VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

Machine Learning
(20CS6PCMAL)

Submitted by

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(1BM19CS072)

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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B. M. S. College of Engineering,

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(Affiliated To Visvesvaraya Technological University, Belgaum)

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "**MACHINE LEARNING**" carried out by **KHUSHIL M SINDHWAD (1BM19CS072),** 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

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. Find S Algorithm

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]:
```
from google.colab import drive
drive.mount("/content/drive")
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=Tru
e).
```

In [3]:
```
data = pd.read_csv("/content/drive/MyDrive/finddata.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 [4]:
```
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 [5]:
```
def findS(c,t):
    for i, val in enumerate(t):
        if val == "Yes":
            specific_hypothesis = c[i].copy()
            break
```


```
 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 [5]:
```
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
```

In [6]:
```
print("\n The final hypothesis is:",findS(d,target))
```

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

2. Candidate Elimination Algorithm

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 [14]:
```
import numpy as np
import pandas as pd

#to read the data in the csv file
data = pd.DataFrame(data=pd.read_csv('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("Initialization of specific hypothesis and general hypothesis:")
    print("S0: ",specific_h)
    general_h = [["?" for i in range(len(specific_h))] for i in range(len(specific_h))]
    print("G0: ",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] = "?"
        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("The steps of Candidate Elimination Algorithm ", i+1)
        print(f"S{i+1}: " ,specific_h)
        actual_general_h= [i for i in general_h if i != ["?" for i in range(len(specific_h))]]
        print(f"G{i+1}: ",actual_general_h)
        print(general_h)
    actual_general_h= [i for i in general_h if i != ["?" for i in range(len(specific_h))]]
```

```
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']
```

In [15]:
```
s_final, g_final = learn(concepts, target)
print("The final Specific hypothesis is: ", s_final, sep="\n")
print("The final General Hypothesis is: ", g_final, sep="\n")
```

```
Initialization of specific hypothesis and general hypothesis:
S0:  ['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
G0:  [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?',
'?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
The steps of Candidate Elimination Algorithm  1
S1:  ['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
G1:  []
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?',
'?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
The steps of Candidate Elimination Algorithm  2
S2:  ['sunny' 'warm' '?' 'strong' 'warm' 'same']
G2:  []
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?',
'?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
The steps of Candidate Elimination Algorithm  3
S3:  ['sunny' 'warm' '?' 'strong' 'warm' 'same']
G3:  [['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?',
'?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]
The steps of Candidate Elimination Algorithm  4
S4:  ['sunny' 'warm' '?' 'strong' '?' '?']
G4:  [['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']]
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?',
'?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
The final Specific hypothesis is:
['sunny' 'warm' '?' 'strong' '?' '?']
The final General Hypothesis is:
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']]
```

3. ID3 Algorithm

Write a program to demonstrate the working of the decision tree based ID3algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.

```
In [32]: import pandas as pd
         import numpy as np
         from sklearn.datasets import load_iris
         data = load_iris()

In [33]: df = pd.DataFrame(data.data, columns = data.feature_names)

In [34]: df
```

Out[34]:

	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
...	...	...	...	...
145	6.7	3.0	5.2	2.3
146	6.3	2.5	5.0	1.9
147	6.5	3.0	5.2	2.0
148	6.2	3.4	5.4	2.3
149	5.9	3.0	5.1	1.8

150 rows × 4 columns

```
In [20]: df['Species'] = data.target
         #replace this with the actual names
         target = np.unique(data.target)
         print(target)
         target_names = np.unique(data.target_names)
         print(target_names)
         targets = dict(zip(target, target_names))
         print(targets)
         df['Species'] = df['Species'].replace(targets)

         [0 1 2]
         ['setosa' 'versicolor' 'virginica']
         {0: 'setosa', 1: 'versicolor', 2: 'virginica'}

In [21]: x = df.drop(columns="Species")
         y = df["Species"]

In [22]: feature_names = x.columns
         labels = y.unique()

