VISVESVARAYATECHNOLOGICALUNIVERSITY

“JnanaNangama”, Belgaum -590014, Karnataka.

LAB REPORT on

Machine Learning

Submitted by

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in partial fulfilment for the award of the degree of

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(Autonomous Institution under VTU)

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Machine Learning" carried out by **G.SAI RAMAKRISHNA (1BM19CS056),** who is bonafide student of **B. M. S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2022. The Lab report has been approved as it satisfies the academic requirements in respect of a **Machine Learning - (20CS6PCMAL)** work prescribed for the said degree.

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Course Outcome

CO1	Ability to apply the different learning algorithms.
CO2	Ability to analyse the learning techniques for given dataset
CO3	Ability to design a model using machine learning to solve a problem.
CO4	Ability to conduct practical experiments to solve problems using appropriate machine learning Techniques.

1)Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples.

a) Using CSV as input:

```
import csv

def updateHypothesis(x,h):
    if h==[]:
        return x

    for i in range(0,len(h)):
        if x[i].upper()!=h[i].upper():
    h[i] = '?' return h

if name    __    == "
    main ": data = [] h = []

    # reading csv file with
    open('Desktop/FindS.csv', 'r') as file:
    reader = csv.reader(file)
        print("Data: ") for
        row in reader:
        data.append(row)
        print(row)
    if data:
        for x in data:
            if x[-1].upper()=="YES":
                x.pop() # removing last field
                h = updateHypothesis(x,h)
    print("\nHypothesis: ",h)
```

Output:

```
Data:
['Time', 'Weather', 'Temperature', 'Company', 'Humidity', 'Wind', 'Goes']
['Morning', 'Sunny', 'Warm', 'Yes', 'Mild', 'Strong', 'Yes']
['Evening', 'Rainy', 'Cold', 'No', 'Mild', 'Normal', 'No']
['Morning', 'Sunny', 'Moderate', 'Yes', 'Normal', 'Normal', 'Yes']
['Evening', 'Sunny', 'Cold', 'Yes', 'High', 'Strong', 'Yes']

Hypothesis:  ['?', 'Sunny', '?', 'Yes', '?', '?']
```

B) Using user Input:

```
import numpy as np
import pandas as pd

n=int(input("Enter the number of attributes "))
l=int(input("Enter the number of rows "))

print("Enter the ",n,"ättributes")
attributes=[] for i in range(1,n+1):
print("Enter the name of ",i," attribute ")
name=input()

for i in range(1,l+1): print("Ënter the
  values of ",i," row") print("Enter the
  values of attributes")
  res=[] for j in
  range(1,l+1):
  res.append(input())
  attributes.append(re
  s)

print("Enter the target values")
target=[] for i in range(1,l+1):
print("Enter the value of ",i," target")
x=input() target.append(x)

def findS(c,t): for i, val in
    enumerate(t):
        if val == "Yes":
            specific_hypothesis =
            c[i].copy() break

    for i, val in enumerate(c):
        if t[i] == "Yes":
            for x in range(len(specific_hypothesis)):
                if val[x] != specific_hypothesis[x]:
                    specific_hypothesis[x] = '?'
                else:
                    pass return specific_hypothesis print("\n

The final hypothesis is:",findS(attributes,target))
```

Output:

```
Enter the  3 ättributes
Enter the name of  1  attribute

Enter the name of  2  attribute

Enter the name of  3  attribute

Ënter the values of  1  row
Enter the values of attributes

Ënter the values of  2  row
Enter the values of attributes

Ënter the values of  3  row
Enter the values of attributes

Enter the target values
Enter the value of  1  target

Enter the value of  2  target

Enter the value of  3  target

 The final hypothesis is: ['?', 'Rainy', 'Cold']
```

2)For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a descripon of the set of all hypotheses consistent with the training examples

```
import numpy as np
import pandas as pd

#to read the data in the csv file
data = pd.DataFrame(data=pd.read_csv('/content/drive/MyDrive/enjoysport.csv'))
print(data,"\n")

#making an array of all the attributes
concepts = np.array(data.iloc[:,0:-1])
print("The attributes are: ",concepts)

#segregating the target that has positive and negative examples
target = np.array(data.iloc[:,-1]) print("\n The target is: ",target)

#training function to implement candidate_elimination algorithm
def learn(concepts, target):
specific_h = concepts[0].copy()
print("\n Initialization of specific_h and general_h")
print(specific_h) general_h = [["?" for i in
range(len(specific_h))] for i in
range(len(specific_h))]
 print(general_h) for i, h in
 enumerate(concepts): if
 target[i] == "yes":
        for x in range(len(specific_h)):
            if h[x]!= specific_h[x]:
                specific_h[x] ='?'
                general_h[x][x] ='?'
           # print(specific_h)
    if target[i] == "no":
        for x in range(len(specific_h)):
            if h[x]!= specific_h[x]:
                general_h[x][x] = specific_h[x]
            else:
                general_h[x][x] = '?'
    print("\n Steps of Candidate Elimination Algorithm",i+1)
    print(specific_h) print(general_h)
indices = [i for i, val in enumerate(general_h) if val ==
['?', '?', '?', '?', '?', '?']]
 for i in indices:
    general_h.remove(['?', '?', '?', '?', '?', '?'])
 return specific_h, general_h s_final,
g_final = learn(concepts, target)
#obtaining the final hypothesis
```

```
print("\nFinal Specific_h:", s_final,
sep="\n")
 print("\nFinal General_h:", g_final,
sep="\n")
```

Output:

```
      sky  temp humidity    wind water forcast enjoysport
0  sunny  warm   normal  strong  warm    same        yes
1  sunny  warm     high  strong  warm    same        yes
2  rainy  cold     high  strong  warm  change         no
3  sunny  warm     high  strong  cool  change        yes

The attributes are:  [['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
 ['sunny' 'warm' 'high' 'strong' 'warm' 'same']
 ['rainy' 'cold' 'high' 'strong' 'warm' 'change']
 ['sunny' 'warm' 'high' 'strong' 'cool' 'change']]

 The target is:  ['yes' 'yes' 'no' 'yes']

 Initialization of specific_h and general_h
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?
'?', '?'], ['?', '?', '?', '?', '?', '?']]

 Steps of Candidate Elimination Algorithm 1
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?
'?', '?'], ['?', '?', '?', '?', '?', '?']]

 Steps of Candidate Elimination Algorithm 2
['sunny' 'warm' '?' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?
'?', '?'], ['?', '?', '?', '?', '?', '?']]

 Steps of Candidate Elimination Algorithm 3
['sunny' 'warm' '?' 'strong' 'warm' 'same']
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?',
'?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]

 Steps of Candidate Elimination Algorithm 4
['sunny' 'warm' '?' 'strong' '?' '?']
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?',
'?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Final Specific_h:
['sunny' 'warm' '?' 'strong' '?' '?']

Final General_h:
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']]
```

3) Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.

