Full implemetation of KNN in Python

Instructions

Complete this notebook and submit it as the solution for question 2 in home assignment no. 1

- In the relevant cell below, fill in the two id numbers for the students submitting this notebook
- Cells with 'COMPLETED - NO CHANGES ARE REQUIRED' in their description require no edits and should be left unchanged
- Cells with 'TO BE COMPLETED' require you to complete the code according to the given description
- **NOTE**: After you complete the notebook and run all cells, **discuss** the results displayed in the graph produced at the end of the notebook

In [65]:
```
# block dedicated to import needed libraries
import numpy as np
from numpy.random import randint
import matplotlib.pyplot as plt
from scipy.special import comb
```

In [66]:
```
# replace the strings below with the personal details of the two students su
Name1 = 'Matan Porat' # student 1 name and surname in the format 'Arik Paran
Name2 = 'Rotem Tsalisher' # student 2 name and surname in the format 'Arik P
id1 = '318734944' # student 1 id
id2 = '203773601' # student 2 id
```

In [67]:
```


def LoadIrisData(fname):
    '''
    ***COMPLETED - NO CHANGES ARE REQUIRED***

    Usage: load data from file in the path 'fname'

    Input: the path for the file that stores the data
    Output: feature matrix X, and labels vector Y
    '''

    # read the features data from the csv file
    X = np.loadtxt(fname,dtype=float, delimiter=',', skiprows = 1,usecols=[1

    # read the labels data from the csv file
    Y = np.loadtxt(fname,dtype=str, delimiter=',', skiprows = 1,usecols=[5])

    return X, Y
```

In [68]:
```
def SplitTrainTest(X,Y):
    '''
    ***COMPLETED - NO CHANGES ARE REQUIRED***

    Input: feature matrix X, labels vector Y
    Output: X_train, Y_train - train data
            X_test, Y_test - test data
    '''

    # permute the ordering of the examples
    ind = np.random.RandomState(seed=int(id1)+int(id2)).permutation(len(Y))

    # randomly choose the size of the training data
    Ntrain = np.random.RandomState(seed=int(id1)+int(id2)).randint(0.6*len(Y

    # split the data into train and test datasets
    X_train = X[ind[:Ntrain]]
    Y_train = Y[ind[:Ntrain]]
    X_test  = X[ind[Ntrain:]]
    Y_test  = Y[ind[Ntrain:]]

    return X_train, Y_train, X_test, Y_test
```

In [69]:
```
def findAxisVal(x):

    ######################################################################
    # a function to determine the neede value for 'axis'
    # attribute of the {later used} function "linalg.norm"
    #
    # shape returns (n,m) dimentions of matrix given by x
    # if matrix collaps into a 1D vector, the len(shape) will return 1
    ######################################################################

    condition = len(x.shape)
    if(condition == 1):
        axis_ = 0
    else:
        axis_ = 1
    return axis_
```

In [70]:
```
def PairwiseDistance(a,b):
    '''
    ***TO BE COMPLETED***

    Usage: compute the euclidean distance between pair of examples

    Input: two numerical vectors of eqaul length
    Output: the euclidean distance between the vectors

    Example:
    PairwiseDistance([3, 1],[6, 5]) returns 5
    [calculation: sqrt((3-6)^2+(1-5)^2) = sqrt(9+16) = 5]
    '''
    axis_=max(findAxisVal(a),findAxisVal(b))
    return np.linalg.norm(a-b,axis = axis_)
```

In [71]:
```
def SortArray(a):
    '''
    ***TO BE COMPLETED***

    Usage: return the ordering of the elements of the input array such that

    Input: a vector with numerical values
    Output: the indices of the input array, such that the array is sorted in

    Example:
    SortArray([1.34, 2.18, 1.21]) returns [2,0,1]
    '''
    return np.argsort(a)
```

In [72]:
```
def MajorityVote(inds,y,K):
    '''
    ***TO BE COMPLETED***

    Usage: find the most frequent label in y's K leading values, after it so

    Input: inds - an ordering of y
           y    - a vector of labels
           K    - an integer
    Output: most frequent label

    Example 1:
    SortArray(inds = [2, 0, 1, 3, 5, 4],
              y    = ['setosa', 'setosa', 'versicolor', 'setosa', 'virginica
              K    = 1)
    returns 'versicolor'

    Example 2:
    SortArray(inds = [2, 0, 1, 3, 5, 4],
              y    = ['setosa', 'setosa', 'versicolor', 'setosa', 'virginica
              K    = 3)
    returns 'setosa'
    '''

    # the labels of the K nearest neighbors
    arr = y[inds[:K]]
    # counting the number occurences of each label amongst the K nearest nei
    unique, counts = np.unique(arr, return_counts=True)
    index = np.argmax(counts)


    # the most frequent label amongst the K nearest neighbors
    return unique[index]
```

In [73]:
```
def KNearestNeighborsClassifier(X_train, Y_train , X_test, K):
    '''
    ***TO BE COMPLETED***

    Usage: estimate the label of each unclassified example in X_test to be t
           frequent label amongst its K nearest neighbors in X_train

    Input:  X_train - training data (features)
            Y_train - training data (labels)
            X_test  - test data (features)
            K       - number of neighbors



    Output: Y_test  - the classifier's labels for the test data

    '''
    Y_pred = []

    # loop through the examples to be classified
    for sample in X_test:
 # compute the pairwise distances between the each unclassified example and
 # all classified example

        dstVec = PairwiseDistance(X_train,sample) # get the vector of sample
        inds = SortArray(dstVec) # find the unclassified example's K nearest
        _Y = MajorityVote(inds,Y_train,K) # classify via most frequenct labe
        Y_pred.append(_Y) # append classified info to classified info's vect
    return Y_pred
```

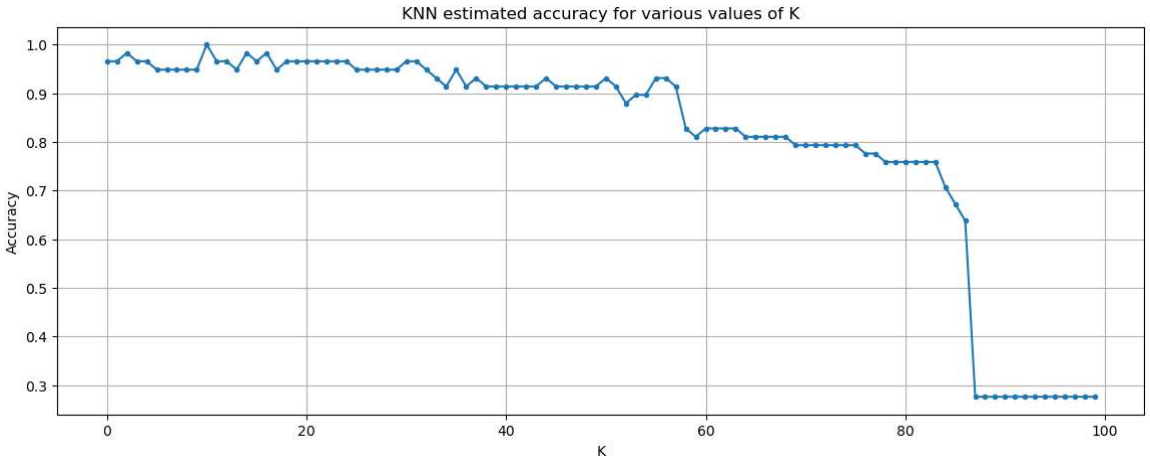
In [74]:
```
def PlotAccuracy(accuracy):

    '''
    ***COMPLETED - NO CHANGES ARE REQUIRED***
    '''
    plt.figure(figsize=(14,5))
    plt.plot(accuracy,'.-')
    plt.xlabel('K')
    plt.ylabel('Accuracy')
    plt.title('KNN estimated accuracy for various values of K');
    plt.grid() # it bothers my eye not to see the grid
    return
```

In [75]:
```
def Accuracy(Y_pred, Y_test):
    '''
    ***TO BE COMPLETED***

    Usage: calculate the classifier accuracy

    Input: Y_test - true labels of X_test
           Y_pred - estimated labels of X_test
    Output: accuracy - the nember of correctly classified examples, divided

    Example:
    calling Accuracy(Y_pred = ['setosa', 'setosa', 'versicolor', 'setosa', '
                     Y_test = ['setosa', 'setosa', 'versicolor', 'versicolor
    returns 0.8
    '''

    # calculate the accuracy - the ratio between the number of examples in X
    # the true label and the estimated label are the same, and the total num
    # of examples in X_test

    return ((np.sum(Y_pred==Y_test))/len(Y_test))
```

In [76]:
```
def main(fname, Kmax):
    '''
    ***COMPLETED - NO CHANGES ARE REQUIRED***
    '''
    # STEP 1: load data
    X,Y = LoadIrisData(fname)

    # STEP 2: split the data into train/test datasets
    X_train, Y_train, X_test, Y_test = SplitTrainTest(X,Y)
    print('Data is split into ' + str(X_train.shape[0]) + ' examples for tra
    # an array to store all computed accuracies
    accuracy = np.zeros(Kmax)

    # repeat for all considered values of K
    for K in range(Kmax):

        # STEP 3: classify the test data using a KNN classifier
        Y_pred = KNearestNeighborsClassifier(X_train, Y_train, X_test , K+1)

        # STEP 4: calculate the KNN classifier accuracy
        accuracy[K] = Accuracy(Y_pred, Y_test)

    # plot results
    PlotAccuracy(accuracy)
    return
```

In [77]:
```
fname = 'iris.csv'
Kmax = 100
main(fname, Kmax)
```

```
Data is split into 92 examples for training and 58 examples for testing
```

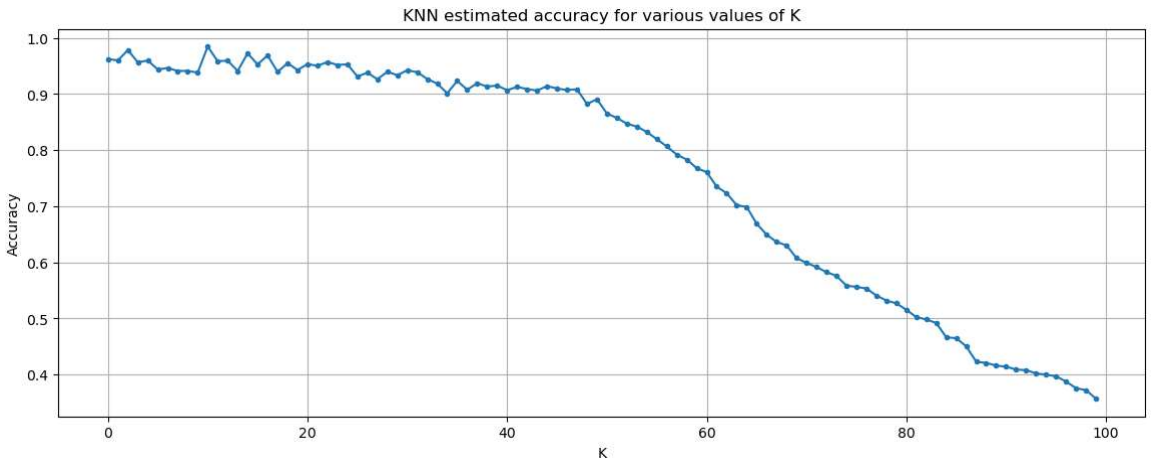


Second Part Of Q2:

In [78]:
```
def SplitTrainTestMatRot(X,Y):

    # Our function to rand the value of Ntrain from a uniform distribution a

    # permute the ordering of the examples
    ind = np.random.RandomState(seed=int(id1)+int(id2)).permutation(len(Y))

    # randomly choose the size of the training data
    Ntrain = 80 + np.random.randint(31) # <= a correction to choose an actua
    # (otherwise, function will always return 92 for Ntrain, based on sectio

    # split the data into train and test datasets
    X_train = X[ind[:Ntrain]]
    Y_train = Y[ind[:Ntrain]]
    X_test  = X[ind[Ntrain:]]
    Y_test  = Y[ind[Ntrain:]]

    return X_train, Y_train, X_test, Y_test
```

In [79]:
```
def oneHundredMiles(Kmax):

    G = 100 # number of itterations

    # STEP 1: load data
    X,Y = LoadIrisData(fname)

    # a matrix to store all computed accuracies
    accuracyMat = np.zeros((G,Kmax))

    # a vector to store mean values for given k in the previous matrix
    accuracyMean = np.zeros(Kmax)
    for i in range(G):

        # STEP 2: split the data into train/test datasets
        X_train, Y_train, X_test, Y_test = SplitTrainTestMatRot(X,Y)
        #print('Data is split into ' + str(X_train.shape[0]) + ' examples fo

        # repeat for all considered values of K
        for K in range(Kmax):

            # STEP 3: classify the test data using a KNN classifier
            Y_pred = KNearestNeighborsClassifier(X_train, Y_train, X_test ,

            # STEP 4: calculate the KNN classifier accuracy
            accuracyMat[i,K] = Accuracy(Y_pred, Y_test)


    accuracyMean = np.mean(accuracyMat,axis = 0) #averaging over column sapc
    PlotAccuracy(accuracyMean)
    return
```

In [80]:
```
oneHundredMiles(100) # sometimes functions runtime get's a little slow, be p
```



Question 3

According to manual Calculations, the p that will get us maximun likelyhood for the sieres (H/T) given in the question is p = K/N.

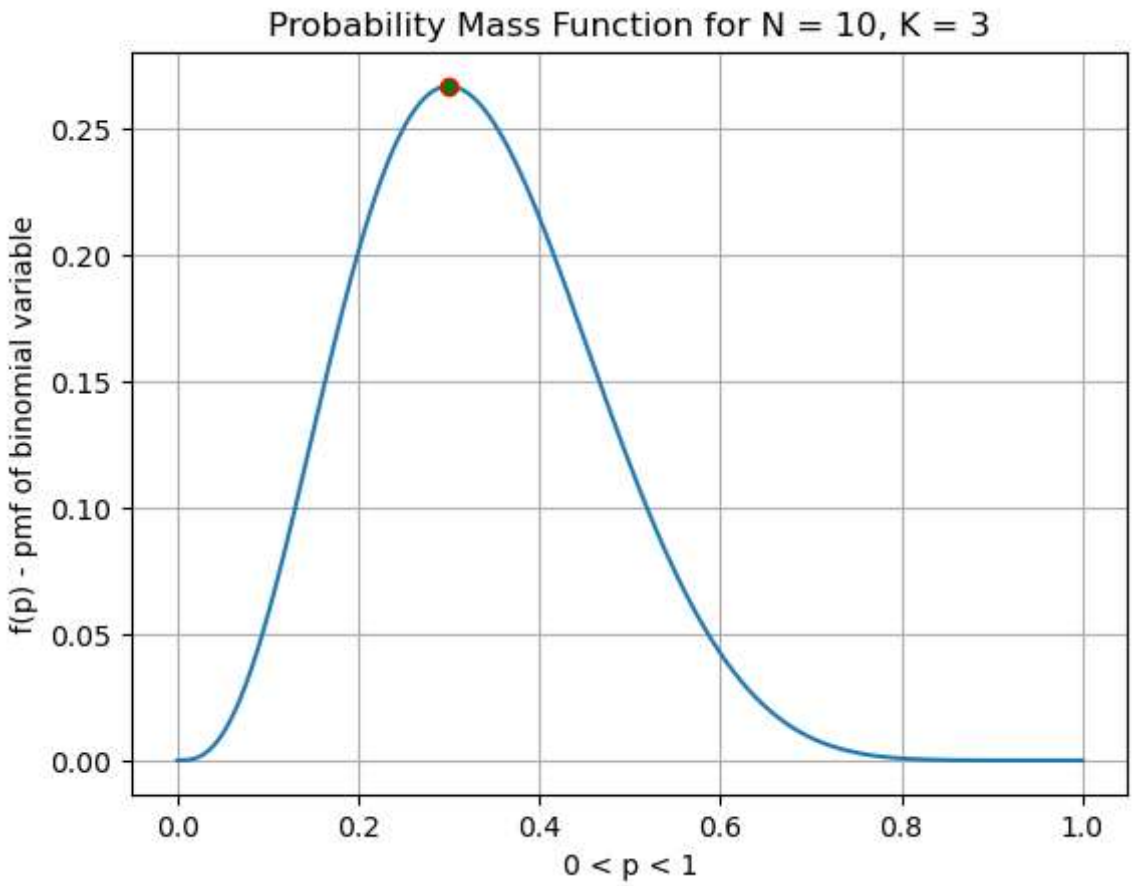
In [81]:
```
def calcProb(p,N,K):

    binomial_coeff = comb(N, K)
    pmf_ = binomial_coeff*(p**K) * ((1 - p)**(N - K))

    return pmf_
```

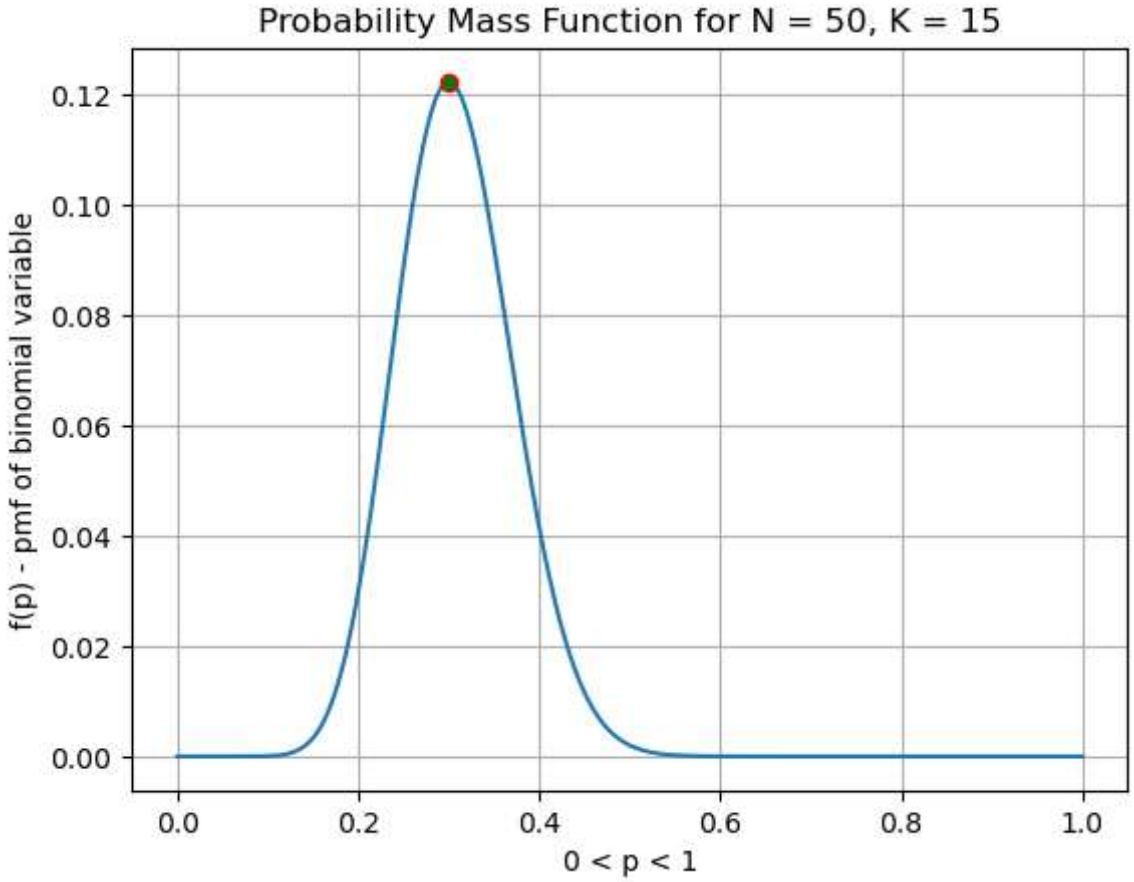
In [82]:
```
def maxProb(N,K):
    p_ml = K/N # applying manually calculated formula
    pmf_p = calcProb(p_ml,N,K)
    plt.plot(p_ml, pmf_p, marker="o", markeredgecolor="red", markerfacecolor
    return
```

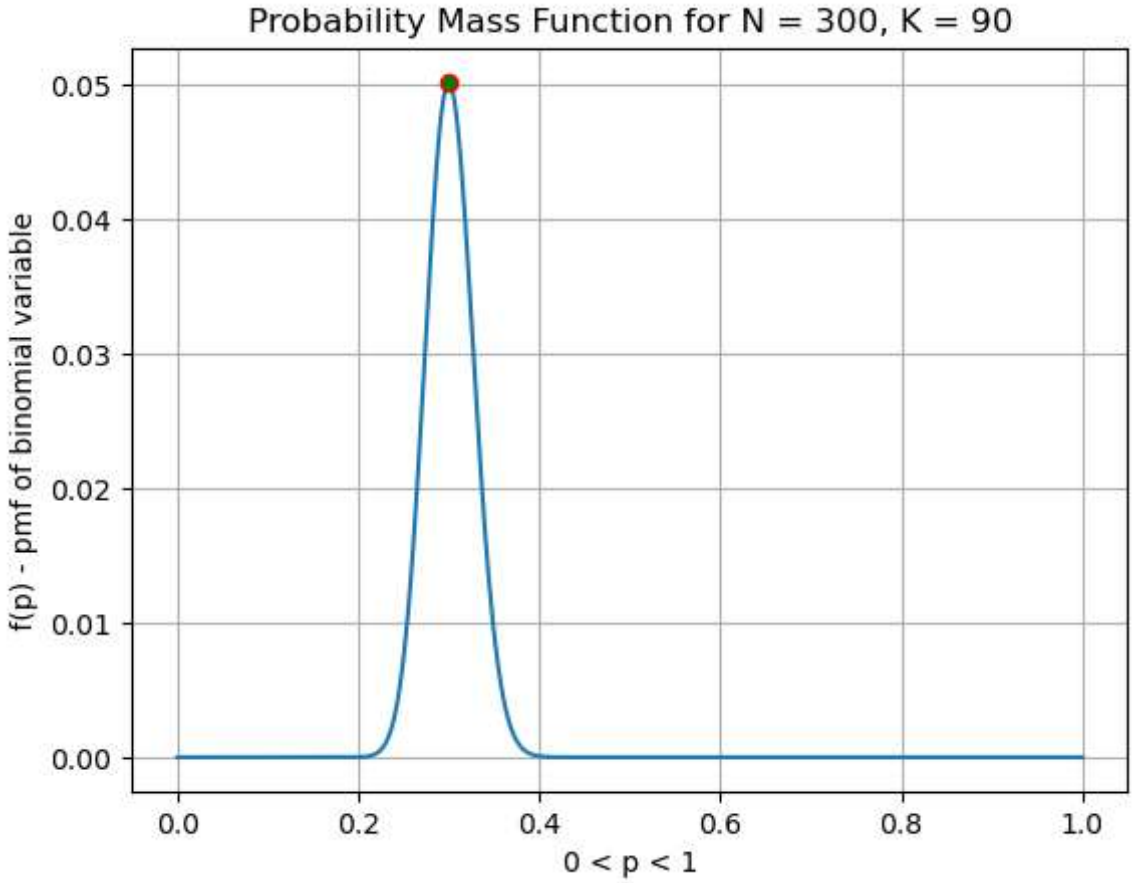
In [83]:
```
def plotProbFunc(pmf_,p_axis,N,K):
    plt.figure()
    plt.plot(p_axis,pmf_)
    maxProb(N,K)
    plt.xlabel("0 < p < 1")
    plt.ylabel(" f(p) - pmf of binomial variable ")
    title = "Probability Mass Function for N = " + str(N) + ", K = " + str(K
    plt.title(title);
    plt.grid()

    return
```

In [84]:
```
def Q3():
    T = 1000 # points of evaluation
    p_axis = np.linspace(0,1,T)
    pmf1 = calcProb(p_axis,10,3)
    pmf2 = calcProb(p_axis,50,15)
    pmf3 = calcProb(p_axis,300,90)
    plotProbFunc(pmf1,p_axis,10,3)
    plotProbFunc(pmf2,p_axis,50,15)
    plotProbFunc(pmf3,p_axis,300,90)
    return
```

In [85]:
```
Q3() # activate
```






Probability Mass Function for N = 300, K = 90
f(p) - pmf of binomial variable
0.05
0.04
0.03
0.02
0.01
0.00
0.0
0.2
0.4
0.6
0.8
1.0
0 < p < 1

In [ ]:

In [ ]: