VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

MACHINE LEARNING

Submitted by

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in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Machine Learning" carried out by **Mithun R K (1BM19CS087),** 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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Index Sheet

Course Outcome

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

In [1]:
```
import numpy as np
import pandas as pd
```

In [2]:
```
data = pd.read_csv("mydata.csv")
print(data,"\n")
```

```
      Time Weather Temperature Company Humidity    Wind Goes
0  Morning   Sunny        Warm     Yes     Mild  Strong  Yes
1  Evening   Rainy        Cold      No     Mild  Normal   No
2  Morning   Sunny    Moderate     Yes   Normal  Normal  Yes
3  Evening   Sunny        Cold     Yes     High  Strong  Yes
```

In [3]:
```
d = np.array(data)[:,:-1]
print("\n The attributes are: ",d)
target = np.array(data)[:,-1]
print("\n The target is: ",target)
```

```
The attributes are:  [['Morning' 'Sunny' 'Warm' 'Yes' 'Mild' 'Strong']
['Evening' 'Rainy' 'Cold' 'No' 'Mild' 'Normal']
['Morning' 'Sunny' 'Moderate' 'Yes' 'Normal' 'Normal']
['Evening' 'Sunny' 'Cold' 'Yes' 'High' 'Strong']]

The target is:  ['Yes' 'No' 'Yes' 'Yes']
```

In [4]:
```
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(d,target))
```

```
The final hypothesis is: ['?' 'Sunny' '?' 'Yes' '?' '?']
```

In [1]:
```
import numpy as np
import pandas as pd
```

In [2]:
```
print("Enter features separated by space")
features = input().split()
print("Features ", features)
num_samples = int(input("enter number of samples: "))
```

```
Enter features separated by space
Time Weather Temperature Company Humidity Wind
Features  ['Time', 'Weather', 'Temperature', 'Company', 'Humidity', 'Wind']
enter number of samples: 4
```

In [11]:
```
def findS():
    specific_hypothesis = ["n"]*len(features)
    for a in range(num_samples):
        print("sample", a)

        temp_features = input("Enter features: ").split()
        target = input("Enter outcome: ")
        if target == "Yes":
            for x in range(len(specific_hypothesis)):
                if specific_hypothesis[x] == "n":
                    specific_hypothesis[x] = temp_features[x]
                elif temp_features[x] != specific_hypothesis[x]:
                    specific_hypothesis[x] = '?'
        print("Specific hypothesis: ", specific_hypothesis)
    return specific_hypothesis
```

In [12]:
```
print("\n The final hypothesis is:",findS())
```

```
sample 0
Enter features: Morning Sunny Warm Yes Mild Strong
Enter outcome: Yes
Specific hypothesis:  ['Morning', 'Sunny', 'Warm', 'Yes', 'Mild', 'Strong']
sample 1
Enter features: Evening Rainy Cold No Mild Normal
Enter outcome: No
Specific hypothesis:  ['Morning', 'Sunny', 'Warm', 'Yes', 'Mild', 'Strong']
sample 2
Enter features: Morning Sunny Moderate Yes Normal Normal
Enter outcome: Yes
Specific hypothesis:  ['Morning', 'Sunny', '?', 'Yes', '?', '?']
sample 3
Enter features: Evening Sunny Cold Yes High Strong
Enter outcome: Yes
Specific hypothesis:  ['?', 'Sunny', '?', 'Yes', '?', '?']

 The final hypothesis is: ['?', 'Sunny', '?', 'Yes', '?', '?']
```

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

In [1]:
```
import numpy as np
import pandas as pd
```

In [2]:
```
data = pd.read_csv('mydata.csv')
concepts = np.array(data.iloc[:,0:-1])
print("\nInstances are:\n",concepts)
target = np.array(data.iloc[:,-1])
print("\nTarget Values are: ",target)
```

```
Instances 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']]

Target Values are:  ['yes' 'yes' 'no' 'yes']
```

In [5]:
```
def learn(concepts, target):
    specific_h = ["null"]*len(concepts[0])
    print("\nInitialization of specific_h and genearal_h")
    print("\nSpecific Boundary: ", specific_h)
    specific_h = concepts[0].copy()
    general_h = [["?" for i in range(len(specific_h))] for i in range(len(specific_h))]
    print("\nGeneric Boundary: ",general_h)

    for i, h in enumerate(concepts):
        print("\nInstance", i+1 , "is ", h)
        if target[i] == "yes":
            print("Instance is Positive ")
            for x in range(len(specific_h)):
                if h[x]!= specific_h[x]:
                    specific_h[x] ='?'
                    general_h[x][x] ='?'

        if target[i] == "no":
            print("Instance is Negative ")
            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] = '?'
                    general_h[x][x] = specific_h[x]
                else:
                    general_h[x][x] = '?'

        print("Specific Bundary after ", i+1, "Instance is ", specific_h)
        print("Generic Boundary after ", i+1, "Instance is ", general_h)
        print("\n")

    indices = [i for i, val in enumerate(general_h) if val == ['?']*len(concepts[0])]
    for i in indices:
        general_h.remove(['?', '?', '?', '?', '?', '?'])
    return specific_h, general_h
```

In [6]:
```
s_final, g_final = learn(concepts, target)

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

```
Initialization of specific_h and genearal_h

Specific Boundary:  ['null', 'null', 'null', 'null', 'null', 'null']

Generic Boundary:  [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'],
['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Instance 1 is  ['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
Instance is Positive
Specific Bundary after  1 Instance is  ['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
Generic Boundary after  1 Instance is  [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?',
'?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]



Instance 2 is  ['sunny' 'warm' 'high' 'strong' 'warm' 'same']
Instance is Positive
Specific Bundary after  2 Instance is  ['sunny' 'warm' '?' 'strong' 'warm' 'same']
Generic Boundary after  2 Instance is  [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?',
'?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]



Instance 3 is  ['rainy' 'cold' 'high' 'strong' 'warm' 'change']
Instance is Negative
Specific Bundary after  3 Instance is  ['sunny' 'warm' '?' 'strong' 'warm' 'same']
Generic Boundary after  3 Instance is  [['sunny' '?' '?' '?' '?' '?'] ['?' 'warm' '?' '?' '?' '?'] ['?' '?' '?' '?' '?' '?'] ['?
```

```
['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Instance 1 is  ['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
Instance is Positive
Specific Bundary after  1 Instance is  ['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
Generic Boundary after  1 Instance is  [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?',
'?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]



Instance 2 is  ['sunny' 'warm' 'high' 'strong' 'warm' 'same']
Instance is Positive
Specific Bundary after  2 Instance is  ['sunny' 'warm' '?' 'strong' 'warm' 'same']
Generic Boundary after  2 Instance is  [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?',
'?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]



Instance 3 is  ['rainy' 'cold' 'high' 'strong' 'warm' 'change']
Instance is Negative
Specific Bundary after  3 Instance is  ['sunny' 'warm' '?' 'strong' 'warm' 'same']
Generic Boundary after  3 Instance is  [['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?',
'?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]



Instance 4 is  ['sunny' 'warm' 'high' 'strong' 'cool' 'change']
Instance is Positive
Specific Bundary after  4 Instance is  ['sunny' 'warm' '?' 'strong' '?' '?']
Generic Boundary after  4 Instance is  [['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?',
'?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]


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

In [ ]:

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.

In [1]:
```
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()
```

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

In [4]:
```
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")
```

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 [10]:
```
from sklearn.tree import DecisionTreeClassifier
clf = DecisionTreeClassifier(random_state = 42, criterion="entropy")
```

In [11]:
```
clf.fit(X_train, y_train)
```

Out[11]:
```
DecisionTreeClassifier(criterion='entropy', random_state=42)
```

In [12]:
```
test_pred = clf.predict(test_x)
```

In [13]:
```
from sklearn import metrics

import seaborn as sns

import matplotlib.pyplot as plt

confusion_matrix = metrics.confusion_matrix(test_lab,test_pred)
```

In [14]:
```
confusion_matrix
```

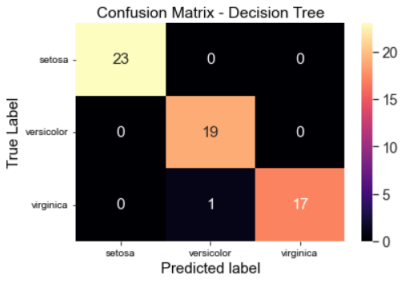
Out[14]:
```
array([[23,  0,  0],
       [ 0, 19,  0],
       [ 0,  1, 17]], dtype=int64)
```

In [15]:
```
matrix_df = pd.DataFrame(confusion_matrix)
```

In [14]:
```
confusion_matrix
```

Out[14]:
```
array([[23,  0,  0],
       [ 0, 19,  0],
       [ 0,  1, 17]], dtype=int64)
```

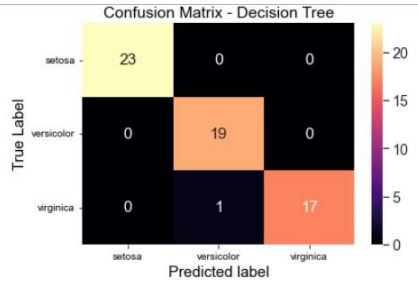
In [15]:
```
matrix_df = pd.DataFrame(confusion_matrix)
ax = plt.axes()
sns.set(font_scale=1.3)
plt.figure(figsize=(10,7))
sns.heatmap(matrix_df, annot=True, fmt="g", ax=ax, cmap="magma")
ax.set_title('Confusion Matrix - Decision Tree')
ax.set_xlabel("Predicted label", fontsize =15)
ax.set_xticklabels(['']+labels)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




```
<Figure size 720x504 with 0 Axes>
```

In [16]:
```
clf.score(test_x,test_lab)
```

Out[16]:
```
0.9833333333333333
```

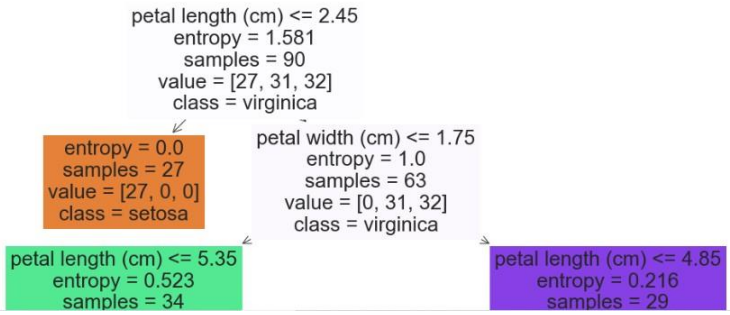


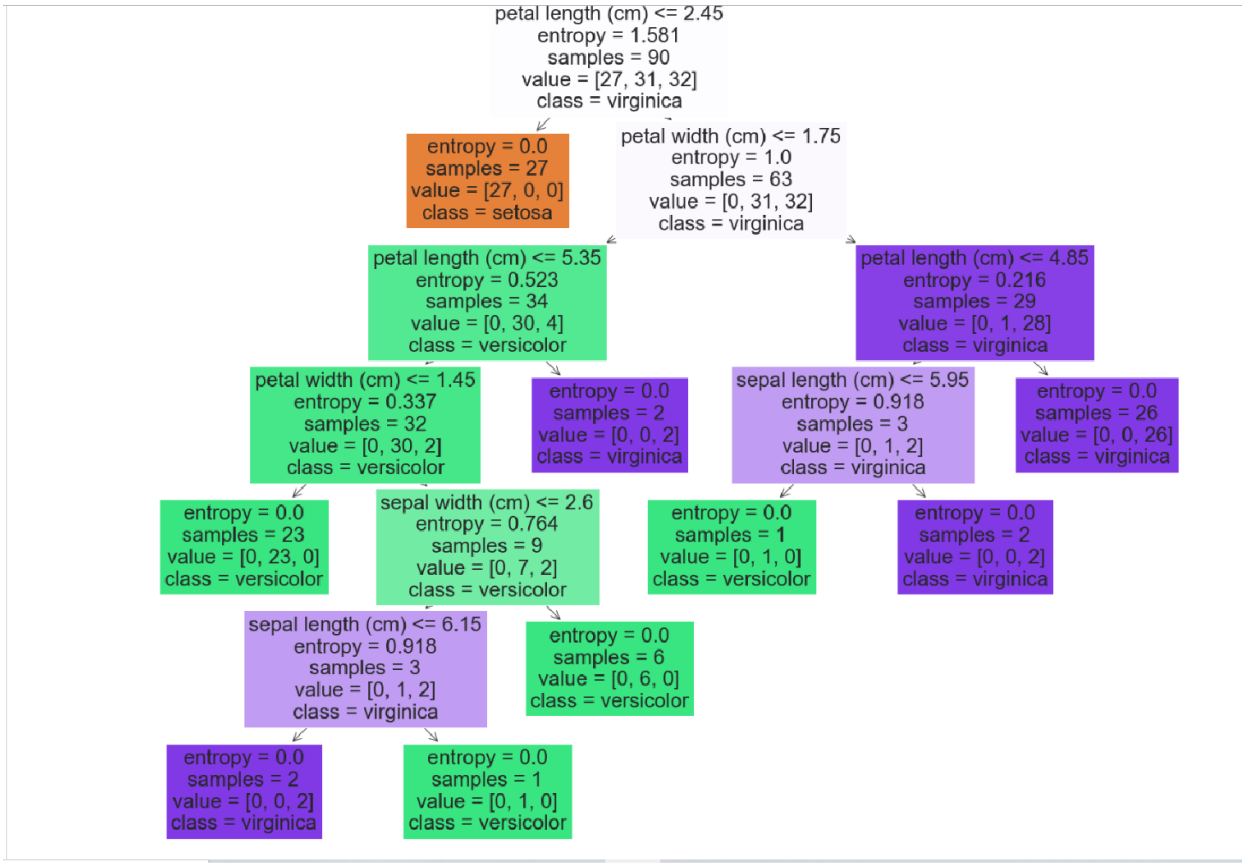

```
<Figure size 720x504 with 0 Axes>
```

In [16]:
```
clf.score(test_x,test_lab)
```

Out[16]:
```
0.9833333333333333
```

In [17]:
```
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)
```





In [1]:
```
import pandas as pd
import math
import numpy as np
```

In [2]:
```
data = pd.read_csv("dataset.csv")
features = [feat for feat in data]
features.remove("answer")
```

In [7]:
```
features
```

Out[7]:
```
['outlook', 'temperature', 'humidity', 'wind']
```

In [4]:
```
data
```

Out[4]:

	outlook	temperature	humidity	wind	answer
0	sunny	hot	high	weak	no
1	sunny	hot	high	strong	no
2	overcast	hot	high	weak	yes
3	rain	mild	high	weak	yes
4	rain	cool	normal	weak	yes
5	rain	cool	normal	strong	no
6	overcast	cool	normal	strong	yes
7	sunny	mild	high	weak	no
8	sunny	cool	normal	weak	yes
9	rain	mild	normal	weak	yes
10	sunny	mild	normal	strong	yes
11	overcast	mild	high	strong	yes
12	overcast	hot	normal	weak	yes

11	overcast	mild	high	strong	yes
12	overcast	hot	normal	weak	yes
13	rain	mild	high	strong	no

In [3]:
```
class Node:
    def __init__(self):
        self.children = []
        self.value = ""
        self.isLeaf = False
        self.pred = ""
```

In [5]:
```
def entropy(examples):
    pos = 0.0
    neg = 0.0
    for _, row in examples.iterrows():
        if row["answer"] == "yes":
            pos += 1
        else:
            neg += 1
    if pos == 0.0 or neg == 0.0:
        return 0.0
    else:
        p = pos / (pos + neg)
        n = neg / (pos + neg)
        return -(p * math.log(p, 2) + n * math.log(n, 2))
```

In [6]:
```
def info_gain(examples, attr):
    uniq = np.unique(examples[attr])
    #print ("\n",uniq)
    gain = entropy(examples)
    #print ("\n",gain)
    for u in uniq:
        subdata = examples[examples[attr] == u]
        #print ("\n",subdata)
        sub_e = entropy(subdata)
        gain -= (float(len(subdata)) / float(len(examples))) * sub_e
        #print ("\n",gain)
    return gain
```

In [8]:
```
def ID3(examples, attrs):
```

In [8]:
```
def ID3(examples, attrs):
    root = Node()

    max_gain = 0
    max_feat = ""
    for feature in attrs:
        #print ("\n",examples)
        gain = info_gain(examples, feature)
        if gain > max_gain:
            max_gain = gain
            max_feat = feature
    root.value = max_feat
    #print ("\nMax feature attr",max_feat)
    uniq = np.unique(examples[max_feat])
    #print ("\n",uniq)
    for u in uniq:
        #print ("\n",u)
        subdata = examples[examples[max_feat] == u]
        #print ("\n",subdata)
        if entropy(subdata) == 0.0:
            newNode = Node()
            newNode.isLeaf = True
            newNode.value = u
            newNode.pred = np.unique(subdata["answer"])
            root.children.append(newNode)
        else:
            dummyNode = Node()
            dummyNode.value = u
            new_attrs = attrs.copy()
            new_attrs.remove(max_feat)
            child = ID3(subdata, new_attrs)
            dummyNode.children.append(child)
            root.children.append(dummyNode)
    return root
```

In [9]:
```
def printTree(root: Node, depth=0):
    for i in range(depth):
        print("\t", end="")
    print(root.value, end="")
    if root.isLeaf:
        print(" -> ", root.pred)
    print()
```

```
            new_attrs = attrs.copy()
            new_attrs.remove(max_feat)
            child = ID3(subdata, new_attrs)
            dummyNode.children.append(child)
            root.children.append(dummyNode)
    return root
```

In [9]:

```
def printTree(root: Node, depth=0):
    for i in range(depth):
        print("\t", end="")
    print(root.value, end="")
    if root.isLeaf:
        print(" -> ", root.pred)
    print()
    for child in root.children:
        printTree(child, depth + 1)
```

In [10]:

```
root = ID3(data, features)
printTree(root)
```

```
outlook
        overcast ->  ['yes']

        rain
                wind
                        strong ->  ['no']

                        weak ->  ['yes']

        sunny
                humidity
                        high ->  ['no']

                        normal ->  ['yes']
```

In [ ]:

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.

In [1]:
```
import numpy as np
import pandas as pd
```

In [2]:
```
data = pd.read_csv('/content/dataset.csv')
data.head()
```

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

In [3]:
```
y = list(data['PlayTennis'].values)
X = data.iloc[:,1:].values
print(f'Target Values: {y}')
print(f'Features: \n{X}')
```

```
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']]
```

In [4]:
```
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)}")
```

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

In [5]:
```
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
```

```
        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
```

In [6]:

```
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)
```

```
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
```

In [18]:

```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB
from sklearn import metrics

df = pd.read_csv("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
xtrain,xtest,ytrain,ytest=train_test_split(X,y,test_size=0.33)
```

In [19]:

```
df.head()
```

Out[19]:

	num_preg	glucose_conc	diastolic_bp	thickness	insulin	bmi	diab_pred	age	diabetes
0	6	148	72	35	0	33.6	0.627	50	1
1	1	85	66	29	0	26.6	0.351	31	0
2	8	183	64	0	0	23.3	0.672	32	1
3	1	89	66	23	94	28.1	0.167	21	0
4	0	137	40	35	168	43.1	2.288	33	1

In [29]:

```
clf = GaussianNB().fit(xtrain,ytrain.ravel())
predicted = clf.predict(xtest)
predictTestData= clf.predict([[6,148,72,35,0,33.6,0.627,50]])
```

In [30]:

```
metrics.confusion_matrix(ytest,predicted)
```

Out[30]:

```
array([[139,  26],
       [ 33,  56]], dtype=int64)
```

In [28]:

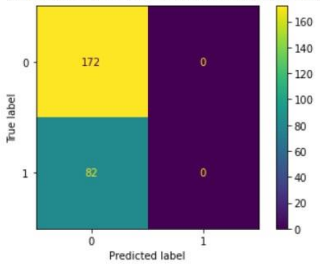
```
print('\nConfusion matrix')
print(metrics.plot_confusion_matrix(clf,ytest,predicted))
```

In [30]:
```
metrics.confusion_matrix(ytest,predicted)
```

Out[30]:
```
array([[139,  26],
       [ 33,  56]], dtype=int64)
```

In [28]:
```
print('\nConfusion matrix')
print(metrics.plot_confusion_matrix(clf,ytest,predicted))
```

```
Confusion matrix
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay object at 0x00000190E55B3670>
```



In [31]:
```
print(metrics.classification_report(ytest,predicted))
```

```
              precision    recall  f1-score   support

           0       0.81      0.84      0.82       165
           1       0.68      0.63      0.65        89

    accuracy                           0.77       254
   macro avg       0.75      0.74      0.74       254
weighted avg       0.76      0.77      0.77       254
```

In [8]:
```
print("Predicted Value for individual Test Data:", predictTestData)
```

```
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.

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
```

In [2]:
```
dataset = pd.read_csv('salary_dataset.csv')
X = dataset.iloc[:, :-1].values
y = dataset.iloc[:, 1].values
```

In [3]:
```
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)
```

In [4]:
```
# Fitting Simple Linear Regression to the Training set
from sklearn.linear_model import LinearRegression
regressor = LinearRegression()
regressor.fit(X_train, y_train)
```

Out[4]:
```
LinearRegression()
```

In [5]:
```
# Predicting the Test set results
y_pred = regressor.predict(X_test)
```

In [6]:
```
# 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()
```

In [7]:
```
# 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()
```

In [ ]:

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

```
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
```

```
/usr/local/lib/python3.7/dist-packages/statsmodels/tools/_testing.py:19: FutureWarni
  import pandas.util.testing as tm
```

```
trainingData = pd.read_csv('/content/bayesian-dataset.csv')
trainingData = trainingData.replace('?',np.nan)
print('The sample instances from the dataset are:')
print(trainingData.head())
print('\n Attributes and datatypes: ')
print(trainingData.dtypes)
```

```
The sample instances from the dataset are:
   age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  oldpeak  slope  \
0   63    1   1       145   233    1        2      150      0      2.3      3
1   67    1   4       160   286    0        2      108      1      1.5      2
2   67    1   4       120   229    0        2      129      1      2.6      2
3   37    1   3       130   250    0        0      187      0      3.5      3
4   41    0   2       130   204    0        2      172      0      1.4      1

  ca thal  heartdisease
0  0    6             0
1  3    3             2
2  2    7             1
3  0    3             0
4  0    3             0

 Attributes and datatypes:
age               int64
sex               int64
cp                int64
trestbps          int64
chol              int64
fbs               int64
restecg           int64
thalach           int64
exang             int64
oldpeak         float64
slope             int64
ca               object
thal             object
heartdisease      int64
dtype: object
```

```
model = BayesianModel([('age','heartdisease'),('sex','heartdisease'),('exang','heartdiseas
print('\n Learning CPD using Maximum likelihood estimators')
model.fit(trainingData,estimator=MaximumLikelihoodEstimator)
print('\n Inferencing with Bayesian Network:')
HeartDiseasetest_infer = VariableElimination(model)
```

```
/usr/local/lib/python3.7/dist-packages/pgmpy/models/BayesianModel.py:10: FutureWarni
  FutureWarning,

 Learning CPD using Maximum likelihood estimators

 Inferencing with Bayesian Network:
```

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

```
 1.Probability of HeartDisease given evidence = restecg (Rest ECG): 1
Finding Elimination Order: :                                    4/4 [00:00<00:00,
100%                                                            8.00it/s]
Eliminating: age: 100%                                  4/4 [00:00<00:00, 4.88it/s]
+-----------------+---------------------+
| heartdisease    |   phi(heartdisease) |
+=================+=====================+
| heartdisease(0) |              0.1012 |
+-----------------+---------------------+
| heartdisease(1) |              0.0000 |
+-----------------+---------------------+
| heartdisease(2) |              0.2392 |
+-----------------+---------------------+
| heartdisease(3) |              0.2015 |
+-----------------+---------------------+
| heartdisease(4) |              0.4581 |
```

```
print('\n 2.Probability of HeartDisease given evidence = chol (Cholestorol): 100 ')
q2 = HeartDiseasetest_infer.query(variables = ['heartdisease'], evidence={'chol':100})
print(q2)
```

```
 2.Probability of HeartDisease given evidence = chol (Cholestorol): 100
/usr/local/lib/python3.7/dist-packages/pgmpy/factors/discrete/DiscreteFactor.py:537:
  UserWarning,
Finding Elimination Order: :                                    4/4 [00:00<00:00,
100%                                                            7.39it/s]
Eliminating: age: 100%                                          4/4 [00:00<00:00, 3.70it/s]
+-----------------+---------------------+
| heartdisease    |   phi(heartdisease) |
+=================+=====================+
| heartdisease(0) |              1.0000 |
+-----------------+---------------------+
| heartdisease(1) |              0.0000 |
+-----------------+---------------------+
| heartdisease(2) |              0.0000 |
+-----------------+---------------------+
| heartdisease(3) |              0.0000 |
+-----------------+---------------------+
```


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

K-Means Clustering

```
import pandas as pd
from sklearn.cluster import KMeans
from sklearn.preprocessing import MinMaxScaler
from matplotlib import pyplot as plt
%matplotlib inline
```

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.r
```

```
df = pd.read_csv('/content/drive/MyDrive/income.csv')
df.head(10)
```

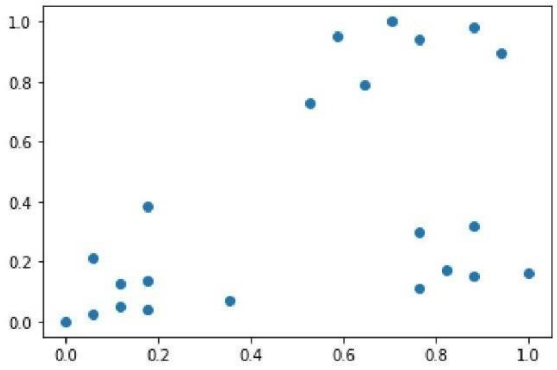
	Name	Age	Income($)
0	Rob	27	70000
1	Michael	29	90000
2	Mohan	29	61000
3	Ismail	28	60000
4	Kory	42	150000
5	Gautam	39	155000
6	David	41	160000
7	Andrea	38	162000
8	Brad	36	156000
9	Angelina	35	130000

```
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)
```

	Name	Age	Income($)
0	Rob	0.058824	0.213675
1	Michael	0.176471	0.384615
2	Mohan	0.176471	0.136752
3	Ismail	0.117647	0.128205
4	Kory	0.941176	0.897436
5	Gautam	0.764706	0.940171
6	David	0.882353	0.982906
7	Andrea	0.705882	1.000000

```
plt.scatter(df['Age'], df['Income($)'])
```

```
<matplotlib.collections.PathCollection at 0x7f7ab3a18bd0>
```



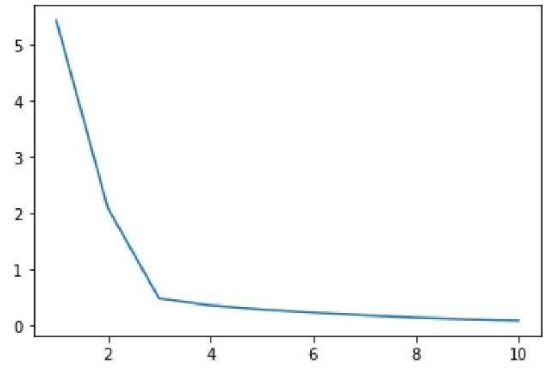
Finding Elbow Point

```
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_)
sse
```

```
[5.434011511988178,
 2.091136388699078,
 0.4750783498553096,
 0.3491047094419566,
 0.27768187154369994,
 0.22020960864009398,
 0.1735559655531264,
 0.1327661931978319,
 0.10188787724979426,
 0.08026197041664467]
```

```
plt.xlabel = 'Number of Clusters'
plt.ylabel = 'Sum of Squared Errors'
plt.plot(k_range, sse)
```

```
[<matplotlib.lines.Line2D at 0x7f7ab3a189d0>]
```



Therefore, the elbow point is 3

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

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

```
y_predict = km.fit_predict(df[['Age', 'Income($)']])
y_predict
```

```
array([1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2],
      dtype=int32)
```

```
df['cluster'] = y_predict
df.head()
```

	Name	Age	Income($)	cluster
0	Rob	0.058824	0.213675	1
1	Michael	0.176471	0.384615	1
2	Mohan	0.176471	0.136752	1
3	Ismail	0.117647	0.128205	1
4	Kory	0.941176	0.897436	0

```
df0 = df[df.cluster == 0]
df0
```

	Name	Age	Income($)	cluster
4	Kory	0.941176	0.897436	0
5	Gautam	0.764706	0.940171	0
6	David	0.882353	0.982906	0
7	Andrea	0.705882	1.000000	0
8	Brad	0.588235	0.948718	0
9	Angelina	0.529412	0.726496	0

```
df1 = df[df.cluster == 1]
df1
```

	Name	Age	Income($)	cluster
0	Rob	0.058824	0.213675	1
1	Michael	0.176471	0.384615	1
2	Mohan	0.176471	0.136752	1
3	Ismail	0.117647	0.128205	1
11	Tom	0.000000	0.000000	1
12	Arnold	0.058824	0.025641	1
13	Jared	0.117647	0.051282	1
14	Stark	0.176471	0.038462	1
15	Ranbir	0.352941	0.068376	1

```
df2 = df[df.cluster == 2]
df2
```

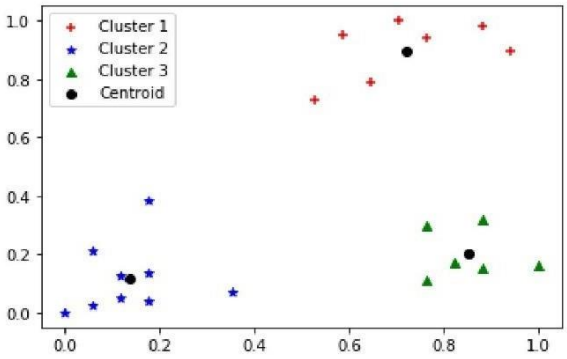
	Name	Age	Income($)	cluster
16	Dipika	0.823529	0.170940	2
17	Priyanka	0.882353	0.153846	2
18	Nick	1.000000	0.162393	2
19	Alia	0.764706	0.299145	2
20	Sid	0.882353	0.316239	2
21	Abdul	0.764706	0.111111	2

```
km.cluster_centers_
```

```
array([[0.72268908, 0.8974359 ],
       [0.1372549 , 0.11633428],
       [0.85294118, 0.2022792 ]])
```

```
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.legend((p1, p2, p3, c),
           ('Cluster 1', 'Cluster 2', 'Cluster 3', 'Centroid'))
```

```
<matplotlib.legend.Legend at 0x7f7aad7cf610>
```



(hardcoded)

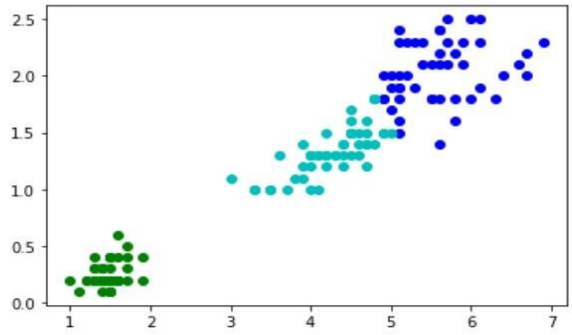
```
import math;
import sys;
import pandas as pd
import numpy as np
from random import choice
from matplotlib import pyplot
from random import shuffle, uniform;



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):
```

```
    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()
```

```
[[6.3, 1.8], [5.1, 1.9], [1.9, 0.4], [1.6, 0.4], [4.9, 1.8], [1.7, 0.4], [4.2, 1.2],

Means =  [[5.583, 2.032], [1.462, 0.257], [4.258, 1.341]]
```



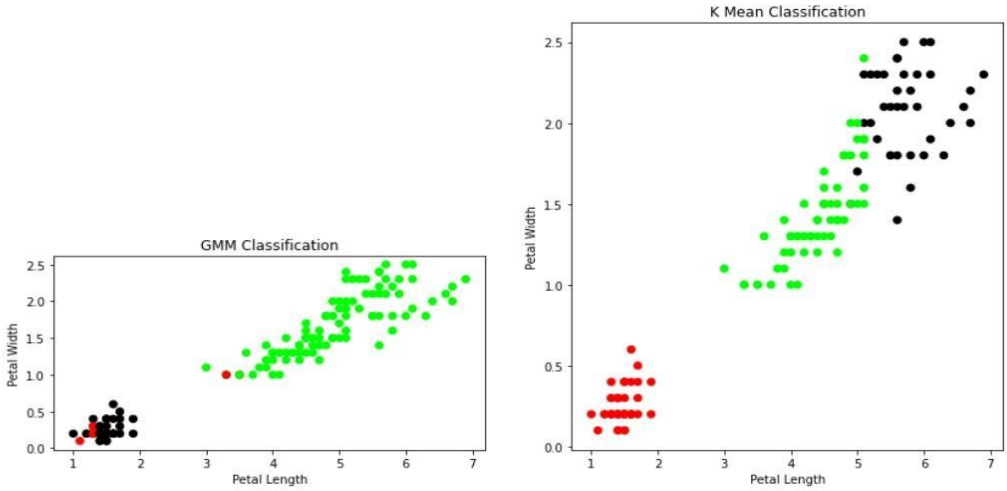

```
1
```


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))
```

```
The accuracy score of K-Mean:  0.8933333333333333
The Confusion matrixof K-Mean:  [[50  0  0]
 [ 0 48  2]
 [ 0 14 36]]
The accuracy score of EM:  0.35333333333333333
The Confusion matrix of EM:  [[ 5  0 45]
 [ 2 48  0]
 [ 0 50  0]]
```



9. Write a program to implement k-Nearest Neighbour algorithm to classify the iris dataset. 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))
```

```
Confusion Matrix
[[13  0  0]
 [ 0 13  2]
 [ 0  1 16]]
Accuracy Metrics
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        13
           1       0.93      0.87      0.90        15
           2       0.89      0.94      0.91        17

    accuracy                           0.93        45
   macro avg       0.94      0.94      0.94        45
weighted avg       0.93      0.93      0.93        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.

(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)]]))
```

```
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 :
```

```
[-3.12282223 -2.9216174  -3.14051918 -3.09805236 -3.08215798 -2.88090494
-3.05412007 -3.12734019 -2.98129254]
Xo Domain Space(10 Samples) :
[-2.97993311 -2.95986622 -2.93979933 -2.91973244 -2.89966555 -2.87959866
-2.85953177 -2.83946488 -2.81939799]
```


(hardcoded)

```
from numpy import *
from os import listdir
import matplotlib
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np1
import numpy.linalg as np
from scipy.stats.stats import pearsonr


def kernel(point,xmat, k):
 m,n = np1.shape(xmat)
 weights = np1.mat(np1.eye((m)))
 for j in range(m):
    diff = point - X[j]
    weights[j,j] = np1.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 = np1.shape(xmat)
 ypred = np1.zeros(m)
 for i in range(m):
    ypred[i] = xmat[i]*localWeight(xmat[i],xmat,ymat,k)
 return ypred


# load data points
data = pd.read_csv('/content/tips.csv')
bill = np1.array(data.total_bill)
tip = np1.array(data.tip)


#preparing and add 1 in bill
mbill = np1.mat(bill)
mtip = np1.mat(tip) # mat is used to convert to n dimesiona to 2 dimensional array form
m= np1.shape(mbill)[1]
# print(m) 244 data is stored in m
one = np1.mat(np1.ones(m))
X= np1.hstack((one.T,mbill.T)) # create a stack of bill from ONE
#print(X)
#set k here
ypred = localWeightRegression(X,mtip,2)
SortIndex = X[:,1].argsort(0)
xsort = X[SortIndex][:,0]


fig = plt.figure()
ax = fig.add_subplot(1,1,1)
```

```
ax.scatter(bill,tip, color='blue')
ax.plot(xsort[:,1],ypred[SortIndex], color = 'red', linewidth=5)
plt.xlabel('Total bill')
plt.ylabel('Tip')
plt.show()
```