a) ID3 :

```
import math import
csv def
load_csv(filename):
    lines=csv.reader(open(filename,"r"
    )); dataset = list(lines) headers =
    dataset.pop(0) return
    dataset,headers

class Node: def init
    (self,attribute):
    self.attribute=attribute
    self.children=[]
    self.answer=""

def subtables(data,col,delete):
    dic={}
    coldata=[row[col] for row in data]
    attr=list(set(coldata))

    counts=[0]*len(attr)
    r=len(data) c=len(data[0])
    for x in range(len(attr)):
    for y in range(r): if
    data[y][col]==attr[x]:
    counts[x]+=1

    for x in range(len(attr)):
        dic[attr[x]]=[[0 for i in range(c)] for j in
        range(counts[x])] pos=0 for y in range(r): if
        data[y][col]==attr[x]: if delete:
                del data[y][col]
            dic[attr[x]][pos]=data[y]
            pos+=1
    return attr,dic

def entropy(S):
    attr=list(set(S))
    if len(attr)==1:
        return 0
     counts=[0,0]
        for i in
       range(2):
```

```
        counts[i]=sum([1 for x in S if attr[i]==x])/(len(S)*1.0)

    sums=0 for cnt
    in counts:
        sums+=-1*cnt*math.log(cnt,2)
    return sums

def compute_gain(data,col): attr,dic =
    subtables(data,col,delete=False)

    total_size=len(data)
    entropies=[0]*len(attr)
    ratio=[0]*len(attr)

    total_entropy=entropy([row[-1] for row in data])
    for x in range(len(attr)):
        ratio[x]=len(dic[attr[x]])/(total_size*1.0) entropies[x]=entropy([row[-
        1] for row in dic[attr[x]]]) total_entropy-=ratio[x]*entropies[x]
    return total_entropy

def build_tree(data,features):
    lastcol=[row[-1] for row in data]
    if(len(set(lastcol)))==1:
    node=Node("")
        node.answer=lastcol[0]
        return node

    n=len(data[0])-1
    gains=[0]*n for col
    in range(n):
        gains[col]=compute_gain(data,col)
    split=gains.index(max(gains))
    node=Node(features[split]) fea =
    features[:split]+features[split+1:]


    attr,dic=subtables(data,split,delete=True)

    for x in range(len(attr)):
        child=build_tree(dic[attr[x]],fea)
    node.children.append((attr[x],child)) return
    node

def print_tree(node,level):
    if node.answer!="":
        print("        "*level,node.answer)
        return

    print("  "*level,node.attribute)
    for value,n in node.children:
    print("        "*(level+1),value)
    print_tree(n,level+2)
```

```
def classify(node,x_test,features):
    if node.answer!="":
        print(node.answer)
        return
    pos=features.index(node.attribute)
    for value, n in node.children:
        if x_test[pos]==value:
            classify(n,x_test,features)

'''Main program'''
dataset,features=load_csv("id3.csv")
node1=build_tree(dataset,features)

print("The decision tree for the dataset using ID3 algorithm is")
print_tree(node1,0)
testdata,features=load_csv("id3.csv")

for xtest in testdata: print("The test
    instance:",xtest) print("The label for test
    instance:",end=" ")
    classify(node1,xtest,features)
```

Output:

```
The decision tree for the dataset using ID3 algorithm is
 Outlook
   rain
     Wind
       strong
         no
       weak
         yes
   overcast
     yes
   sunny
     Humidity
       normal
         yes
       high
         no
The test instance: ['sunny', 'hot', 'high', 'weak', 'no']
The label for test instance:   no
The test instance: ['sunny', 'hot', 'high', 'strong', 'no']
The label for test instance:   no
The test instance: ['overcast', 'hot', 'high', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'mild', 'high', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'cool', 'normal', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'cool', 'normal', 'strong', 'no']
The label for test instance:   no
The test instance: ['overcast', 'cool', 'normal', 'strong', 'yes']
The label for test instance:   yes
The test instance: ['sunny', 'mild', 'high', 'weak', 'no']
The label for test instance:   no
The test instance: ['sunny', 'cool', 'normal', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'mild', 'normal', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['sunny', 'mild', 'normal', 'strong', 'yes']
The label for test instance:   yes
The test instance: ['overcast', 'mild', 'high', 'strong', 'yes']
The label for test instance:   yes
The test instance: ['overcast', 'hot', 'normal', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'mild', 'high', 'strong', 'no']
The label for test instance:   no
```

b) Using SKlearn:

import pandas **as** pd

import numpy **as** np

```
from sklearn.datasets import load_iris

data = load_iris()
                                                                        In [2]:
df = pd.DataFrame(data.data, columns = data.feature_names)
                                                                        In [3]:
df.head()
df['Species'] = data.target

#replace this with the actual names target =

np.unique(data.target) target_names =

np.unique(data.target_names) targets =

dict(zip(target, target_names))

df['Species'] = df['Species'].replace(targets)
                                        In [5]: x = df.drop(columns="Species")

y = df["Species"]
                                                                        In [6]:
feature_names = x.columns labels = y.unique()
                        In [7]: from sklearn.model_selection import train_test_split

X_train, test_x, y_train, test_lab = train_test_split(x,y,test_size = 0.4,random_state = 42)
                                                                        In [8]:
from sklearn.tree import DecisionTreeClassifier clf = DecisionTreeClassifier(max_depth =4, random_state =
42)
                                                                        In [9]:

clf.fit(X_train, y_train) test_pred = clf.predict(test_x)
                                                                        In [11]:

from sklearn import metrics import seaborn as sns import matplotlib.pyplot as plt

confusion_matrix = metrics.confusion_matrix(test_lab,test_pred)
                                                                        In [12]:
confusion_matrix matrix_df = pd.DataFrame(confusion_matrix) ax = plt.axes() sns.set(font_scale=1.3)
plt.figure(figsize=(10,7))
sns.heatmap(matrix_df, annot=True, fmt="g", ax=ax, cmap="magma")
ax.set_title('Confusion Matrix - Decision Tree')
ax.set_xlabel("Predicted label", fontsize =15)
ax.set_xticklabels(['']+labels)
ax.set_ylabel("True Label", fontsize=15)
ax.set_yticklabels(list(labels), rotation = 0)
plt.show() clf.score(test_x,test_lab)

from sklearn import tree
fig = plt.figure(figsize=(25,20))
```

```
_ = tree.plot_tree(clf,
                   feature_names=data.feature_names,
                   class_names=data.target_names,
                   filled=True)
```

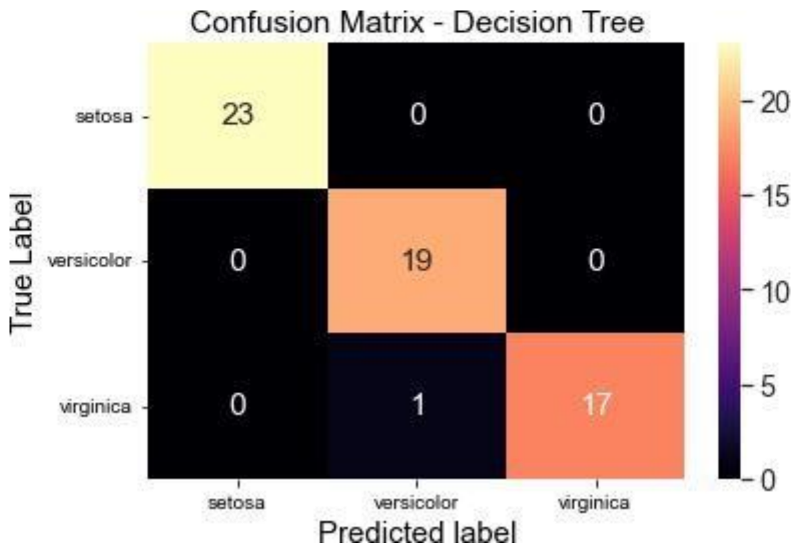
Output:

Out[3]:

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)
0	5.1	3.5	1.4	0.2
1	4.9	3.0	1.4	0.2
2	4.7	3.2	1.3	0.2
3	4.6	3.1	1.5	0.2
4	5.0	3.6	1.4	0.2

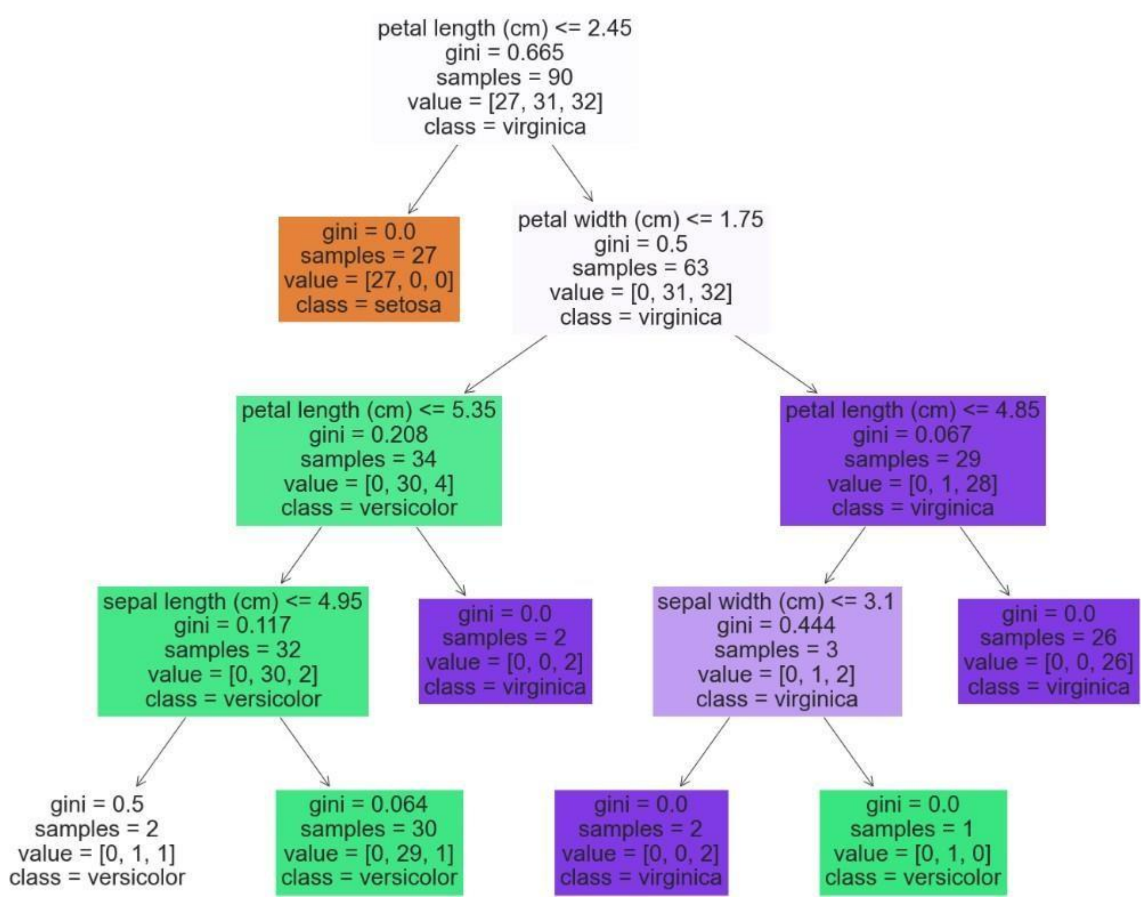
```
Out[9]: DecisionTreeClassifier(max_depth=4, random_state=42)
```

```
Out[12]: array([[23,  0,  0],
               [ 0, 19,  0],
               [ 0,  1, 17]], dtype=int64)
```



In [14]:
```
clf.score(test_x,test_lab)
```

Out[14]: 0.9833333333333333



4) Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets

a)Without using SKlearn:

```
import numpy as np
import pandas as pd

data = pd.read_csv('/content/dataset.csv')
data.head()

y = list(data['PlayTennis'].values)
X = data.iloc[:,1:].values
print(f'Target Values: {y}')
print(f'Features: \n{X}') y_train =
y[:8] y_val = y[8:] X_train = X[:8]
X_val = X[8:]
print(f"Number of instances in training set: {len(X_train)}")
print(f"Number of instances in testing set: {len(X_val)}")
class NaiveBayesClassifier:
    def_init_(self, X, y): self.X,
        self.y = X, y self.N =
        len(self.X) self.dim =
        len(self.X[0])
        self.attrs = [[] for _ in range(self.dim)]
        self.output_dom = {}
        self.data = [] for i in
        range(len(self.X)): for j
        in range(self.dim):
                if not self.X[i][j] in self.attrs[j]:
                    self.attrs[j].append(self.X[i][j])
            if not self.y[i] in self.output_dom.keys():
                self.output_dom[self.y[i]] = 1
            else: self.output_dom[self.y[i]]
                += 1
            self.data.append([self.X[i], self.y[i]])
    def classify(self, entry): solve = None max_arg = -1 for y in
        self.output_dom.keys(): prob = self.output_dom[y]/self.N for i in
        range(self.dim): cases = [x for x in self.data if x[0][i] == entry[i]
        and x[1] == y] n = len(cases) prob *= n/self.N if prob > max_arg:
        max_arg = prob
                solve = y
```

```
        return solve
nbc = NaiveBayesClassifier(X_train, y_train)
total_cases = len(y_val)
good = 0
bad = 0
predictions = [] for i in
range(total_cases): predict =
nbc.classify(X_val[i])
predictions.append(predict) if
y_val[i] == predict: good += 1
else:
        bad += 1
print('Predicted values:', predictions)
print('Actual values:', y_val)
print()
print('Total number of testing instances in the dataset:', total_cases)
print('Number of correct predictions:', good)
print('Number of wrong predictions:', bad)
print() print('Accuracy of Bayes Classifier:',
good/total_cases)
```

Output:

Out[2]:

	PlayTennis	Outlook	Temperature	Humidity	Wind
0	No	Sunny	Hot	High	Weak
1	No	Sunny	Hot	High	Strong
2	Yes	Overcast	Hot	High	Weak
3	Yes	Rain	Mild	High	Weak
4	Yes	Rain	Cool	Normal	Weak

```
Target Values: ['No', 'No', 'Yes', 'Yes', 'Yes', 'No', 'Yes', 'No', 'Yes', 'Yes', 'Yes', 'Yes', 'Yes', 'No']
Features:
[['Sunny' 'Hot' 'High' 'Weak']
 ['Sunny' 'Hot' 'High' 'Strong']
 ['Overcast' 'Hot' 'High' 'Weak']
 ['Rain' 'Mild' 'High' 'Weak']
 ['Rain' 'Cool' 'Normal' 'Weak']
 ['Rain' 'Cool' 'Normal' 'Strong']
 ['Overcast' 'Cool' 'Normal' 'Strong']
 ['Sunny' 'Mild' 'High' 'Weak']
 ['Sunny' 'Cool' 'Normal' 'Weak']
 ['Rain' 'Mild' 'Normal' 'Weak']
 ['Sunny' 'Mild' 'Normal' 'Strong']
 ['Overcast' 'Mild' 'High' 'Strong']
 ['Overcast' 'Hot' 'Normal' 'Weak']
 ['Rain' 'Mild' 'High' 'Strong']]
```

```
Number of instances in training set: 8
Number of instances in testing set: 6
```

```
Predicted values: ['No', 'Yes', 'No', 'Yes', 'Yes', 'No']
Actual values: ['Yes', 'Yes', 'Yes', 'Yes', 'Yes', 'No']

Total number of testing instances in the dataset: 6
Number of correct predictions: 4
Number of wrong predictions: 2

Accuracy of Bayes Classifier: 0.6666666666666666
```

b)Using SKlearn:

```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB
from sklearn import metrics

df = pd.read_csv("/content/pima_indian.csv")
feature_col_names = ['num_preg', 'glucose_conc', 'diastolic_bp', 'thickness', 'insulin', 'bmi', 'diab_pred', 'age']
predicted_class_names = ['diabetes'] X = df[feature_col_names].values y =
df[predicted_class_names].values
print(df.head)
xtrain,xtest,ytrain,ytest=train_test_split(X,y,test_size=0.3
3) print ('\nThe total number of Training
Data:',ytrain.shape) print ('The total number of Test
Data:',ytest.shape) clf =
GaussianNB().fit(xtrain,ytrain.ravel()) predicted =
clf.predict(xtest)
predictTestData= clf.predict([[6,148,72,35,0,33.6,0.627,50]])
print('\nConfusion matrix')
print(metrics.confusion_matrix(ytest,predicted)) print('\nAccuracy of the
classifier:',metrics.accuracy_score(ytest,predicted)) print('The value of
Precision:', metrics.precision_score(ytest,predicted)) print('The value of
Recall:', metrics.recall_score(ytest,predicted)) print("Predicted Value for
individual Test Data:", predictTestData)
```

Output:

```
<bound method NDFrame.head of      num_preg  glucose_conc  diastolic_bp  ...  diab_pred  age  diabetes
0           6           148            72  ...      0.627   50         1
1           1            85            66  ...      0.351   31         0
2           8           183            64  ...      0.672   32         1
3           1            89            66  ...      0.167   21         0
4           0           137            40  ...      2.288   33         1
..        ...           ...           ...  ...        ...  ...       ...
763        10           101            76  ...      0.171   63         0
764         2           122            70  ...      0.340   27         0
765         5           121            72  ...      0.245   30         0
766         1           126            60  ...      0.349   47         1
767         1            93            70  ...      0.315   23         0

[768 rows x 9 columns]>

The total number of Training Data: (514, 1)
The total number of Test Data: (254, 1)
```

```
Confusion matrix
[[156  16]
 [ 35  47]]

Accuracy of the classifier: 0.7992125984251969
The value of Precision: 0.746031746031746
The value of Recall: 0.573170731707317
Predicted Value for individual Test Data: [1]
```

5) Implement the Linear Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs.

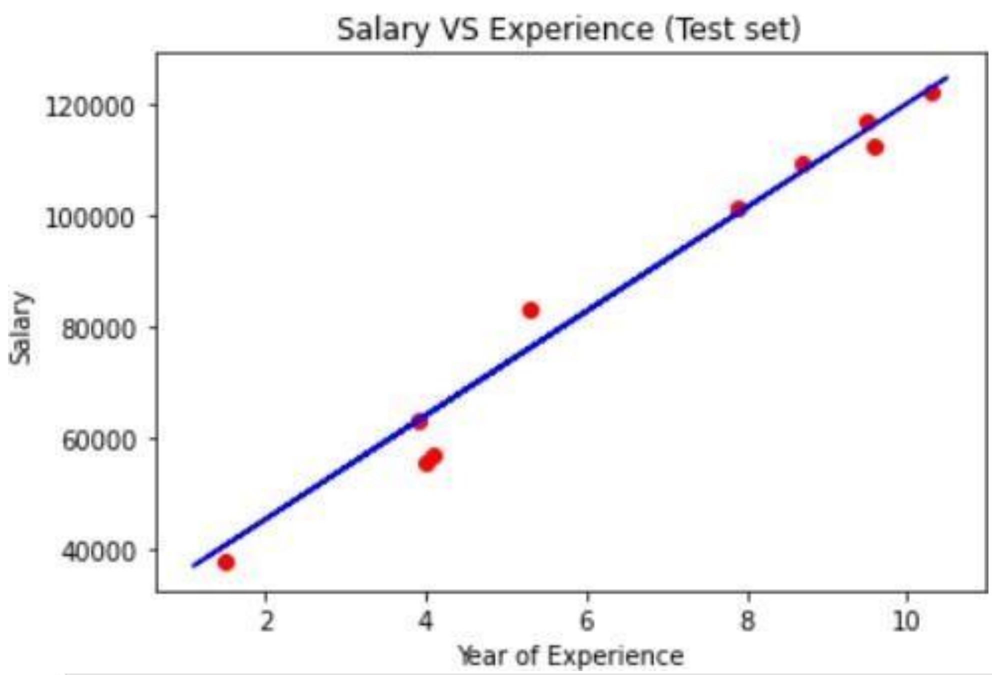
a) Using SKlearn:

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd

# Importing the dataset
dataset = pd.read_csv('salary_data.csv')
X = dataset.iloc[:, :-1].values #get a copy of dataset exclude last column
y = dataset.iloc[:, 1].values #get array of dataset in column 1st:

# Splitting the dataset into the Training set and Test set
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=1/3, random_state=0)

# Fitting Simple Linear Regression to the Training set
from sklearn.linear_model import LinearRegression
regressor = LinearRegression() regressor.fit(X_train,
y_train)

# Visualizing the Training set results
viz_train = plt
viz_train.scatter(X_train, y_train, color='red')
```

```
viz_train.plot(X_train, regressor.predict(X_train), color='blue')
viz_train.title('Salary VS Experience (Training set)')
viz_train.xlabel('Year of  Experience') viz_train.ylabel('Salary')
viz_train.show()
# Visualizing the Test set results
viz_test = plt
viz_test.scatter(X_test, y_test, color='red')
viz_test.plot(X_train, regressor.predict(X_train), color='blue')
viz_test.title('Salary VS Experience (Test set)')
viz_test.xlabel('Year of Experience')
viz_test.ylabel('Salary')
viz_test.show()
# Predicting the Test set results
y_pred = regressor.predict(X_test)
print(y_pred)
```

Output:

Out[4]:
```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```



In [8]:
```
# Predicting the Test set results
y_pred = regressor.predict(X_test)
print(y_pred)
```

```
[ 40835.10590871 123079.39940819  65134.55626083  63265.36777221
 115602.64545369 108125.8914992  116537.23969801  64199.96201652
  76349.68719258 100649.1375447 ]
```

b) Without using SKlearn:

```
import pandas as pd
import numpy as np
class LR():
    def init (self):
        self.w = []
    def fit(self, X, y): self.w =
        np.linalg.solve(X.T@X, X.T@y)
    def predict(self, X):
        return X@self.w
    def score(self, X, y):
        SS_reg = np.sum((X@self.w - y)**2)
        SS_tot = np.sum((y - np.mean(y))**2)
        return (1 - (SS_reg/SS_tot))
```

```
from sklearn.model_selection import train_test_split from
sklearn.datasets import fetch_california_housing
fetch_california_housing data, labels =
fetch_california_housing(return_X_y = True) data.shape,
labels.shape one = np.ones(data.shape[0]) data =
np.column_stack((one, data))
X_train,X_test, y_train, y_test = train_test_split(data, labels, train_size = 0.75, random_state = 42)
lro = LR()
lro.fit(X_train, y_train)
lro.w lro.predict(X_test)
lro.score(X_test, y_test)
```

Output:

```
data.shape, labels.shape
```

```
((20640, 9), (20640,))
```

```
lro.w
```

```
array([-3.70278276e+01,  4.47600069e-01,  9.56752596e-03, -1.24755956e-01,
        7.94471254e-01, -1.43902596e-06, -3.44307993e-03, -4.18555257e-01,
       -4.33405135e-01])
```

```
lro.predict(X_test)
```

```
array([0.72412832, 1.76677807, 2.71151581, ..., 1.72382152, 2.34689276,
       3.52917352])
```

```
lro.score(X_test, y_test)
```

```
0.5910509795491321
```

6) Write a program to construct a Bayesian network considering training data. Use this model to make predictions.

a)Using built-in:

```
!pip install pgmpy import numpy as np import pandas as pd
import csv from pgmpy.estimators import
MaximumLikelihoodEstimator from pgmpy.models import
BayesianModel from pgmpy.inference import
VariableElimination heartDisease =
pd.read_csv('heart_disease.csv') heartDisease =
heartDisease.replace('?',np.nan)

print('Sample instances from the dataset are given below')
print(heartDisease.head())

print('\n Attributes and datatypes')
print(heartDisease.dtypes)
model=
BayesianModel([('age','Heartdisease'),('sex','Heartdisease'),('exang','Heartdisease'),('cp','Heartdisease'),('He
artdisease','restecg'),('Heartdisease','chol')])
print('\nLearning CPD using Maximum likelihood estimators')
model.fit(heartDisease,estimator=MaximumLikelihoodEstimator)
print('\n Inferencing with Bayesian Network:')
HeartDiseasetest_infer = VariableElimination(model)

print('\n 1. Probability of HeartDisease given evidence= restecg')
q1=HeartDiseasetest_infer.query(variables=['Heartdisease'],evidence={'restecg':1})
print(q1)
```

```
print('\n 2. Probability of HeartDisease given evidence= cp ')
q2=HeartDiseasetest_infer.query(variables=['Heartdisease'],evidence={'cp':2})
print(q2)
```

Output:

```
Inferencing with Bayesian Network:

1. Probability of HeartDisease given evidence= restecg

Finding Elimination Order: : 100%  4/4 [00:00<00:00, 100.26it/s]

Eliminating: exang: 100%  4/4 [00:00<00:00, 190.96it/s]

+-----------------+---------------------+
| Heartdisease    |   phi(Heartdisease) |
+=================+=====================+
| Heartdisease(0) |              0.1012 |
+-----------------+---------------------+
| Heartdisease(1) |              0.0000 |
+-----------------+---------------------+
| Heartdisease(2) |              0.2392 |
+-----------------+---------------------+
| Heartdisease(3) |              0.2015 |
+-----------------+---------------------+
| Heartdisease(4) |              0.4581 |
+-----------------+---------------------+

2. Probability of HeartDisease given evidence= cp

Finding Elimination Order: : 100%  3/3 [00:00<00:00, 60.16it/s]

Eliminating: exang: 100%  3/3 [00:00<00:00, 91.15it/s]

+-----------------+---------------------+
| Heartdisease    |   phi(Heartdisease) |
+=================+=====================+
| Heartdisease(0) |              0.3610 |
+-----------------+---------------------+
| Heartdisease(1) |              0.2159 |
+-----------------+---------------------+
| Heartdisease(2) |              0.1373 |
+-----------------+---------------------+
| Heartdisease(3) |              0.1537 |
+-----------------+---------------------+
| Heartdisease(4) |              0.1321 |
+-----------------+---------------------+
```

b) Without using built-in:

```
import bayespy as bp import numpy as
np import csv from colorama import init
from colorama import Fore, Back, Style
init()
# Define Parameter Enum values
```

```
# Age
ageEnum = {'SuperSeniorCitizen': 0, 'SeniorCitizen': 1,
        'MiddleAged': 2, 'Youth': 3, 'Teen': 4}
# Gender genderEnum = {'Male': 0,
'Female': 1}
# FamilyHistory familyHistoryEnum =
{'Yes': 0, 'No': 1} # Diet(Calorie Intake)
dietEnum = {'High': 0, 'Medium': 1, 'Low': 2}
# LifeStyle lifeStyleEnum = {'Athlete': 0, 'Active': 1, 'Moderate': 2,
'Sedetary': 3}
# Cholesterol cholesterolEnum = {'High': 0, 'BorderLine':
1, 'Normal': 2}
# HeartDisease heartDiseaseEnum = {'Yes':
0, 'No': 1} import pandas as pd data =
pd.read_csv("heart_disease_data.csv") data
=np.array(data, dtype='int8') N = len(data)
# Input data column assignment p_age =
bp.nodes.Dirichlet(1.0*np.ones(5)) age =
bp.nodes.Categorical(p_age, plates=(N,))
age.observe(data[:, 0])

p_gender = bp.nodes.Dirichlet(1.0*np.ones(2)) gender
= bp.nodes.Categorical(p_gender, plates=(N,))
gender.observe(data[:, 1])

p_familyhistory = bp.nodes.Dirichlet(1.0*np.ones(2)) familyhistory
= bp.nodes.Categorical(p_familyhistory, plates=(N,))
familyhistory.observe(data[:, 2])

p_diet = bp.nodes.Dirichlet(1.0*np.ones(3)) diet
= bp.nodes.Categorical(p_diet, plates=(N,))
diet.observe(data[:, 3])
p_lifestyle = bp.nodes.Dirichlet(1.0*np.ones(4)) lifestyle
= bp.nodes.Categorical(p_lifestyle, plates=(N,))
lifestyle.observe(data[:, 4])

p_cholesterol = bp.nodes.Dirichlet(1.0*np.ones(3)) cholesterol =
bp.nodes.Categorical(p_cholesterol, plates=(N,))
cholesterol.observe(data[:, 5]) p_heartdisease =
```

bp.nodes.Dirichlet(np.ones(2), plates=(5, 2, 2, 3, 4, 3)) heartdisease =
bp.nodes.MultiMixture(
[age, gender, familyhistory, diet, lifestyle, cholesterol], bp.nodes.Categorical, p_heartdisease)
heartdisease.observe(data[:, 6]) p_heartdisease.update()
m = 0 while m == 0: print("\n") res = bp.nodes.MultiMixture([int(input('Enter Age: ' +
str(ageEnum))), int(input('Enter Gender: ' +
str(genderEnum))), int(input('Enter FamilyHistory: ' + str(familyHistoryEnum))), int(input('Enter dietEnum: ' +
str(dietEnum))), int(input('Enter LifeStyle: ' + str(lifeStyleEnum))), int(input('Enter Cholesterol: ' +
str(cholesterolEnum)))], bp.nodes.Categorical, p_heartdisease).get_moments()[0][heartDiseaseEnum['Yes']]
print("Probability(HeartDisease) = " + str(res))

print(Style.RESET_ALL) m = int(input("Enter
for Continue:0, Exit :1 ")) **Output:**

```
Enter Age: {'SuperSeniorCitizen': 0, 'SeniorCitizen': 1, 'MiddleAged': 2, 'Youth': 3, 'Teen': 4}0
Enter Gender: {'Male': 0, 'Female': 1}0
Enter FamilyHistory: {'Yes': 0, 'No': 1}0
Enter dietEnum: {'High': 0, 'Medium': 1, 'Low': 2}0
Enter LifeStyle: {'Athlete': 0, 'Active': 1, 'Moderate': 2, 'Sedetary': 3}2
Enter Cholesterol: {'High': 0, 'BorderLine': 1, 'Normal': 2}1
Probability(HeartDisease) = 0.5
Enter for Continue:0, Exit :1 0
```

7) Apply k-Means algorithm to cluster a set of data stored in a .CSV file

a) Using built-in:

import pandas as pd from sklearn.cluster import
KMeans from sklearn.preprocessing import
MinMaxScaler from matplotlib import pyplot as
plt
%matplotlib inline df =
pd.read_csv('income.csv')
df.head(10) scaler =
MinMaxScaler()
scaler.fit(df[['Age']]) df[['Age']] =
scaler.transform(df[['Age']])

scaler.fit(df[['Income($)']]) df[['Income($)']] =
scaler.transform(df[['Income($)']]) df.head(10)
plt.scatter(df['Age'], df['Income($)'])

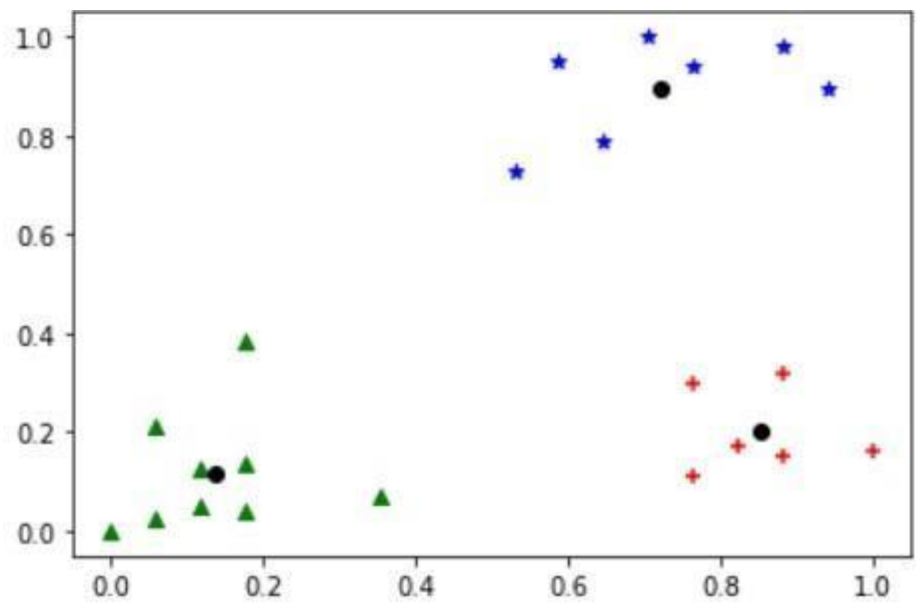
```
k_range = range(1, 11)
sse   =   []   for   k   in
k_range:
    kmc = KMeans(n_clusters=k)
    kmc.fit(df[['Age', 'Income($)']])
    sse.append(kmc.inertia_)
plt.xlabel = 'Number of Clusters'
plt.ylabel = 'Sum of Squared Errors'
plt.plot(k_range, sse)

km = KMeans(n_clusters=3)
km
df0 = df[df.cluster == 0]
df0 df1 = df[df.cluster
== 1] df1 df2 =
df[df.cluster == 2] df2
```

p1 = plt.scatter(df0['Age'], df0['Income($)'], marker='+', color='red') p2 = plt.scatter(df1['Age'], df1['Income($)'], marker='*', color='blue') p3 = plt.scatter(df2['Age'], df2['Income($)'], marker='^', color='green') c = plt.scatter(km.cluster_centers_[:,0], km.cluster_centers_[:,1], color='black') plt.xlabel('Age') plt.ylabel('Income($)') plt.legend((p1, p2, p3, c),

('Cluster 1', 'Cluster 2', 'Cluster 3', 'Centroid'))

Output:

```
KMeans(n_clusters=3)
```



b) Without using built-in:

import math; import sys; import pandas as pd import numpy as np from random import choice from matplotlib import pyplot from random import shuffle, uniform; def ReadData(fileName): f = open(fileName,'r') lines = f.read().splitlines() f.close()

items = [] for i in range(1,len(lines)): line = lines[i].split(',') itemFeatures = [] for j in range(len(line)-1): v = float(line[j]) itemFeatures.append(v)

items.append(itemFeatures)

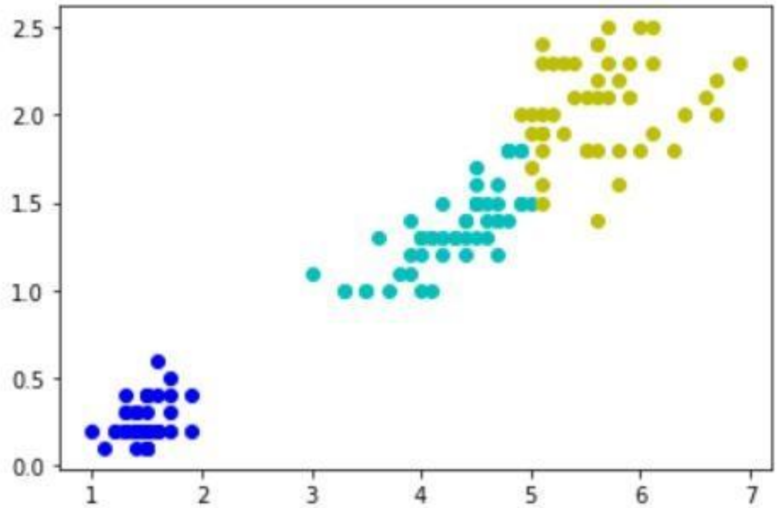
```
    shuffle(items)
    return items
def      FindColMinMax(items):      n      =
    len(items[0]) minima = [float('inf') for i in
    range(n)] maxima = [float('-inf') -1 for i in
    range(n)] for item in items:
        for f in range(len(item)):
            if(item[f] < minima[f]):
                minima[f] = item[f]
            if(item[f] > maxima[f]):
                maxima[f] = item[f]
    return minima,maxima

def EuclideanDistance(x,y):
    S = 0
    for i in range(len(x)):
        S += math.pow(x[i]-y[i],2)
    return math.sqrt(S)
def InitializeMeans(items,k,cMin,cMax): f =
    len(items[0]) means = [[0 for i in range(f)] for
    j in range(k)] for mean in means: for i in
    range(len(mean)): mean[i] =
    uniform(cMin[i]+1,cMax[i]-1)

    return means def

UpdateMean(n,mean,item): for

i in range(len(mean)): m =

mean[i]

        m = (m*(n-1)+item[i])/float(n)
        mean[i] = round(m,3)
    return mean
def FindClusters(means,items):
    clusters = [[] for i in range(len(means))]
    for item in items:
```

```
        index = Classify(means,item)
        clusters[index].append(item)
    return clusters

def Classify(means,item):
        minimum = float('inf');
    index = -1 for i in range(len(means)): dis
    = EuclideanDistance(item,means[i]) if(dis
    < minimum): minimum = dis index = i
        return index
def CalculateMeans(k,items,maxIterations=100000):
    cMin, cMax = FindColMinMax(items) means =
    InitializeMeans(items,k,cMin,cMax) clusterSizes =
    [0 for i in range(len(means))] belongsTo = [0 for i
    in range(len(items))] for e in range(maxIterations):
    noChange = True; for i in range(len(items)):
            item = items[i]; index = Classify(means,item)
            clusterSizes[index] += 1 cSize = clusterSizes[index]
            means[index] =
            UpdateMean(cSize,means[index],item) if(index !=
            belongsTo[i]): noChange = False belongsTo[i] = index
        if (noChange):
            break
    return means

def CutToTwoFeatures(items,indexA,indexB):
    n = len(items)
    X = []
    for i in range(n): item = items[i] newItem
        = [item[indexA],item[indexB]]
        X.append(newItem)
    return X

def PlotClusters(clusters):
    n = len(clusters) X = [[]
    for i in range(n)] for i in
    range(n):    cluster    =
    clusters[i]   for   item   in
    cluster:
```

```
            X[i].append(item)
    colors =
    ['r','b','g','c','m','y'] for x in
    X: c = choice(colors)
    colors.remove(c)
        Xa = []
        Xb = [] for
        item in x:
            Xa.append(item[0])
            Xb.append(item[1])
        pyplot.plot(Xa,Xb,'o',color=c)
    pyplot.show()


def main(): items =
    ReadData('data.txt')
    k = 3
    items = CutToTwoFeatures(items,2,3)
    print(items)
    means = CalculateMeans(k,items)
    print("\nMeans = ", means) clusters =
    FindClusters(means,items)
    PlotClusters(clusters) newItem =
    [1.5,0.2]
    print(Classify(means,newItem))

if__name__ == " main ":
    main()
```

Output:

```
Means =  [[4.308, 1.372], [5.639, 2.059], [1.465, 0.255]]
```




```
2
```

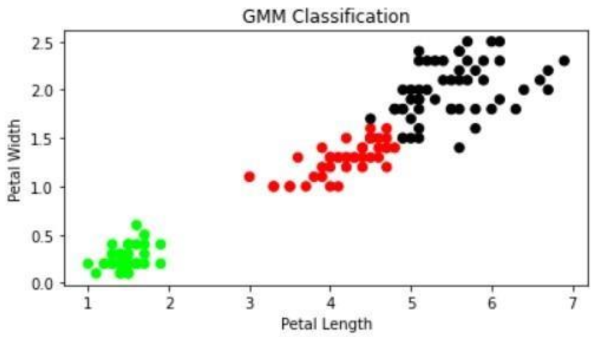
8)Apply EM algorithm to cluster a set of data stored in a .CSV file. Compare the results of k-Means algorithm and EM algorithm.

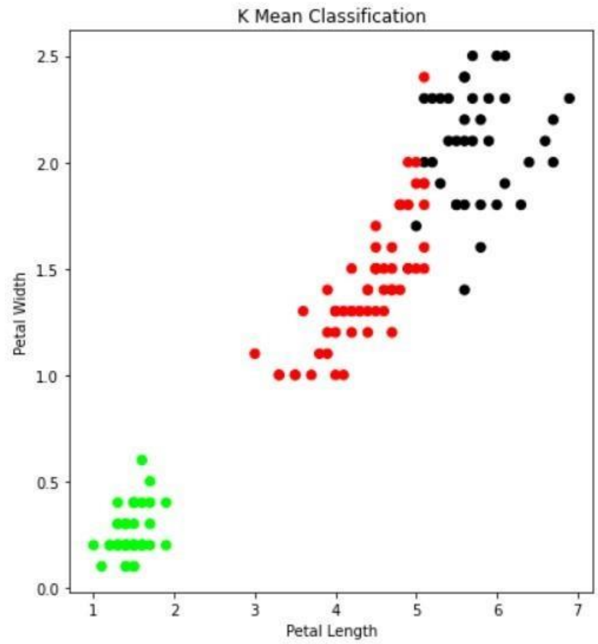
```
import matplotlib.pyplot as plt from
sklearn import datasets from
sklearn.cluster import KMeans
import sklearn.metrics as sm
import pandas as pd import numpy
as np
iris = datasets.load_iris()
X = pd.DataFrame(iris.data)
X.columns = ['Sepal_Length','Sepal_Width','Petal_Length','Petal_Width']
y = pd.DataFrame(iris.target)
y.columns = ['Targets'] model = KMeans(n_clusters=3) model.fit(X)
plt.figure(figsize=(14,7)) colormap = np.array(['red', 'lime', 'black']) # Plot
the Original Classifications plt.subplot(1, 2, 1)
plt.scatter(X.Petal_Length, X.Petal_Width, c=colormap[y.Targets], s=40)
plt.title('Real Classification') plt.xlabel('Petal Length') plt.ylabel('Petal
Width')
# Plot the Models Classifications plt.subplot(1, 2, 2)
plt.scatter(X.Petal_Length, X.Petal_Width, c=colormap[model.labels_], s=40)
plt.title('K Mean Classification') plt.xlabel('Petal Length') plt.ylabel('Petal
Width')
```

```
print('The accuracy score of K-Mean: ',sm.accuracy_score(y, model.labels_))
print('The Confusion matrixof K-Mean: ',sm.confusion_matrix(y, model.labels_))

from sklearn import preprocessing scaler =
preprocessing.StandardScaler() scaler.fit(X)
xsa = scaler.transform(X) xs =
pd.DataFrame(xsa, columns = X.columns)
#xs.sample(5)

from sklearn.mixture import GaussianMixture
gmm = GaussianMixture(n_components=3)
gmm.fit(xs)

y_gmm = gmm.predict(xs) #y_cluster_gmm plt.subplot(2, 2, 3)
plt.scatter(X.Petal_Length, X.Petal_Width, c=colormap[y_gmm], s=40)
plt.title('GMM Classification') plt.xlabel('Petal Length') plt.ylabel('Petal
Width') print('The accuracy score of EM: ',sm.accuracy_score(y,
y_gmm)) print('The Confusion matrix of EM: ',sm.confusion_matrix(y,
y_gmm))
```

Output:

```
The accuracy score of K-Mean:  0.24
The Confusion matrixof K-Mean:  [[ 0 50  0]
 [48  0  2]
 [14  0 36]]
The accuracy score of EM:  0.3333333333333333
The Confusion matrix of EM:  [[ 0 50  0]
 [45  0  5]
 [ 0  0 50]]
```





9) Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions.

from sklearn.model_selection import train_test_split from
sklearn.neighbors import KNeighborsClassifier from
sklearn.metrics import classification_report, confusion_matrix from
sklearn import datasets

iris=datasets.load_iris()

x = iris.data y = iris.target print ('sepal-length', 'sepal-width',
'petal-length', 'petal-width') print(x) print('class: 0-Iris-Setosa, 1-
Iris-Versicolour, 2- Iris-Virginica') print(y) x_train, x_test, y_train,
y_test = train_test_split(x,y,test_size=0.3)
#To Training the model and Nearest nighbors K=5
classifier = KNeighborsClassifier(n_neighbors=5)
classifier.fit(x_train, y_train)
#To make predictions on our test data

```
y_pred=classifier.predict(x_test)
print('Confusion Matrix')
print(confusion_matrix(y_test,y_pred))
print('Accuracy Metrics')
print(classification_report(y_test,y_pred))
```

Output:

```
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 2 2]
Confusion Matrix
[[14  0  0]
 [ 0 14  0]
 [ 0  2 15]]
Accuracy Metrics
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        14
           1       0.88      1.00      0.93        14
           2       1.00      0.88      0.94        17

    accuracy                           0.96        45
   macro avg       0.96      0.96      0.96        45
weighted avg       0.96      0.96      0.96        45
```

10) Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs.

a) Using built-in:

```
import numpy as np from bokeh.plotting import figure,
show, output_notebook from bokeh.layouts import
gridplot from bokeh.io import push_notebook

def local_regression(x0, X, Y, tau):# add bias term
x0 = np.r_[1, x0] # Add one to avoid the loss in information X
= np.c_[np.ones(len(X)), X]

# fit model: normal equations with kernel xw = X.T *
radial_kernel(x0, X, tau) # XTranspose * W

beta = np.linalg.pinv(xw @ X) @ xw @ Y #@ Matrix Multiplication or Dot Product



# predict value return x0 @ beta # @ Matrix Multiplication or Dot
Product for prediction
def radial_kernel(x0, X, tau):
return np.exp(np.sum((X - x0) ** 2, axis=1) / (-2 * tau * tau))
# Weight or Radial Kernal Bias Function

n = 1000
# generate dataset X =
np.linspace(-3, 3, num=n)
print("The Data Set ( 10 Samples) X :\n",X[1:10])
Y = np.log(np.abs(X ** 2 - 1) + .5)
print("The Fitting Curve Data Set (10 Samples) Y :\n",Y[1:10])
# jitter X
X += np.random.normal(scale=.1, size=n)
print("Normalised (10 Samples) X :\n",X[1:10])

domain = np.linspace(-3, 3, num=300)
print(" Xo Domain Space(10 Samples) :\n",domain[1:10])
```

def plot_lwr(tau): # prediction through regression prediction =
[local_regression(x0, X, Y, tau) for x0 in domain] plot =
figure(plot_width=400, plot_height=400)
plot.title.text='tau=%g' % tau plot.scatter(X, Y, alpha=.3)
plot.line(domain, prediction, line_width=2, color='red') return
plot

show(gridplot([[plot_lwr(10.)
, plot_lwr(1.)],
[plot_lwr(0.1), plot_lwr(0.01)]]))

Output:

```
The Data Set ( 10 Samples) X :
 [-2.99399399 -2.98798799 -2.98198198 -2.97597598 -2.96996997 -2.96396396
 -2.95795796 -2.95195195 -2.94594595]
The Fitting Curve Data Set (10 Samples) Y :
 [2.13582188 2.13156806 2.12730467 2.12303166 2.11874898 2.11445659
 2.11015444 2.10584249 2.10152068]
Normalised (10 Samples) X :
 [-3.08663662 -2.79327673 -3.13292877 -3.03726639 -3.0967025  -2.9652877
 -3.00708877 -2.94234969 -2.79405157]
 Xo Domain Space(10 Samples) :
 [-2.97993311 -2.95986622 -2.93979933 -2.91973244 -2.89966555 -2.87959866
 -2.85953177 -2.83946488 -2.81939799]
```

b) Without using built-in:

import matplotlib.pyplot as plt
import pandas as pd import
numpy as np

def kernel(point, xmat, k): m,n =
np.shape(xmat) weights =
np.mat(np.eye((m))) for j in range(m): diff =
point - X[j] weights[j,j] = np.exp(diff*diff.T/(-
2.0*k**2)) return weights

def localWeight(point, xmat, ymat, k): wei
= kernel(point,xmat,k) W =
(X.T*(wei*X)).I*(X.T*(wei*ymat.T))
return W

def localWeightRegression(xmat, ymat, k):

```
    m,n = np.shape(xmat)
    ypred = np.zeros(m)
    for i in range(m):
        ypred[i] = xmat[i]*localWeight(xmat[i],xmat,ymat,k)
    return ypred
data = pd.read_csv('10-dataset.csv')
bill = np.array(data.total_bill) tip =
np.array(data.tip)

#preparing and add 1 in bill mbill =
np.mat(bill) mtip = np.mat(tip) m=
np.shape(mbill)[1] one =
np.mat(np.ones(m)) X =
np.hstack((one.T,mbill.T)) ypred =
localWeightRegression(X,mtip,0.5)
SortIndex = X[:,1].argsort(0) xsort =
X[SortIndex][:,0] fig = plt.figure() ax =
fig.add_subplot(1,1,1) ax.scatter(bill,tip,
color='green')
ax.plot(xsort[:,1],ypred[SortIndex], color = 'red', linewidth=5)
plt.xlabel('Total bill') plt.ylabel('Tip') plt.show();
```

Output: