710087292058

Cross Entropy of Train while m=18 is: 68.36913095181563

Cross Entropy of Train while m=19 is: 67.71618506654971

Cross Entropy of Train while m=20 is: 67.10307507053558

Cross Entropy of Train while m=21 is: 66.52543520211124

Cross Entropy of Train while m=22 is: 65.97955927445867

Cross Entropy of Train while m=23 is: 65.46227594737482

Cross Entropy of Train while m=24 is: 64.9708519557837

Cross Entropy of Train while m=25 is: 64.50291614717172

Cross Entropy of Train while m=26 is: 64.0563992076066

Cross Entropy of Train while m=27 is: 63.629485357996835

Cross Entropy of Train while m=28 is: 63.2205732856995

Cross Entropy of Train while m=29 is: 62.82824427573286

Cross Entropy of Train while m=30 is: 62.4512360091805

Cross Entropy of Train while m=31 is: 62.088420863038635

Cross Entropy of Train while m=32 is: 61.7387878158665
```

```
Cross Entropy of Train while m=33 is: 61.40142726468205

Cross Entropy of Train while m=34 is: 61.07551820974243

Cross Entropy of Train while m=35 is: 60.76031737860726

Cross Entropy of Train while m=36 is: 60.45514994876821

Cross Entropy of Train while m=37 is: 60.15940159600176

Cross Entropy of Train while m=38 is: 59.87251164844155

Cross Entropy of Train while m=39 is: 59.59396716781627

Cross Entropy of Train while m=40 is: 59.32329781204434

Cross Entropy of Train while m=41 is: 59.06007135942961

Cross Entropy of Train while m=42 is: 58.8038897955549

Cross Entropy of Train while m=43 is: 58.55438588077386

Cross Entropy of Train while m=44 is: 58.31122012981193

Cross Entropy of Train while m=45 is: 58.0740781460787

Cross Entropy of Train while m=46 is: 57.842668262377

Cross Entropy of Train while m=47 is: 57.616719447169935

Cross Entropy of Train while m=48 is: 57.39597944175026

Cross Entropy of Train while m=49 is: 57.18021309879273

Cross Entropy of Train while m=50 is: 56.96920089705518

Cross Entropy of Train while m=51 is: 56.76273761058361

Cross Entropy of Train while m=52 is: 56.56063111379609

Cross Entropy of Train while m=53 is: 56.36270130636765

Cross Entropy of Train while m=54 is: 56.16877914399721

Cross Entropy of Train while m=55 is: 55.97870576297331

Cross Entropy of Train while m=56 is: 55.79233168801731

Cross Entropy of Train while m=57 is: 55.60951611422447

Cross Entropy of Train while m=58 is: 55.430126255068274

Cross Entropy of Train while m=59 is: 55.25403674942262

Cross Entropy of Train while m=60 is: 55.081129121408324

Cross Entropy of Train while m=61 is: 54.911291287607604

Cross Entropy of Train while m=62 is: 54.74441710682846

Cross Entropy of Train while m=63 is: 54.58040596815797

Cross Entropy of Train while m=64 is: 54.4191624135254
```

```
Cross Entropy of Train while m=65 is: 54.260595791421174

Cross Entropy of Train while m=66 is: 54.10461993878538

Cross Entropy of Train while m=67 is: 53.95115288840541

Cross Entropy of Train while m=68 is: 53.80011659944683

Cross Entropy of Train while m=69 is: 53.65143670899151

Cross Entropy of Train while m=70 is: 53.50504230268172

Cross Entropy of Train while m=71 is: 53.36086570275955

Cross Entropy of Train while m=72 is: 53.2188422719687

Cross Entropy of Train while m=73 is: 53.07891023193746

Cross Entropy of Train while m=74 is: 52.94101049479722

Cross Entropy of Train while m=75 is: 52.80508650691414

Cross Entropy of Train while m=76 is: 52.671084103718506

Cross Entropy of Train while m=77 is: 52.538951374713676

Cross Entropy of Train while m=78 is: 52.408638537831514

Cross Entropy of Train while m=79 is: 52.280097822380405

Cross Entropy of Train while m=80 is: 52.15328335989947

Cross Entropy of Train while m=81 is: 52.02815108229543

Cross Entropy of Train while m=82 is: 51.90465862669491

Cross Entropy of Train while m=83 is: 51.78276524649402

Cross Entropy of Train while m=84 is: 51.66243172813407

Cross Entropy of Train while m=85 is: 51.543620313170806

Cross Entropy of Train while m=86 is: 51.426294625244815

Cross Entropy of Train while m=87 is: 51.31041960158964

Cross Entropy of Train while m=88 is: 51.19596142874961

Cross Entropy of Train while m=89 is: 51.08288748220189