In [36]: 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)
         # print(x_train)
         # print(test_x)
         # print(y_train)
         # print(test_lab)
```

In [24]:
```
from sklearn.tree import DecisionTreeClassifier
clf = DecisionTreeClassifier(max_depth =3, random_state = 42,criterion='entropy')
```

In [25]:
```
clf.fit(x_train, y_train)
```

Out[25]:
```
DecisionTreeClassifier(criterion='entropy', max_depth=3, random_state=42)
```

In [35]:
```
test_pred = clf.predict(test_x)
test_pred
```

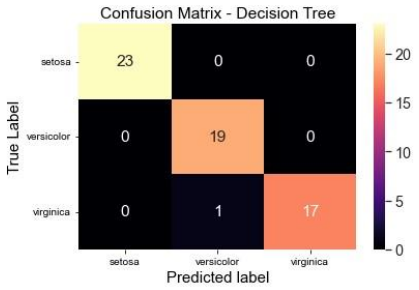
Out[35]:
```
array(['versicolor', 'setosa', 'virginica', 'versicolor', 'versicolor',
       'setosa', 'versicolor', 'virginica', 'versicolor', 'versicolor',
       'virginica', 'setosa', 'setosa', 'setosa', 'setosa', 'versicolor',
       'virginica', 'versicolor', 'versicolor', 'virginica', 'setosa',
       'virginica', 'setosa', 'virginica', 'virginica', 'virginica',
       'virginica', 'virginica', 'setosa', 'setosa', 'setosa', 'setosa',
       'versicolor', 'setosa', 'setosa', 'virginica', 'versicolor',
       'setosa', 'setosa', 'setosa', 'virginica', 'versicolor',
       'versicolor', 'setosa', 'setosa', 'versicolor', 'versicolor',
       'virginica', 'versicolor', 'virginica', 'versicolor', 'virginica',
       'versicolor', 'setosa', 'virginica', 'versicolor', 'setosa',
       'setosa', 'setosa', 'versicolor'], dtype=object)
```

In [27]:
```
from sklearn import metrics

import seaborn as sns

import matplotlib.pyplot as plt

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

In [28]:
```
confusion_matrix
```

Out[28]:
```
array([[23,  0,  0],
       [ 0, 19,  0],
       [ 0,  1, 17]], dtype=int64)
```

In [29]:
```
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()
```



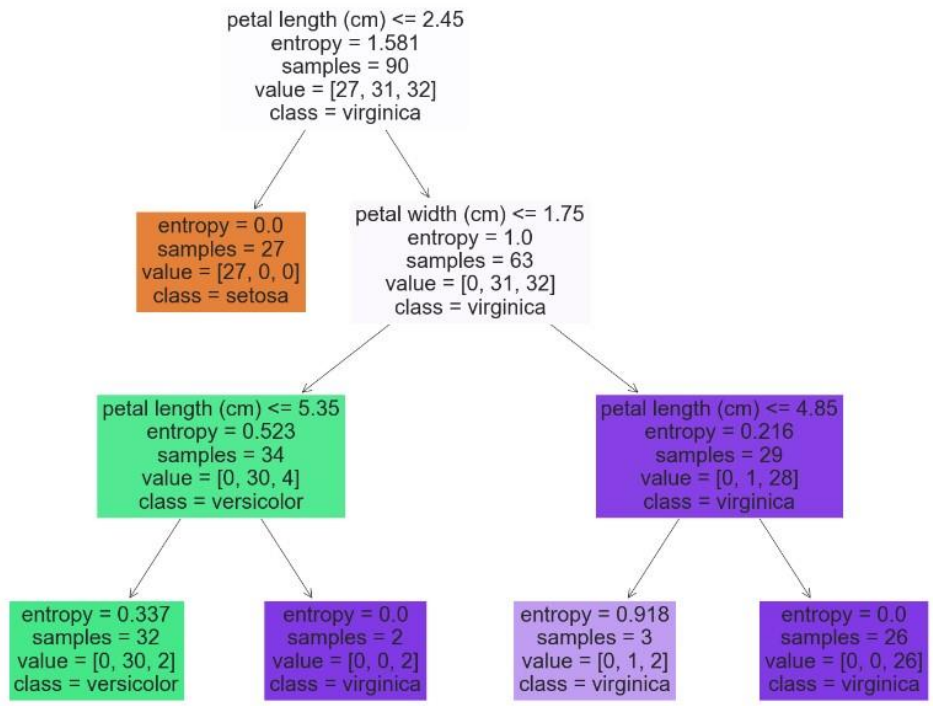

```
<Figure size 720x504 with 0 Axes>
```

In [30]:
```
clf.score(test_x,test_lab)
```

Out[30]:
```
0.9833333333333333
```

In [31]:
```
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 [31]:
```
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 [ ]:

4. Naïve Bayes

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 [10]:
```
import pandas as pd
data = pd.read_csv('PlayTennis.csv')
data
```

Out[10]:

	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
5	No	Rain	Cool	Normal	Strong
6	Yes	Overcast	Cool	Normal	Strong
7	No	Sunny	Mild	High	Weak
8	Yes	Sunny	Cool	Normal	Weak
9	Yes	Rain	Mild	Normal	Weak
10	Yes	Sunny	Mild	Normal	Strong
11	Yes	Overcast	Mild	High	Strong
12	Yes	Overcast	Hot	Normal	Weak
13	No	Rain	Mild	High	Strong

In [11]:
```
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' 'Normal' 'Weak']
['Sunny' 'Mild' 'Normal' 'Strong']
['Overcast' 'Mild' 'High' 'Strong']
['Overcast' 'Hot' 'Normal' 'Weak']
['Rain' 'Mild' 'High' 'Strong']]
```

In [12]:
```
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 [17]:
```
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]])
            print(self.attrs)
            print(self.output_dom)
#             print(self.data)
    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
```

In [18]:
```
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)
```

```
[['Sunny'], ['Hot'], ['High'], ['Weak']]
{'No': 1}
[['Sunny'], ['Hot'], ['High'], ['Weak', 'Strong']]
{'No': 2}
[['Sunny', 'Overcast'], ['Hot'], ['High'], ['Weak', 'Strong']]
{'No': 2, 'Yes': 1}
[['Sunny', 'Overcast', 'Rain'], ['Hot', 'Mild'], ['High'], ['Weak', 'Strong']]
{'No': 2, 'Yes': 2}
[['Sunny', 'Overcast', 'Rain'], ['Hot', 'Mild', 'Cool'], ['High', 'Normal'], ['Weak', 'Strong']]
{'No': 2, 'Yes': 3}
[['Sunny', 'Overcast', 'Rain'], ['Hot', 'Mild', 'Cool'], ['High', 'Normal'], ['Weak', 'Strong']]
{'No': 3, 'Yes': 3}
[['Sunny', 'Overcast', 'Rain'], ['Hot', 'Mild', 'Cool'], ['High', 'Normal'], ['Weak', 'Strong']]
{'No': 3, 'Yes': 4}
[['Sunny', 'Overcast', 'Rain'], ['Hot', 'Mild', 'Cool'], ['High', 'Normal'], ['Weak', 'Strong']]
{'No': 4, 'Yes': 4}
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
```

5. Linear Regression

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_data.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)
```

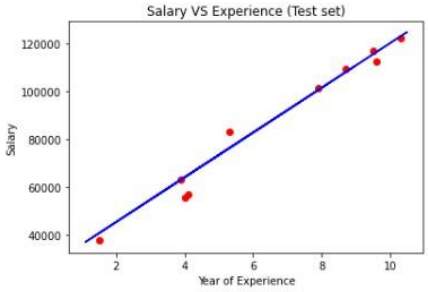
In [4]:
```
# Fitting Simple Linear Regression to the Training set
from sklearn.linear_model import LinearRegression
regressor = LinearRegression()
regressor.fit(X_train, y_train)
```

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)
```

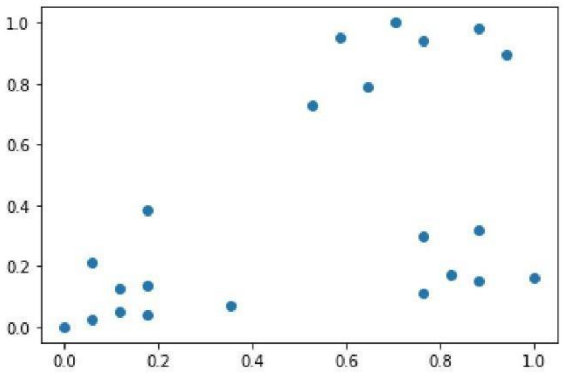
	Name	Age	Income($)
0	Rob	27	70000
1	Michael	29	90000
2	Mohan	29	61000
3	Ismail	28	60000
4	Kory	42	150000
5	Gautam	39	155000
6	David	41	160000
7	Andrea	38	162000
8	Brad	36	156000
9	Angelina	35	130000

```
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>
```



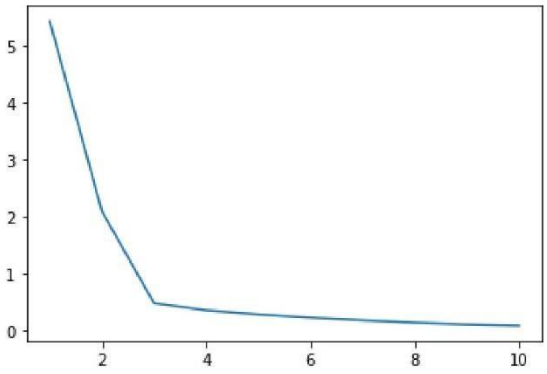
Finding Elbow Point

```
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
```

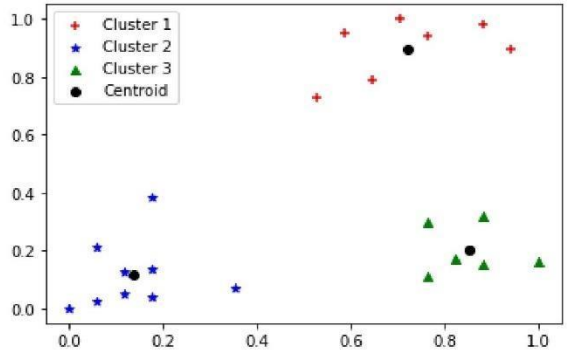
	Name	Age	Income($)	cluster
16	Dipika	0.823529	0.170940	2
17	Priyanka	0.882353	0.153846	2
18	Nick	1.000000	0.162393	2
19	Alia	0.764706	0.299145	2
20	Sid	0.882353	0.316239	2
21	Abdul	0.764706	0.111111	2

```
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)

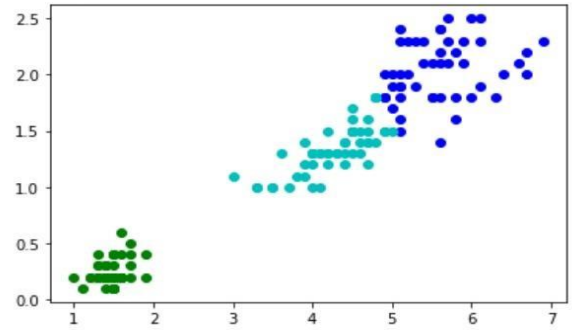
```
import math;
import sys;
import pandas as pd
import numpy as np
from random import choice
from matplotlib import pyplot
from random import shuffle, uniform;



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]]
```



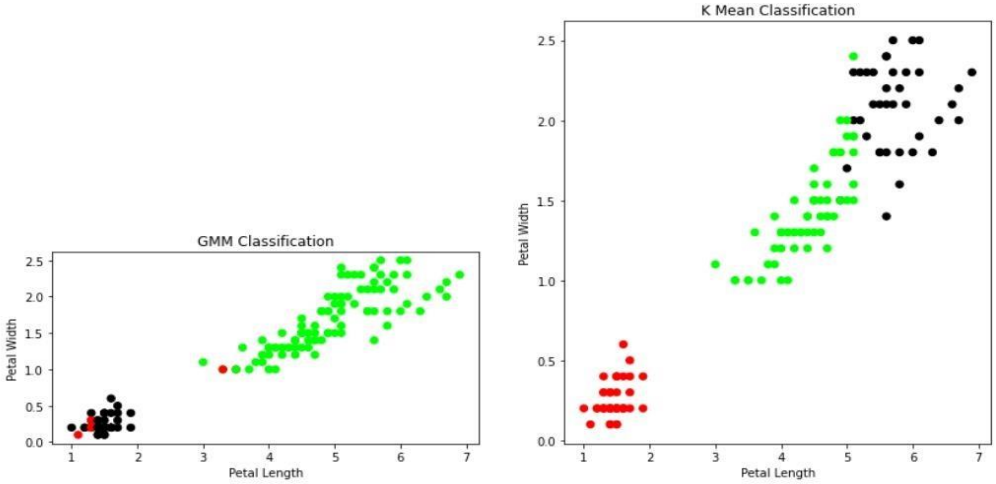

```
1
```

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
```

```
#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.


```
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()
```