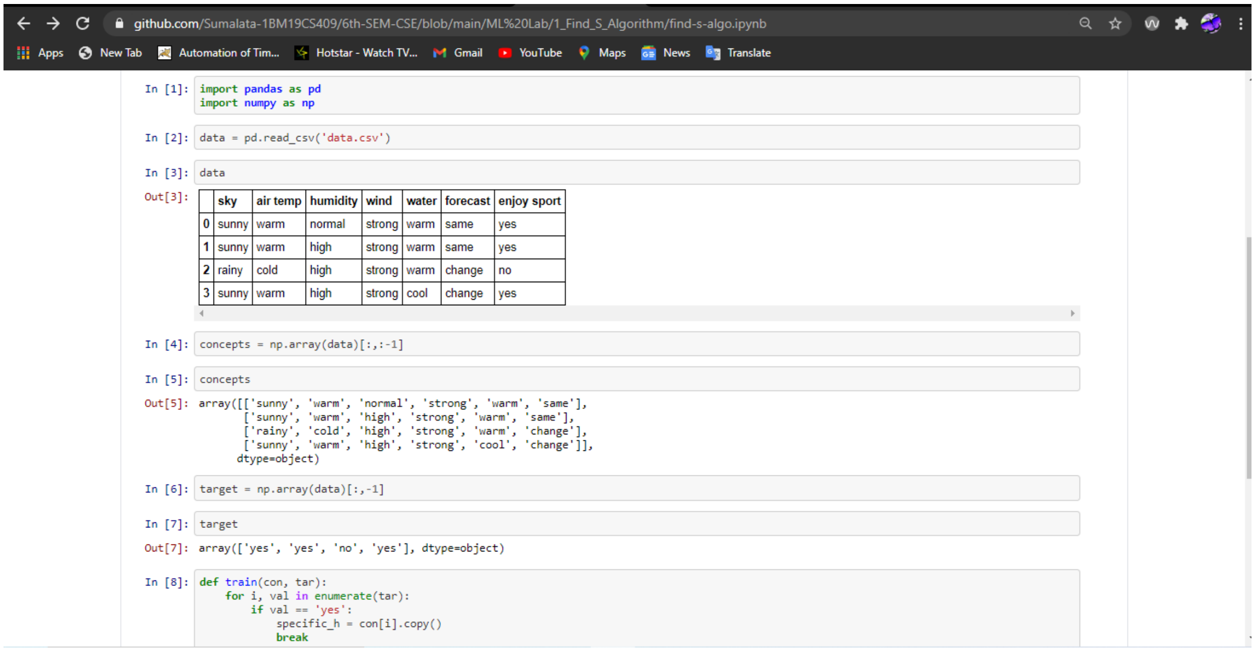
Sumalata
1BM19CS409

1. Fins – S algorithm

```
import pandas as pd
import numpy as np
data = pd.read_csv('data.csv')
data
concepts = np.array(data)[:,:-1]
concepts
target = np.array(data)[:,-1]
target
def train(con, tar):
    for i, val in enumerate(tar):
        if val == 'yes':
            specific_h = con[i].copy()
            break

    for i, val in enumerate(con):
        if tar[i] == 'yes':
            for x in range(len(specific_h)):
                if val[x] != specific_h[x]:
                    specific_h[x] = '?'
                else:
                    pass
    return specific_h
print(train(concepts, target))
```

Output



github.com/Sumalata-1BM19CS409/6th-SEM-CSE/blob/main/ML%20Lab/1_Find_S_Algorithm/find-s-algo.ipynb
Apps
New Tab
Automation of Tim...
Hotstar - Watch TV...
Gmail
YouTube
Maps
News
Translate

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

In [2]: data = pd.read_csv('data.csv')

In [3]: data
Out[3]:
```

	sky	air temp	humidity	wind	water	forecast	enjoy sport
0	sunny	warm	normal	strong	warm	same	yes
1	sunny	warm	high	strong	warm	same	yes
2	rainy	cold	high	strong	warm	change	no
3	sunny	warm	high	strong	cool	change	yes

```
In [4]: concepts = np.array(data)[:,:-1]

In [5]: concepts
Out[5]: array([['sunny', 'warm', 'normal', 'strong', 'warm', 'same'],
               ['sunny', 'warm', 'high', 'strong', 'warm', 'same'],
               ['rainy', 'cold', 'high', 'strong', 'warm', 'change'],
               ['sunny', 'warm', 'high', 'strong', 'cool', 'change']],
              dtype=object)

In [6]: target = np.array(data)[:,-1]

In [7]: target
Out[7]: array(['yes', 'yes', 'no', 'yes'], dtype=object)

In [8]: def train(con, tar):
            for i, val in enumerate(tar):
                if val == 'yes':
                    specific_h = con[i].copy()
                    break
```

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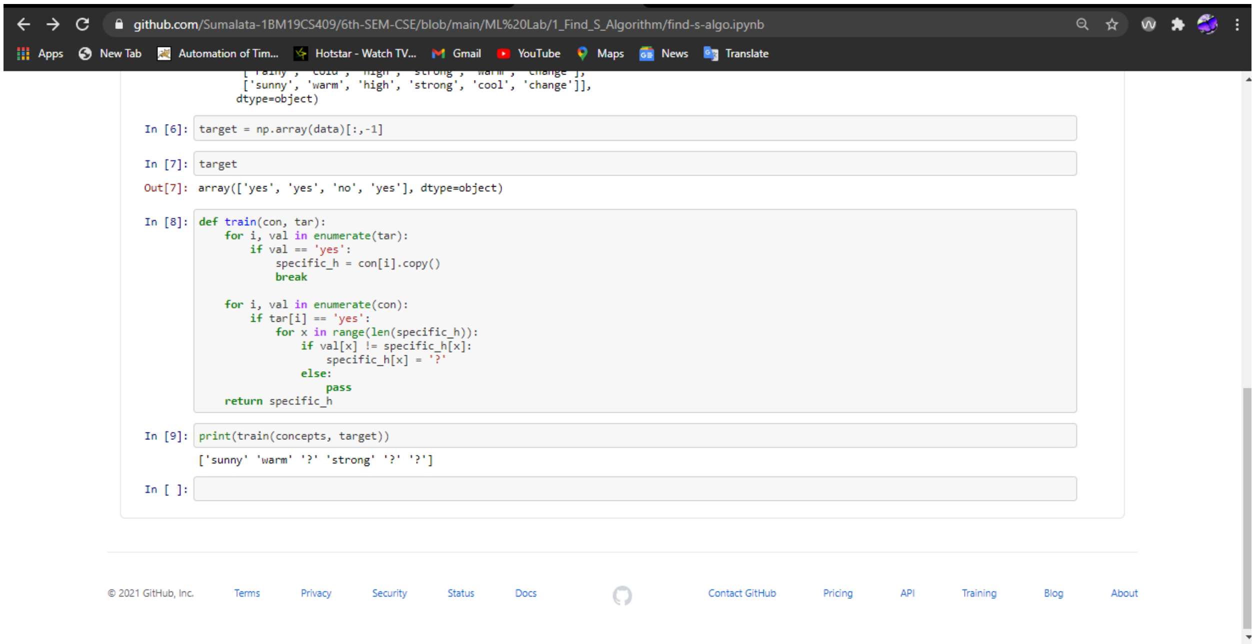
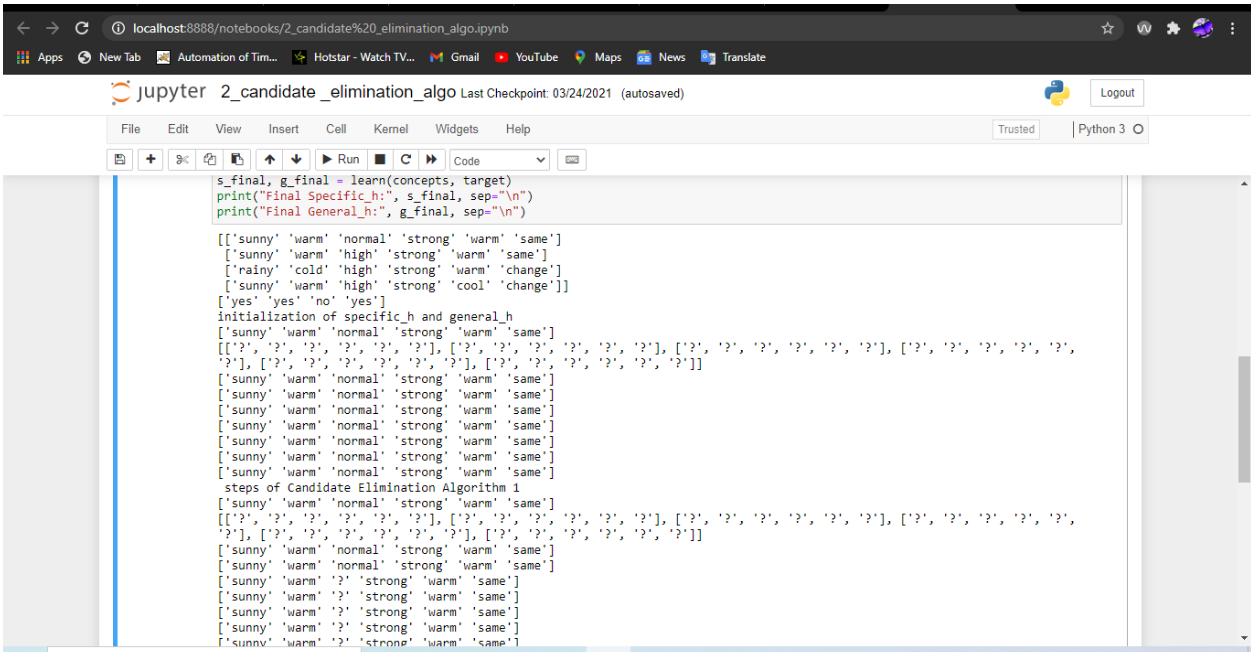


```
        ['rainy', 'cold', 'high', 'strong', 'warm', 'change'],
        ['sunny', 'warm', 'high', 'strong', 'cool', 'change']],
       dtype=object)

In [6]: target = np.array(data)[:,-1]

In [7]: target

Out[7]: array(['yes', 'yes', 'no', 'yes'], dtype=object)

In [8]: def train(con, tar):
            for i, val in enumerate(tar):
                if val == 'yes':
                    specific_h = con[i].copy()
                    break

            for i, val in enumerate(con):
                if tar[i] == 'yes':
                    for x in range(len(specific_h)):
                        if val[x] != specific_h[x]:
                            specific_h[x] = '?'
                        else:
                            pass
            return specific_h

In [9]: print(train(concepts, target))

        ['sunny' 'warm' '?' 'strong' '?' '?']

In [ ]:
```

2. Candidate elimination algorithm

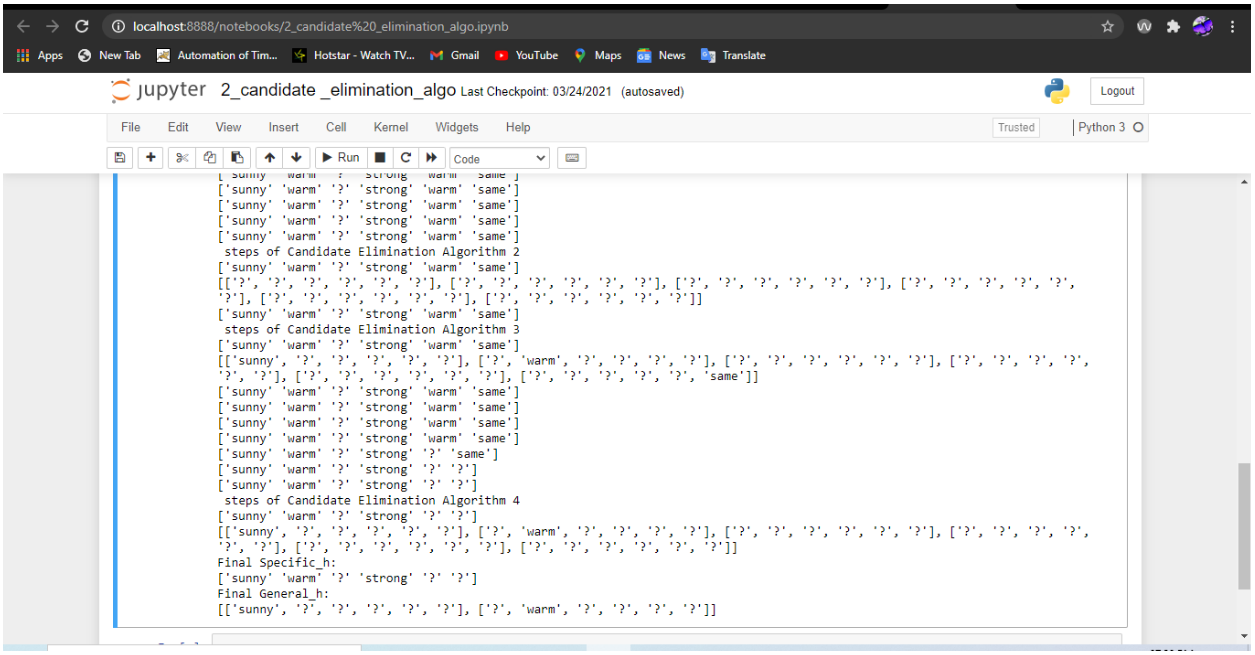
```
import numpy as np
import pandas as pd
data = pd.DataFrame(data=pd.read_csv('enjoysport.csv'))
concepts = np.array(data.iloc[:,0:-1])
print(concepts)
target = np.array(data.iloc[:,-1])
print(target)

def learn(concepts, target):
    specific_h = concepts[0].copy()
    print("initialization of specific_h and general_h")
    print(specific_h)
    general_h = [["?" for i in range(len(specific_h))] for i in
range(len(specific_h))]
    print(general_h)
    for i, h in enumerate(concepts):
        if target[i] == "yes":
            for x in range(len(specific_h)):
                if h[x]!= specific_h[x]:
                    specific_h[x] ='?'
                    general_h[x][x] ='?'
                print(specific_h)
        print(specific_h)
        if target[i] == "no":
            for x in range(len(specific_h)):
                if h[x]!= specific_h[x]:
                    general_h[x][x] = specific_h[x]
                else:
                    general_h[x][x] = '?'
        print(" steps of Candidate Elimination Algorithm",i+1)
        print(specific_h)
        print(general_h)
    indices = [i for i, val in enumerate(general_h) if val ==
['?', '?', '?', '?', '?', '?']]
    for i in indices:
        general_h.remove(['?', '?', '?', '?', '?', '?'])
    return specific_h, general_h
s_final, g_final = learn(concepts, target)
print("Final Specific_h:", s_final, sep="\n")
print("Final General_h:", g_final, sep="\n")
```

Output



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

```
[['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
 ['sunny' 'warm' 'high' 'strong' 'warm' 'same']
 ['rainy' 'cold' 'high' 'strong' 'warm' 'change']
 ['sunny' 'warm' 'high' 'strong' 'cool' 'change']]
['yes' 'yes' 'no' 'yes']
initialization of specific_h and general_h
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?',
'?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
 steps of Candidate Elimination Algorithm 1
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?',
'?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
```



```
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
 steps of Candidate Elimination Algorithm 2
['sunny' 'warm' '?' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?',
'?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
['sunny' 'warm' '?' 'strong' 'warm' 'same']
 steps of Candidate Elimination Algorithm 3
['sunny' 'warm' '?' 'strong' 'warm' 'same']
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?',
'?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' '?' 'same']
['sunny' 'warm' '?' 'strong' '?' '?']
['sunny' 'warm' '?' 'strong' '?' '?']
 steps of Candidate Elimination Algorithm 4
['sunny' 'warm' '?' 'strong' '?' '?']
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?',
'?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
Final Specific_h:
['sunny' 'warm' '?' 'strong' '?' '?']
Final General_h:
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']]
```

3. ID3 algorithm

```
import math
import csv
```

In [2]:

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

In [3]:

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

In [4]:

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

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

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

In [5]:

```
def entropy(S):
    attr = list(set(S))
    if len(attr) == 1:
        return 0

    counts = [0,0]
    for i in range(2):
        counts[i] = sum([1 for x in S if attr[i] == x])/(len(S)*1.0)
    sums = 0
    for cnt in counts:
        sums+=-1*cnt*math.log(cnt,2)
    return sums
```

In [6]:

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

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

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

In [7]:

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

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

    attr, dic = subtables(data, split, delete = True)
    for x in range(len(attr)):
        child = build_tree(dic[attr[x]], fea)
        node.children.append((attr[x], child))
    return node
```

In [8]:

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

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

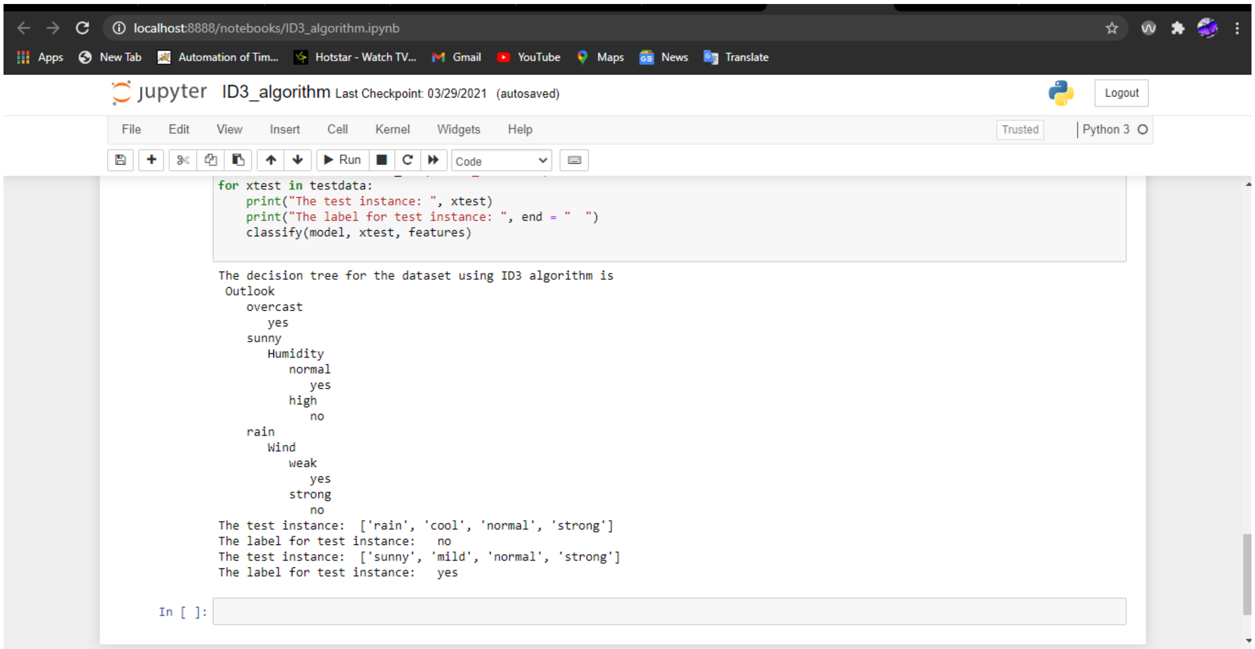
In [9]:

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

In [10]:

```
'''Main Program'''
dataset, features = load_csv("data3.csv")
model = build_tree(dataset, features)

print("The decision tree for the dataset using ID3 algorithm is")
print_tree(model, 0)
testdata, features = load_csv("data3_test.csv")
for xtest in testdata:
    print("The test instance: ", xtest)
    print("The label for test instance: ", end = "  ")
    classify(model, xtest, features)
```

Output



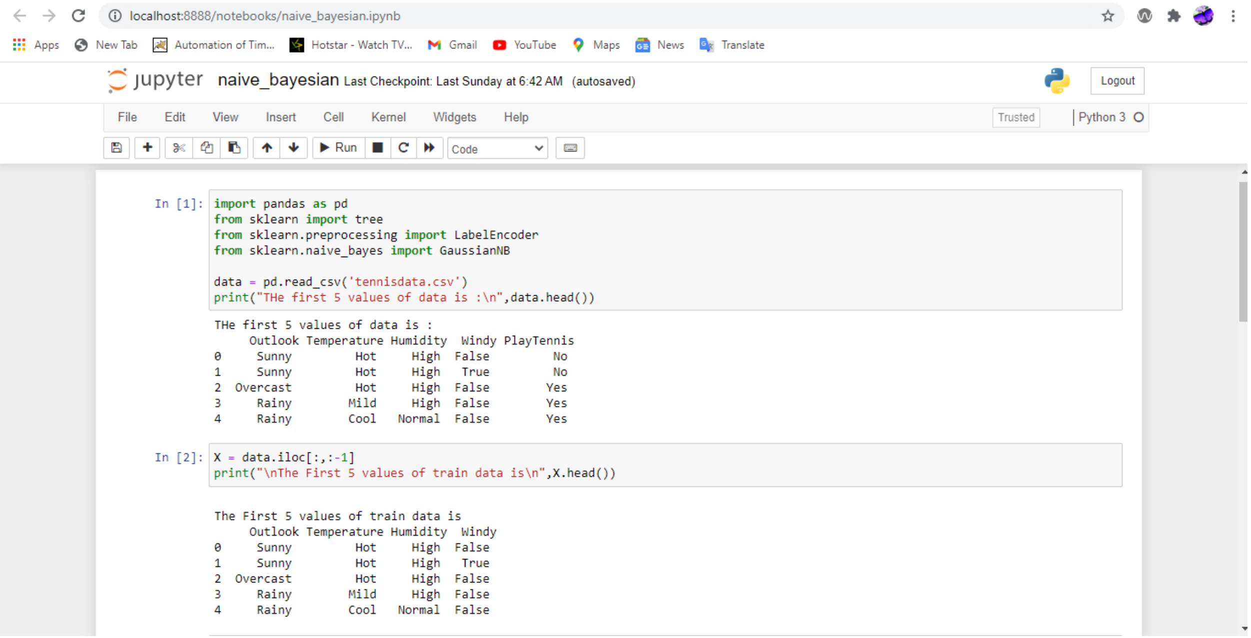
```
for xtest in testdata:
    print("The test instance: ", xtest)
    print("The label for test instance: ", end = "  ")
    classify(model, xtest, features)
```

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

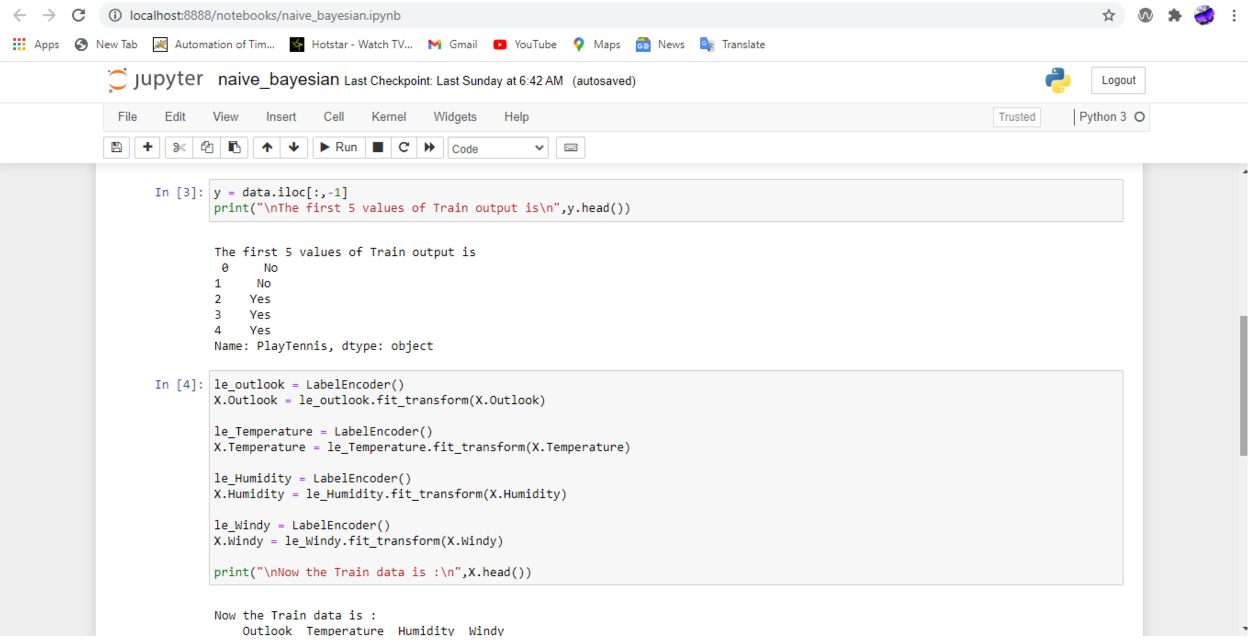
4. Naïve Bayesian algorithm

```
import pandas as pd
from sklearn import tree
from sklearn.preprocessing import LabelEncoder
from sklearn.naive_bayes import GaussianNB

data = pd.read_csv('tennisdata.csv')
print("THe first 5 values of data is :\n",data.head())
                                                                          In [2]:
X = data.iloc[:,:-1]
print("\nThe First 5 values of train data is\n",X.head())
                                                                          In [3]:
y = data.iloc[:,-1]
print("\nThe first 5 values of Train output is\n",y.head())
                                                                          In [4]:
le_outlook = LabelEncoder()
X.Outlook = le_outlook.fit_transform(X.Outlook)

le_Temperature = LabelEncoder()
X.Temperature = le_Temperature.fit_transform(X.Temperature)

le_Humidity = LabelEncoder()
X.Humidity = le_Humidity.fit_transform(X.Humidity)

le_Windy = LabelEncoder()
X.Windy = le_Windy.fit_transform(X.Windy)

print("\nNow the Train data is :\n",X.head())
                                                                          In [5]:
le_PlayTennis = LabelEncoder()
y = le_PlayTennis.fit_transform(y)
print("\nNow the Train output is\n",y)
                                                                          In [6]:
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.20)

classifier = GaussianNB()
classifier.fit(X_train,y_train)

from sklearn.metrics import accuracy_score
print("Accuracy is:",accuracy_score(classifier.predict(X_test),y_test))
```

Output

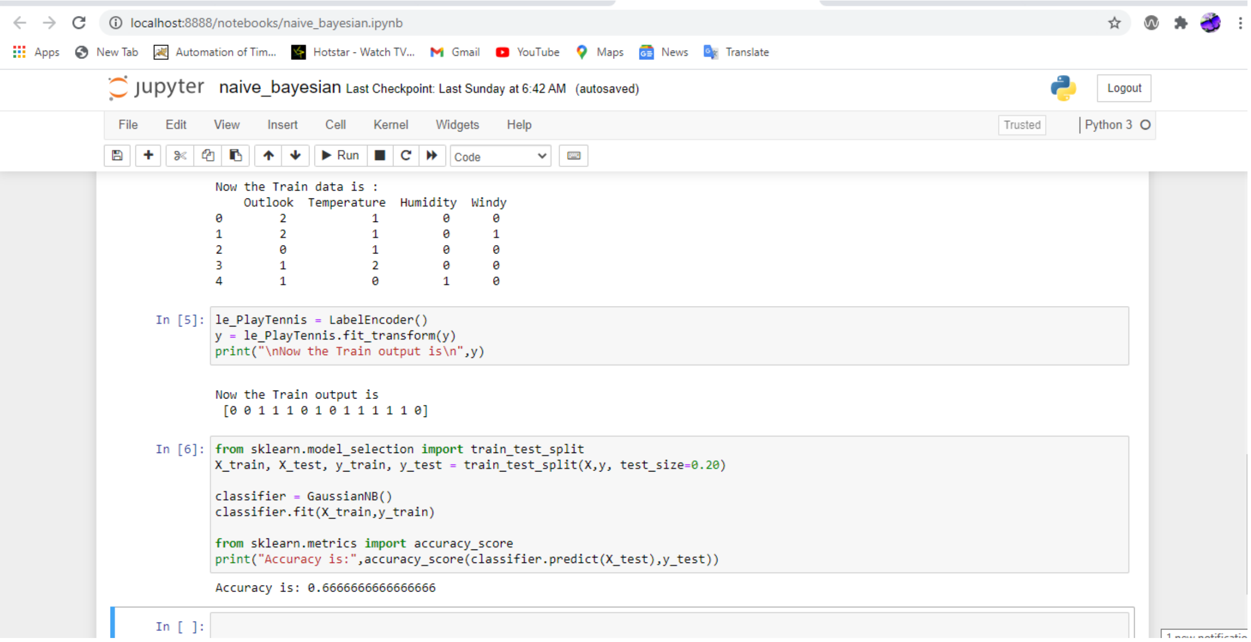


```
In [1]: import pandas as pd
        from sklearn import tree
        from sklearn.preprocessing import LabelEncoder
        from sklearn.naive_bayes import GaussianNB

        data = pd.read_csv('tennisdata.csv')
        print("THe first 5 values of data is :\n",data.head())

        THe first 5 values of data is :
             Outlook Temperature Humidity  Windy PlayTennis
        0     Sunny         Hot     High  False         No
        1     Sunny         Hot     High   True         No
        2  Overcast         Hot     High  False        Yes
        3     Rainy        Mild     High  False        Yes
        4     Rainy        Cool   Normal  False        Yes

In [2]: X = data.iloc[:,:-1]
        print("\nThe First 5 values of train data is\n",X.head())


        The First 5 values of train data is
             Outlook Temperature Humidity  Windy
        0     Sunny         Hot     High  False
        1     Sunny         Hot     High   True
        2  Overcast         Hot     High  False
        3     Rainy        Mild     High  False
        4     Rainy        Cool   Normal  False
```



```
In [3]: y = data.iloc[:,-1]
        print("\nThe first 5 values of Train output is\n",y.head())


        The first 5 values of Train output is
         0     No
        1     No
        2    Yes
        3    Yes
        4    Yes
        Name: PlayTennis, dtype: object

In [4]: le_outlook = LabelEncoder()
        X.Outlook = le_outlook.fit_transform(X.Outlook)

        le_Temperature = LabelEncoder()
        X.Temperature = le_Temperature.fit_transform(X.Temperature)

        le_Humidity = LabelEncoder()
        X.Humidity = le_Humidity.fit_transform(X.Humidity)

        le_Windy = LabelEncoder()
        X.Windy = le_Windy.fit_transform(X.Windy)

        print("\nNow the Train data is :\n",X.head())


        Now the Train data is :
            Outlook  Temperature  Humidity  Windy
```

Sumalata
1BM19CS409



```
Now the Train data is :
    Outlook  Temperature  Humidity  Windy
0        2            1         0      0
1        2            1         0      1
2        0            1         0      0
3        1            2         0      0
4        1            0         1      0
```

In [5]:

```
le_PlayTennis = LabelEncoder()
y = le_PlayTennis.fit_transform(y)
print("\nNow the Train output is\n",y)
```

```
Now the Train output is
 [0 0 1 1 1 0 1 0 1 1 1 1 1 0]
```

In [6]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.20)

classifier = GaussianNB()
classifier.fit(X_train,y_train)

from sklearn.metrics import accuracy_score
print("Accuracy is:",accuracy_score(classifier.predict(X_test),y_test))
```

```
Accuracy is: 0.6666666666666666
```

In [ ]:

5. Bayesian Network Classifier algorithm

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

In [3]:

```
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']
```

In [4]:

```
X = df[feature_col_names].values # these are factors for the prediction
y = df[predicted_class_names].values # this is what we want to predict
```

In [5]:

```
#splitting the dataset into train and test data
print(df.head)
xtrain,xtest,ytrain,ytest=train_test_split(X,y,test_size=0.33)
```

In [6]:

```
print ('\n the total number of Training Data :',ytrain.shape)
print ('\n the total number of Test Data :',ytest.shape)
```

In [7]:

```
# Training Naive Bayes (NB) classifier on training data.

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

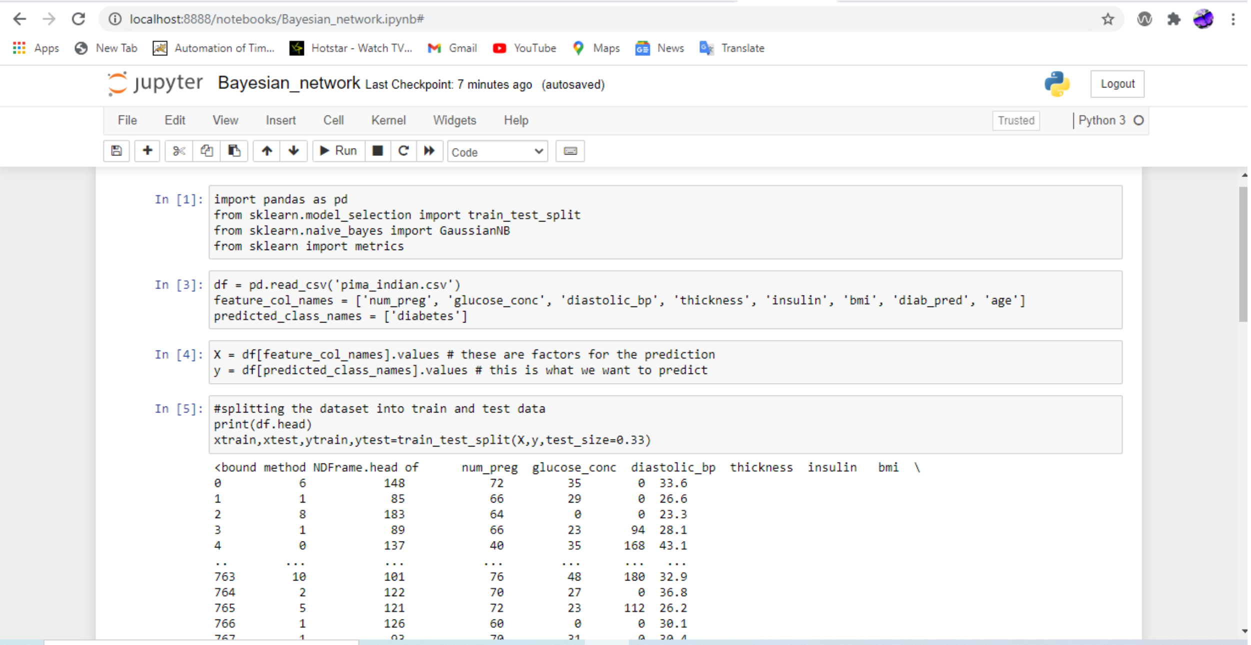
In [8]:

```
#printing Confusion matrix, accuracy, Precision and Recall

print('\n Confusion matrix')
print(metrics.confusion_matrix(ytest,predicted))
```

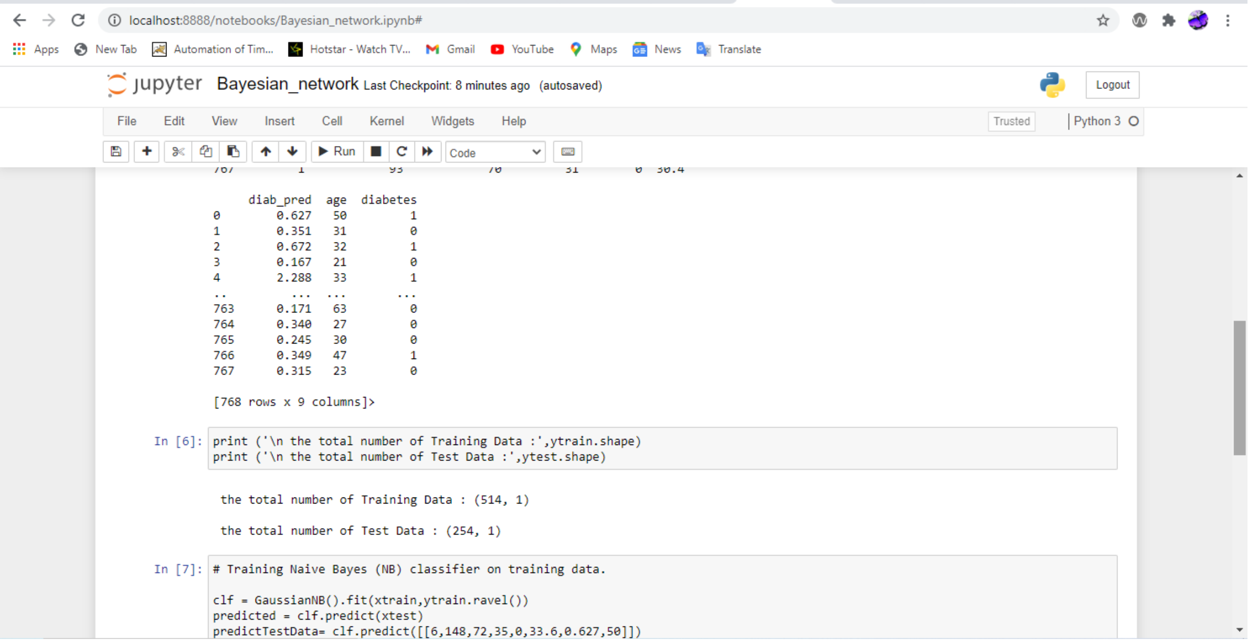
In [9]:

```
print('\n Accuracy of the classifier is',metrics.accuracy_score(ytest,predicted))

print('\n The value of Precision', metrics.precision_score(ytest,predicted))

print('\n The value of Recall', metrics.recall_score(ytest,predicted))

print("Predicted Value for individual Test Data:", predictTestData)
```

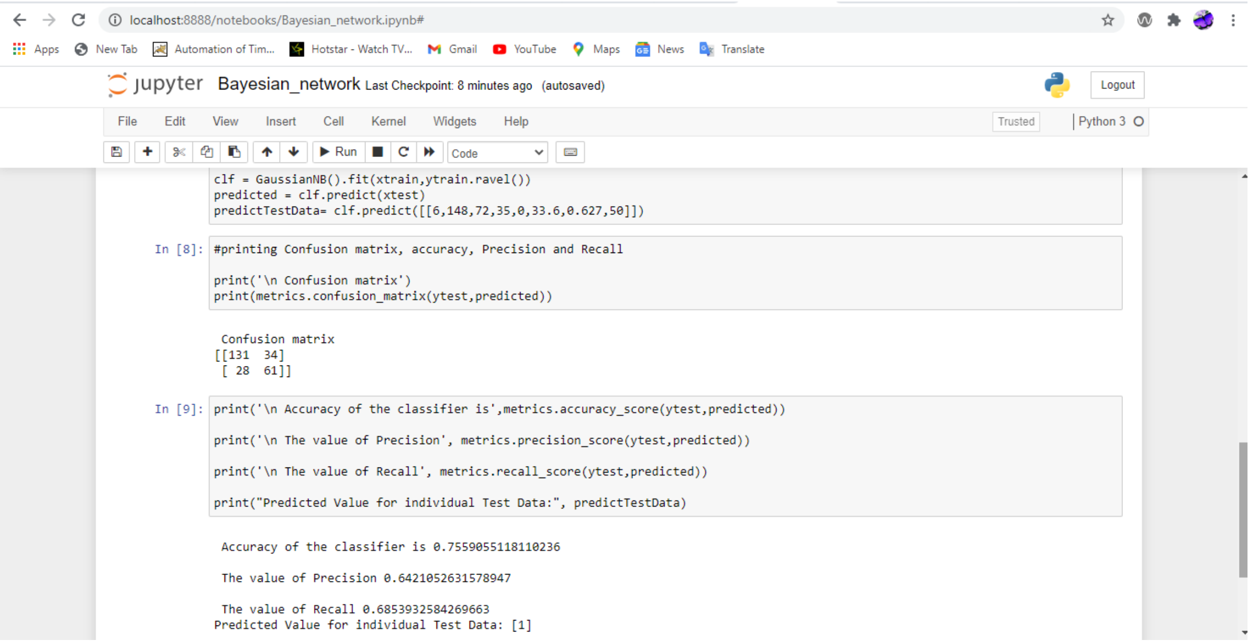
Output



```
In [1]: import pandas as pd
        from sklearn.model_selection import train_test_split
        from sklearn.naive_bayes import GaussianNB
        from sklearn import metrics

In [3]: 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']

In [4]: X = df[feature_col_names].values # these are factors for the prediction
        y = df[predicted_class_names].values # this is what we want to predict

In [5]: #splitting the dataset into train and test data
        print(df.head)
        xtrain,xtest,ytrain,ytest=train_test_split(X,y,test_size=0.33)

        <bound method NDFrame.head of      num_preg  glucose_conc  diastolic_bp  thickness  insulin   bmi  \
        0           6           148            72         35        0  33.6
        1           1            85            66         29        0  26.6
        2           8           183            64          0        0  23.3
        3           1            89            66         23       94  28.1
        4           0           137            40         35      168  43.1
        ..        ...           ...           ...        ...      ...   ...
        763        10           101            76         48      180  32.9
        764         2           122            70         27        0  36.8
        765         5           121            72         23      112  26.2
        766         1           126            60          0        0  30.1
        767         1            93            70         31        0  30.4
```



```
        767         1            93            70         31        0  30.4

             diab_pred  age  diabetes
        0        0.627   50         1
        1        0.351   31         0
        2        0.672   32         1
        3        0.167   21         0
        4        2.288   33         1
        ..         ...  ...       ...
        763      0.171   63         0
        764      0.340   27         0
        765      0.245   30         0
        766      0.349   47         1
        767      0.315   23         0

        [768 rows x 9 columns]>

In [6]: print ('\n the total number of Training Data :',ytrain.shape)
        print ('\n the total number of Test Data :',ytest.shape)

         the total number of Training Data : (514, 1)

         the total number of Test Data : (254, 1)

In [7]: # Training Naive Bayes (NB) classifier on training data.

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



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

In [8]:

```
#printing Confusion matrix, accuracy, Precision and Recall

print('\n Confusion matrix')
print(metrics.confusion_matrix(ytest,predicted))
```

```
 Confusion matrix
[[131  34]
 [ 28  61]]
```

In [9]:

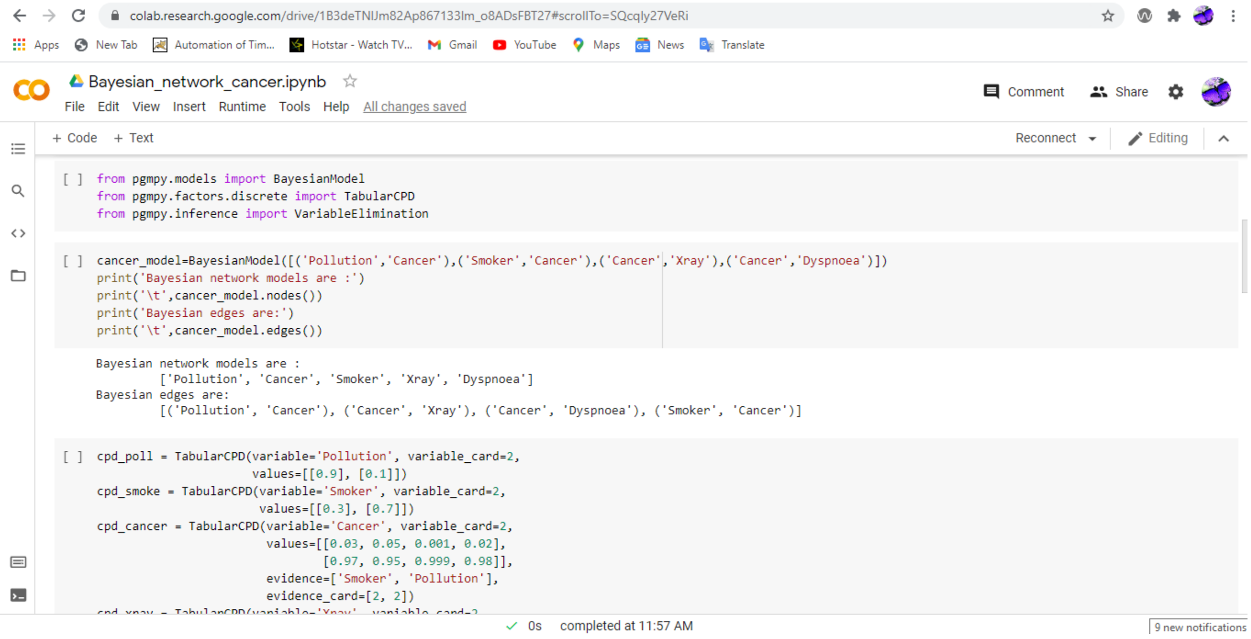
```
print('\n Accuracy of the classifier is',metrics.accuracy_score(ytest,predicted))

print('\n The value of Precision', metrics.precision_score(ytest,predicted))

print('\n The value of Recall', metrics.recall_score(ytest,predicted))

print("Predicted Value for individual Test Data:", predictTestData)
```

```
 Accuracy of the classifier is 0.7559055118110236

 The value of Precision 0.6421052631578947

 The value of Recall 0.6853932584269663
Predicted Value for individual Test Data: [1]
```

6. Bayesian Network using cancer dataset

```
from pgmpy.models import BayesianModel
from pgmpy.factors.discrete import TabularCPD
from pgmpy.inference import VariableElimination

cancer_model=BayesianModel([('Pollution','Cancer'),('Smoker','Cancer'),('Cancer','Xray'),('Cancer','Dyspnoea')
])
print('Bayesian network models are :')
print('\t',cancer_model.nodes())
print('Bayesian edges are:')
print('\t',cancer_model.edges())


cpd_poll = TabularCPD(variable='Pollution', variable_card=2,
                    values=[[0.9], [0.1]])
cpd_smoke = TabularCPD(variable='Smoker', variable_card=2,
                     values=[[0.3], [0.7]])
cpd_cancer = TabularCPD(variable='Cancer', variable_card=2,
                      values=[[0.03, 0.05, 0.001, 0.02],
                              [0.97, 0.95, 0.999, 0.98]],
                      evidence=['Smoker', 'Pollution'],
                      evidence_card=[2, 2])
cpd_xray = TabularCPD(variable='Xray', variable_card=2,
                    values=[[0.9, 0.2], [0.1, 0.8]],
                    evidence=['Cancer'], evidence_card=[2])
cpd_dysp = TabularCPD(variable='Dyspnoea', variable_card=2,
                    values=[[0.65, 0.3], [0.35, 0.7]],
                    evidence=['Cancer'], evidence_card=[2])

# Associating the parameters with the model structure.
cancer_model.add_cpds(cpd_poll, cpd_smoke, cpd_cancer, cpd_xray, cpd_dysp)

# Checking if the cpds are valid for the model.
cancer_model.check_model()

cancer_infer=VariableElimination(cancer_model)

print('All local independecies are as follows')
cancer_model.get_independencies()
print('Displaying CPDs')
print(cancer_model.get_cpds('Pollution'))
print(cancer_model.get_cpds('Smoker'))
print(cancer_model.get_cpds('Cancer'))
print(cancer_model.get_cpds('Xray'))
print(cancer_model.get_cpds('Dyspnoea'))

print('\n Probablity of Cancer given smoker')
q=cancer_infer.query(variables=['Cancer'],evidence={'Smoker':1})
print(q)

print('\n Probablity of Cancer given smoker, pollution')
q=cancer_infer.query(variables=['Cancer'],evidence={'Smoker':1,'Pollution':1})
print(q)
```

Output

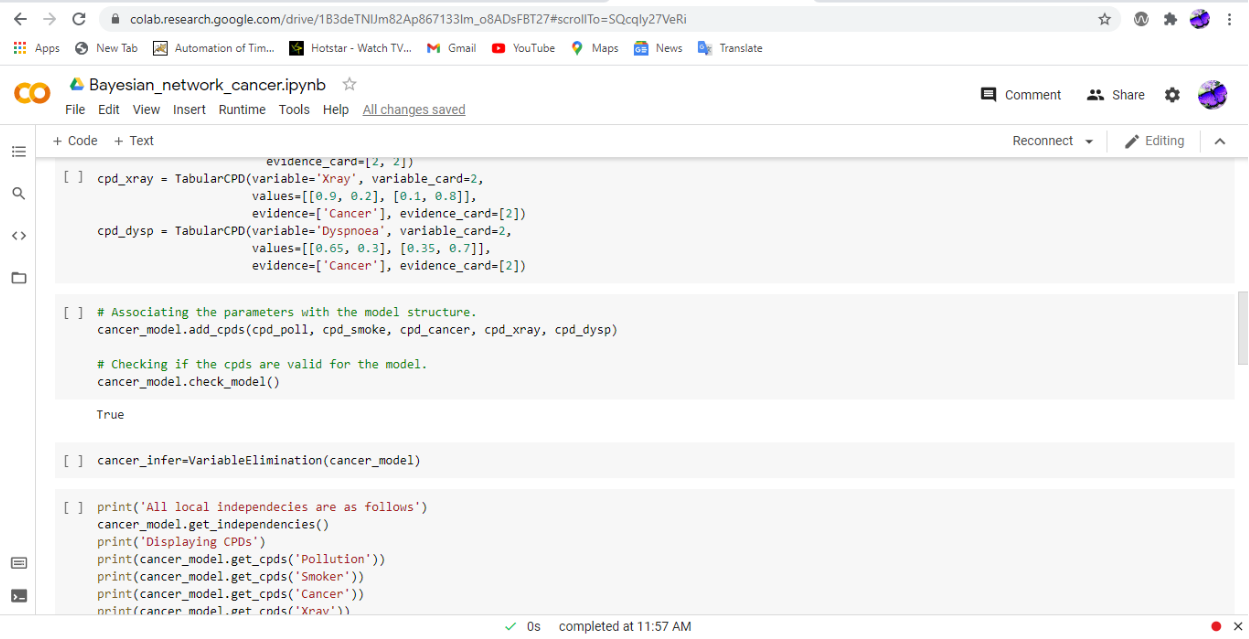


```
[ ] from pgmpy.models import BayesianModel
    from pgmpy.factors.discrete import TabularCPD
    from pgmpy.inference import VariableElimination
```

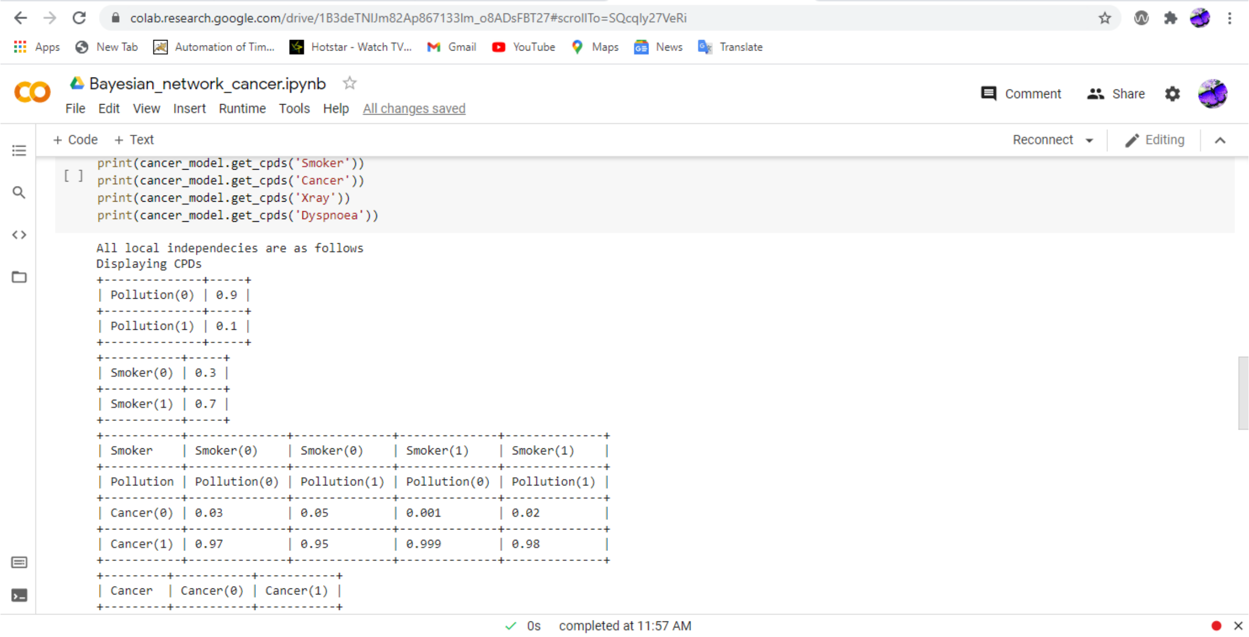
```
[ ] cancer_model=BayesianModel([('Pollution','Cancer'),('Smoker','Cancer'),('Cancer','Xray'),('Cancer','Dyspnoea')])
    print('Bayesian network models are :')
    print('\t',cancer_model.nodes())
    print('Bayesian edges are:')
    print('\t',cancer_model.edges())
```

```
Bayesian network models are :
         ['Pollution', 'Cancer', 'Smoker', 'Xray', 'Dyspnoea']
Bayesian edges are:
         [('Pollution', 'Cancer'), ('Cancer', 'Xray'), ('Cancer', 'Dyspnoea'), ('Smoker', 'Cancer')]
```

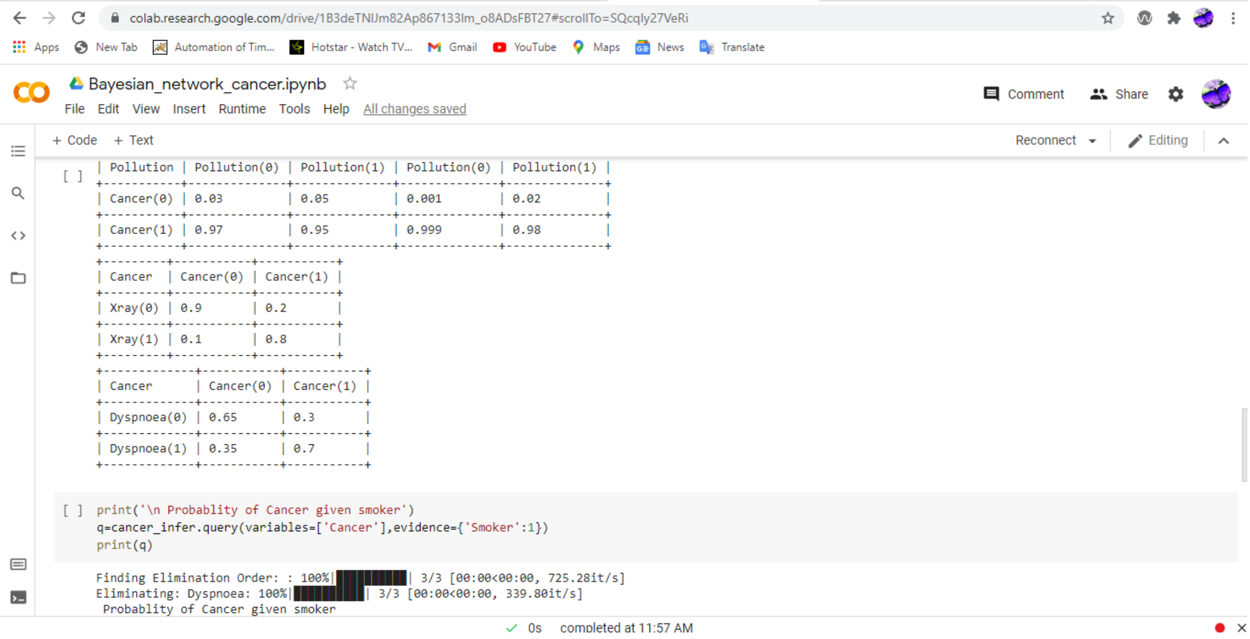
```
[ ] cpd_poll = TabularCPD(variable='Pollution', variable_card=2,
                          values=[[0.9], [0.1]])
    cpd_smoke = TabularCPD(variable='Smoker', variable_card=2,
                           values=[[0.3], [0.7]])
    cpd_cancer = TabularCPD(variable='Cancer', variable_card=2,
                            values=[[0.03, 0.05, 0.001, 0.02],
                                    [0.97, 0.95, 0.999, 0.98]],
                            evidence=['Smoker', 'Pollution'],
                            evidence_card=[2, 2])
    cpd_xray = TabularCPD(variable='Xray', variable_card=2
```



```
                      evidence_card=[2, 2])
[ ] cpd_xray = TabularCPD(variable='Xray', variable_card=2,
                   values=[[0.9, 0.2], [0.1, 0.8]],
                   evidence=['Cancer'], evidence_card=[2])
    cpd_dysp = TabularCPD(variable='Dyspnoea', variable_card=2,
                   values=[[0.65, 0.3], [0.35, 0.7]],
                   evidence=['Cancer'], evidence_card=[2])

[ ] # Associating the parameters with the model structure.
    cancer_model.add_cpds(cpd_poll, cpd_smoke, cpd_cancer, cpd_xray, cpd_dysp)

    # Checking if the cpds are valid for the model.
    cancer_model.check_model()

    True

[ ] cancer_infer=VariableElimination(cancer_model)

[ ] print('All local independecies are as follows')
    cancer_model.get_independencies()
    print('Displaying CPDs')
    print(cancer_model.get_cpds('Pollution'))
    print(cancer_model.get_cpds('Smoker'))
    print(cancer_model.get_cpds('Cancer'))
    print(cancer_model.get_cpds('Xray'))
```



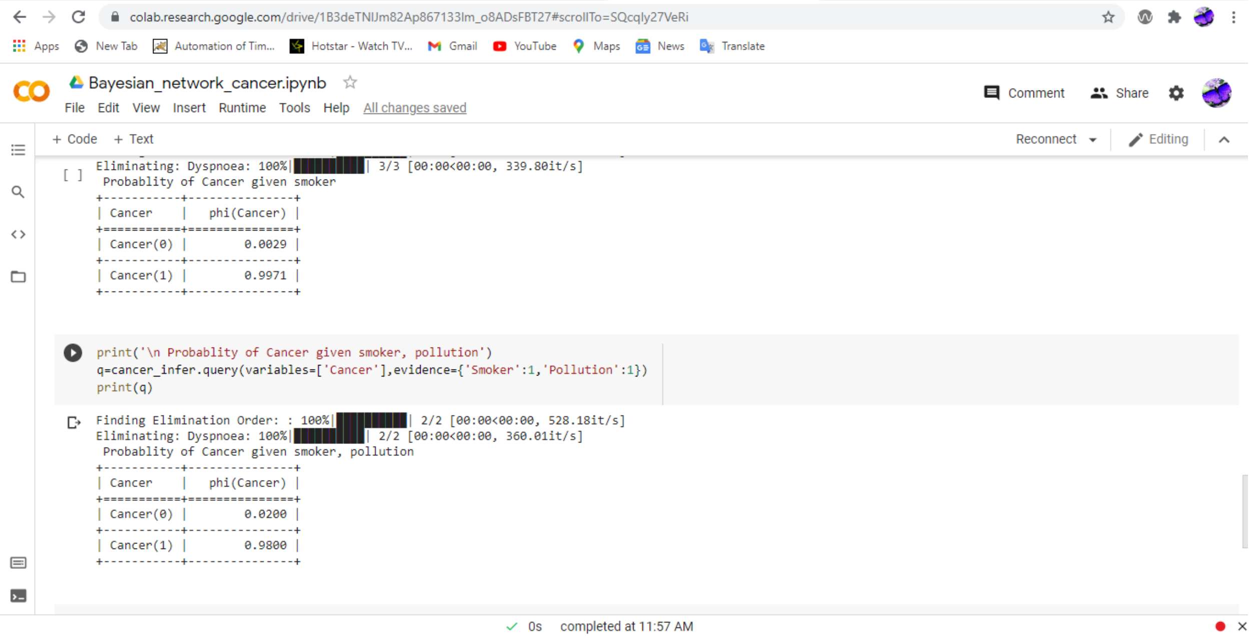
```
    print(cancer_model.get_cpds('Smoker'))
[ ] print(cancer_model.get_cpds('Cancer'))
    print(cancer_model.get_cpds('Xray'))
    print(cancer_model.get_cpds('Dyspnoea'))

    All local independecies are as follows
    Displaying CPDs
    +--------------+-----+
    | Pollution(0) | 0.9 |
    +--------------+-----+
    | Pollution(1) | 0.1 |
    +--------------+-----+
    +-----------+-----+
    | Smoker(0) | 0.3 |
    +-----------+-----+
    | Smoker(1) | 0.7 |
    +-----------+-----+
    +-----------+--------------+--------------+--------------+--------------+
    | Smoker    | Smoker(0)    | Smoker(0)    | Smoker(1)    | Smoker(1)    |
    +-----------+--------------+--------------+--------------+--------------+
    | Pollution | Pollution(0) | Pollution(1) | Pollution(0) | Pollution(1) |
    +-----------+--------------+--------------+--------------+--------------+
    | Cancer(0) | 0.03         | 0.05         | 0.001        | 0.02         |
    +-----------+--------------+--------------+--------------+--------------+
    | Cancer(1) | 0.97         | 0.95         | 0.999        | 0.98         |
    +-----------+--------------+--------------+--------------+--------------+
    +---------+-----------+-----------+
    | Cancer  | Cancer(0) | Cancer(1) |
    +---------+-----------+-----------+
```



```
[ ] | Pollution | Pollution(0) | Pollution(1) | Pollution(0) | Pollution(1) |
    +-----------+--------------+--------------+--------------+--------------+
    | Cancer(0) | 0.03         | 0.05         | 0.001        | 0.02         |
    +-----------+--------------+--------------+--------------+--------------+
    | Cancer(1) | 0.97         | 0.95         | 0.999        | 0.98         |
    +-----------+--------------+--------------+--------------+--------------+
    +---------+-----------+-----------+
    | Cancer  | Cancer(0) | Cancer(1) |
    +---------+-----------+-----------+
    | Xray(0) | 0.9       | 0.2       |
    +---------+-----------+-----------+
    | Xray(1) | 0.1       | 0.8       |
    +---------+-----------+-----------+
    +-------------+-----------+-----------+
    | Cancer      | Cancer(0) | Cancer(1) |
    +-------------+-----------+-----------+
    | Dyspnoea(0) | 0.65      | 0.3       |
    +-------------+-----------+-----------+
    | Dyspnoea(1) | 0.35      | 0.7       |
    +-------------+-----------+-----------+
```

```
[ ] print('\n Probablity of Cancer given smoker')
    q=cancer_infer.query(variables=['Cancer'],evidence={'Smoker':1})
    print(q)
```

```
Finding Elimination Order: : 100%|██████████| 3/3 [00:00<00:00, 725.28it/s]
Eliminating: Dyspnoea: 100%|██████████| 3/3 [00:00<00:00, 339.80it/s]
 Probablity of Cancer given smoker
```



```
[ ] Eliminating: Dyspnoea: 100%|██████████| 3/3 [00:00<00:00, 339.80it/s]
     Probablity of Cancer given smoker
    +-----------+---------------+
    | Cancer    |   phi(Cancer) |
    +===========+===============+
    | Cancer(0) |        0.0029 |
    +-----------+---------------+
    | Cancer(1) |        0.9971 |
    +-----------+---------------+
```

```
print('\n Probablity of Cancer given smoker, pollution')
q=cancer_infer.query(variables=['Cancer'],evidence={'Smoker':1,'Pollution':1})
print(q)
```

```
Finding Elimination Order: : 100%|██████████| 2/2 [00:00<00:00, 528.18it/s]
Eliminating: Dyspnoea: 100%|██████████| 2/2 [00:00<00:00, 360.01it/s]
 Probablity of Cancer given smoker, pollution
+-----------+---------------+
| Cancer    |   phi(Cancer) |
+===========+===============+
| Cancer(0) |        0.0200 |
+-----------+---------------+
| Cancer(1) |        0.9800 |
+-----------+---------------+
```