B.M.S. COLLEGE OF ENGINEERING BENGALURU
Autonomous Institute, Affiliated to VTU

Lab Record

Machine Learning

Submitted in partial fulfillment for the 6th Semester Laboratory

Bachelor of Technology in
Computer Science and Engineering

Submitted by:

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B.M.S. COLLEGE OF ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

CERTIFICATE

This is to certify that the Machine Learning (20CS6PCMAL) laboratory has been carried out by Ronit Bangard (1BM20CS130) during the 6th Semester Mar-July-2023.

Signature of the Faculty Incharge:
Asha G R
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Department of Computer Science and Engineering

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Contents

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

In [ ]:
```
# Interactive

len_x = int(input('enter no. of samples: '))
x = []
attrib = input('enter attributes: ').split()
n_attrib = len(attrib)
for i in range(len_x):
    X = input(f'enter sample {i}: ').split()
    x.append(X)
y = []
for i in range(len_x):
    Y = input(f'output for sample {i} (true/false): ')
    Y = Y.lower()
    y.append(True if Y == 'true' else False)
```

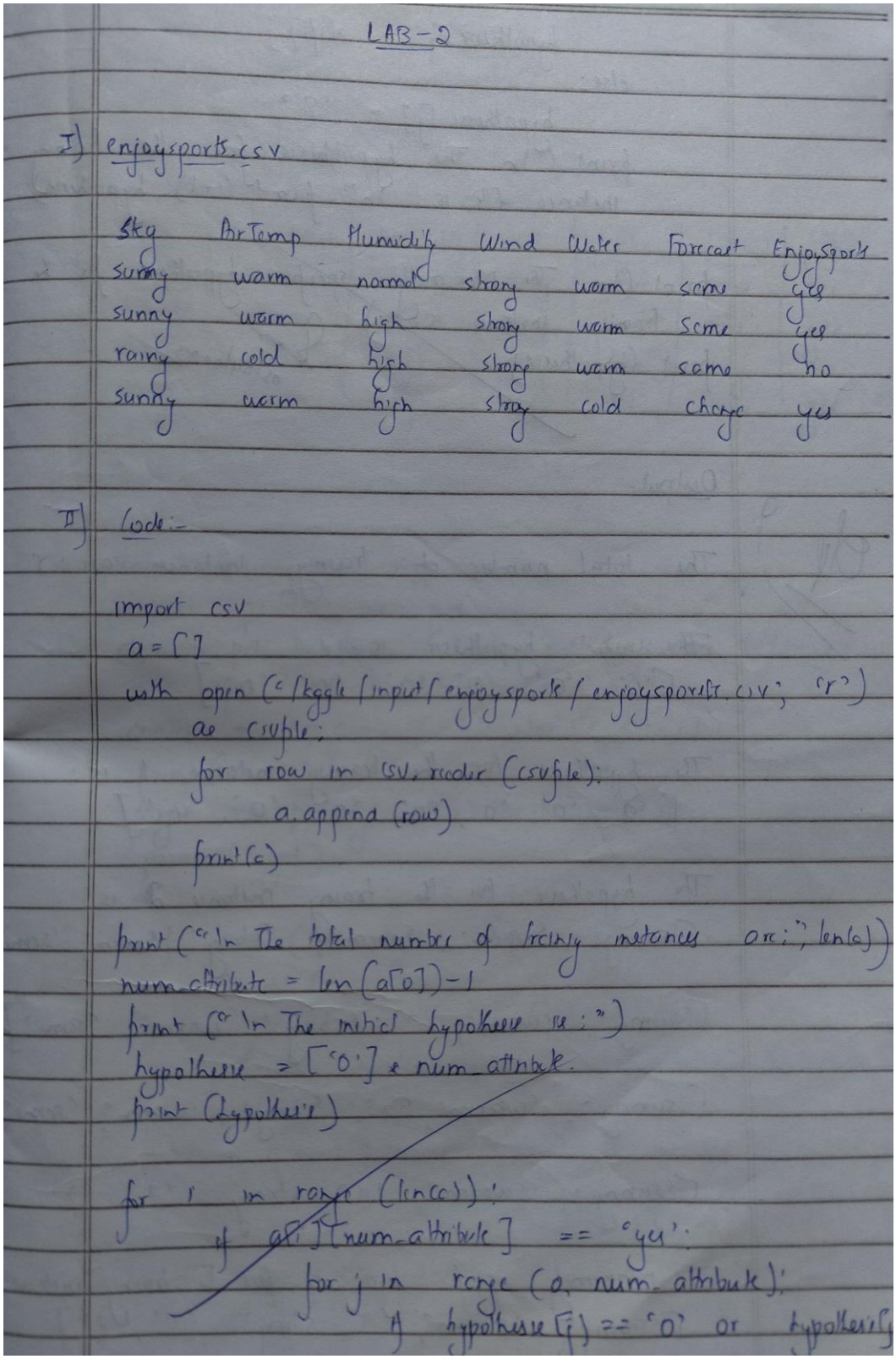
In [4]:
```
# Read from csv

import pandas as pd
import numpy as np

data = pd.read_csv("data.csv")
print(data)
x = np.array(data)[:,:-1]
y = np.array(data)[:,-1]
len_x = len(x)
print(x)
print(y)
```

```
   temp       time is_holiday  result
0   hot  afternoon        yes    True
1   hot    morning         no   False
2  cold  afternoon        yes    True
[['hot' 'afternoon' 'yes']
 ['hot' 'morning' 'no']
 ['cold' 'afternoon' 'yes']]
[True False True]
```

In [7]:
```
def findSAlgo(x, y, len_x):
    h = x[0] # initial generalization

    for i in range(1, len_x):
        if not y[i]:
            continue

        for j, attrib in enumerate(x[i]):
            if h[j] != attrib:
                h[j] = '?'

    return h
```

In [8]:
```
findSAlgo(x, y, len_x)
```

Out[8]:
```
array(['?', 'afternoon', 'yes'], dtype=object)
```



LAB-2

I) enjoysports.csv

Sky	AirTemp	Humidity	Wind	Water	Forecast	EnjoySport
sunny	warm	normal	strong	warm	same	yes
sunny	warm	high	strong	warm	same	yes
rainy	cold	high	strong	warm	same	no
sunny	warm	high	strong	cold	change	yes

II) Code:-

```
import csv
a=[]
with open('/kaggle/input/enjoysports/enjoysports.csv','r')
    as csvfile:
    for row in csv.reader(csvfile):
        a.append(row)
    print(a)

print("\n The total number of training instances are:",len(a))
num_attribute = len(a[0])-1
print("\n The initial hypothesis is:")
hypothesis = ['0']*num_attribute
print(hypothesis)

for i in range(len(a)):
    if a[i][num_attribute] == 'yes':
        for j in range(0, num_attribute):
            if hypothesis[j] == '0' or hypothesis
```

ALGORITHM:

```
        hypothesis[j] = a[i][j]
    else:
        hypothesis[j] = '?'
    print("\n The hypothesis for the training instance {} is: \n" format(i+1), hypothesis)

print("\n The Maximally specific hypothesis for the training instance is ")
print(hypothesis)
```

Output:

The total number of training instances are: 5

The initial hypothesis is:
['0', '0', '0', '0', '0', '0']

The hypothesis for the training instance 1 is:
['0', '0', '0', '0', '0', '0', '0']

The hypothesis for the training instance 2 is:
['sunny', 'warm', 'normal', 'strong', 'warm', 'same']

['sunny', 'warm', '?', 'strong', 'warm', 'same']

['sunny', 'warm', '?', 'strong', 'warm', 'same']

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

The Maximally specific hypothesis for the training instance is
['sunny', 'warm', '?', 'strong', '?', '?']

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

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

In [2]:
```
data = pd.read_csv('../input/enjoysport/enjoysport.csv')
X = data.to_numpy()[:, :-1]
y = data.to_numpy()[:, -1]
```

In [3]:
```
def candidateElimination(X, y):
    n_attrib = len(X[0])
    specific_h = ['0' for _ in range(n_attrib)]
    general_h = [['?' for _ in range(n_attrib)] for _ in range(n_attrib)]

    print('================ Iteration 0 ================')
    print(f'Specific Boundary: {specific_h}')
    print(f'General Boundary: {general_h}')
    print()

    specific_h = X[0].copy()

    for i, x in enumerate(X):
        print(f'================ Iteration {i + 1} ================')
        print(f'Instance {i + 1}: {x} \t Target: {y[i]}')

        if y[i] == 'yes':
            for j in range(n_attrib):
                if x[j] != specific_h[j]:
                    specific_h[j] = '?'
                    general_h[j][j] = '?'
        else:
            for j in range(n_attrib):
                if x[j] != specific_h[j]:
                    general_h[j][j] = specific_h[j]
                else:
                    general_h[j][j] = '?'

        print(f'Specific Boundary: {specific_h}')
        print(f'General Boundary: {general_h}')
        print()

    general_h = [h for h in general_h if h != ['?' for _ in range(n_attrib)]]

    print('================ Result ================')
    print(f'Specific Boundary: {specific_h}')
    print(f'General Boundary: {general_h}')
    print()

    return list(specific_h), list(general_h)
```

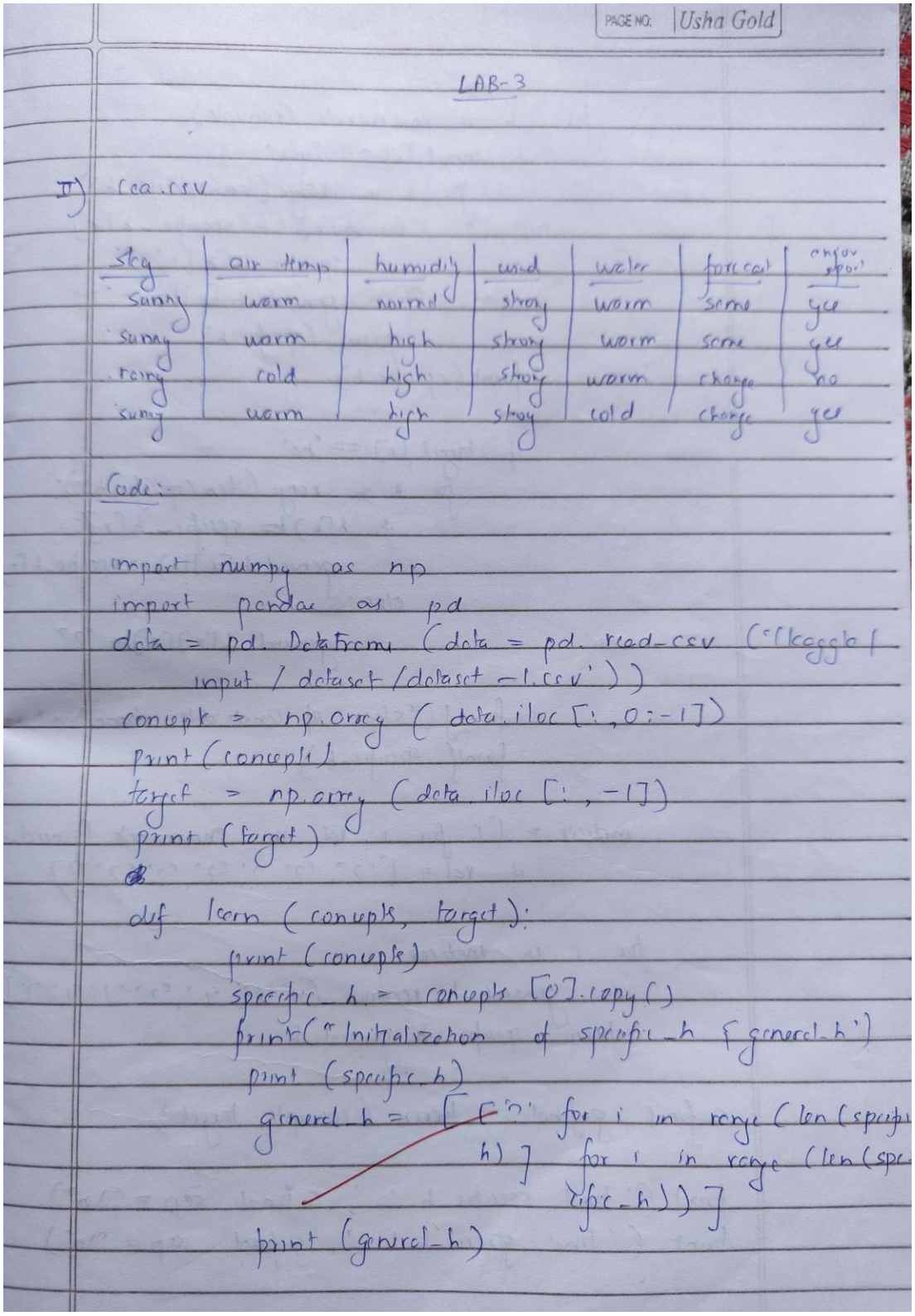
A

In [4]:
```
candidateElimination(X, y)
```

```
================ Iteration 0 ================
Specific Boundary: ['0', '0', '0', '0', '0', '0']
General Boundary: [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'],
['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

================ Iteration 1 ================
Instance 1: ['sunny' 'warm' 'normal' 'strong' 'warm' 'same']     Target: yes
Specific Boundary: ['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
General Boundary: [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'],
['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

================ Iteration 2 ================
Instance 2: ['sunny' 'warm' 'high' 'strong' 'warm' 'same']       Target: yes
Specific Boundary: ['sunny' 'warm' '?' 'strong' 'warm' 'same']
General Boundary: [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'],
['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

================ Iteration 3 ================
Instance 3: ['rainy' 'cold' 'high' 'strong' 'warm' 'change']     Target: no
Specific Boundary: ['sunny' 'warm' '?' 'strong' 'warm' 'same']
General Boundary: [['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?',
'?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]

================ Iteration 4 ================
Instance 4: ['sunny' 'warm' 'high' 'strong' 'cool' 'change']     Target: yes
Specific Boundary: ['sunny' 'warm' '?' 'strong' '?' '?']
General Boundary: [['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?',
'?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

================ Result ================
Specific Boundary: ['sunny' 'warm' '?' 'strong' '?' '?']
General Boundary: [['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']]
```

Out[4]:
```
(['sunny', 'warm', '?', 'strong', '?', '?'],
 [['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']])
```

ALGORITHM:



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LAB-3

II) cca.csv

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

Code:-

```
import numpy as np
import pandas as pd
data = pd.DataFrame(data = pd.read_csv('/kaggle/
    input/dataset/dataset_1.csv'))
concepts = np.array(data.iloc[:,0:-1])
print(concepts)
target = np.array(data.iloc[:,-1])
print(target)

def learn(concepts, target):
    print(concepts)
    specific_h = concepts[0].copy()
    print("Initialization of specific_h & general_h")
    print(specific_h)
    general_h = [["?" for i in range(len(specific_
    h))] for i in range(len(spec
    ific_h))]
    print(general_h)
```

```
for i,h in enumerate(conuple):
    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", i+1)
    print(specific_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(conuple, target)

print("Final specific_h: ", s_final, sep="\n")
print("Final general_h: ", g_final, sep="\n")
```

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

In [62]:
```
import numpy as np
import pandas as pd
eps = np.finfo(float).eps
from numpy import log2 as log
```

In [63]:
```
df = pd.read_csv('../input/playtennis/playtennis.csv')
df
```

Out[63]:

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

In [64]:
```
def find_entropy(df):
    Class = df.keys()[-1]
    entropy = 0
    values = df[Class].unique()
    for value in values:
        fraction = df[Class].value_counts()[value]/len(df[Class])
        entropy += -fraction*np.log2(fraction)
    return entropy

def find_entropy_attribute(df,attribute):
    Class = df.keys()[-1]
    target_variables = df[Class].unique()
    variables = df[attribute].unique()
    entropy2 = 0
    for variable in variables:
        entropy = 0
        for target_variable in target_variables:
            num = len(df[attribute][df[attribute]==variable][df[Class] ==target_variable])
            den = len(df[attribute][df[attribute]==variable])
```

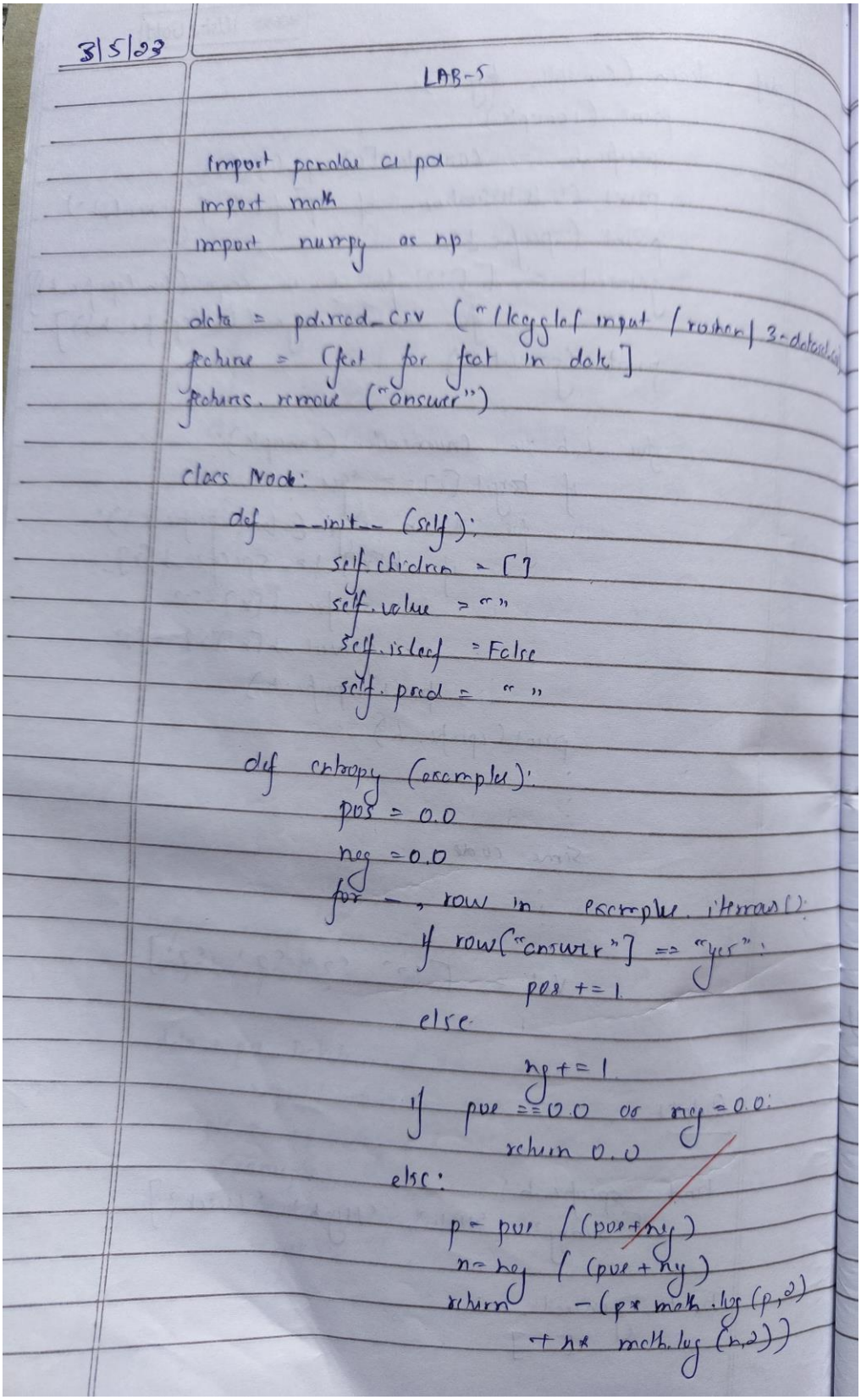
```
            fraction = num/(den+eps)
            entropy += -fraction*log(fraction+eps)
        fraction2 = den/len(df)
        entropy2 += -fraction2*entropy
    return abs(entropy2)


def find_winner(df):
    Entropy_att = []
    IG = []
    for key in df.keys()[:-1]:
        IG.append(find_entropy(df)-find_entropy_attribute(df,key))
    return df.keys()[:-1][np.argmax(IG)]

def get_subtable(df, node,value):
    return df[df[node] == value].reset_index(drop=True)

def buildTree(df,tree=None):
    Class = df.keys()[-1]
    node = find_winner(df)
    attValue = np.unique(df[node])
    if tree is None:
        tree={}
        tree[node] = {}

    for value in attValue:

        subtable = get_subtable(df,node,value)
        clValue,counts = np.unique(subtable['play'],return_counts=True)

        if len(counts)==1:
            tree[node][value] = clValue[0]
        else:
            tree[node][value] = buildTree(subtable)

    return tree
```

In [65]:
```
t = buildTree(df)
t
```

Out[65]:
```
{'outlook': {'overcast': 'yes',
  'rain': {'wind': {'strong': 'no', 'weak': 'yes'}},
  'sunny': {'humidity': {'high': 'no', 'normal': 'yes'}}}}
```

In [ ]:

ALGORITHM:



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LAB-5

```
import pandas as pd
import math
import numpy as np

data = pd.read_csv ("/leggs/of input /rohan/ 3-dataset.csv")
feature = [feat for feat in data]
features.remove ("answer")

class Node:
    def __init__ (self):
        self.children = []
        self.value = ""
        self.isleaf = False
        self.pred = ""

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

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```
def learn (conuple, target):
    print (conuple)
    specific_h = conuple [0].copy ()
    print ("Initialization of specific_h & general_h")
    print (specific_h)
    general = [['?' for i in range (len (specific_h))]
               for i in range (len (specific_h))]
    print (general_h)

    for i, h in enumerate (conuple):
        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)
        :
        :
    Some code
        :
        :
    Val = ['?', '?', '?', '?']
```

Output:

Final specific_h:
['sunny', 'Hot', 'High', 'Weak']

Final general_h:
[ ]

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

In [1]:
```
import csv
import random
import math
```

In [2]:
```
def load_csv(filename):
    lines = csv.reader(open(filename, "r"));
    dataset = list(lines)
    for i in range(len(dataset)):
        dataset[i] = [float(x) for x in dataset[i]]
    return dataset

def split_dataset(dataset, splitratio):
    trainsize = int(len(dataset) * splitratio);
    trainset = []
    copy = list(dataset);
    while len(trainset) < trainsize:
        index = random.randrange(len(copy));
        trainset.append(copy.pop(index))
    return [trainset, copy]

def separate_by_class(dataset):
    separated = {}
    for i in range(len(dataset)):
        vector = dataset[i]
        if (vector[-1] not in separated):
            separated[vector[-1]] = []
        separated[vector[-1]].append(vector)
    return separated

def mean(numbers):
    return sum(numbers)/float(len(numbers))

def std_dev(numbers):
    avg = mean(numbers)
    variance = sum([pow(x-avg,2) for x in numbers])/float(len(numbers)-1)
    return math.sqrt(variance)

def summarize(dataset):
    summaries = [(mean(attribute), std_dev(attribute)) for attribute in zip(*dataset)];
    del summaries[-1]
    return summaries

def summarize_by_class(dataset):
    separated = separate_by_class(dataset);
    summaries = {}
    for classvalue, instances in separated.items():
        summaries[classvalue] = summarize(instances)
    return summaries

def calculate_probability(x, mean, stdev):
    exponent = math.exp(-(math.pow(x-mean,2)/(2*math.pow(stdev,2))))
    return (1 / (math.sqrt(2*math.pi) * stdev)) * exponent

def calculate_class_probabilities(summaries, inputvector):
    probabilities = {}
```

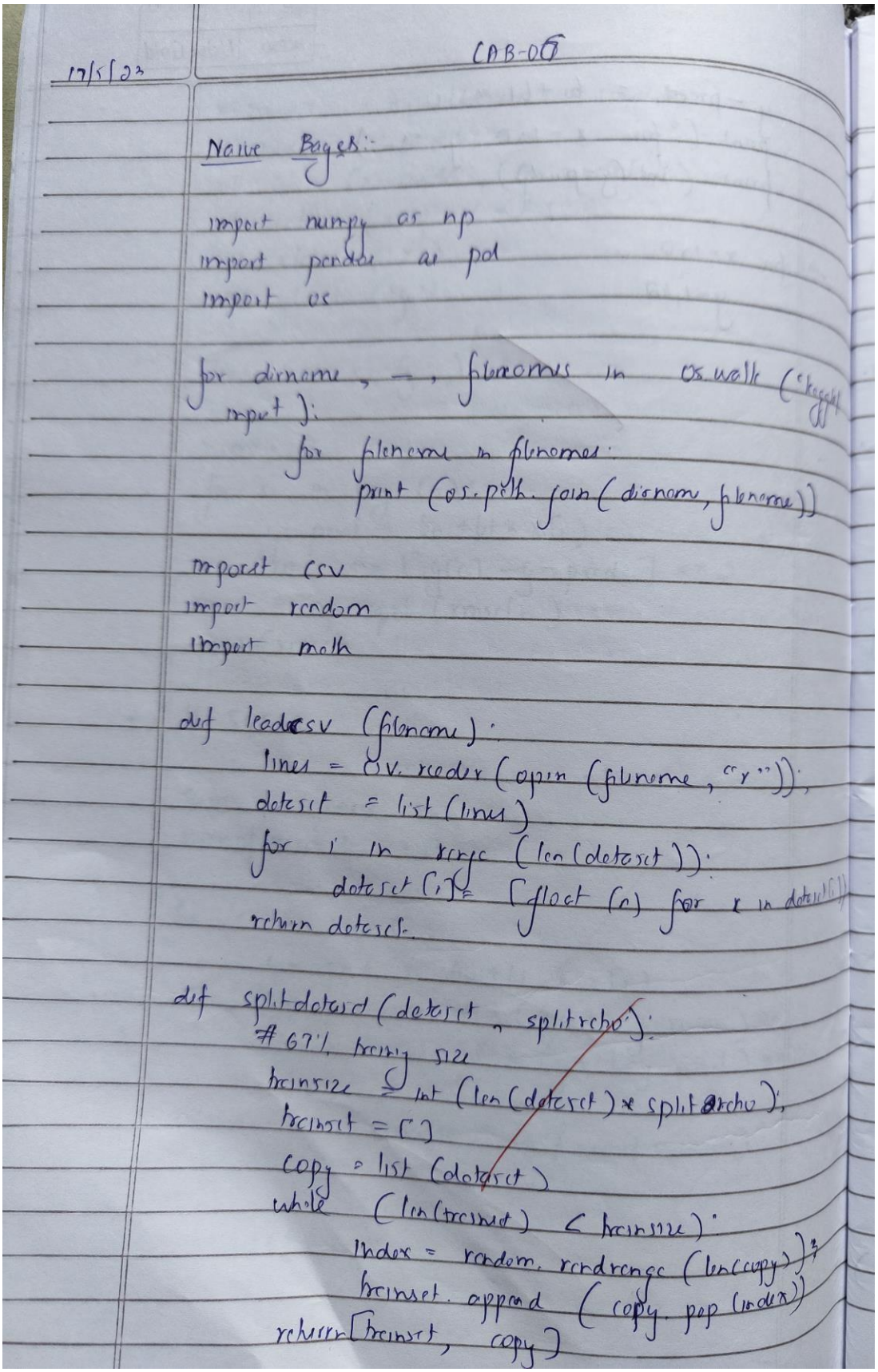
```
    for classvalue, classsummaries in summaries.items():
        probabilities[classvalue] = 1
    for i in range(len(classsummaries)):
        mean, stdev = classsummaries[i]
        x = inputvector[i]
        probabilities[classvalue] *= calculate_probability(x, mean, stdev)
    return probabilities

def predict(summaries, inputvector):
    probabilities = calculate_class_probabilities(summaries, inputvector)
    bestLabel, bestProb = None, -1
    for classvalue, probability in probabilities.items():
        if bestLabel is None or probability > bestProb:
            bestProb = probability
            bestLabel = classvalue
    return bestLabel

def get_predictions(summaries, testset):
    predictions = []
    for i in range(len(testset)):
        result = predict(summaries, testset[i])
        predictions.append(result)
    return predictions

def get_accuracy(testset, predictions):
    correct = 0
    for i in range(len(testset)):
        if testset[i][-1] == predictions[i]:
            correct += 1
    return (correct/float(len(testset))) * 100.0
```

In [3]:
```
splitratio = 0.67
dataset = load_csv('../input/pimaindiansdiabetescsv/pima-indians-diabetes.csv');

trainingset, testset = split_dataset(dataset, splitratio)

print(f'Split {len(dataset)} rows into train={len(trainingset)} and test={len(testset)} rows')

summaries = summarize_by_class(trainingset);
predictions = get_predictions(summaries, testset)
accuracy = get_accuracy(testset, predictions)

print(f'Accuracy of the classifier is :{accuracy}%')
```

```
Split 768 rows into train=514 and test=254 rows
Accuracy of the classifier is :64.96062992125984%
```

In [ ]:

ALGORITHM:



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CAB-06

Naive Bayes:

```
import numpy as np
import pandas as pd
import os

for dirname, _, filenames in os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))

import csv
import random
import math

def loadcsv(filename):
    lines = csv.reader(open(filename, "r"));
    dataset = list(lines)
    for i in range(len(dataset)):
        dataset[i] = [float(x) for x in dataset[i]]
    return dataset

def splitdataset(dataset, splitratio):
    #67% training size
    trainsize = int(len(dataset) * splitratio);
    trainset = []
    copy = list(dataset)
    while (len(trainset) < trainsize):
        index = random.randrange(len(copy));
        trainset.append(copy.pop(index))
    return [trainset, copy]
```

3-dataset.csv

outlook	temperature	humidity	wind	answer
sunny	hot	high	week	no
sunny	hot	high	strong	no
overcast	hot	high	week	yes
rain	mild	high	week	yes
rain	cool	normal	week	yes
rain	cool	normal	strong	no
overcast	cool	normal	strong	yes
sunny	mild	high	week	no
sunny	cool	normal	week	yes
rain	mild	normal	week	yes
sunny	mild	normal	strong	yes
overcast	mild	high	strong	yes
overcast	hot	normal	week	yes
rain	mild	high	strong	no

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Program 5: Write a program to construct a Bayesian network considering training data. Use this model to make predictions.

In [1]:
```
import numpy as np
import pandas as pd
import csv
!pip install pgmpy
from pgmpy.estimators import MaximumLikelihoodEstimator
from pgmpy.models import BayesianModel
from pgmpy.inference import VariableElimination
```

```
Collecting pgmpy
  Downloading pgmpy-0.1.14-py3-none-any.whl (331 kB)
     |████████████████████████████████| 331 kB 3.0 MB/s
Requirement already satisfied: pandas in /opt/conda/lib/python3.7/site-packages (from pgmpy) (1.2.3)
Requirement already satisfied: scikit-learn in /opt/conda/lib/python3.7/site-packages (from pgmpy) (0.24.1)
Requirement already satisfied: scipy in /opt/conda/lib/python3.7/site-packages (from pgmpy) (1.5.4)
Requirement already satisfied: torch in /opt/conda/lib/python3.7/site-packages (from pgmpy) (1.7.0)
Requirement already satisfied: tqdm in /opt/conda/lib/python3.7/site-packages (from pgmpy) (4.59.0)
Requirement already satisfied: joblib in /opt/conda/lib/python3.7/site-packages (from pgmpy) (1.0.1)
Requirement already satisfied: pyparsing in /opt/conda/lib/python3.7/site-packages (from pgmpy) (2.4.7)
Requirement already satisfied: statsmodels in /opt/conda/lib/python3.7/site-packages (from pgmpy) (0.12.2)
Requirement already satisfied: networkx in /opt/conda/lib/python3.7/site-packages (from pgmpy) (2.5)
Requirement already satisfied: numpy in /opt/conda/lib/python3.7/site-packages (from pgmpy) (1.19.5)
Requirement already satisfied: decorator>=4.3.0 in /opt/conda/lib/python3.7/site-packages (from networkx->pgmpy) (4.4.
2)
Requirement already satisfied: python-dateutil>=2.7.3 in /opt/conda/lib/python3.7/site-packages (from pandas->pgmpy)
(2.8.1)
Requirement already satisfied: pytz>=2017.3 in /opt/conda/lib/python3.7/site-packages (from pandas->pgmpy) (2021.1)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.7/site-packages (from python-dateutil>=2.7.3->pandas
->pgmpy) (1.15.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /opt/conda/lib/python3.7/site-packages (from scikit-learn->pgmp
y) (2.1.0)
Requirement already satisfied: patsy>=0.5 in /opt/conda/lib/python3.7/site-packages (from statsmodels->pgmpy) (0.5.1)
Requirement already satisfied: future in /opt/conda/lib/python3.7/site-packages (from torch->pgmpy) (0.18.2)
Requirement already satisfied: typing_extensions in /opt/conda/lib/python3.7/site-packages (from torch->pgmpy) (3.7.4.
3)
Requirement already satisfied: dataclasses in /opt/conda/lib/python3.7/site-packages (from torch->pgmpy) (0.6)
Installing collected packages: pgmpy
Successfully installed pgmpy-0.1.14
```

In [2]:
```
heartDisease = pd.read_csv('../input/heartdisease/heart.csv')
heartDisease = heartDisease.replace('?',np.nan)

print('Sample instances from the dataset are given below')
print(heartDisease.head())
print('\n Attributes and datatypes')
print(heartDisease.dtypes)
```

```
Sample instances from the dataset are given below
   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
```

In [3]:
```
model = BayesianModel([('age','heartdisease'),('sex','heartdisease'),('exang','heartdisease'),('cp','heartdisease'),
('heartdisease','restecg'),('heartdisease','chol')])
```

In [4]:
```
print('\nLearning CPD using Maximum likelihood estimators')
model.fit(heartDisease,estimator=MaximumLikelihoodEstimator)

print('\nInferencing with Bayesian Network:')
HeartDiseasetest_infer = VariableElimination(model)
```

```
Learning CPD using Maximum likelihood estimators

Inferencing with Bayesian Network:
```

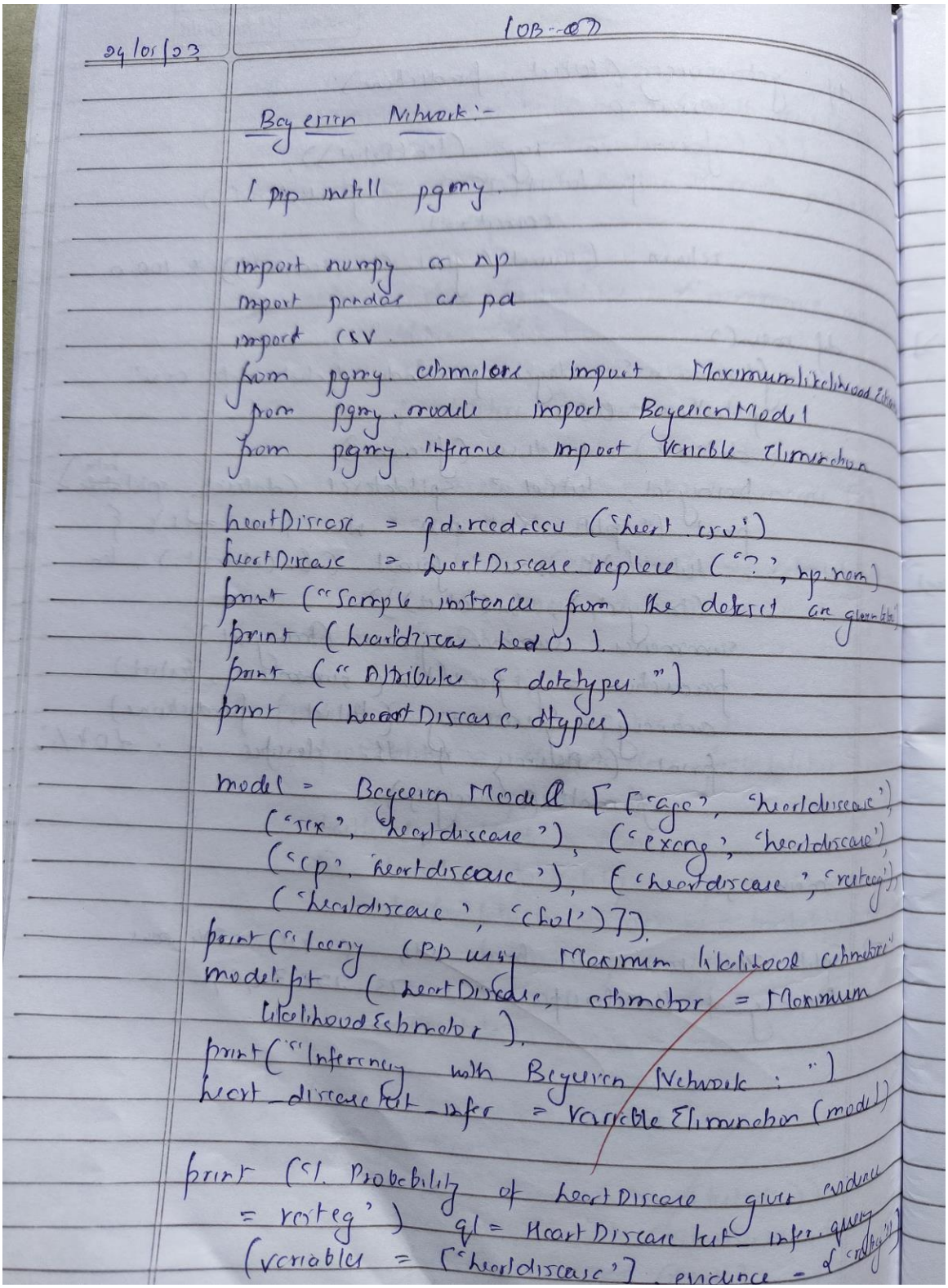
In [5]:
```
print('\n1.Probability of HeartDisease given evidence = restecg :')
q1=HeartDiseasetest_infer.query(variables=['heartdisease'],evidence={'restecg':1})
print(q1)

print('\n2.Probability of HeartDisease given evidence = cp :')
q2=HeartDiseasetest_infer.query(variables=['heartdisease'],evidence={'cp':2})
print(q2)
```

```
Finding Elimination Order: :   0%|          | 0/5 [00:00<?, ?it/s]
  0%|          | 0/5 [00:00<?, ?it/s]
Finding Elimination Order: : 100%|██████████| 5/5 [00:00<00:00, 480.98it/s]

Eliminating: age:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: sex:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: chol:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: exang: 100%|██████████| 5/5 [00:00<00:00, 92.85it/s]
```

```
1.Probability of HeartDisease given evidence = restecg :
+-----------------+---------------------+
| heartdisease    |   phi(heartdisease) |
+=================+=====================+
| heartdisease(0) |              0.1012 |
+-----------------+---------------------+
| heartdisease(1) |              0.0000 |
+-----------------+---------------------+
| heartdisease(2) |              0.2392 |
+-----------------+---------------------+
| heartdisease(3) |              0.2015 |
+-----------------+---------------------+
| heartdisease(4) |              0.4581 |
+-----------------+---------------------+

2.Probability of HeartDisease given evidence = cp :
Finding Elimination Order: :   0%|          | 0/5 [00:00<?, ?it/s]
  0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: age:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: sex:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: chol:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: exang:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: restecg: 100%|██████████| 5/5 [00:00<00:00, 227.41it/s]
+-----------------+---------------------+
| heartdisease    |   phi(heartdisease) |
+=================+=====================+
| heartdisease(0) |              0.3610 |
+-----------------+---------------------+
| heartdisease(1) |              0.2159 |
+-----------------+---------------------+
| heartdisease(2) |              0.1373 |
+-----------------+---------------------+
| heartdisease(3) |              0.1537 |
+-----------------+---------------------+
| heartdisease(4) |              0.1321 |
+-----------------+---------------------+
```

In [ ]:

ALGORITHM:



24/01/23 LOB-07

Bayesian Network:-

! pip install pgmpy

```
import numpy as np
import pandas as pd
import csv
from pgmpy.estimators import MaximumLikelihoodEstimator
from pgmpy.models import BayesianModel
from pgmpy.inference import VariableElimination

heartDisease = pd.read_csv('heart.csv')
heartDisease = heartDisease.replace('?', np.nan)
print("Sample instances from the dataset are given below")
print(heartDisease.head())
print("Attributes & datatypes")
print(heartDisease.dtypes)

model = BayesianModel([['age', 'heartdisease'],
    ('sex', 'heartdisease'), ('exang', 'heartdisease'),
    ('cp', 'heartdisease'), ('heartdisease', 'restecg'),
    ('heartdisease', 'chol')])
print("Learning CPD using Maximum likelihood estimators")
model.fit(heartDisease, estimator = MaximumLikelihoodEstimator)
print("Inferencing with Bayesian Network:")
heart_disease_test_infer = VariableElimination(model)

print("1. Probability of HeartDisease given evidence
    = restecg")
q1 = heart_disease_test_infer.query(
    variables = ['heartdisease'], evidence = {'restecg':1})
```

```
print ('q')

print ('2: Probability of heartdisease given evidence = cp')
q2 = HeartDisease1.query(variables = ['heartdisease'],
     evidence = {'cp': 2})
print (q2)
```

→ Output:-

Simple instances from dataset

Attributes & datatypes

Learning CPD using Maximum likelihood estimators

Inferencing with Bayesian Network:

1) Probability of HeartDisease given evidence = restecg

heartdisease	phi(heartdisease)
heartdisease(0)	0.1012
heartdisease(1)	0.000
heartdisease(2)	0.2392
heartdisease(3)	0.2015
heartdisease(4)	0.4581

2) Probability of heartdisease given evidence = cp

heartdisease	phi(heartdisease)
(0)	0.3610
(1)	0.2159
(2)	0.1373
(3)	0.1537
(4)	0.1821

Program 6: Apply k-Means algorithm to cluster a set of data stored in a .CSV file.

In [1]:
```
from sklearn import datasets
import matplotlib.pyplot as plt
import pandas as pd
from sklearn.cluster import KMeans
from sklearn.metrics import accuracy_score, confusion_matrix
```

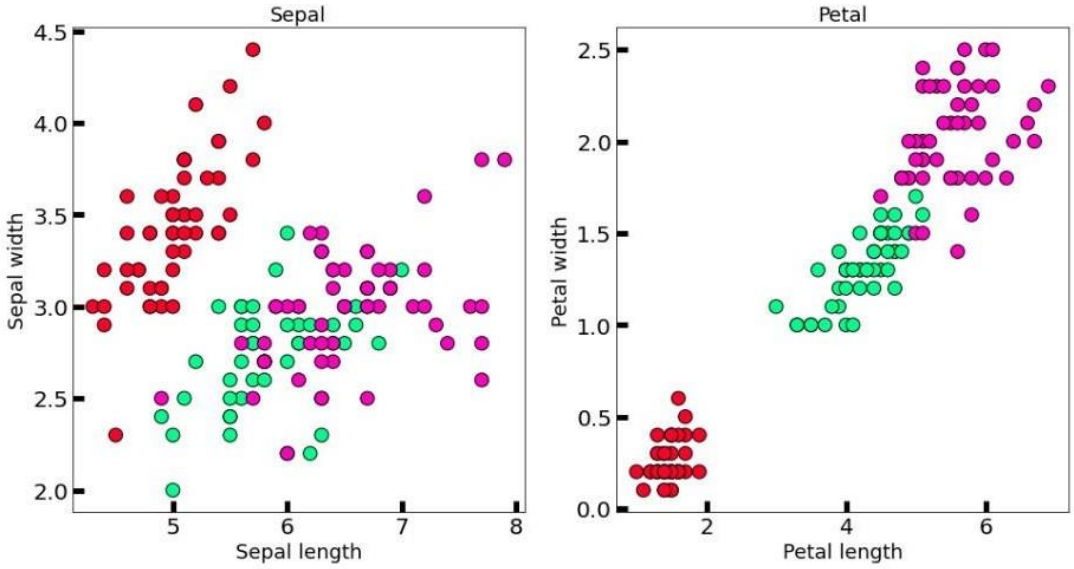
Dataset

In [2]:
```
iris = datasets.load_iris()
iris
```

Out[2]:
```
{'data': array([[5.1, 3.5, 1.4, 0.2],
        [4.9, 3. , 1.4, 0.2],
        [4.7, 3.2, 1.3, 0.2],
        [4.6, 3.1, 1.5, 0.2],
        [5. , 3.6, 1.4, 0.2],
        [5.4, 3.9, 1.7, 0.4],
        [4.6, 3.4, 1.4, 0.3],
        [5. , 3.4, 1.5, 0.2],
        [4.4, 2.9, 1.4, 0.2],
        [4.9, 3.1, 1.5, 0.1],
        [5.4, 3.7, 1.5, 0.2],
        [4.8, 3.4, 1.6, 0.2],
        [4.8, 3. , 1.4, 0.1],
        [4.3, 3. , 1.1, 0.1],
        [5.8, 4. , 1.2, 0.2],
        [5.7, 4.4, 1.5, 0.4],
        [5.4, 3.9, 1.3, 0.4],
        [5.1, 3.5, 1.4, 0.3],
        [5.7, 3.8, 1.7, 0.3],
        [5.1, 3.8, 1.5, 0.3],
        [5.4, 3.4, 1.7, 0.2],
        [5.1, 3.7, 1.5, 0.4],
        [4.6, 3.6, 1. , 0.2],
        [5.1, 3.3, 1.7, 0.5],
        [4.8, 3.4, 1.9, 0.2],
        [5. , 3. , 1.6, 0.2],
        [5. , 3.4, 1.6, 0.4],
        [5.2, 3.5, 1.5, 0.2],
        [5.2, 3.4, 1.4, 0.2],
        [4.7, 3.2, 1.6, 0.2],
        [4.8, 3.1, 1.6, 0.2],
        [5.4, 3.4, 1.5, 0.4],
        [5.2, 4.1, 1.5, 0.1],
        [5.5, 4.2, 1.4, 0.2],
        [4.9, 3.1, 1.5, 0.2],
        [5. , 3.2, 1.2, 0.2],
        [5.5, 3.5, 1.3, 0.2],
        [4.9, 3.6, 1.4, 0.1],
        [4.4, 3. , 1.3, 0.2],
        [5.1, 3.4, 1.5, 0.2],
```

```
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
       2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
       2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2]),
 'frame': None,
 'target_names': array(['setosa', 'versicolor', 'virginica'], dtype='<U10'),
 'DESCR': '.. _iris_dataset:\n\nIris plants dataset\n--------------------\n\n**Data Set Characteristics:**\n\n    :Number of Instances: 150 (50 in each of three classes)\n    :Number of Attributes: 4 numeric, predictive attributes and the class\n    :Attribute Information:\n        - sepal length in cm\n        - sepal width in cm\n        - petal length in cm\n        - petal width in cm\n        - class:\n                - Iris-Setosa\n                - Iris-Versicolour\n                - Iris-Virginica\n                \n    :Summary Statistics:\n\n    ============== ==== ==== ======= ===== ====================\n                    Min  Max   Mean    SD   Class Correlation\n    ============== ==== ==== ======= ===== ====================\n    sepal length:   4.3  7.9   5.84   0.83    0.7826\n    sepal width:    2.0  4.4   3.05   0.43   -0.4194\n    petal length:   1.0  6.9   3.76   1.76    0.9490  (high!)\n    petal width:    0.1  2.5   1.20   0.76    0.9565  (high!)\n    ============== ==== ==== ======= ===== ====================\n\n    :Missing Attribute Values: None\n    :Class Distribution: 33.3% for each of 3 classes.\n    :Creator: R.A. Fisher\n    :Donor: Michael Marshall (MARSHALL%PLU@io.arc.nasa.gov)\n    :Date: July, 1988\n\nThe famous Iris database, first used by Sir R.A. Fisher. The dataset is taken\nfrom Fisher\'s paper. Note that it\'s the same as in R, but not as in the UCI\nMachine Learning Repository, which has two wrong data points.\n\nThis is perhaps the best known database to be found in the\npattern recognition literature.  Fisher\'s paper is a classic in the field and\nis referenced frequently to this day.  (See Duda & Hart, for example.)  The\ndata set contains 3 classes of 50 instances each, where each class refers to a\ntype of iris plant.  One class is linearly separable from the other 2; the\nlatter are NOT linearly separable from each other.\n\n.. topic:: References\n\n   - Fisher, R.A. "The use of multiple measurements in taxonomic problems"\n     Annual Eugenics, 7, Part II, 179-188 (1936); also in "Contributions to\n     Mathematical Statistics" (John Wiley, NY, 1950).\n   - Duda, R.O., & Hart, P.E. (1973) Pattern Classification and Scene Analysis.\n     (Q327.D83) John Wiley & Sons.  ISBN 0-471-22361-1.  See page 218.\n   - Dasarathy, B.V. (1980) "Nosing Around the Neighborhood: A New System\n     Structure and Classification Rule for Recognition in Partially Exposed\n     Environments".  IEEE Transactions on Pattern Analysis and Machine\n     Intelligence, Vol. PAMI-2, No. 1, 67-71.\n   - Gates, G.W. (1972) "The Reduced Nearest Neighbor Rule".  IEEE Transactions\n     on Information Theory, May 1972, 431-433.\n   - See also: 1988 MLC Proceedings, 54-64.  Cheeseman et al"s AUTOCLASS II\n     conceptual clustering system finds 3 classes in the data.\n   - Many, many more ...',
 'feature_names': ['sepal length (cm)',
  'sepal width (cm)',
  'petal length (cm)',
  'petal width (cm)'],
 'filename': '/opt/conda/lib/python3.7/site-packages/sklearn/datasets/data/iris.csv'}
```

In [3]:
```
sepal_X = iris.data[:, :2]
petal_X = iris.data[:, 2:]
y = iris.target
categories = len(iris.target_names)

fig, axes = plt.subplots(1, 2, figsize=(16,8))
axes[0].scatter(sepal_X[:, 0], sepal_X[:, 1], c=y, cmap='gist_rainbow', edgecolor='k', s=150)
axes[1].scatter(petal_X[:, 0], petal_X[:, 1], c=y, cmap='gist_rainbow', edgecolor='k', s=150)
axes[0].set_xlabel('Sepal length', fontsize=18)
axes[0].set_ylabel('Sepal width', fontsize=18)
axes[1].set_xlabel('Petal length', fontsize=18)
axes[1].set_ylabel('Petal width', fontsize=18)
axes[0].tick_params(direction='in', length=10, width=5, colors='k', labelsize=20)
axes[1].tick_params(direction='in', length=10, width=5, colors='k', labelsize=20)
axes[0].set_title('Sepal', fontsize=18)
axes[1].set_title('Petal', fontsize=18)
plt.show()
```



Model

In [4]:
```
model_sepal = KMeans(n_clusters=3)
model_sepal.fit(sepal_X)
model_petal = KMeans(n_clusters=3)
model_petal.fit(petal_X)
```

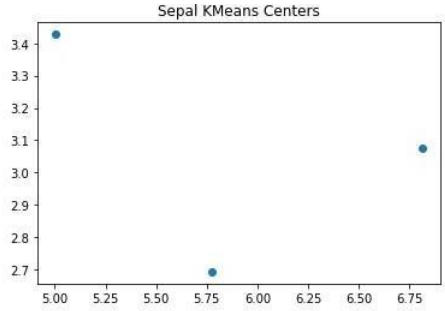
Out[4]:
```
KMeans(n_clusters=3)
```

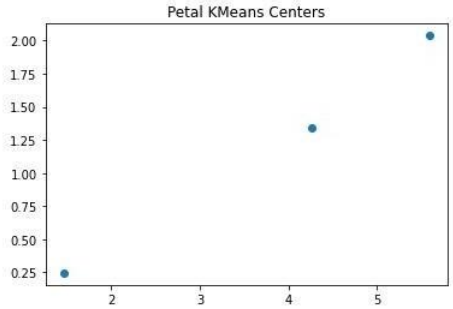
Analysis

In [5]:
```
def plot_centers(sepal_centers, petal_centers):
    plt.scatter([point[0] for point in sepal_centers], [point[1] for point in sepal_centers])
    plt.title('Sepal KMeans Centers')
    plt.show()
```

```
    plt.title( 'Petal KMeans Centers' )
    plt.show()

def plot_actualvpredicted(X, y, predicted, part):
    fig, axes = plt.subplots(1, 2, figsize=(16,8))
    axes[0].scatter(X[:, 0], X[:, 1], c=y, cmap='gist_rainbow', edgecolor='k', s=150)
    axes[1].scatter(X[:, 0], X[:, 1], c=predicted, cmap='jet', edgecolor='k', s=150)
    axes[0].set_xlabel(f'{part} length', fontsize=18)
    axes[0].set_ylabel(f'{part} width', fontsize=18)
    axes[1].set_xlabel(f'{part} length', fontsize=18)
    axes[1].set_ylabel(f'{part} width', fontsize=18)
    axes[0].tick_params(direction='in', length=10, width=5, colors='k', labelsize=20)
    axes[1].tick_params(direction='in', length=10, width=5, colors='k', labelsize=20)
    axes[0].set_title('Actual', fontsize=18)
    axes[1].set_title('Predicted', fontsize=18)
    plt.show()

def plot_confusion(accuracy, confusion, part):
    print(f'{part} Accuracy: {accuracy}')

    fig, ax = plt.subplots()
    im = ax.imshow(confusion)

    ax.set_xticks(range(categories))
    ax.set_yticks(range(categories))
    ax.set_xticklabels(iris.target_names)
    ax.set_yticklabels(iris.target_names)

    plt.setp(ax.get_xticklabels(), rotation=45, ha="right",
             rotation_mode="anchor")

    for i in range(categories):
        for j in range(categories):
            text = ax.text(j, i, confusion[i, j],
                           ha="center", va="center", color="w")

    ax.set_title(f"{part} Confusion Matrix (Actual / Predicted)")
    fig.tight_layout()
    plt.show()
```

In [6]:
```
sepal_centers = model_sepal.cluster_centers_
petal_centers = model_petal.cluster_centers_
plot_centers(sepal_centers, petal_centers)
```

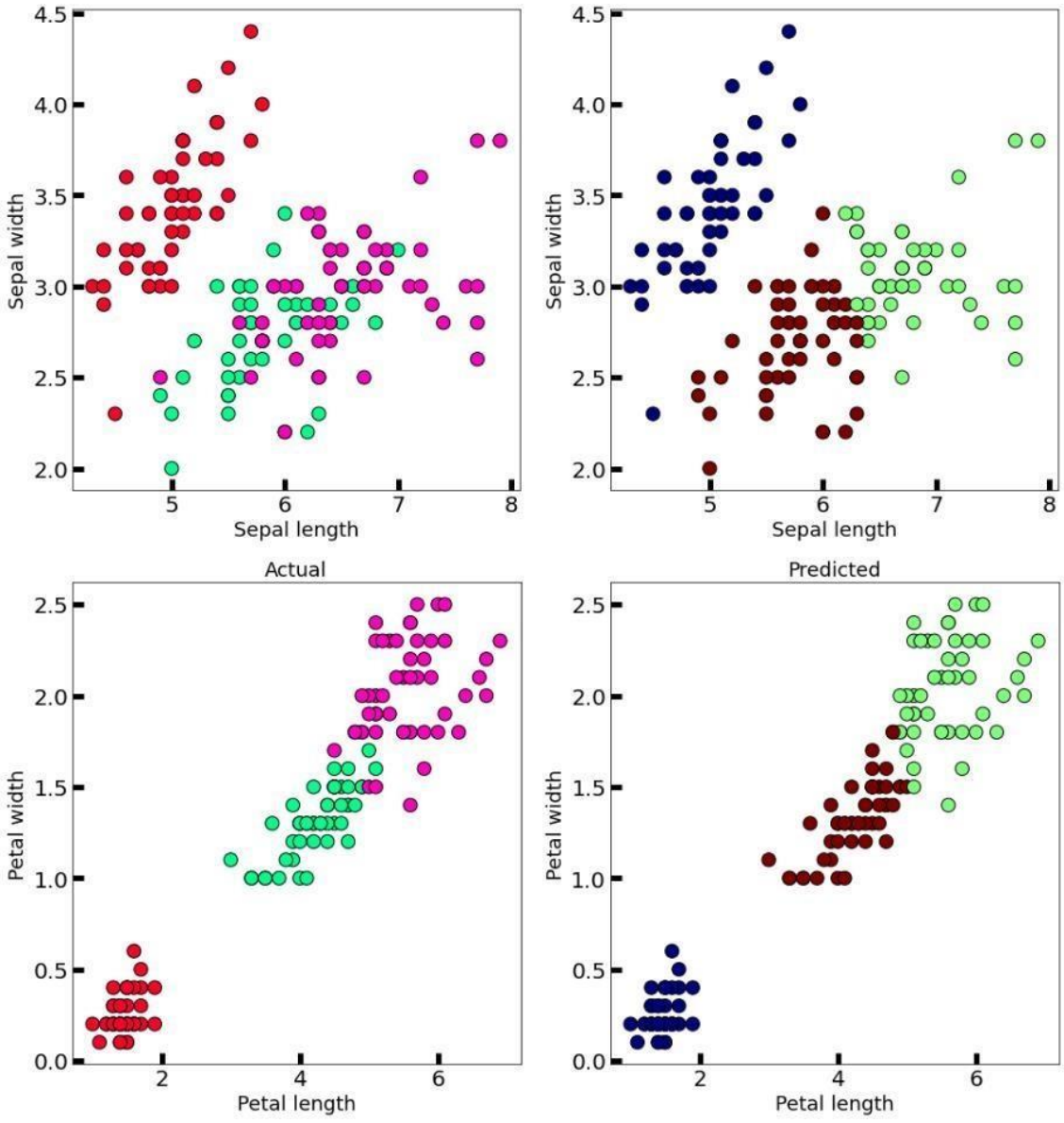




In [7]:
```
sepal_labels = model_sepal.labels_
petal_labels = model_petal.labels_
print(sepal_labels, petal_labels, sep='\n')
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 2 1 2 1 2 1 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2
 1 1 1 1 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 1 2 1 1 1 1 2 1 1 1 1
 1 1 2 2 1 1 1 1 2 1 2 1 2 1 1 2 2 1 1 1 1 1 2 2 1 1 1 2 1 1 1 2 1 1 1 2 1
 1 2]
[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 2 2 2 1 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 1 1 1 1 1 2 1 1 1 1
 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1
 1 1]
```

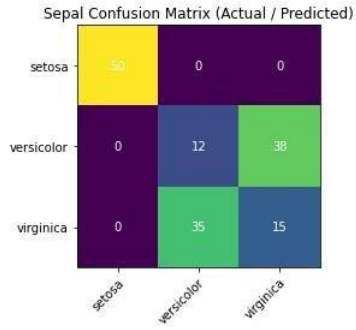
In [8]:
```
plot_actualvpredicted(sepal_X, y, sepal_labels, 'Sepal')
plot_actualvpredicted(petal_X, y, petal_labels, 'Petal')
```


Sepal width
Sepal length
Sepal width
Sepal length
Actual
Petal width
Petal length
Predicted
Petal width
Petal length

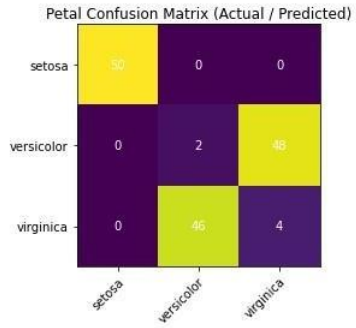
In [9]:
```
sepal_accuracy = accuracy_score(y, sepal_labels)
petal_accuracy = accuracy_score(y, petal_labels)

sepal_confusion = confusion_matrix(y, sepal_labels)
petal_confusion = confusion_matrix(y, petal_labels)
```

In [10]:
```
plot_confusion(sepal_accuracy, sepal_confusion, 'Sepal')
plot_confusion(petal_accuracy, petal_confusion, 'Petal')
```

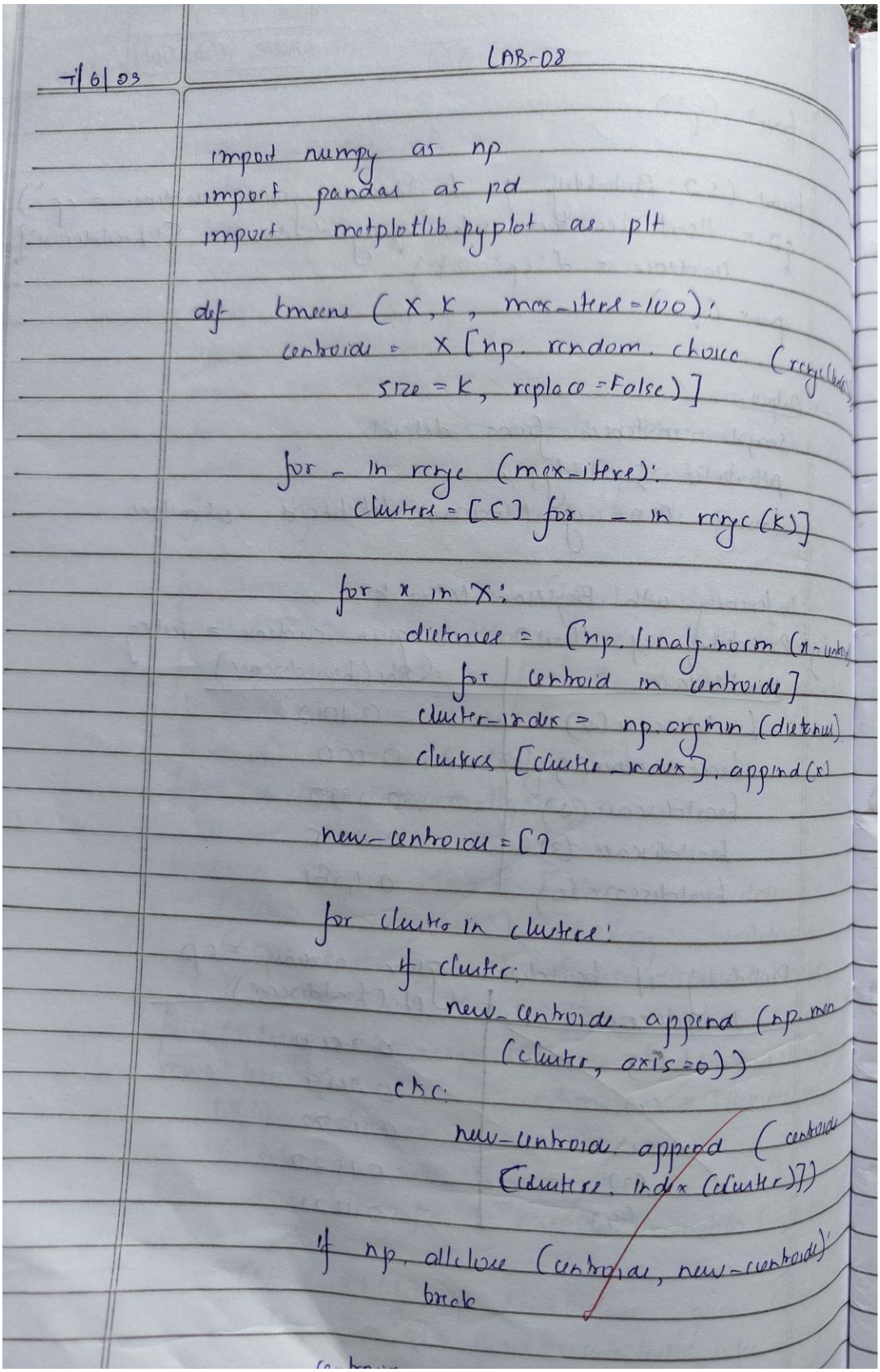
```
Sepal Accuracy: 0.5133333333333333
```




```
Petal Accuracy: 0.37333333333333335
```



ALGORITHM:



7/6/03

LAB-08

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

def kmeans(X, k, max_iters=100):
    centroids = X[np.random.choice(range(len(X)),
                size=k, replace=False)]

    for _ in range(max_iters):
        clusters = [[] for _ in range(k)]

        for x in X:
            distances = [np.linalg.norm(x - centroid)
                         for centroid in centroids]
            cluster_index = np.argmin(distances)
            clusters[cluster_index].append(x)

        new_centroids = []

        for cluster in clusters:
            if cluster:
                new_centroids.append(np.mean
                    (cluster, axis=0))
            else:
                new_centroids.append(centroids
                    [clusters.index(cluster)])

        if np.allclose(centroids, new_centroids):
            break
```

return centroids, cluster

```
data = pd.read_csv('/kaggle/input/k-mean-data/data.csv')

X = data.values
k = 3
centroids, clusters = kmeans(X,k)

centroids = np.array(centroids)

colors = ['r', 'g', 'b']

for i, cluster in enumerate(clusters):
    for point in cluster:
        plt.scatter(point[0], point[1], c=colors[i])

plt.scatter(centroids[:, 0], centroids[:,1], c='k', marker='x')
plt.show()
```

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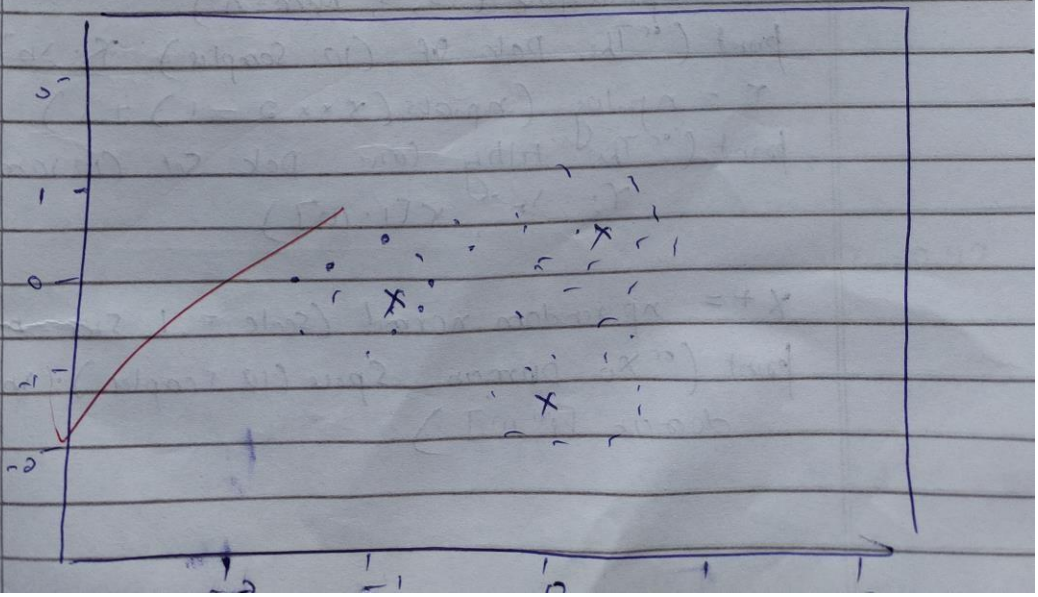
Output:-



Program 7: Apply EM algorithm to cluster a set of data stored in a .CSV file. Compare the results of k-Means algorithm and EM algorithm.

In [1]:
```
import matplotlib.pyplot as plt
import pandas as pd
from sklearn.mixture import GaussianMixture
from sklearn.metrics import accuracy_score, confusion_matrix
```

Data

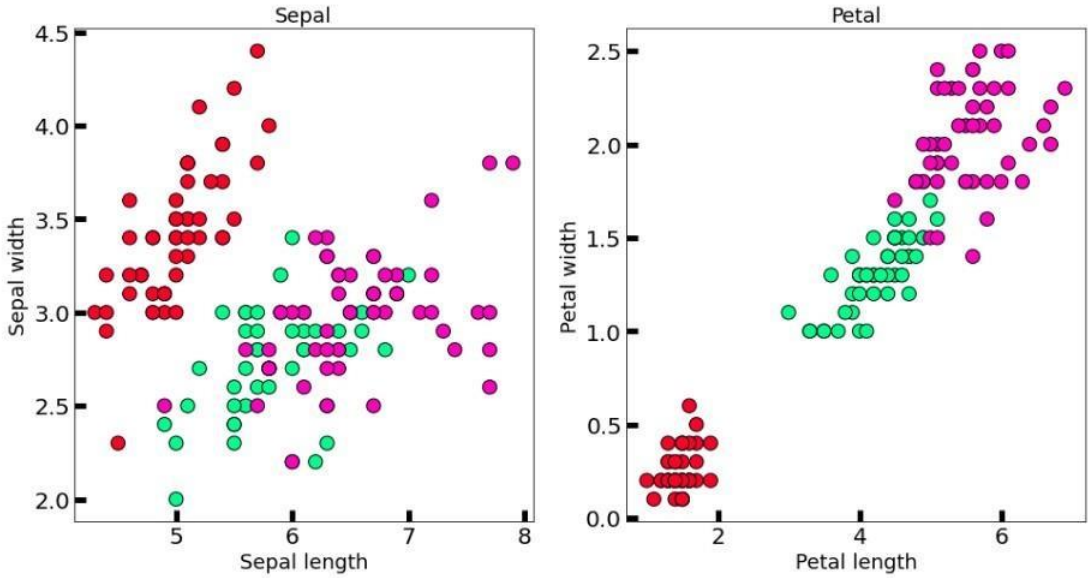
In [2]:
```
data = pd.read_csv('../input/iris/Iris.csv')
data.head()
```

Out[2]:

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Species
0	1	5.1	3.5	1.4	0.2	Iris-setosa
1	2	4.9	3.0	1.4	0.2	Iris-setosa
2	3	4.7	3.2	1.3	0.2	Iris-setosa
3	4	4.6	3.1	1.5	0.2	Iris-setosa
4	5	5.0	3.6	1.4	0.2	Iris-setosa

In [3]:
```
sepal_X = data[['SepalLengthCm', 'SepalWidthCm']]
petal_X = data[['PetalLengthCm', 'PetalWidthCm']]
y = data['Species'].astype("category").cat.codes
num_cat = y.nunique()
categories = data['Species'].astype("category").cat.categories
```

In [4]:
```
fig, axes = plt.subplots(1, 2, figsize=(16,8))
axes[0].scatter(sepal_X.SepalLengthCm, sepal_X.SepalWidthCm, c=y, cmap='gist_rainbow', edgecolor='k', s=150)
axes[1].scatter(petal_X.PetalLengthCm, petal_X.PetalWidthCm, c=y, cmap='gist_rainbow', edgecolor='k', s=150)
axes[0].set_xlabel('Sepal length', fontsize=18)
axes[0].set_ylabel('Sepal width', fontsize=18)
axes[1].set_xlabel('Petal length', fontsize=18)
axes[1].set_ylabel('Petal width', fontsize=18)
axes[0].tick_params(direction='in', length=10, width=5, colors='k', labelsize=20)
axes[1].tick_params(direction='in', length=10, width=5, colors='k', labelsize=20)
axes[0].set_title('Sepal', fontsize=18)
axes[1].set_title('Petal', fontsize=18)
plt.show()
```



Model

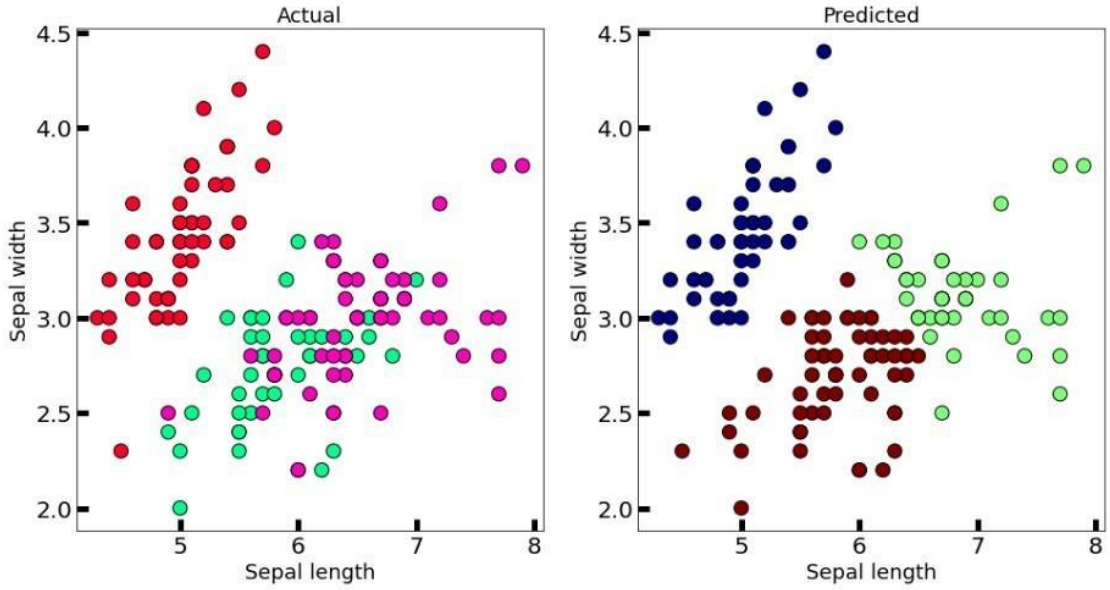
In [5]:
```
model_sepal = GaussianMixture(n_components=3)
sepal_labels = model_sepal.fit_predict(sepal_X)
model_petal = GaussianMixture(n_components=3)
petal_labels = model_petal.fit_predict(petal_X)
```

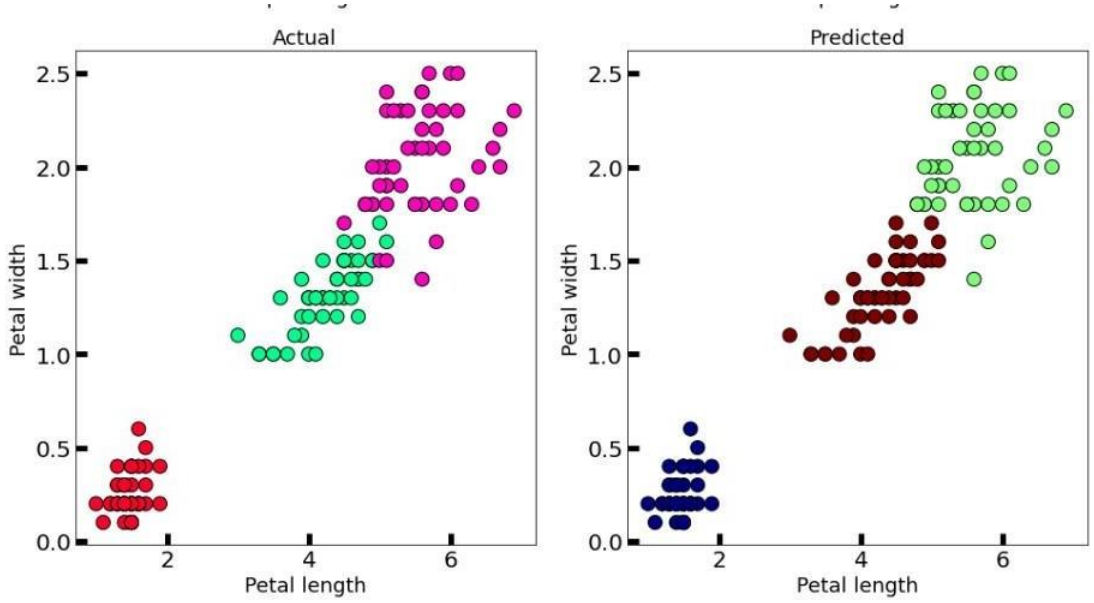
Analysis

In [6]:
```
def plot_actualvpredicted(X, y, predicted, part):
    fig, axes = plt.subplots(1, 2, figsize=(16,8))
    axes[0].scatter(X[f'{part}LengthCm'], X[f'{part}WidthCm'], c=y, cmap='gist_rainbow', edgecolor='k', s=150)
    axes[1].scatter(X[f'{part}LengthCm'], X[f'{part}WidthCm'], c=predicted, cmap='jet', edgecolor='k', s=150)
    axes[0].set_xlabel(f'{part} length', fontsize=18)
    axes[0].set_ylabel(f'{part} width', fontsize=18)
    axes[1].set_xlabel(f'{part} length', fontsize=18)
    axes[1].set_ylabel(f'{part} width', fontsize=18)
    axes[0].tick_params(direction='in', length=10, width=5, colors='k', labelsize=20)
    axes[1].tick_params(direction='in', length=10, width=5, colors='k', labelsize=20)
    axes[0].set_title('Actual', fontsize=18)
    axes[1].set_title('Predicted', fontsize=18)
    plt.show()
```

```
def plot_confusion(accuracy, confusion, part):
    print(f'{part} Accuracy: {accuracy}')

    fig, ax = plt.subplots()
    im = ax.imshow(confusion)

    ax.set_xticks(range(num_cat))
    ax.set_yticks(range(num_cat))
    ax.set_xticklabels(categories)
    ax.set_yticklabels(categories)

    plt.setp(ax.get_xticklabels(), rotation=45, ha="right",
             rotation_mode="anchor")

    for i in range(num_cat):
        for j in range(num_cat):
            text = ax.text(j, i, confusion[i, j],
                           ha="center", va="center", color="w")

    ax.set_title(f"{part} Confusion Matrix (Actual / Predicted)")
    fig.tight_layout()
    plt.show()
```

In [7]:
```
plot_actualvpredicted(sepal_X, y, sepal_labels, 'Sepal')
plot_actualvpredicted(petal_X, y, petal_labels, 'Petal')
```

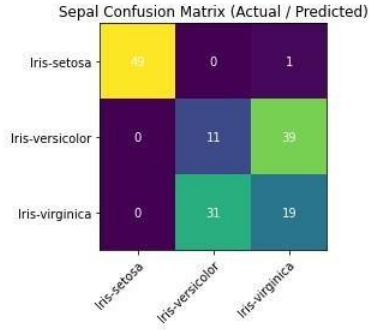




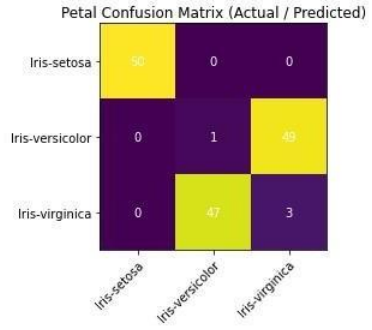
In [8]:
```
sepal_accuracy = accuracy_score(y, sepal_labels)
petal_accuracy = accuracy_score(y, petal_labels)

sepal_confusion = confusion_matrix(y, sepal_labels)
petal_confusion = confusion_matrix(y, petal_labels)
```

In [9]:
```
plot_confusion(sepal_accuracy, sepal_confusion, 'Sepal')
plot_confusion(petal_accuracy, petal_confusion, 'Petal')
```

```
Sepal Accuracy: 0.5266666666666666
```




```
Petal Accuracy: 0.36
```



Comparison with K-Means

When we compare the results of the GaussianMixture model (uses EM algorithm) with that of K-Means clustering we observe that both give almost equal accuracies:

- K-Means: 0.5133333333333333 (*Sepal*) & 0.37333333333333335 (*Petal*)
- GaussianMixture: 0.5333333333333333 (*Sepal*) & 0.02 (*Petal*)

GaussianMixture performs slightly better when classified based on the *Sepal* length & width. Likewise K-Means performs slightly better when classified based on the *Petal* length & width.

In [ ]:
```
```

ALGORITHM:

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```
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 = ['Target']

model = KMeans(n_clusters=3)
model.fit(X)

plt.figure(figsize=(14,7))

colormap = np.array(['red', 'lime', 'black'])

plt.subplot(1,2,1)
plt.scatter(X.Petal_length, X.Petal_Width, c=colormap[y.Target], s=40)
plt.title('Real Classification')
plt.xlabel('Petal Length')
plt.ylabel('Petal Width')

plt.subplot(1,2,2)
```

print("The confusion matrix of EM:",
sm.confusion_matrix(y, y_gmm))

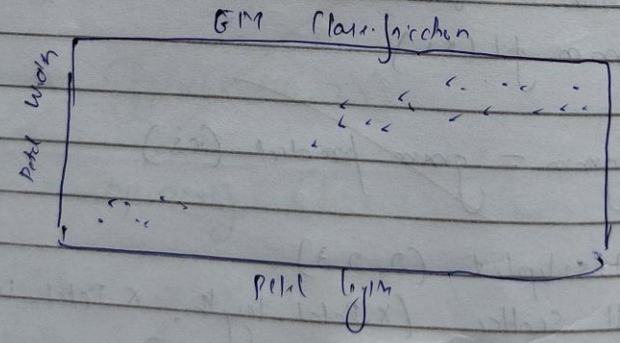
Output:

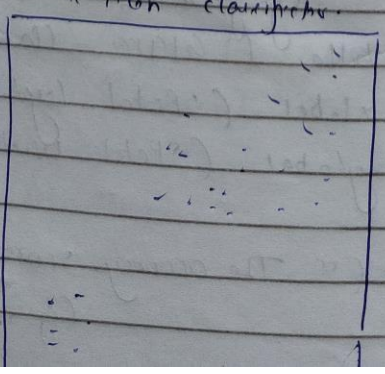
The accuracy score of K-Mean = 0.893333

The confusion matrix of K-Mean = [[50 0 0]
[0 48 0]
[0 14 36]]

The accuracy score of EM: 0.35333333

The confusion matrix of EM: [[50 0 0]
[0 48 0]
[0 50 0]]





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Program 8: Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions.

In [1]:
```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report
from sklearn.model_selection import train_test_split
```

Data

In [2]:
```
data = pd.read_csv('../input/iris/Iris.csv')
```

In [3]:
```
data.head()
```

Out[3]:

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Species
0	1	5.1	3.5	1.4	0.2	Iris-setosa
1	2	4.9	3.0	1.4	0.2	Iris-setosa
2	3	4.7	3.2	1.3	0.2	Iris-setosa
3	4	4.6	3.1	1.5	0.2	Iris-setosa
4	5	5.0	3.6	1.4	0.2	Iris-setosa

In [4]:
```
data.describe()
```

Out[4]:

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm
count	150.000000	150.000000	150.000000	150.000000	150.000000
mean	75.500000	5.843333	3.054000	3.758667	1.198667
std	43.445368	0.828066	0.433594	1.764420	0.763161
min	1.000000	4.300000	2.000000	1.000000	0.100000
25%	38.250000	5.100000	2.800000	1.600000	0.300000
50%	75.500000	5.800000	3.000000	4.350000	1.300000
75%	112.750000	6.400000	3.300000	5.100000	1.800000
max	150.000000	7.900000	4.400000	6.900000	2.500000

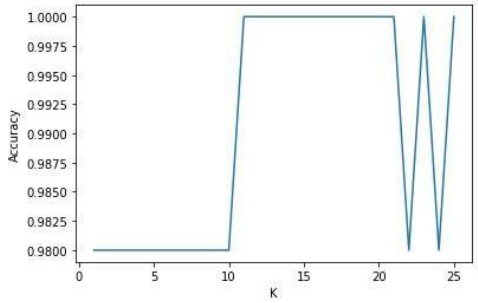
In [5]:
```
X = data[['SepalLengthCm', 'SepalWidthCm', 'PetalLengthCm', 'PetalWidthCm']]
sepal_X = data[['SepalLengthCm', 'SepalWidthCm']]
petal_X = data[['PetalLengthCm', 'PetalWidthCm']]
y = data['Species'].astype("category").cat.codes
num_cat = y.nunique()
categories = data['Species'].astype("category").cat.categories
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, random_state=42)
```

Model

In [6]:
```
scores = {}
scores_list = []
for k in range(1, 26):
    knn = KNeighborsClassifier(n_neighbors=k)
    knn.fit(X_train, y_train)
    y_pred = knn.predict(X_test)
    scores[k] = accuracy_score(y_test, y_pred)
    scores_list.append(scores[k])
```

Analysis

In [7]:
```
plt.plot(range(1, 26), scores_list)
plt.xlabel('K')
plt.ylabel('Accuracy')
plt.show()
```



In [8]:
```
knn = KNeighborsClassifier(n_neighbors=5)
knn.fit(X_train, y_train)
y_pred = knn.predict(X_test)
print("Confusion Matrix")
print(confusion_matrix(y_test, y_pred))
print(f"Correct Predictions: {accuracy_score(y_test, y_pred)}")
print(f"Wrong Predictions: {1 - accuracy_score(y_test, y_pred)}")
print("Accuracy Metrics: ")
print(classification_report(y_test,y_pred))
```

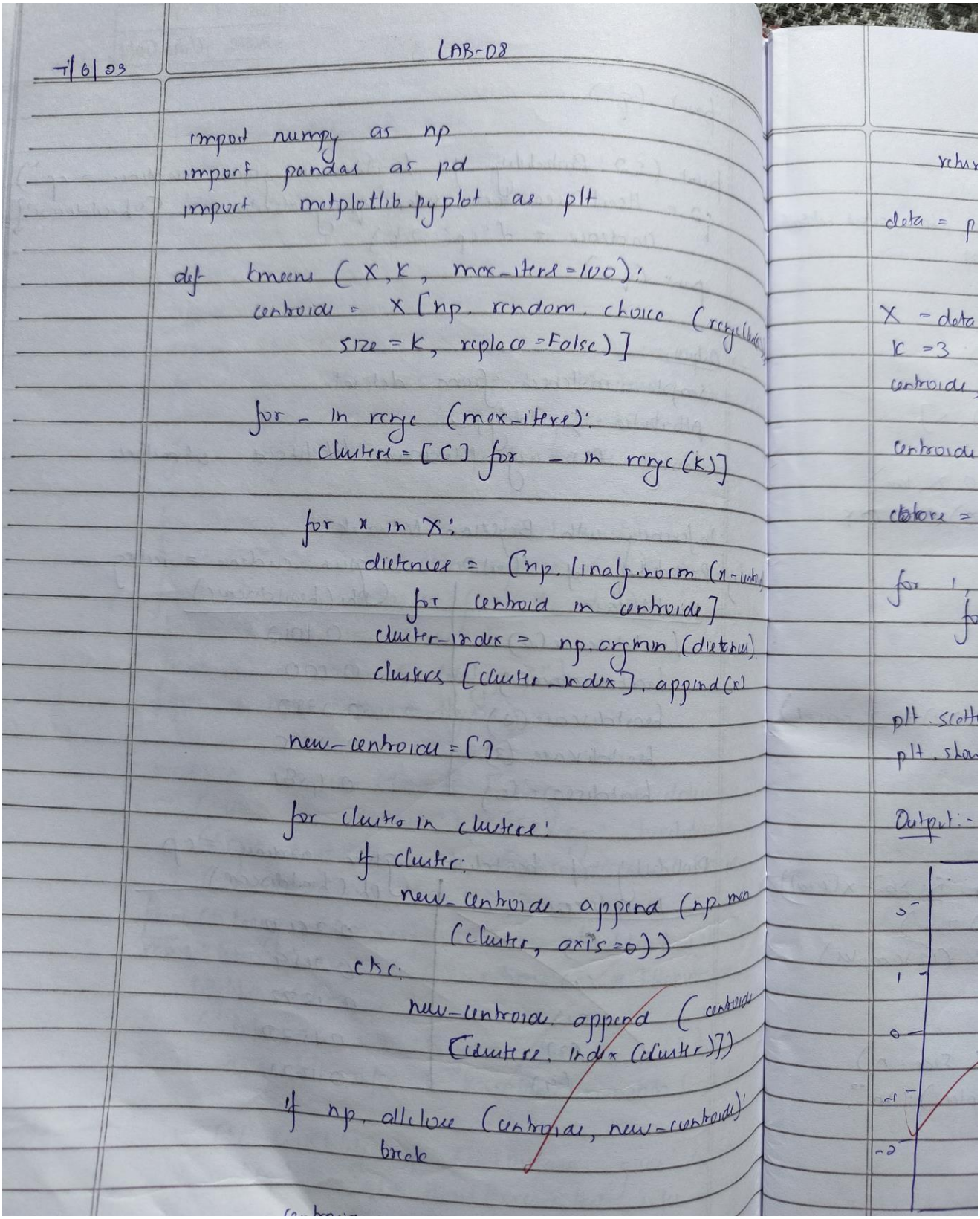
```
Confusion Matrix
[[19  0  0]
 [ 0 15  0]
 [ 0  1 15]]
Correct Predictions: 0.98
Wrong Predictions: 0.020000000000000018
Accuracy Metrics:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        19
           1       0.94      1.00      0.97        15
           2       1.00      0.94      0.97        16

    accuracy                           0.98        50
   macro avg       0.98      0.98      0.98        50
weighted avg       0.98      0.98      0.98        50
```

In [ ]:

ALGORITHM:



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LAB-08

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

def kmeans(X, k, max_iters=100):
    centroids = X[np.random.choice(range(len(X)),
                size=k, replace=False)]

    for _ in range(max_iters):
        clusters = [[] for _ in range(k)]

        for x in X:
            distances = [np.linalg.norm(x-centroid)
                for centroid in centroids]
            cluster_index = np.argmin(distances)
            clusters[cluster_index].append(x)

        new_centroids = []

        for cluster in clusters:
            if cluster:
                new_centroids.append(np.mean
                    (cluster, axis=0))
            else:
                new_centroids.append(centroids
                    [clusters.index(cluster)])

        if np.allclose(centroids, new_centroids):
            break
```

```
data = p

X = data
k = 3
centroids

centroids

clusters =

for i,
    fo

plt.scatt
plt.show

Output:-
```

Program 9: Implement the Linear Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs.

In [1]:
```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error
```

Data

In [2]:
```
df = pd.read_csv('../input/housesalesprediction/kc_house_data.csv')
```

In [3]:
```
df.head()
```

Out[3]:

	id	date	price	bedrooms	bathrooms	sqft_living	sqft_lot	floors	waterfront	view	...	grade	sqft_above
0	7129300520	20141013T000000	221900.0	3	1.00	1180	5650	1.0	0	0	...	7	1180
1	6414100192	20141209T000000	538000.0	3	2.25	2570	7242	2.0	0	0	...	7	2170
2	5631500400	20150225T000000	180000.0	2	1.00	770	10000	1.0	0	0	...	6	770
3	2487200875	20141209T000000	604000.0	4	3.00	1960	5000	1.0	0	0	...	7	1050
4	1954400510	20150218T000000	510000.0	3	2.00	1680	8080	1.0	0	0	...	8	1680

5 rows × 21 columns

In [4]:
```
X = np.array(df['sqft_living']).reshape(-1, 1)
y = df['price']
```

In [5]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, random_state=42)
```

Model

In [6]:
```
model = LinearRegression()
model.fit(X_train, y_train)
# model.fit(X, y)
```

Out[6]:
```
LinearRegression()
```

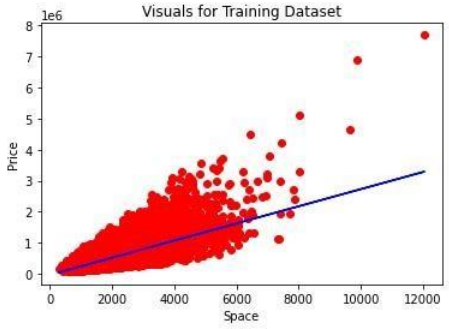
Analysis

In [7]:
```
y_pred = model.predict(X_test)
print(f"Mean Squared Error: {mean_squared_error(y_pred, y_test)}")
```

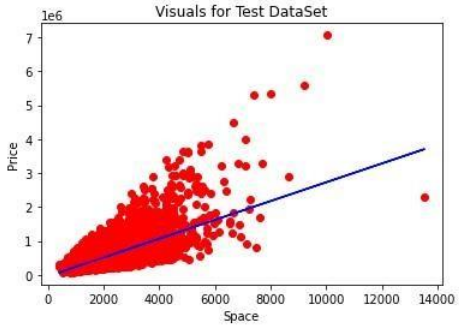
```
Mean Squared Error: 76715223988.35832
```

In [8]:
```
#Visualizing the training Test Results
plt.scatter(X_train, y_train, color= 'red')
```

In [8]:
```
#Visualizing the training Test Results
plt.scatter(X_train, y_train, color= 'red')
plt.plot(X_train, model.predict(X_train), color = 'blue')
plt.title ("Visuals for Training Dataset")
plt.xlabel("Space")
plt.ylabel("Price")
plt.show()
```

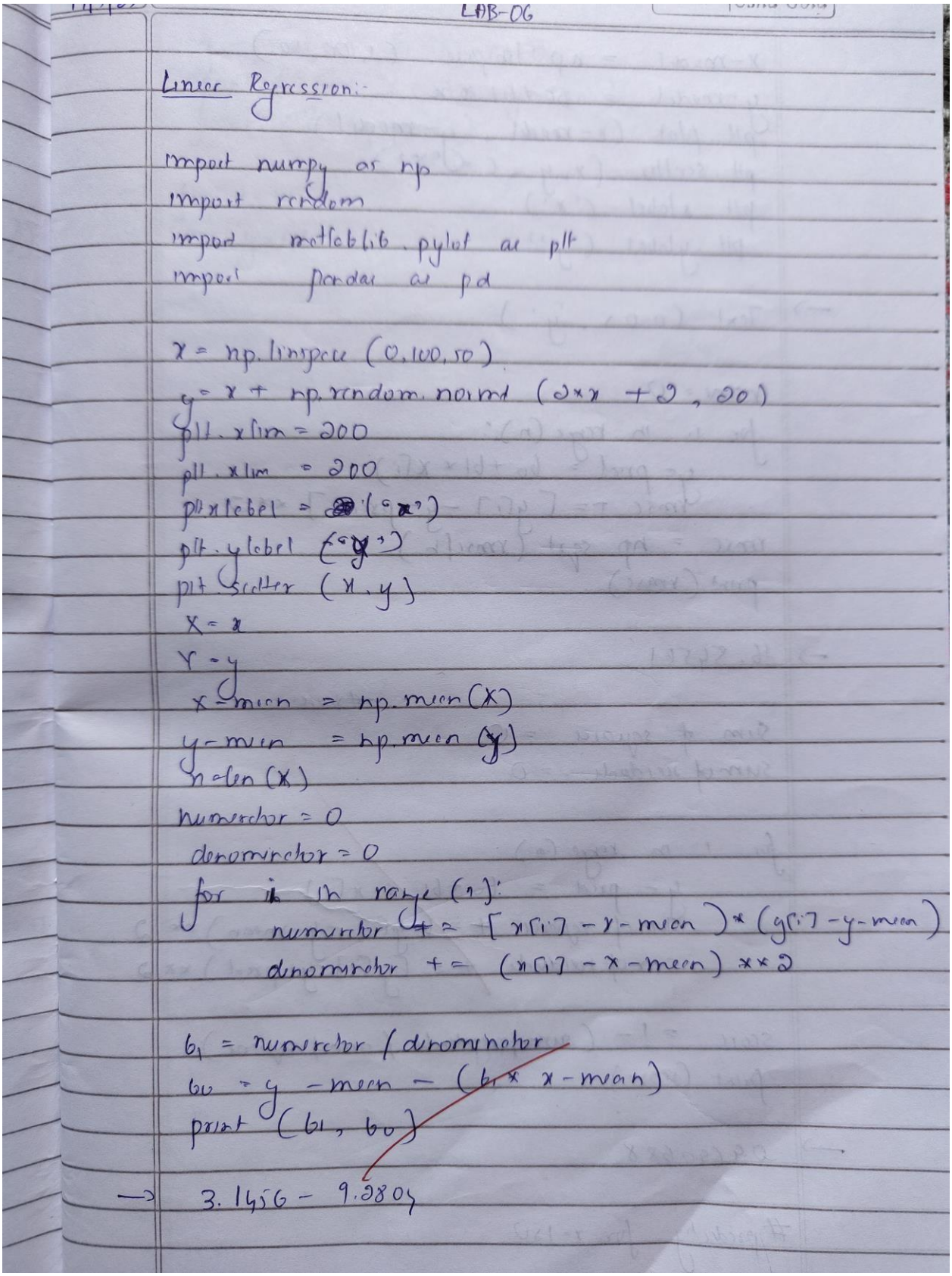


In [9]:
```
#Visualizing the Test Results
plt.scatter(X_test, y_test, color= 'red')
plt.plot(X_test, model.predict(X_test), color = 'blue')
plt.title("Visuals for Test DataSet")
plt.xlabel("Space")
plt.ylabel("Price")
plt.show()
```



In [ ]:

ALGORITHM:



LAB-06

Linear Regression:

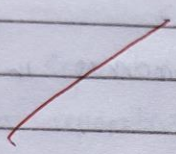
```
import numpy as np
import random
import matplotlib.pylot as plt
import pandas as pd

x = np.linspace (0,100,50)
y = x + np.random.normal (2*x + 2, 20)
plt.xlim = 200
plt.xlim = 200
plt.xlabel = ('x')
plt.ylabel ('y')
plt.scatter (x, y)
X = x
Y = y
x_mean = np.mean(X)
y_mean = np.mean(y)
n = len(X)
numerator = 0
denominator = 0
for i in range (n):
    numerator += (x[i] - x_mean) * (y[i] - y_mean)
    denominator += (x[i] - x_mean) **2

b1 = numerator / denominator
b0 = y_mean - (b1 * x_mean)
print (b1, b0)
```

→ 3.1456 - 9.2804

```
y_pred = b0 + b1 * 150
print ("for x = 150 y = ", y)
print (int(y_pred))
```

→ for x = 150

y = 4.62



Program 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.

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

Functions

In [2]:
```
# kernel smoothing function
def kernel(point, xmat, k):
    m,n = np.shape(xmat)
    weights = np.mat(np.eye((m)))

    for j in range(m):
        diff = point - X[j]
        weights[j, j] = np.exp(diff * diff.T / (-2.0 * k**2))

    return weights

# function to return local weight of eah training example
def localWeight(point, xmat, ymat, k):
    wt = kernel(point, xmat, k)
    W = (X.T * (wt*X)).I * (X.T * wt * ymat.T)
    return W

# root function that drives the algorithm
def localWeightRegression(xmat, ymat, k):
    m,n = np.shape(xmat)
    ypred = np.zeros(m)

    for i in range(m):
        ypred[i] = xmat[i] * localWeight(xmat[i], xmat, ymat, k)

    return ypred
```

Data

In [3]:
```
#import data
data = pd.read_csv('../input/tipsdata/tips.csv')

# place them in suitable data types
colA = np.array(data.total_bill)
colB = np.array(data.tip)

mcolA = np.mat(colA)
mcolB = np.mat(colB)

m = np.shape(mcolB)[1]
one = np.ones((1, m), dtype = int)

# horizontal stacking
X = np.hstack((one.T, mcolA.T))
print(X.shape)
```

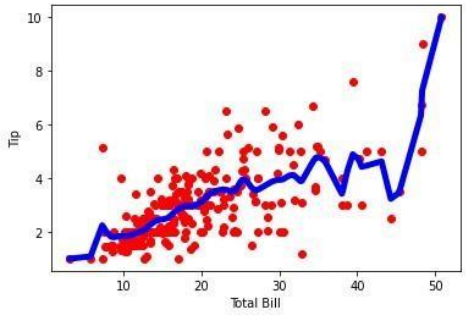
```
(244, 2)
```

Model

In [4]:
```
# predicting values using LWLR
ypred = localWeightRegression(X, mcolB, 0.8)
```

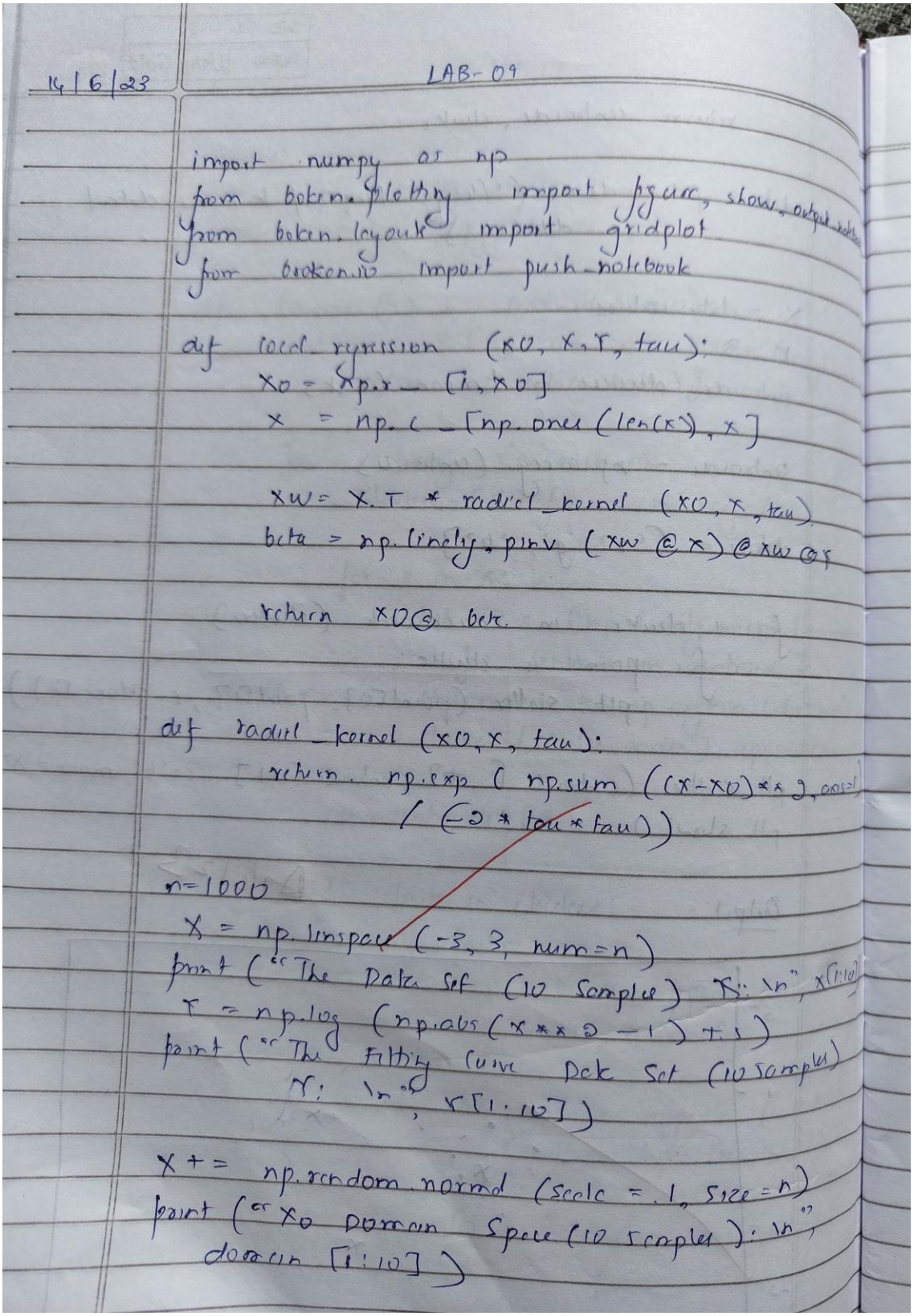
Analysis

In [5]:
```
# plotting the predicted graph
xsort = X.copy()
xsort.sort(axis=0)
plt.scatter(colA, colB, color='red')
plt.plot(xsort[:, 1], ypred[X[:, 1].argsort(0)], color='blue', linewidth=5)
plt.xlabel('Total Bill')
plt.ylabel('Tip')
plt.show()
```



In [ ]:

ALGORITHM:



14/6/23 LAB-09

```
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, T, tau):
    x0 = np.r_ [1, x0]
    X = np.c_ [np.ones (len(X)), X]

    xw = X.T * radial_kernel (x0, X, tau)
    beta = np.linalg.pinv (xw @ X) @ xw @ T

    return x0 @ beta

def radial_kernel (x0, X, tau):
    return np.exp ( np.sum ((X-x0) ** 2, axis=1)
                    / (-2 * tau * tau))

n=1000
X = np.linspace (-3, 3, num=n)
print ("The Data Set (10 Samples) X: \n", X[1:10])
T = np.log (np.abs (X ** 2 - 1) + 1)
print ("The Fitting Curve Data Set (10 Samples)
        Y: \n", Y[1:10])

X += np.random.normal (scale = .1, size = n)
print ("X0 Domain Space (10 Samples): \n",
    domain [1:10])
```

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```
def plot_lwr(tau):
    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(10.1), plot_lwr(1.)],
    [plot_lwr(0.1), plot_lwr(0.01)]]))
```

Output:-

The Data Set (10 samples) X:

[-2.99399399 -2.98798799 -2.98198198
-2.97597598 -2.96 -2.96 -2.95
-2.95 -2.94]

The Tilby Cuna Data Set (10 samples) Y:

[2.13 2.13 2.12 2.12 2.118 2.114 2.11
2.105 2.101]

Normalised (10 samples) X:

[-3.04 -3.05 -2.98 -2.96 -2.97 -2.97
-2.93 -3.05 2.95]

Xo Domain Space (10 samples):

[-2.97 -2.95 -2.93 -2.91 -2.89 -2.87
-2.85 -2.83 -2.81]