Cross Entropy of Train while m=90 is: 50.971166269605625

Cross Entropy of Train while m=91 is: 50.860767377421986

Cross Entropy of Train while m=92 is: 50.751661420669386

Cross Entropy of Train while m=93 is: 50.643819995598335

Cross Entropy of Train while m=94 is: 50.53721563508497

Cross Entropy of Train while m=95 is: 50.431821766560645

Cross Entropy of Train while m=96 is: 50.32761267230674
```

```
Cross Entropy of Train while m=97 is: 50.224563451958076

Cross Entropy of Train while m=98 is: 50.122649987070616

Cross Entropy of Train while m=99 is: 50.02184890761777

Cross Entropy of Train while m=100 is: 49.922137560293045

Cross Entropy of Train while m=101 is: 49.82349397850211

Cross Entropy of Train while m=102 is: 49.72589685393905

Cross Entropy of Train while m=103 is: 49.629325509646584

Cross Entropy of Train while m=104 is: 49.53375987446936

Cross Entropy of Train while m=105 is: 49.439180458813865

Cross Entropy of Train while m=106 is: 49.345568331636514

Cross Entropy of Train while m=107 is: 49.25290509858506

Cross Entropy of Train while m=108 is: 49.161172881225056

Cross Entropy of Train while m=109 is: 49.07035429728718

Cross Entropy of Train while m=110 is: 48.98043244187543

Cross Entropy of Train while m=111 is: 48.89139086958031

Cross Entropy of Train while m=112 is: 48.803213577445426

Cross Entropy of Train while m=113 is: 48.715884988738395

Cross Entropy of Train while m=114 is: 48.62938993748054

Cross Entropy of Train while m=115 is: 48.54371365369329

Cross Entropy of Train while m=116 is: 48.45884174932135

Cross Entropy of Train while m=117 is: 48.37476020479491

Cross Entropy of Train while m=118 is: 48.29145535619672

Cross Entropy of Train while m=119 is: 48.208913883001

Cross Entropy of Train while m=120 is: 48.12712279635328

Cross Entropy of Train while m=121 is: 48.04606942786289

Cross Entropy of Train while m=122 is: 47.96574141888083

Cross Entropy of Train while m=123 is: 47.88612671023722

Cross Entropy of Train while m=124 is: 47.8072135324158

Cross Entropy of Train while m=125 is: 47.72899039614113

Cross Entropy of Train while m=126 is: 47.65144608335928

Cross Entropy of Train while m=127 is: 47.57456963859101

Cross Entropy of Train while m=128 is: 47.49835036063885
```

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Cross Entropy of Train while m=129 is: 47.42277779463123

Cross Entropy of Train while m=130 is: 47.34784172438633

Cross Entropy of Train while m=131 is: 47.27353216507981

Cross Entropy of Train while m=132 is: 47.19983935620282

Cross Entropy of Train while m=133 is: 47.12675375479507

Cross Entropy of Train while m=134 is: 47.05426602894055

Cross Entropy of Train while m=135 is: 46.98236705151347

Cross Entropy of Train while m=136 is: 46.91104789416202

Cross Entropy of Train while m=137 is: 46.84029982151996

Cross Entropy of Train while m=138 is: 46.770114285634556

Cross Entropy of Train while m=139 is: 46.70048292060118

Cross Entropy of Train while m=140 is: 46.63139753739579

Cross Entropy of Train while m=141 is: 46.56285011889553

Cross Entropy of Train while m=142 is: 46.4948328150793

Cross Entropy of Train while m=143 is: 46.427337938400896

Cross Entropy of Train while m=144 is: 46.36035795932614

Cross Entropy of Train while m=145 is: 46.293885502027464

Cross Entropy of Train while m=146 is: 46.227913340229264

Cross Entropy of Train while m=147 is: 46.1624343931969

Cross Entropy of Train while m=148 is: 46.09744172186372

Cross Entropy of Train while m=149 is: 46.03292852509032

Cross Entropy of Train while m=150 is: 45.968888136049856

Cross Entropy of Train while m=151 is: 45.905314018735154

Cross Entropy of Train while m=152 is: 45.84219976458164

Cross Entropy of Train while m=153 is: 45.77953908920167

Cross Entropy of Train while m=154 is: 45.717325829226176

Cross Entropy of Train while m=155 is: 45.655553939248584

Cross Entropy of Train while m=156 is: 45.59421748886705

Cross Entropy of Train while m=157 is: 45.53331065982191

Cross Entropy of Train while m=158 is: 45.47282774322308

Cross Entropy of Train while m=159 is: 45.41276313686562

Cross Entropy of Train while m=160 is: 45.35311134262841
```

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Cross Entropy of Train while m=161 is: 45.29386696395375

Cross Entropy of Train while m=162 is: 45.23502470340493

Cross Entropy of Train while m=163 is: 45.17657936029759

Cross Entropy of Train while m=164 is: 45.118525828403435

Cross Entropy of Train while m=165 is: 45.060859093722904

Cross Entropy of Train while m=166 is: 45.003574232324446

Cross Entropy of Train while m=167 is: 44.94666640824754

Cross Entropy of Train while m=168 is: 44.890130871467875

Cross Entropy of Train while m=169 is: 44.83396295592168

Cross Entropy of Train while m=170 is: 44.778158077587506

Cross Entropy of Train while m=171 is: 44.72271173262346

Cross Entropy of Train while m=172 is: 44.66761949555731

Cross Entropy of Train while m=173 is: 44.61287701752845

Cross Entropy of Train while m=174 is: 44.558480024579254

Cross Entropy of Train while m=175 is: 44.50442431599441

Cross Entropy of Train while m=176 is: 44.45070576268642

Cross Entropy of Train while m=177 is: 44.39732030562576

Cross Entropy of Train while m=178 is: 44.344263954314435

Cross Entropy of Train while m=179 is: 44.29153278530057

Cross Entropy of Train while m=180 is: 44.23912294073402

Cross Entropy of Train while m=181 is: 44.187030626960336

Cross Entropy of Train while m=182 is: 44.13525211315266

Cross Entropy of Train while m=183 is: 44.083783729979885

Cross Entropy of Train while m=184 is: 44.03262186831012

Cross Entropy of Train while m=185 is: 43.98176297794798

Cross Entropy of Train while m=186 is: 43.9312035664052

Cross Entropy of Train while m=187 is: 43.88094019770283

Cross Entropy of Train while m=188 is: 43.83096949120455

Cross Entropy of Train while m=189 is: 43.78128812047966

Cross Entropy of Train while m=190 is: 43.73189281219515

Cross Entropy of Train while m=191 is: 43.68278034503605

Cross Entropy of Train while m=192 is: 43.63394754865253
```

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Cross Entropy of Train while m=193 is: 43.58539130263376

Cross Entropy of Train while m=194 is: 43.537108535507144

Cross Entropy of Train while m=195 is: 43.48909622376221

Cross Entropy of Train while m=196 is: 43.4413513908989

Cross Entropy of Train while m=197 is: 43.39387110649868

Cross Entropy of Train while m=198 is: 43.346652485318714

Cross Entropy of Train while m=199 is: 43.29969268640744

Cross Entropy of Train while m=200 is: 43.252988912242174

Cross Entropy of Train while m=201 is: 43.206538407886676

Cross Entropy of Train while m=202 is: 43.160338460168994

Cross Entropy of Train while m=203 is: 43.114386396879205

Cross Entropy of Train while m=204 is: 43.06867958598531

Cross Entropy of Train while m=205 is: 43.02321543486819

Cross Entropy of Train while m=206 is: 42.97799138957411

Cross Entropy of Train while m=207 is: 42.933004934084494

Cross Entropy of Train while m=208 is: 42.888253589602954

Cross Entropy of Train while m=209 is: 42.84373491385813

Cross Entropy of Train while m=210 is: 42.79944650042301

Cross Entropy of Train while m=211 is: 42.755385978049425

Cross Entropy of Train while m=212 is: 42.7115510100177

Cross Entropy of Train while m=213 is: 42.66793929350104

Cross Entropy of Train while m=214 is: 42.62454855894412

Cross Entropy of Train while m=215 is: 42.58137656945533

Cross Entropy of Train while m=216 is: 42.5384211202131

Cross Entropy of Train while m=217 is: 42.495680037884576

Cross Entropy of Train while m=218 is: 42.453151180057894

Cross Entropy of Train while m=219 is: 42.410832434686235

Cross Entropy of Train while m=220 is: 42.36872171954442

Cross Entropy of Train while m=221 is: 42.326816981697185

Cross Entropy of Train while m=222 is: 42.28511619697892

Cross Entropy of Train while m=223 is: 42.24361736948459

Cross Entropy of Train while m=224 is: 42.20231853107181
```

```
Cross Entropy of Train while m=225 is: 42.161217740873106

Cross Entropy of Train while m=226 is: 42.120313084818996

Cross Entropy of Train while m=227 is: 42.079602675170804

Cross Entropy of Train while m=228 is: 42.03908465006378

Cross Entropy of Train while m=229 is: 41.99875717305905

Cross Entropy of Train while m=230 is: 41.95861843270584

Cross Entropy of Train while m=231 is: 41.91866664211219

Cross Entropy of Train while m=232 is: 41.878900038524606

Cross Entropy of Train while m=233 is: 41.839316882916805

Cross Entropy of Train while m=234 is: 41.79991545958637

Cross Entropy of Train while m=235 is: 41.760694075760306

Cross Entropy of Train while m=236 is: 41.72165106120785

Cross Entropy of Train while m=237 is: 41.68278476786181

Cross Entropy of Train while m=238 is: 41.64409356944748

Cross Entropy of Train while m=239 is: 41.605575861118474

Cross Entropy of Train while m=240 is: 41.567230059100844

Cross Entropy of Train while m=241 is: 41.529054600343336

Cross Entropy of Train while m=242 is: 41.49104794217528

Cross Entropy of Train while m=243 is: 41.45320856197102

Cross Entropy of Train while m=244 is: 41.41553495682103

Cross Entropy of Train while m=245 is: 41.37802564320944

Cross Entropy of Train while m=246 is: 41.340679156698116

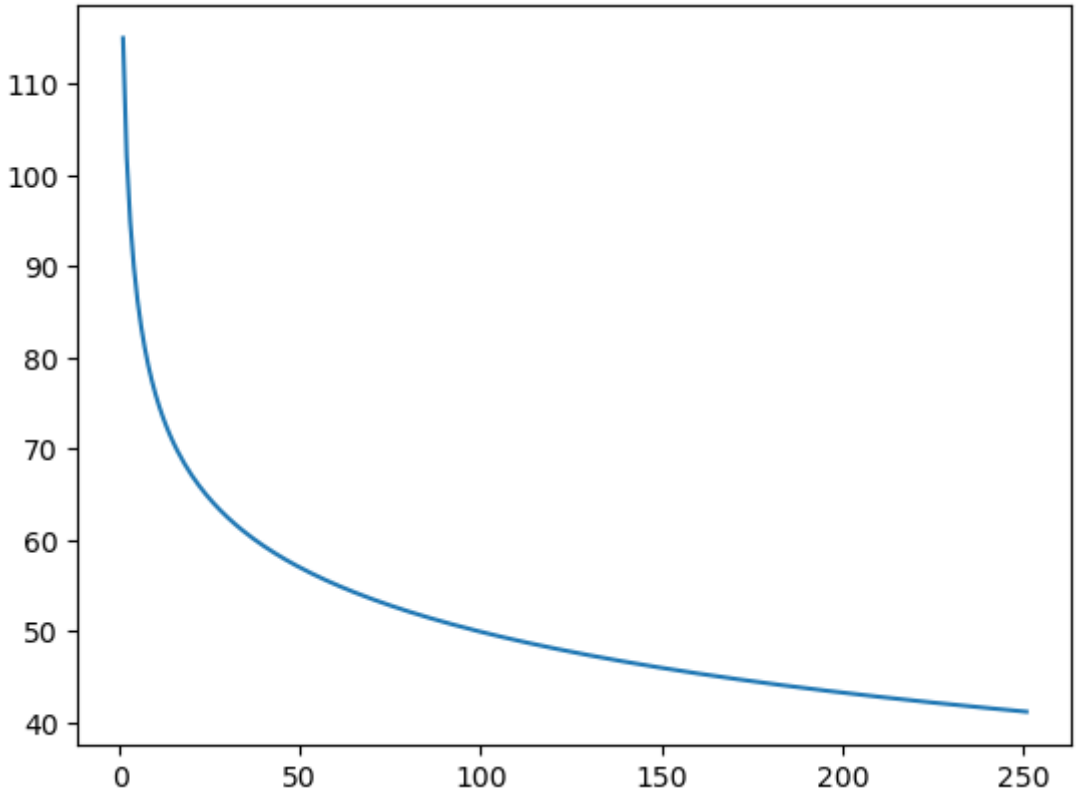
Cross Entropy of Train while m=247 is: 41.30349405161667

Cross Entropy of Train while m=248 is: 41.26646890075863

Cross Entropy of Train while m=249 is: 41.22960229508353

Cross Entropy of Train while m=250 is: 41.1928928434248

Cross Entropy of Train while m=251 is: 41.15633917220315
Out[32]: [<matplotlib.lines.Line2D at 0x1b0bf1a4910>]
```



In [33]:

```
# Cross Entropy of Test
#same explanation and operation as this part above
crossEntropy=np.zeros(len(W_coff))
m = np.array(range(1,len(W_coff)+1))
for i in range(len(W_coff)):
    crossEntropy[i]= cross_entropy(Ytest,P_arr2[i])
    print("\nCross Entropy of Test while m=" + str(m[i]) +" is: "+str(crossEntropy
plt.plot(m,crossEntropy)
```

```
Cross Entropy of Test while m=1 is: 29.11218158351767

Cross Entropy of Test while m=2 is: 25.04542836837632

Cross Entropy of Test while m=3 is: 22.924219205910692

Cross Entropy of Test while m=4 is: 21.645651266645633

Cross Entropy of Test while m=5 is: 20.79705148677861

Cross Entropy of Test while m=6 is: 20.195698700465183

Cross Entropy of Test while m=7 is: 19.74855088166321

Cross Entropy of Test while m=8 is: 19.403430415900587

Cross Entropy of Test while m=9 is: 19.128985633536082

Cross Entropy of Test while m=10 is: 18.90536327864023

Cross Entropy of Test while m=11 is: 18.71944964689554

Cross Entropy of Test while m=12 is: 18.562271431820783

Cross Entropy of Test while m=13 is: 18.42749941528468

Cross Entropy of Test while m=14 is: 18.310549649570728

Cross Entropy of Test while m=15 is: 18.20802391906588

Cross Entropy of Test while m=16 is: 18.117350474542317

Cross Entropy of Test while m=17 is: 18.036546962979894

Cross Entropy of Test while m=18 is: 17.96406010791836

Cross Entropy of Test while m=19 is: 17.89865486099915

Cross Entropy of Test while m=20 is: 17.839336196863446

Cross Entropy of Test while m=21 is: 17.785292912755263

Cross Entropy of Test while m=22 is: 17.735856554891317

Cross Entropy of Test while m=23 is: 17.690470932722388

Cross Entropy of Test while m=24 is: 17.648669168483647

Cross Entropy of Test while m=25 is: 17.610056192649672

Cross Entropy of Test while m=26 is: 17.574295231683855

Cross Entropy of Test while m=27 is: 17.54109726133002

Cross Entropy of Test while m=28 is: 17.51021268988321

Cross Entropy of Test while m=29 is: 17.48142473749408

Cross Entropy of Test while m=30 is: 17.454544119118776

Cross Entropy of Test while m=31 is: 17.42940473942055

Cross Entropy of Test while m=32 is: 17.405860180440996
```

```
Cross Entropy of Test while m=33 is: 17.383780815678335

Cross Entropy of Test while m=34 is: 17.363051423105027

Cross Entropy of Test while m=35 is: 17.343569198590153

Cross Entropy of Test while m=36 is: 17.325242092922437

Cross Entropy of Test while m=37 is: 17.307987412098072

Cross Entropy of Test while m=38 is: 17.291730633125052

Cross Entropy of Test while m=39 is: 17.276404397294005

Cross Entropy of Test while m=40 is: 17.26194765039513

Cross Entropy of Test while m=41 is: 17.248304905248606

Cross Entropy of Test while m=42 is: 17.23542560655088

Cross Entropy of Test while m=43 is: 17.223263581712413

Cross Entropy of Test while m=44 is: 17.211776564290012

Cross Entropy of Test while m=45 is: 17.200925778964933

Cross Entropy of Test while m=46 is: 17.19067557891076

Cross Entropy of Test while m=47 is: 17.18099312792921

Cross Entropy of Test while m=48 is: 17.17184812098167

Cross Entropy of Test while m=49 is: 17.16321253776729

Cross Entropy of Test while m=50 is: 17.155060424838997

Cross Entropy of Test while m=51 is: 17.1473677024434

Cross Entropy of Test while m=52 is: 17.14011199284619

Cross Entropy of Test while m=53 is: 17.133272467383986

Cross Entropy of Test while m=54 is: 17.12682970988403

Cross Entropy of Test while m=55 is: 17.120765594429113

Cross Entropy of Test while m=56 is: 17.115063175727865

Cross Entropy of Test while m=57 is: 17.109706590589333

Cross Entropy of Test while m=58 is: 17.10468096920309

Cross Entropy of Test while m=59 is: 17.09997235509806

Cross Entropy of Test while m=60 is: 17.095567632799888

Cross Entropy of Test while m=61 is: 17.09145446233214

Cross Entropy of Test while m=62 is: 17.087621219813933

Cross Entropy of Test while m=63 is: 17.084056943499053

Cross Entropy of Test while m=64 is: 17.080751284681508
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Cross Entropy of Test while m=66 is: 17.074877225421798

Cross Entropy of Test while m=67 is: 17.072290809329747

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Cross Entropy of Test while m=69 is: 17.06777763951286

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Cross Entropy of Test while m=72 is: 17.062544597127804

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Cross Entropy of Test while m=74 is: 17.06000122994239

Cross Entropy of Test while m=75 is: 17.05899468691139

Cross Entropy of Test while m=76 is: 17.05815735527117

Cross Entropy of Test while m=77 is: 17.05748388964237

Cross Entropy of Test while m=78 is: 17.05696917947356

Cross Entropy of Test while m=79 is: 17.056608335127997

Cross Entropy of Test while m=80 is: 17.056396674978775

Cross Entropy of Test while m=81 is: 17.05632971342777

Cross Entropy of Test while m=82 is: 17.05640314977211

Cross Entropy of Test while m=83 is: 17.05661285784885

Cross Entropy of Test while m=84 is: 17.056954876394865

Cross Entropy of Test while m=85 is: 17.057425400064876

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Cross Entropy of Test while m=87 is: 17.05873747128826

Cross Entropy of Test while m=88 is: 17.05957211510735

Cross Entropy of Test while m=89 is: 17.060521442454426

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Cross Entropy of Test while m=128 is: 17.16193381844614
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Cross Entropy of Test while m=191 is: 17.454286552329844

Cross Entropy of Test while m=192 is: 17.45947838963084
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Cross Entropy of Test while m=223 is: 17.62418163282339

Cross Entropy of Test while m=224 is: 17.629584860651107
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Cross Entropy of Test while m=225 is: 17.634992114993473

Cross Entropy of Test while m=226 is: 17.640403274617768

Cross Entropy of Test while m=227 is: 17.645818220862424

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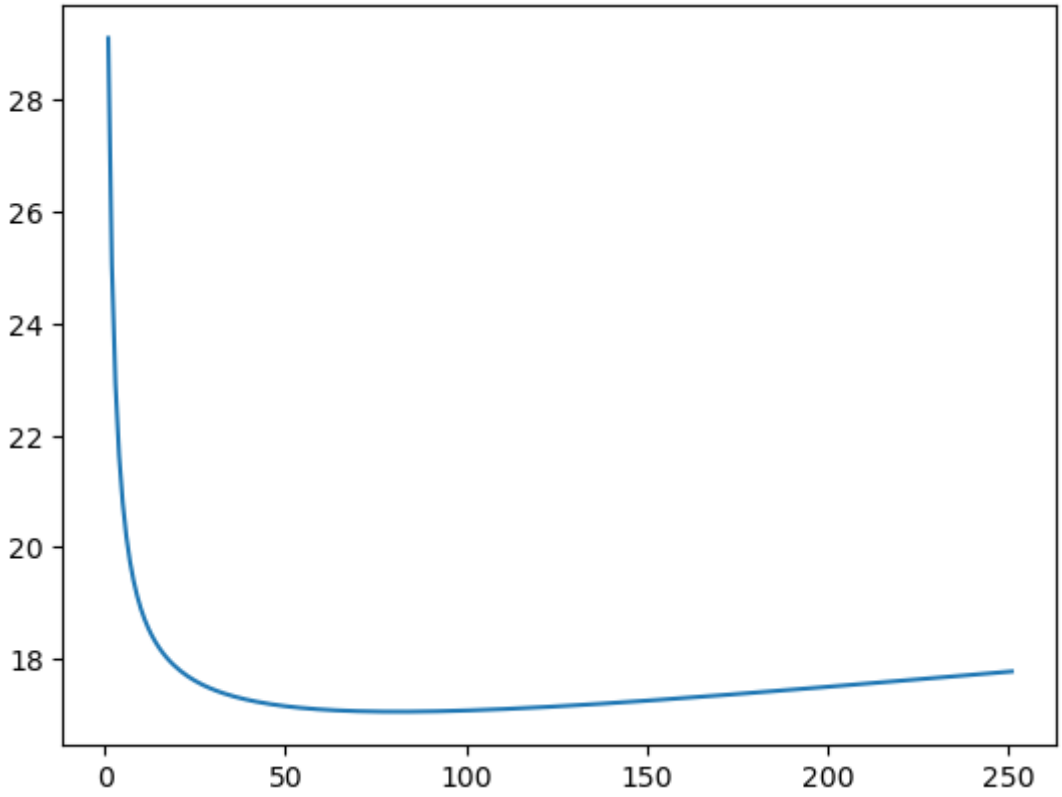
Cross Entropy of Test while m=251 is: 17.776644830680784
Out[33]: [<matplotlib.lines.Line2D at 0x1b0bf213610>]
```

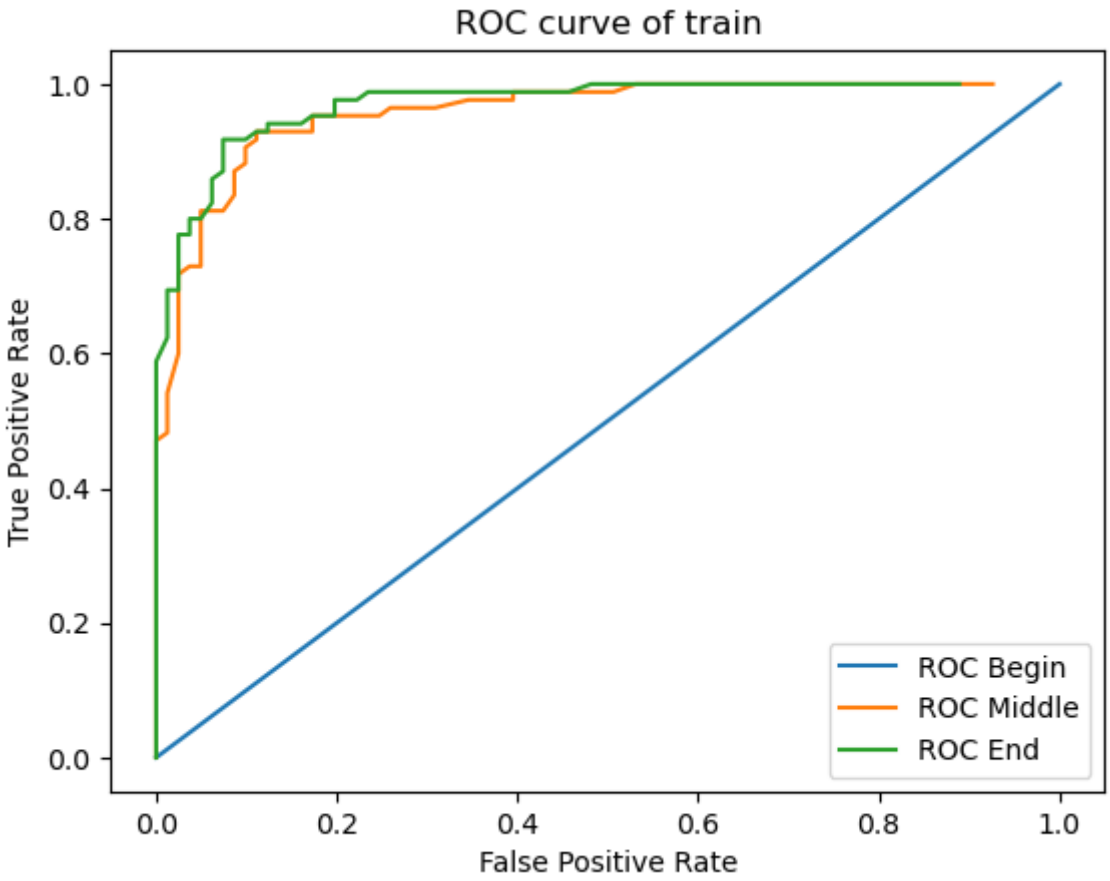


In [36]:
```
# Q10 - Section C - ROC Train
#same explanation and operation as this part above
print("Train:")
print("Begin:")
roc_train_begin=rocMatrix(P_arr1[0],Ytrain,len(Xtrain))
print("Middle:")
mid=round(T/2)
roc_train_middle=rocMatrix(P_arr1[mid],Ytrain,len(Xtrain))
print("End:")
roc_train_end=rocMatrix(P_arr1[T],Ytrain,len(Xtrain))

index_vlues = ["th", "TPR", "FPR"]
df1 = pd.DataFrame(data = roc_train_begin, index = index_vlues)
df2 = pd.DataFrame(data = roc_train_middle, index = index_vlues)
df3 = pd.DataFrame(data = roc_train_end, index = index_vlues)
plt.plot(df1.loc["FPR"].values, df1.loc["TPR"].values)
plt.plot(df2.loc["FPR"].values, df2.loc["TPR"].values)
plt.plot(df3.loc["FPR"].values, df3.loc["TPR"].values)
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.legend(['ROC Begin', 'ROC Middle','ROC End'])
plt.title('ROC curve of train')
```

```
Train:
Begin:
max accuracy of roc matrix is 51.204819277108435%
Middle:
max accuracy of roc matrix is 90.96385542168674%
End:
max accuracy of roc matrix is 92.16867469879519%
```

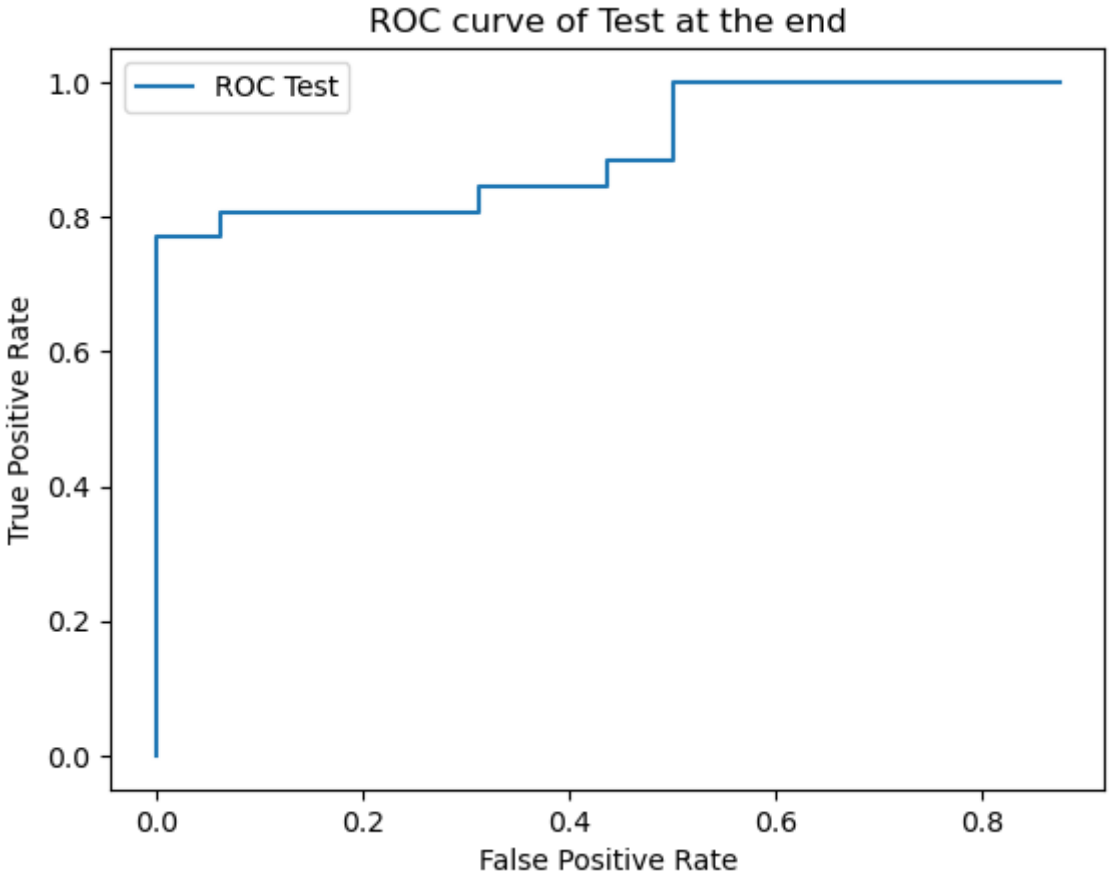
Out[36]:
```
Text(0.5, 1.0, 'ROC curve of train')
```



In [37]:
```
# Q10 - Section D - ROC Test
#same explanation and operation as this part above
print("Test:")
roc_test=rocMatrix(P_arr2[T],Ytest,len(Xtest))
index_vlues = ["th", "TPR", "FPR"]
df1 = pd.DataFrame(data = roc_test, index = index_vlues)
plt.plot(df1.loc["FPR"].values, df1.loc["TPR"].values)
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.legend(['ROC Test'])
plt.title('ROC curve of Test at the end')
```

```
Test:
max accuracy of roc matrix is 85.71428571428571%
```

Out[37]:
```
Text(0.5, 1.0, 'ROC curve of Test at the end')
```


ROC curve of Test at the end
ROC Test
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0