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
(Autonomous Institution under VTU)
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B. M. S. College of Engineering,

Bull Temple Road, Bangalore 560019
(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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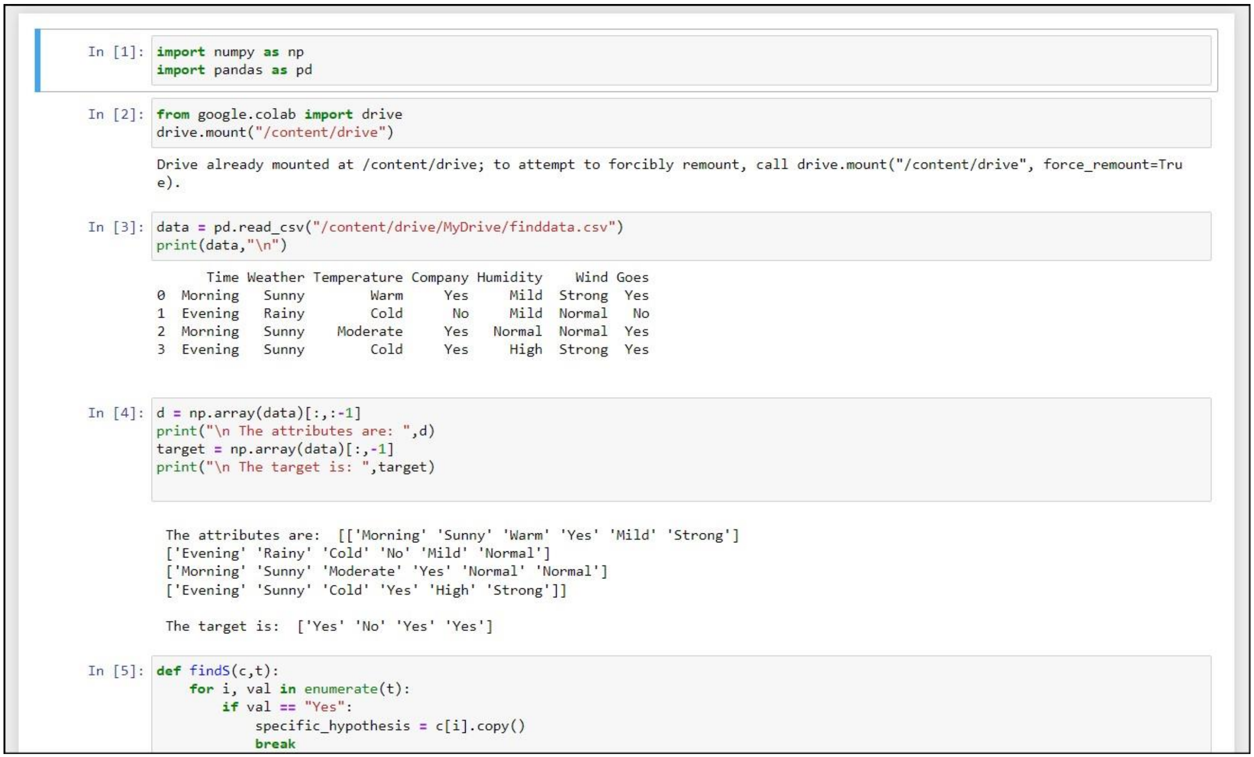
Index Sheet

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).
```

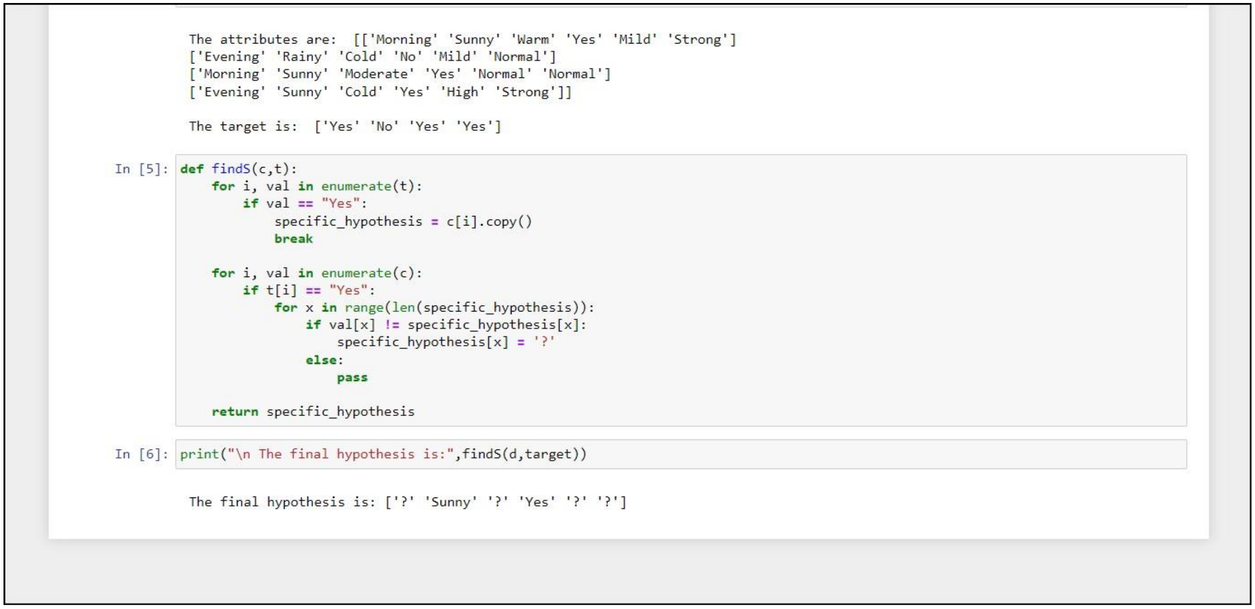
```
In [3]: data = pd.read_csv("/content/drive/MyDrive/finddata.csv")
        print(data,"\n")
```

```
      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']
```

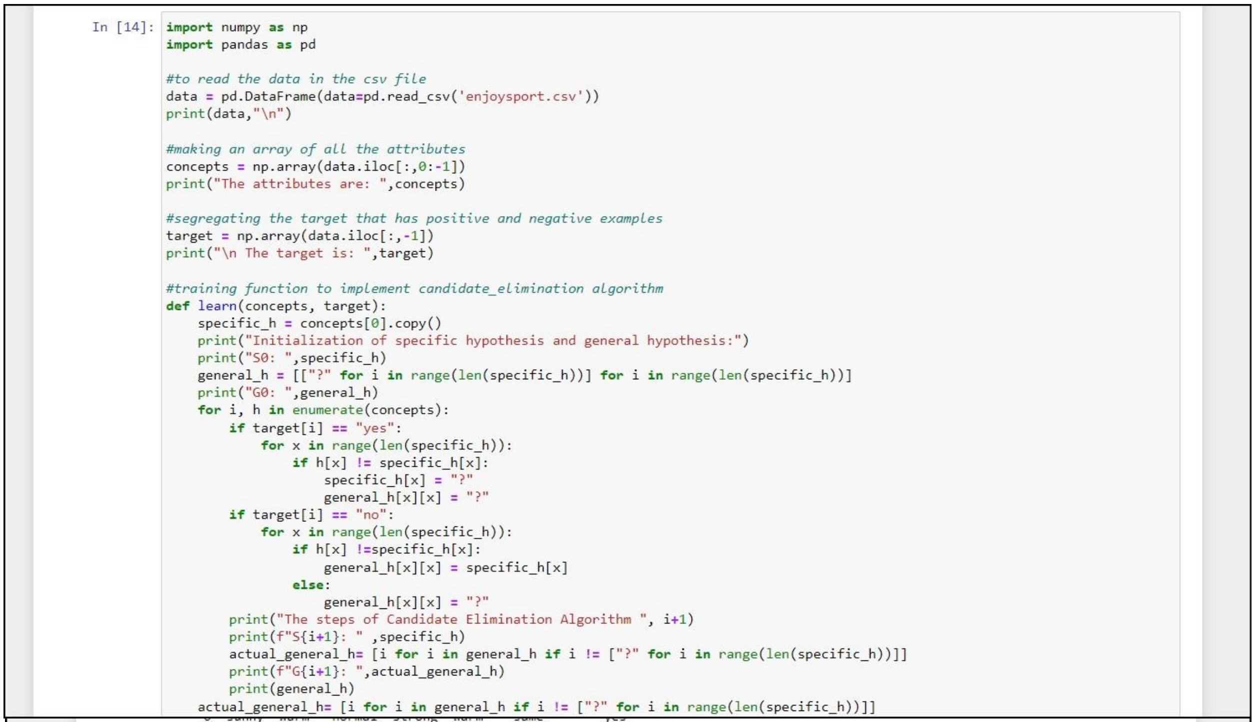
```
In [5]: def findS(c,t):
            for i, val in enumerate(t):
                if val == "Yes":
                    specific_hypothesis = c[i].copy()
                    break

            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))
```

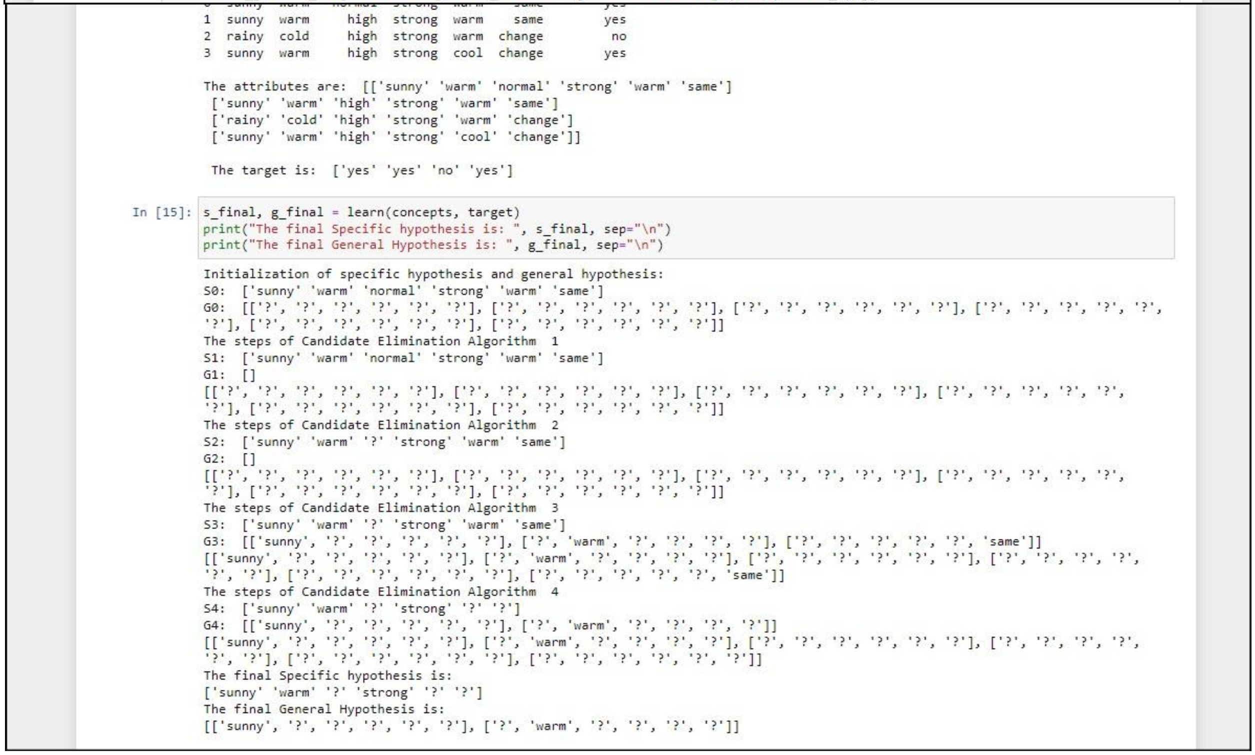
```
 The final hypothesis is: ['?' 'Sunny' '?' 'Yes' '?' '?']
```

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.



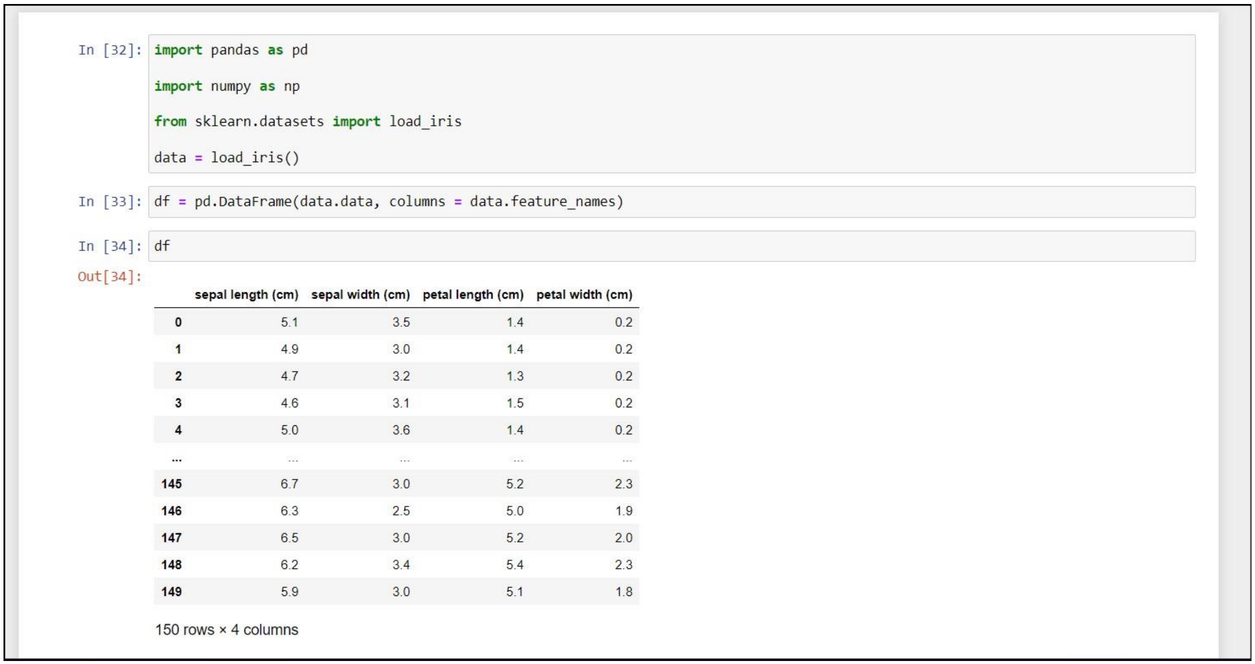
```
In [14]: import numpy as np
         import pandas as pd

         #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

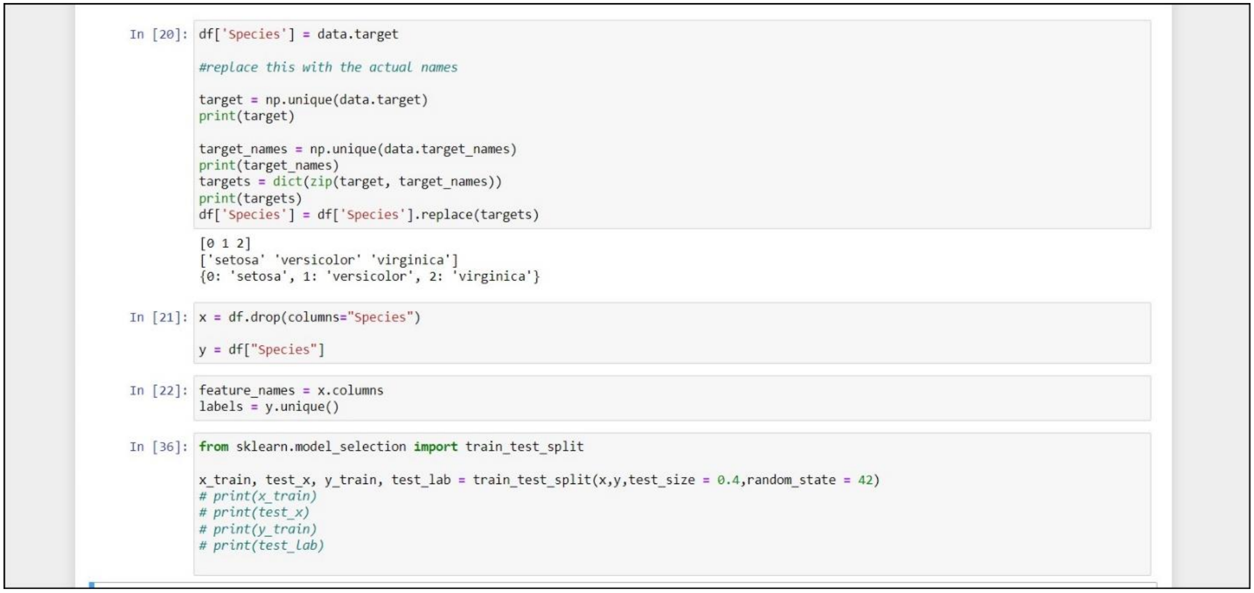
Write a program to demonstrate the working of the decision tree based ID3algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.



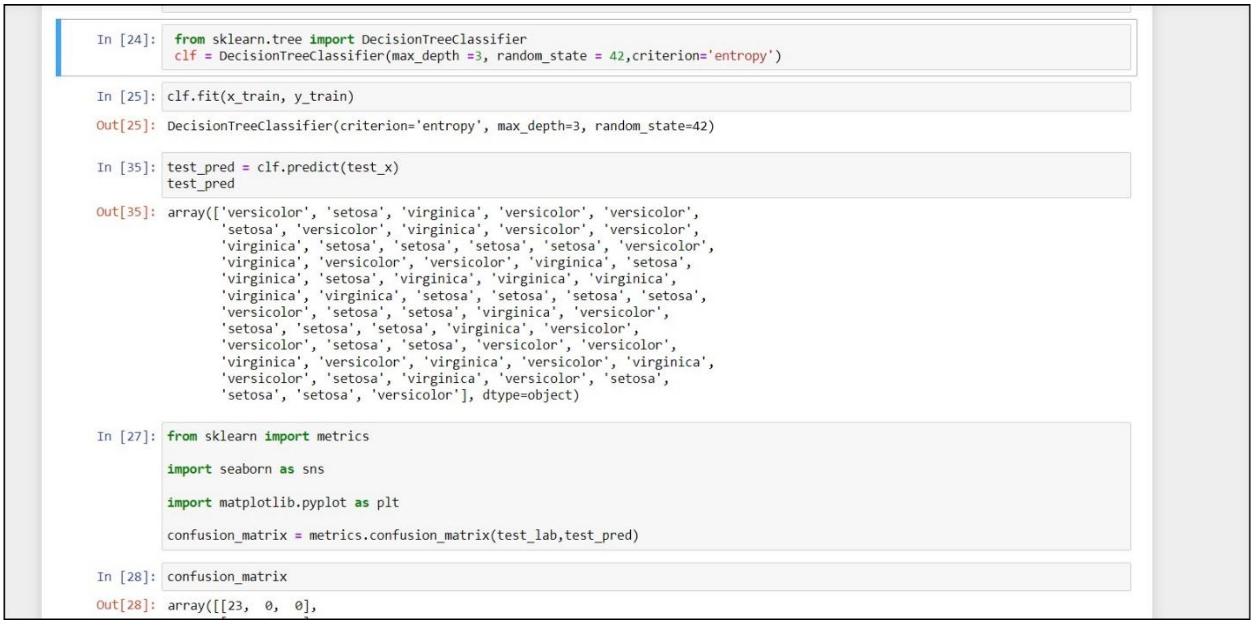
```
In [32]: import pandas as pd

         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

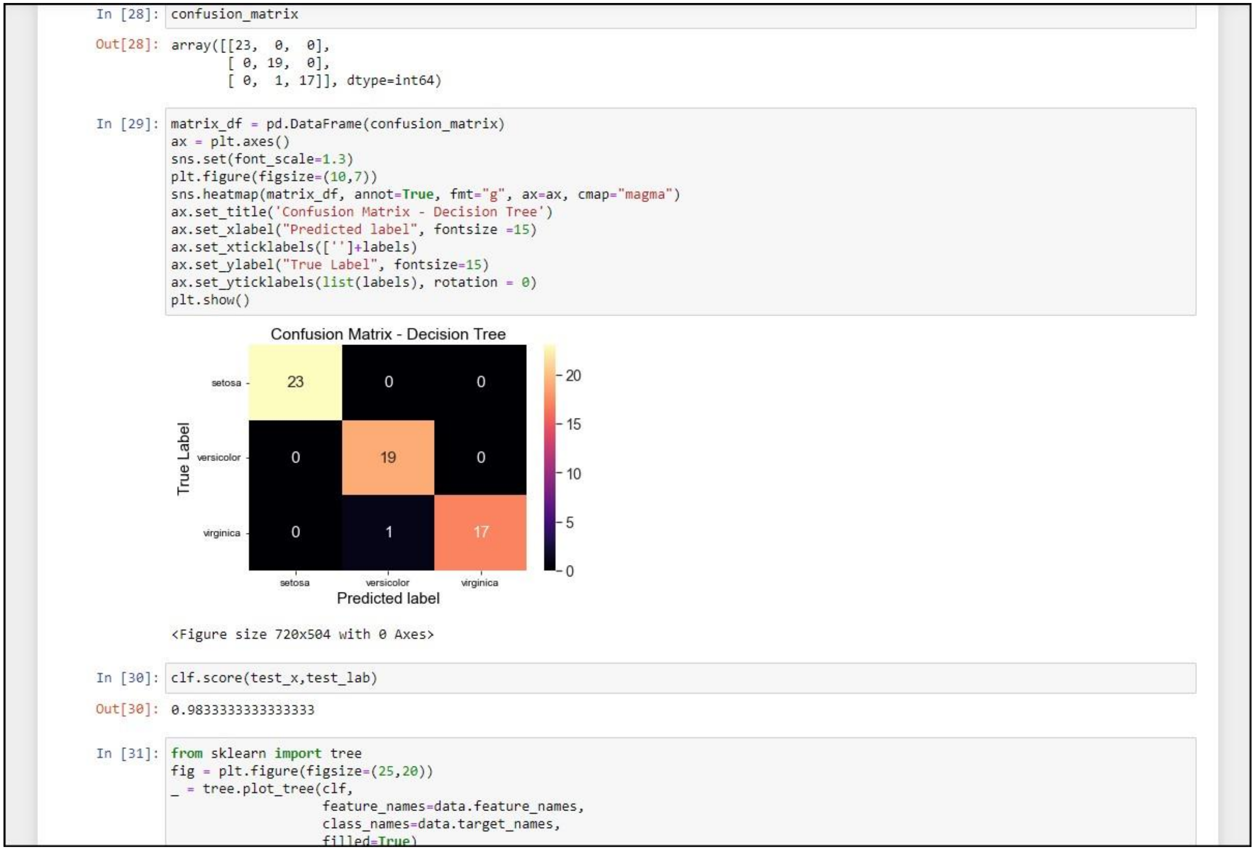
150 rows × 4 columns



```
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)
```

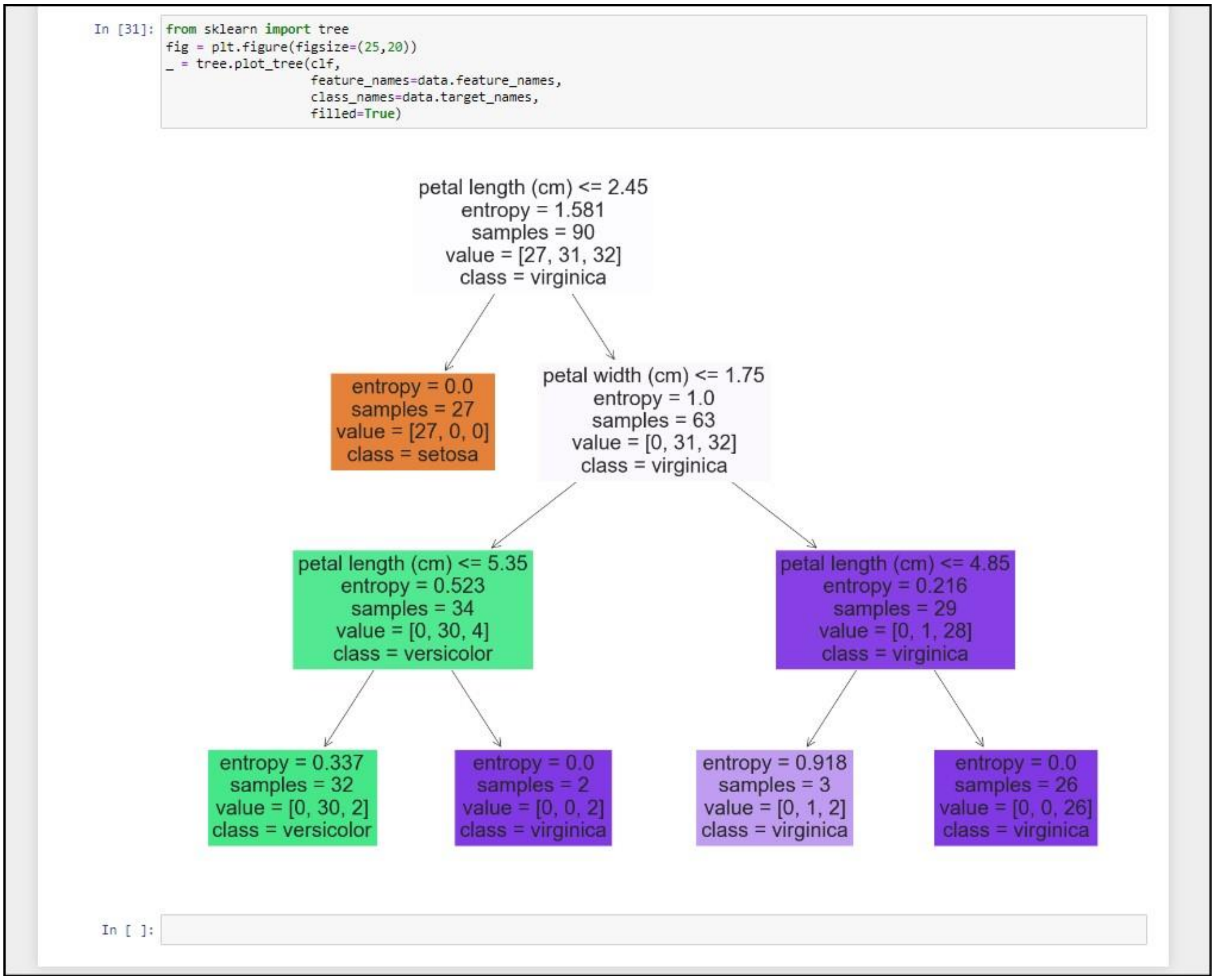


```
In [24]: from sklearn.tree import DecisionTreeClassifier
         clf = DecisionTreeClassifier(max_depth =3, random_state = 42,criterion='entropy')

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],
```



```
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)
```

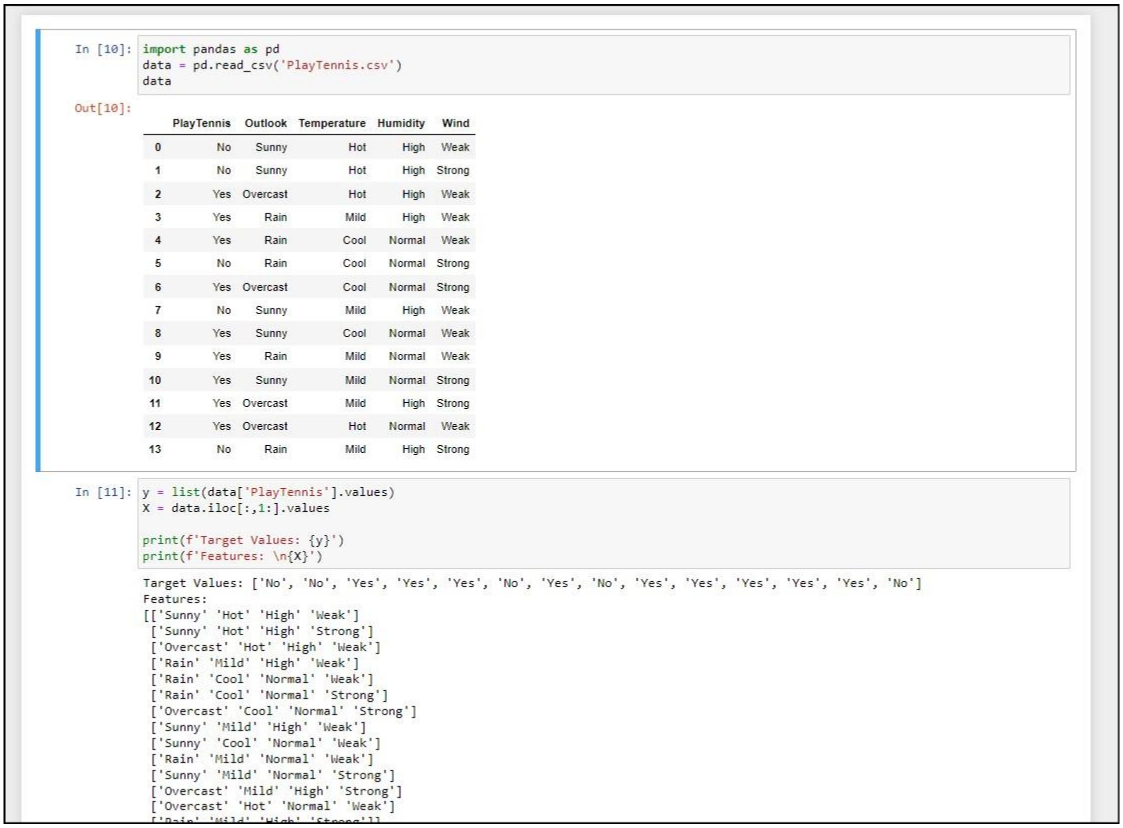


```
In [31]: from sklearn import tree
         fig = plt.figure(figsize=(25,20))
         _ = tree.plot_tree(clf,
                            feature_names=data.feature_names,
                            class_names=data.target_names,
                            filled=True)
```

```
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



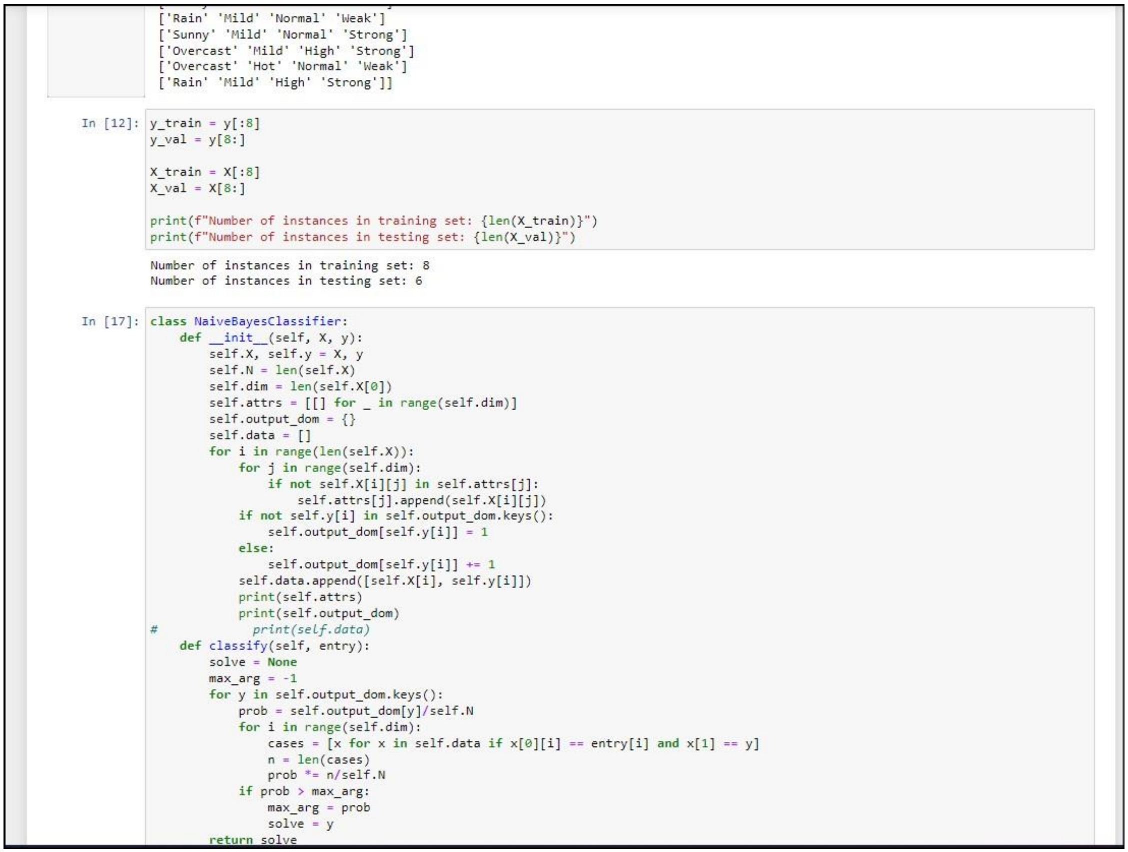
```
In [10]: import pandas as pd
         data = pd.read_csv('PlayTennis.csv')
         data
```

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' 'High' 'Strong']]
```

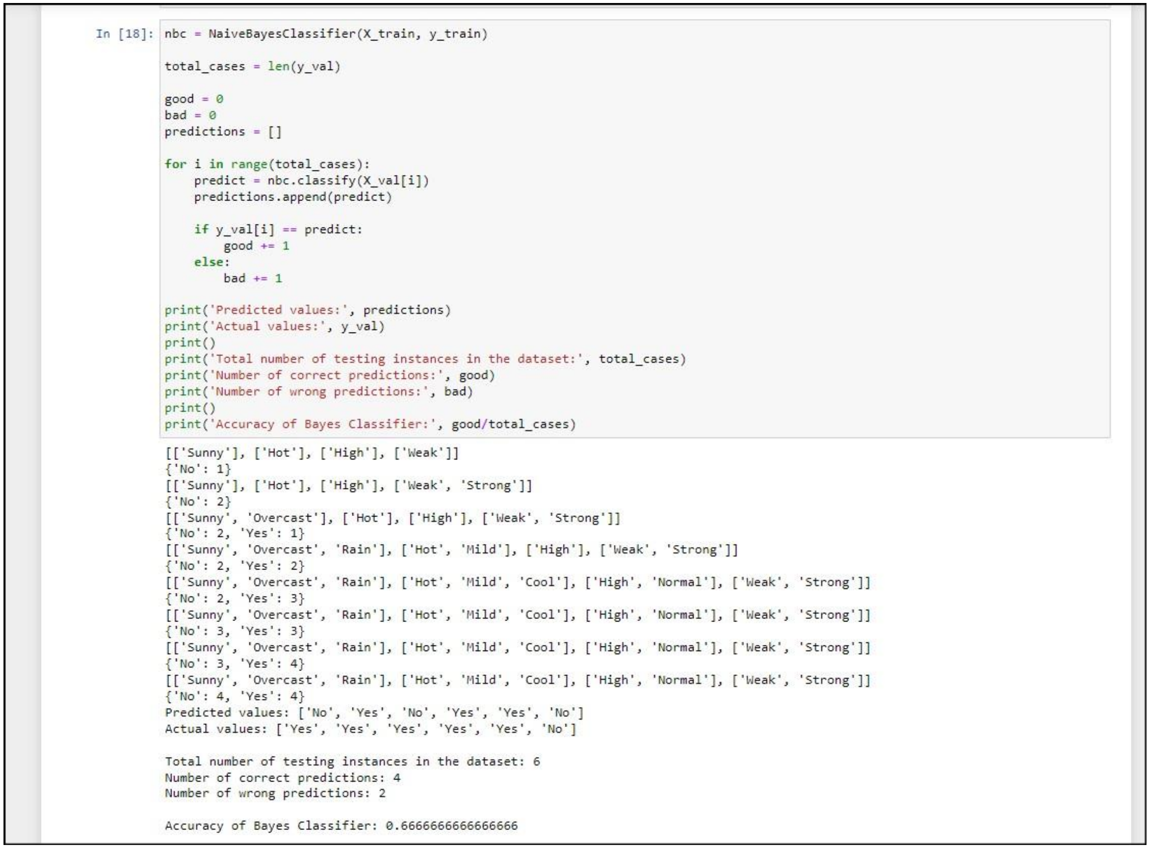


```
 ['Rain' 'Mild' 'Normal' 'Weak']
 ['Sunny' 'Mild' 'Normal' 'Strong']
 ['Overcast' 'Mild' 'High' 'Strong']
 ['Overcast' 'Hot' 'Normal' 'Weak']
 ['Rain' 'Mild' 'High' 'Strong']]
```

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
```

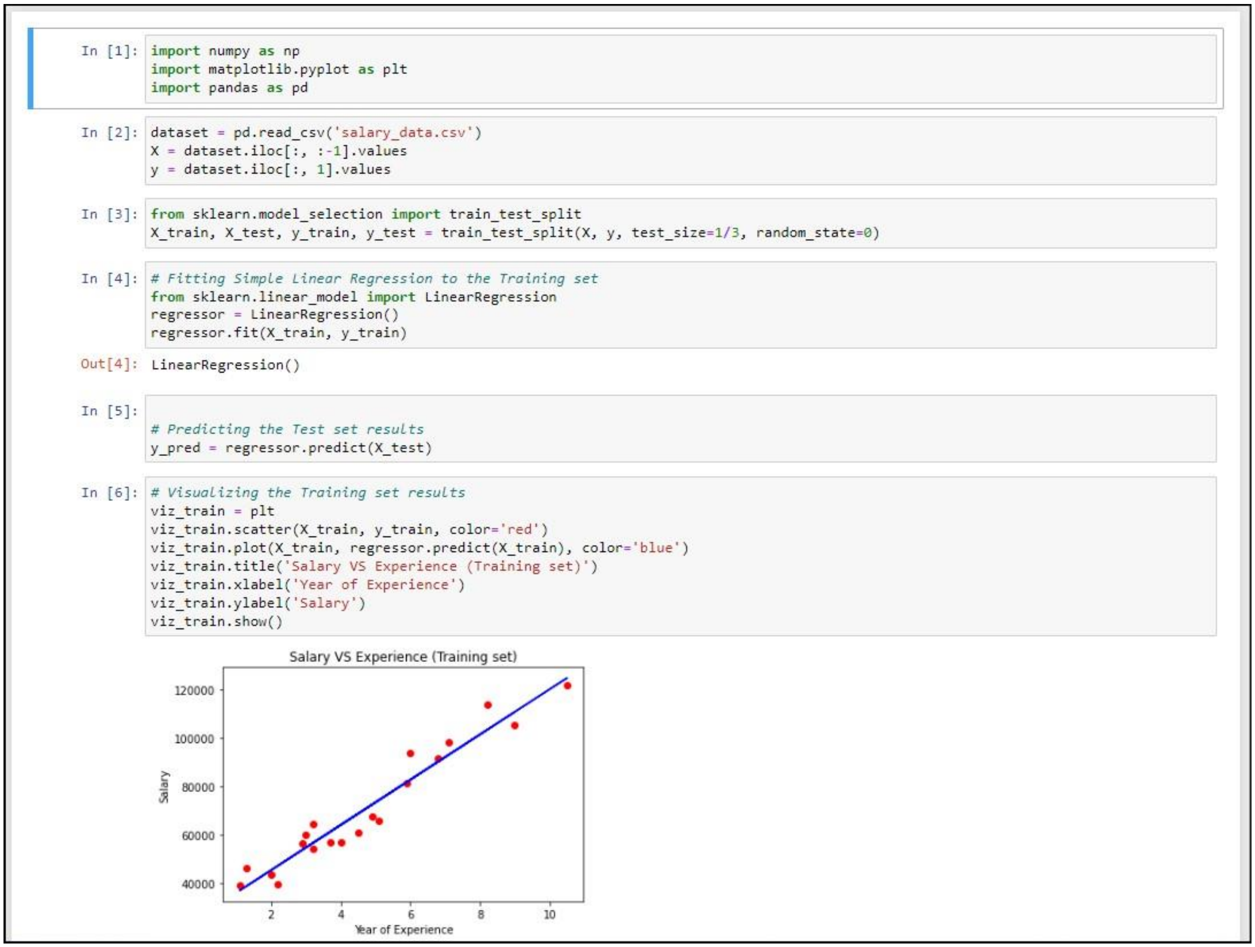


In [18]:
```
nbc = NaiveBayesClassifier(X_train, y_train)

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
```

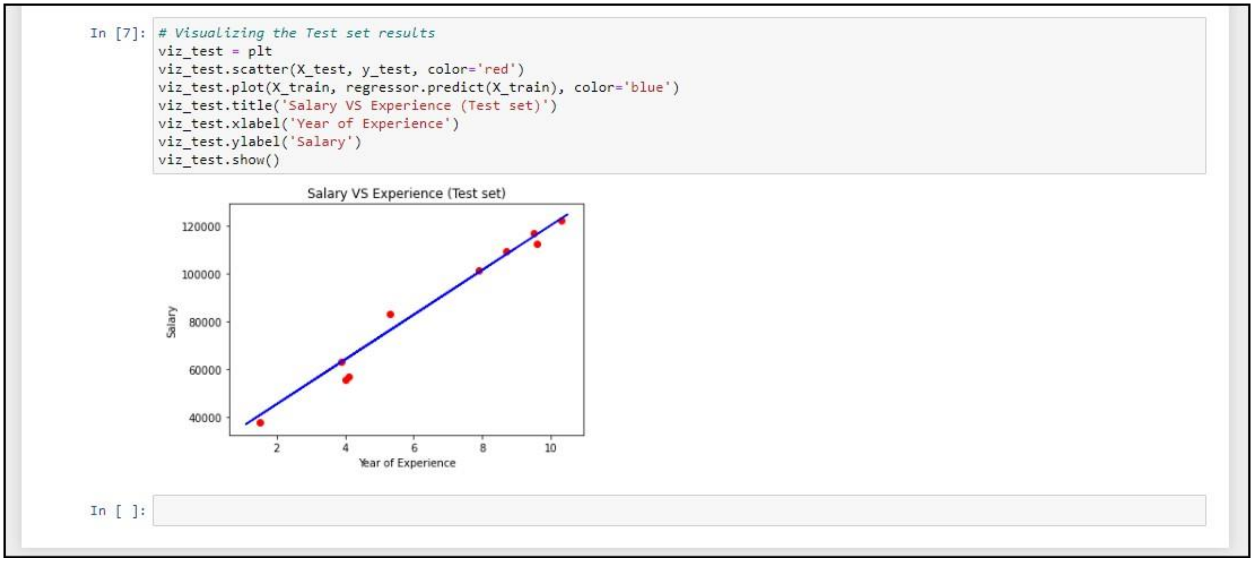
```
In [2]: dataset = pd.read_csv('salary_data.csv')
        X = dataset.iloc[:, :-1].values
        y = dataset.iloc[:, 1].values
```

```
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 [ ]:
```