

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY

“JnanaSangama”, Belgaum- 590014, Karnataka.



## LAB REPORT on **Machine Learning (23CS6PCMAL)**

*Submitted by*

**Samraat Dabolay (1BM22CS236)**

*in partial fulfillment for the award of the degree of*

### **BACHELOR OF ENGINEERING**

*in*

### **COMPUTER SCIENCE AND ENGINEERING**



**B.M.S. COLLEGE OF ENGINEERING**  
(Autonomous Institution under VTU)  
**BENGALURU - 560019**  
**February 2025 – July 25**

# B.M.S. College of Engineering

Bull Temple Road, Bangalore 560019

(Affiliated To Visvesvaraya Technological University, Belgaum)

## Department of Computer Science and Engineering



## CERTIFICATE

This is to certify that the Lab work entitled “Machine Learning (23CS6PCMAL)” carried out by **Samraat Dabolay (1BM22CS236)**, who is bonafide student of **B.M.S. College of Engineering**. It is in partial fulfilment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum. The Laboratory report has been approved as it satisfies the academic requirements in respect of an Machine Learning (23CS6PCMAL) work prescribed for the said degree.

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Github Link: <https://github.com/samraatd/ML-LAB>

# LABORATORY PROGRAM – 1

**Write a python program to import and export data using Pandas library functions**

## OBSERVATION BOOK

Lab 0																																					
<p><u>5/3/25</u></p> <p><u>70 00</u></p> <p>① Initialize values directly into database</p> <pre>import pandas as pd data = {     'USN': ['IBM22CS100', 'IBM22CS200',             'IBM22CS300', 'IBM22CS400',             'IBM22CS500'],     'Name': ['Alice', 'Bob', 'Charlie', 'David',              'Eve'],     'Marks': [85, 78, 92, 88, 76] } df = pd.DataFrame(data) print(df)</pre> <p><u>O/P</u></p> <table border="1"> <thead> <tr> <th>USN</th> <th>Name</th> <th>Marks</th> </tr> </thead> <tbody> <tr> <td>0 IBM22CS100</td> <td>Alice</td> <td>85</td> </tr> <tr> <td>1 IBM22CS200</td> <td>Bob</td> <td>78</td> </tr> <tr> <td>2 IBM22CS300</td> <td>Charlie</td> <td>92</td> </tr> <tr> <td>3 IBM22CS400</td> <td>David</td> <td>88</td> </tr> <tr> <td>4 IBM22CS500</td> <td>Eve</td> <td>76</td> </tr> </tbody> </table>	USN	Name	Marks	0 IBM22CS100	Alice	85	1 IBM22CS200	Bob	78	2 IBM22CS300	Charlie	92	3 IBM22CS400	David	88	4 IBM22CS500	Eve	76	<p>③ Importing datasets from a specific .csv file</p> <pre>file = 'sample-sales-data.csv' df = pd.read_csv(file) df.head()</pre> <p><u>O/P</u></p> <table border="1"> <thead> <tr> <th></th> <th>Product</th> <th>Quantity</th> <th>Price</th> <th>Sales</th> <th>Region</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>laptop</td> <td>3</td> <td>1000</td> <td>5000</td> <td>North</td> </tr> <tr> <td>1</td> <td>mouse</td> <td>15</td> <td>20</td> <td>300</td> <td>West</td> </tr> </tbody> </table>		Product	Quantity	Price	Sales	Region	0	laptop	3	1000	5000	North	1	mouse	15	20	300	West
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<p>② Download dataset from repositories</p> <pre>file = "dataset-of-diabetes.csv" df = pd.read_csv(file) df.head()</pre> <p><u>O/P</u></p> <table border="1"> <thead> <tr> <th>ID</th> <th>No.</th> <th>Glucose</th> <th>Age</th> <th>Skin</th> <th>BMI</th> <th>PedAlc</th> <th>Chol</th> <th>TG</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>32</td> <td>179.75</td> <td>30</td> <td>6.7</td> <td>46</td> <td>4.9</td> <td>3.2</td> <td>0.1</td> </tr> <tr> <td>HDL</td> <td>LDL</td> <td>VLDL</td> <td>BMI</td> <td>CLASS</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2.9</td> <td>1.4</td> <td>0.5</td> <td>24.0</td> <td>N</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	ID	No.	Glucose	Age	Skin	BMI	PedAlc	Chol	TG	0	32	179.75	30	6.7	46	4.9	3.2	0.1	HDL	LDL	VLDL	BMI	CLASS					2.9	1.4	0.5	24.0	N					<p>To Do : Stock Market Data Analysis</p> <pre>import numpy as np import pandas as pd import matplotlib.pyplot as plt tickers = ['HDFCBANK.NS', 'ICICIBANK.NS',            'KOTAKBANK.NS']  data = yf.download(tickers, start="2024-01-01",                    end="2024-12-31", group_by='ticker') data.head()  print(data.shape) print(data.columns)</pre>
ID	No.	Glucose	Age	Skin	BMI	PedAlc	Chol	TG																													
0	32	179.75	30	6.7	46	4.9	3.2	0.1																													
HDL	LDL	VLDL	BMI	CLASS																																	
2.9	1.4	0.5	24.0	N																																	

```

hdfc -> data = data ['HDFC BANK. NS']
print (hdfc -> data . describe ())
hdfc -> data ['Daily Returns'] = hdfc -> data ['close'] . pct-
change ()
plt . figure (figsize =(12,8))
plt . subplot (2,1,1)
hdfc -> data ['close'] . plot (title ="HDFC - Closing Price",
color ='blue')
plt . xlabel ('Closing Price')
plt . subplot (2,1,2)
hdfc -> data ['Daily Returns'] . plot (title :"HDFC -
Daily returns", color ="red")
plt . xlabel ('Daily Returns')
plt . tight_layout ()
plt . show ()

```

Repeat for ICICI and KOTAK Banks

## CODE WITH OUTPUT

```

# Summary statistics
print(df.describe())

      ID    No_Pation     AGE      Urea      Cr \
count 1000.000000 1.000000e+03 1000.000000 1000.000000 1000.000000
mean 340.500000 2.705514e+05 53.528000 5.124743 68.943000
std 240.397673 3.380758e+06 8.799241 2.935165 59.984747
min 1.000000 1.230000e+02 20.000000 0.500000 6.000000
25% 125.750000 2.406375e+04 51.000000 3.700000 48.000000
50% 300.500000 3.439559e+04 55.000000 4.600000 60.000000
75% 550.250000 4.538425e+04 59.000000 5.700000 73.000000
max 800.000000 7.543566e+07 79.000000 38.900000 800.000000

      HbA1c      Chol       TG      HDL      LDL \
count 1000.000000 1000.000000 1000.000000 1000.000000 1000.000000
mean 8.281160 4.862820 2.349610 1.204750 2.609790
std 2.534003 1.301738 1.401176 0.660414 1.115102
min 0.900000 0.000000 0.300000 0.200000 0.300000
25% 6.500000 4.000000 1.500000 0.900000 1.800000
50% 8.000000 4.800000 2.000000 1.100000 2.500000
75% 10.200000 5.600000 2.900000 1.300000 3.300000
max 16.000000 10.300000 13.800000 9.900000 9.900000

      VLDL      BMI
count 1000.000000 1000.000000
mean 1.854700 29.578020
std 3.663599 4.962388
min 0.100000 19.000000
25% 0.700000 26.000000
50% 0.900000 30.000000
75% 1.500000 33.000000
max 35.000000 47.750000

missing_values=df.isnull().sum()
print(missing_values[missing_values > 0])

Series([], dtype: int64)

```

## Diabetes Dataset

```
df=pd.read_csv('/content/Dataset of Diabetes .csv')
df.head()
```

	ID	No_Pation	Gender	AGE	Urea	Cr	HbA1c	Chol	TG	HDL	LDL	VLDL	BMI	CLASS
0	502	17975	F	50	4.7	46	4.9	4.2	0.9	2.4	1.4	0.5	24.0	N
1	735	34221	M	26	4.5	62	4.9	3.7	1.4	1.1	2.1	0.6	23.0	N
2	420	47975	F	50	4.7	46	4.9	4.2	0.9	2.4	1.4	0.5	24.0	N
3	680	87656	F	50	4.7	46	4.9	4.2	0.9	2.4	1.4	0.5	24.0	N
4	504	34223	M	33	7.1	46	4.9	4.9	1.0	0.8	2.0	0.4	21.0	N

```
df.shape
```

```
(1000, 14)
```

```
print(df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 14 columns):
 #   Column      Non-Null Count  Dtype  
 ---  --          --          --    
 0   ID          1000 non-null    int64  
 1   No_Pation   1000 non-null    int64  
 2   Gender       1000 non-null    object 
 3   AGE          1000 non-null    int64  
 4   Urea         1000 non-null    float64 
 5   Cr           1000 non-null    int64  
 6   HbA1c        1000 non-null    float64 
 7   Chol          1000 non-null    float64 
 8   TG            1000 non-null    float64 
 9   HDL           1000 non-null    float64 
 10  LDL           1000 non-null    float64 
 11  VLDL          1000 non-null    float64 
 12  BMI           1000 non-null    float64 
 13  CLASS         1000 non-null    object 
dtypes: float64(8), int64(4), object(2)
memory usage: 109.5+ KB
None
```

```

categorical_cols = df.select_dtypes(include=['object']).columns
print("Categorical columns identified:", categorical_cols)
if len(categorical_cols) > 0:
    df = pd.get_dummies(df, columns=categorical_cols, drop_first=True)
    print("\nDataFrame after one-hot encoding:")
    print(df.head())
else:
    print("\nNo categorical columns found in the dataset.")

```

Categorical columns identified: Index(['Gender', 'CLASS'], dtype='object')

DataFrame after one-hot encoding:

	ID	No_Patition	AGE	Urea	Cr	HbA1c	Chol	TG	HDL	LDL	VLDL	BMI	\
0	502	17975	50	4.7	46	4.9	4.2	0.9	2.4	1.4	0.5	24.0	
1	735	34221	26	4.5	62	4.9	3.7	1.4	1.1	2.1	0.6	23.0	
2	420	47975	50	4.7	46	4.9	4.2	0.9	2.4	1.4	0.5	24.0	
3	680	87656	50	4.7	46	4.9	4.2	0.9	2.4	1.4	0.5	24.0	
4	504	34223	33	7.1	46	4.9	4.9	1.0	0.8	2.0	0.4	21.0	

	Gender_M	Gender_f	CLASS_N	CLASS_P	CLASS_Y	CLASS_Y
0	False	False	False	False	False	False
1	True	False	False	False	False	False
2	False	False	False	False	False	False
3	False	False	False	False	False	False
4	True	False	False	False	False	False

```

from sklearn.preprocessing import MinMaxScaler, StandardScaler
import pandas as pd

numerical_cols = df.select_dtypes(include=['number']).columns

scaler = MinMaxScaler()
df_minmax = df.copy() # Create a copy to avoid modifying the original
df_minmax[numerical_cols] = scaler.fit_transform(df[numerical_cols])

scaler = StandardScaler()
df_standard = df.copy()
df_standard[numerical_cols] = scaler.fit_transform(df[numerical_cols])
print("\nDataFrame after Min-Max Scaling:")
print(df_minmax.head())
print("\nDataFrame after Standardization:")
print(df_standard.head())

```

DataFrame after Min-Max Scaling:

	ID	No_Pation	AGE	Urea	Cr	HbA1c	Chol	\
0	0.627034	0.000237	0.508475	0.109375	0.050378	0.264901	0.407767	
1	0.918648	0.000452	0.101695	0.104167	0.070529	0.264901	0.359223	
2	0.524406	0.000634	0.508475	0.109375	0.050378	0.264901	0.407767	
3	0.849812	0.001160	0.508475	0.109375	0.050378	0.264901	0.407767	
4	0.629537	0.000452	0.220339	0.171875	0.050378	0.264901	0.475728	

	TG	HDL	LDL	VLDL	BMI	Gender_M	Gender_f	\
0	0.044444	0.226804	0.114583	0.011461	0.173913	False	False	
1	0.081481	0.092784	0.187500	0.014327	0.139130	True	False	
2	0.044444	0.226804	0.114583	0.011461	0.173913	False	False	
3	0.044444	0.226804	0.114583	0.011461	0.173913	False	False	
4	0.051852	0.061856	0.177083	0.008596	0.069565	True	False	

	CLASS_N	CLASS_P	CLASS_Y	CLASS_Y
0	False	False	False	False
1	False	False	False	False
2	False	False	False	False
3	False	False	False	False
4	False	False	False	False

DataFrame after Standardization:

	ID	No_Pation	AGE	Urea	Cr	HbA1c	Chol	\
0	0.672140	-0.074747	-0.401144	-0.144781	-0.382672	-1.334983	-0.509436	
1	1.641852	-0.069940	-3.130017	-0.212954	-0.115804	-1.334983	-0.893730	
2	0.330868	-0.065869	-0.401144	-0.144781	-0.382672	-1.334983	-0.509436	
3	1.412950	-0.054126	-0.401144	-0.144781	-0.382672	-1.334983	-0.509436	
4	0.680463	-0.069939	-2.334096	0.673299	-0.382672	-1.334983	0.028576	

	TG	HDL	LDL	VLDL	BMI	Gender_M	Gender_f	\
0	-1.035084	1.810756	-1.085457	-0.369958	-1.124622	False	False	
1	-0.678063	-0.158692	-0.457398	-0.342649	-1.326239	True	False	
2	-1.035084	1.810756	-1.085457	-0.369958	-1.124622	False	False	
3	-1.035084	1.810756	-1.085457	-0.369958	-1.124622	False	False	
4	-0.963680	-0.613180	-0.547121	-0.397267	-1.729472	True	False	

	CLASS_N	CLASS_P	CLASS_Y	CLASS_Y
0	False	False	False	False
1	False	False	False	False
2	False	False	False	False
3	False	False	False	False
4	False	False	False	False

## LABORATORY PROGRAM – 2

Demonstrate various data pre-processing techniques for a given dataset

### OBSERVATION BOOK

Lab 1

5/3/23

To Do

```
import pandas as pd
data = pd.read_csv('housing.csv')
print(data.info())
print(data.describe())
print(data['Ocean Proximity'].value_counts())
print(data.isnull().sum()[(data.isnull().sum() > 0)])
```

Op ocean - proximity

Location	Count
ISLAND	9136
INLAND	6551
NEAR OCEAN	2688
NEAR BAY	2210

Op total - bedrooms - 207

Scribble

① 00 - Diabetes Dataset  
df = pd.read\_csv("diabetes.csv")

② Missing values:

val = df.isnull().sum()

val: series ([], dtype: int64)

③ Handling missing values

num\_col = df.select\_dtypes(include=['float64', 'int64'])  
columns

inputer = SimpleImputer(strategy='mean')

df[num\_col] = inputer.fit\_transform(df[num\_col])

cat\_col = df.select\_dtypes(include=['object'])  
columns

inputer\_cat = SimpleImputer(strategy='most-frequent')

df[cat\_col] = inputer\_cat.fit\_transform(df[cat\_col])

④ Handling Categorical Attributes

df1 = df.copy()

df1['Gender'] = df1['Gender'].str.upper()

ordinal\_encoder = OrdinalEncoder(categories=[['M', 'F']])  
df1['Gender-encoded'] = ordinal\_encoder.fit\_transform(df1[['Gender']])

onehot\_encoder = OneHotEncoder()

encoded\_data = onehot\_encoder.fit\_transform(df1[['CLASS']])

encoded\_array = encoded\_data.toarray()

encoded\_df = pd.DataFrame(encoded\_array,  
columns=onehot\_encoder.get\_feature\_names\_out()  
(['CLASS']))

df\_encoded = pd.concat([df1, encoded\_df], axis=1)  
df\_encoded.drop(['class'], axis=1, inplace=True)

⑤ Data Normalisation

norm = MinMaxScaler()

df\_encoded[['Urea']] = norm.fit\_transform(df\_encoded[['Urea']])

scaler = StandardScaler()

df\_encoded[['Age']] = scaler.fit\_transform(df\_encoded[['Age']])

⑥ Removing Outliers

df1 = df\_encoded

Q1 = df1['Urea'].quantile(0.25)

Q3 = df1['Urea'].quantile(0.75)

IQR = Q3 - Q1

lower = Q1 - 1.5 \* IQR

upper = Q3 + 1.5 \* IQR

df1['Urea'] = np.where(df1['Urea'] > upper, upper,  
np.where(df1['Urea'] < lower, lower, df1['Urea']))

df2 = df\_encoded

df2['Urea-zscore'] = stats.zscore(df2['Urea'])

df2['Urea'] = np.where(df2['Urea-zscore'].abs() > 3, np.nan,  
df2['Urea'])

df3 = df\_encoded

df3['Urea-zscore'] = stats.zscore(df3['Urea'])

median\_urea = df3['Urea'].median()

df3['Urea'] = np.where(df3['Urea-zscore'].abs() > 3, median\_urea, df3['Urea'])

(skewness and kurtosis)

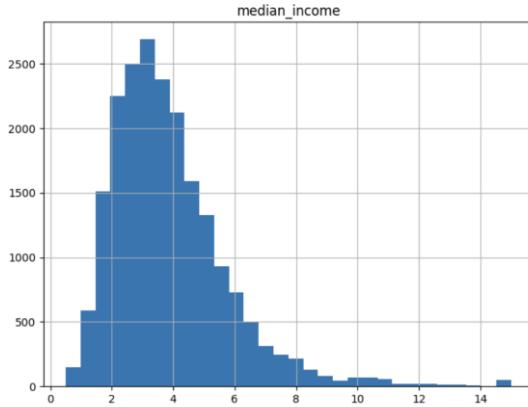
## CODE WITH OUTPUT

```
# Load the dataset into a pandas DataFrame
df = pd.read_csv('housing.csv')

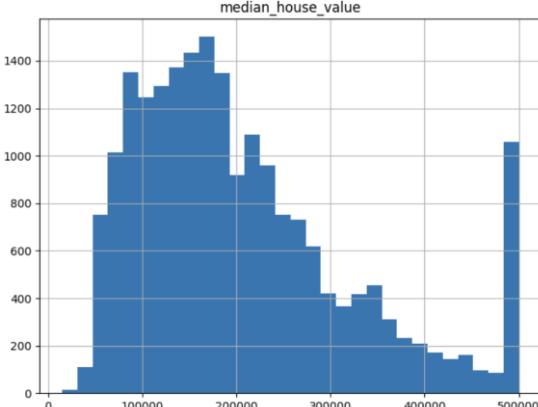
# Display descriptive statistics
df.describe()
```

	longitude	latitude	housing_median_age	total_rooms	total_bedrooms	population
count	20640.000000	20640.000000	20640.000000	20640.000000	20433.000000	20640.000000
mean	-119.569704	35.631861	28.639486	2635.763081	537.870553	1425.476744
std	2.003532	2.135952	12.585558	2181.615252	421.385070	1132.462122
min	-124.350000	32.540000	1.000000	2.000000	1.000000	3.000000
25%	-121.800000	33.930000	18.000000	1447.750000	296.000000	787.000000
50%	-118.490000	34.260000	29.000000	2127.000000	435.000000	1166.000000
75%	-118.010000	37.710000	37.000000	3148.000000	647.000000	1725.000000
max	-114.310000	41.950000	52.000000	39320.000000	6445.000000	35682.000000

```
import matplotlib.pyplot as plt
df.hist(column="median_income", bins=30, figsize=(8,6))
plt.show()
```



```
import matplotlib.pyplot as plt
df.hist(column="median_house_value", bins=30, figsize=(8,6))
plt.show()
```



```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split, StratifiedShuffleSplit

# Load the dataset
housing = pd.read_csv('housing.csv')

# For this demonstration, consider only 'median_income' and 'median_house_value'
housing_selected = housing[['median_income', 'median_house_value']].copy()

# Random split: This splits the data randomly without preserving any specific distribution.
train_set_random, test_set_random = train_test_split(housing_selected, test_size=0.2, random_state=42)

# For stratified sampling, first create an income category.
housing_selected['income_cat'] = pd.cut(housing_selected['median_income'],
                                         bins=[0., 1.5, 3.0, 4.5, 6., np.inf],
                                         labels=[1, 2, 3, 4, 5])

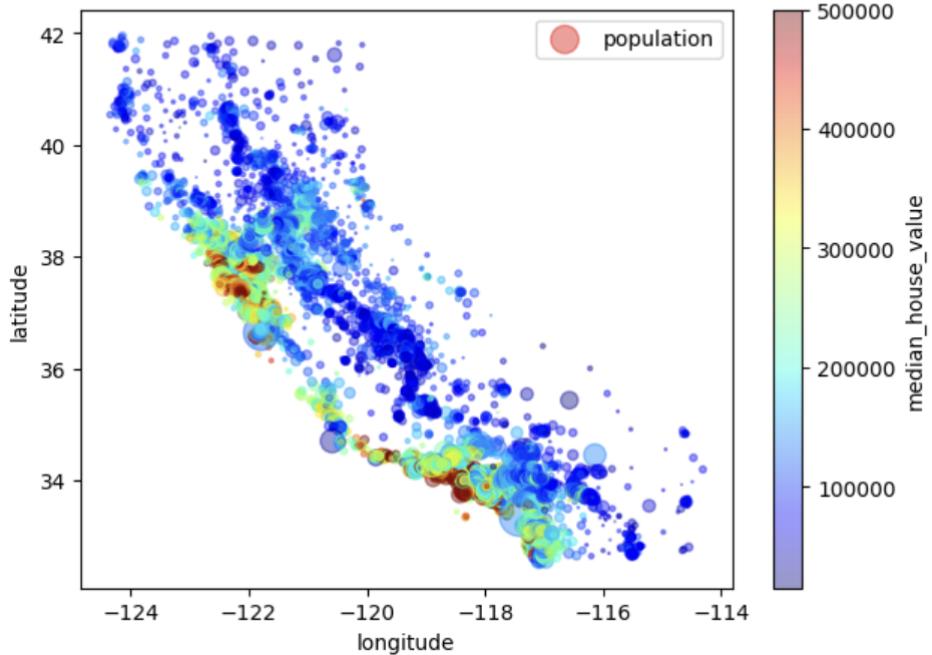
# Use StratifiedShuffleSplit to ensure the income distribution is preserved in both sets.
split = StratifiedShuffleSplit(n_splits=1, test_size=0.2, random_state=42)
for train_index, test_index in split.split(housing_selected, housing_selected['income_cat']):
    strat_train_set = housing_selected.loc[train_index]
    strat_test_set = housing_selected.loc[test_index]

# Remove the temporary income category attribute.
for dataset in (strat_train_set, strat_test_set):
```

```
dataset.drop("income_cat", axis=1, inplace=True)
```

```
import matplotlib.pyplot as plt
housing.plot(kind="scatter", x="longitude", y="latitude", alpha=0.4,
             s=housing["population"]/100, label="population", figsize=(7,5),
             c="median_house_value", cmap=plt.get_cmap("jet"), colorbar=True,)
plt.legend()
```

```
<matplotlib.legend.Legend at 0x7e55a2076b10>
```

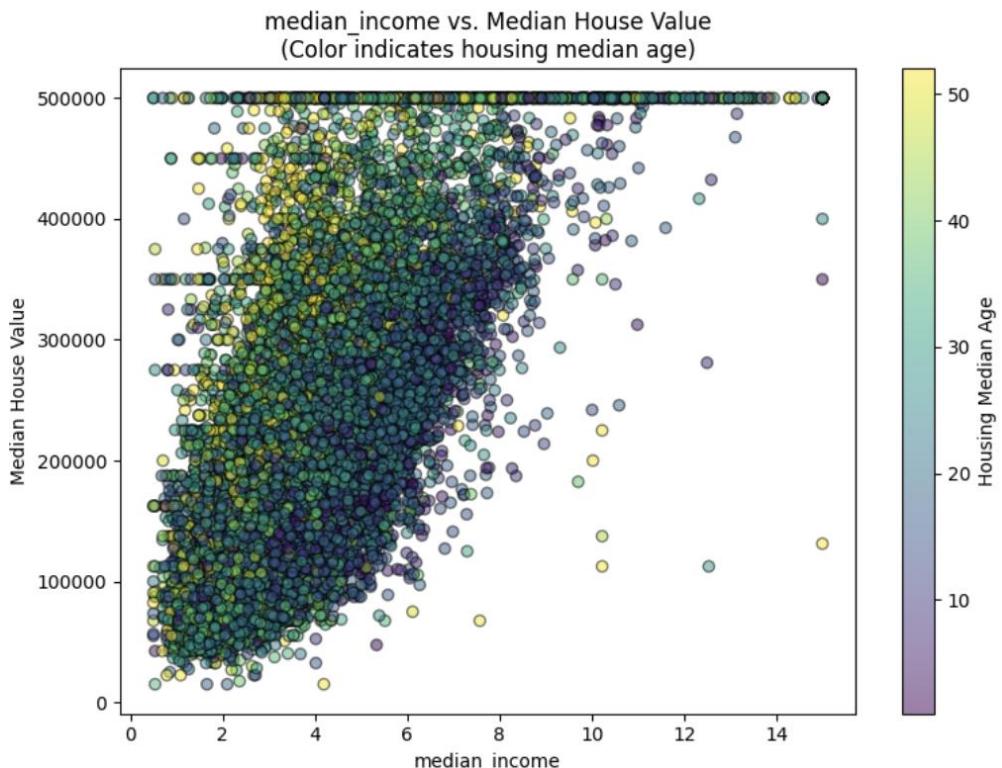


```

import matplotlib.pyplot as plt
import seaborn as sns

plt.figure(figsize=(8,6))
# Differentiate by using 'housing_median_age' for the color
scatter = plt.scatter(housing_numeric[max_feature],
                      housing_numeric["median_house_value"],
                      alpha=0.5,
                      c=housing_numeric["housing_median_age"],
                      cmap='viridis',
                      edgecolor='k')
plt.xlabel(max_feature)
plt.ylabel("Median House Value")
plt.title(f"{max_feature} vs. Median House Value\n(Color indicates housing median age)")
# Add a colorbar to explain the color mapping
cbar = plt.colorbar(scatter)
cbar.set_label("Housing Median Age")
plt.tight_layout()
plt.show()

```



```

from sklearn.preprocessing import OneHotEncoder

# Extract the categorical attribute
housing_cat = housing[["ocean_proximity"]]

# Perform one-hot encoding
encoder = OneHotEncoder()
housing_cat_1hot = encoder.fit_transform(housing_cat).toarray()

# Create a DataFrame for the encoded features
housing_cat_1hot_df = pd.DataFrame(housing_cat_1hot,
                                    columns=encoder.get_feature_names_out(["ocean_proximity"]))
housing_cat_1hot_df.head()
from sklearn.base import BaseEstimator, TransformerMixin
from sklearn.pipeline import Pipeline
from sklearn.compose import ColumnTransformer
from sklearn.preprocessing import StandardScaler

# Custom transformer to add engineered attributes
class CombinedAttributesAdder(BaseEstimator, TransformerMixin):

```

```

def __init__(self, add_bedrooms_per_room=True):
    self.add_bedrooms_per_room = add_bedrooms_per_room
def fit(self, X, y=None):
    return self
def transform(self, X):
    # Assumes X is a NumPy array with the following columns:
    # total_rooms (index 3), total_bedrooms (index 2), population (index 4), households (index 5)
    rooms_per_household = X[:, 3] / X[:, 5]
    population_per_household = X[:, 4] / X[:, 5]
    if self.add_bedrooms_per_room:
        bedrooms_per_room = X[:, 2] / X[:, 3]
        return np.c_[X, rooms_per_household, population_per_household, bedrooms_per_room]
    else:
        return np.c_[X, rooms_per_household, population_per_household]

# Identify numerical and categorical columns
num_attribs = housing.drop("ocean_proximity", axis=1).columns # All numeric columns
cat_attribs = ["ocean_proximity"]

# Build numerical pipeline: impute missing values, add new attributes, then scale
num_pipeline = Pipeline([
    ('imputer', SimpleImputer(strategy="median")),
    ('attribs_adder', CombinedAttributesAdder()),
    ('std_scaler', StandardScaler()),
])
# Build the full pipeline combining numerical and categorical processing
full_pipeline = ColumnTransformer([
    ("num", num_pipeline, num_attribs),
    ("cat", OneHotEncoder(), cat_attribs),
])
# Process the dataset using the pipeline
housing_prepared = full_pipeline.fit_transform(housing)
print("Shape of processed data:", housing_prepared.shape)

```

## LABORATORY PROGRAM – 3

Use an appropriate data set for building the decision tree (ID3) and apply this knowledge to classify a new sample.

### OBSERVATION BOOK

12/3/25 Lab 2

```
(5 import pandas as pd
from collections import Counter

def entropy(data):
    labels = data['label'].to_list()
    counts = Counter(labels)
    probabilities = [count / len(labels) for count in
                     counts.values()]
    entropy_value = -sum(p * math.log2(p) for
                          p in probabilities if p > 0)
    return entropy_value

def gain(data, feature):
    initial_entropy = entropy(data)
    feature_values = data[feature].unique()
    weighted_entropy = 0
    for value in feature_values:
        subset = data[data[feature] == value]
        weighted_entropy += (len(subset) / len(data)) *
                             entropy(subset)
    return initial_entropy - weighted_entropy
```

```

def id_3(data, features, target_attribute):
    if len(data[features].unique()) == 1:
        return data['label'].iloc[0]

    if len(features) == 0:
        return data['label'].value_counts().index[0]

    best_feature = max(features, key=lambda feature:
        gain(data, feature))

    tree = {best_feature: {}}

    features = [f for f in features if f != best_feature]
    for value in data[best_feature].unique():
        subset = data[data[best_feature] == value].drop(columns=[best_feature])
        if len(subset) == 0:
            tree[best_feature][value] = data['label'].value_counts().index[0]
        else:
            tree[best_feature][value] = id_3(subset,
                features, target_attribute)

    return tree

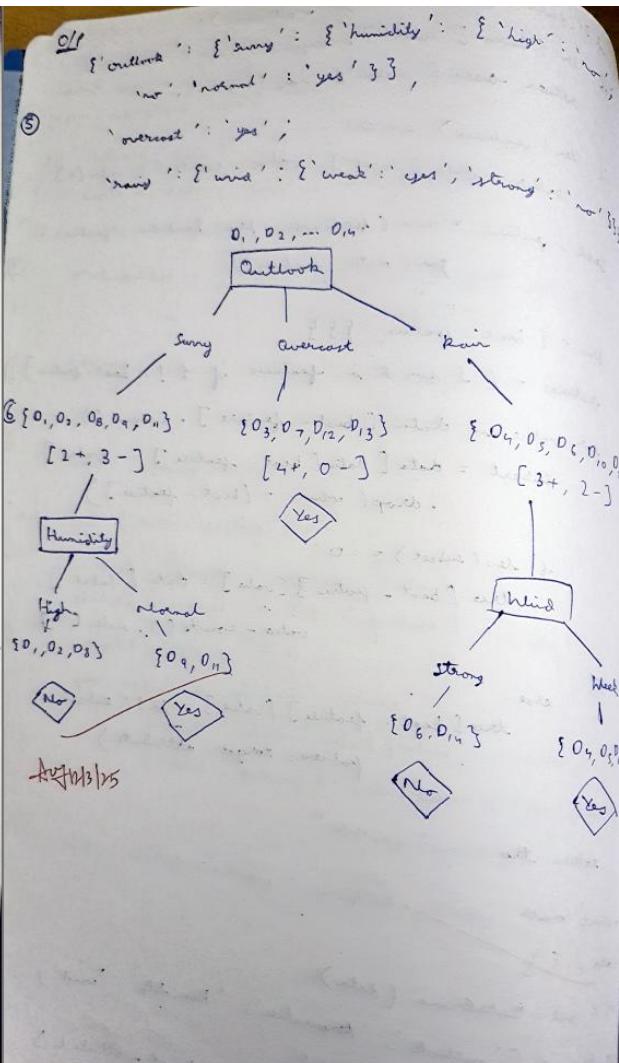
```

return tree

```

import math
data = []
df = pd.read_csv('data.csv')
features = ['outlook', 'temperature', 'humidity', 'wind']
target_attribute = 'label'
decision = tree = id_3(df, features, target_attribute)

```



## CODE WITH OUTPUT

```

import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report
import matplotlib.pyplot as plt
from sklearn.tree import plot_tree

# Load the iris dataset (make sure iris.csv is in the working directory)
iris = pd.read_csv("iris.csv")
# Assuming the last column is the target (species) and the rest are features.
X = iris.iloc[:, :-1]
y = iris.iloc[:, -1]

# Split data into training and testing sets (80% training, 20% testing)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Initialize and train the Decision Tree classifier
clf_iris = DecisionTreeClassifier(criterion='entropy', random_state=42)
clf_iris.fit(X_train, y_train)

# Make predictions and evaluate the model

```

```

y_pred_iris = clf_iris.predict(X_test)
accuracy_iris = accuracy_score(y_test, y_pred_iris)
conf_matrix_iris = confusion_matrix(y_test, y_pred_iris)

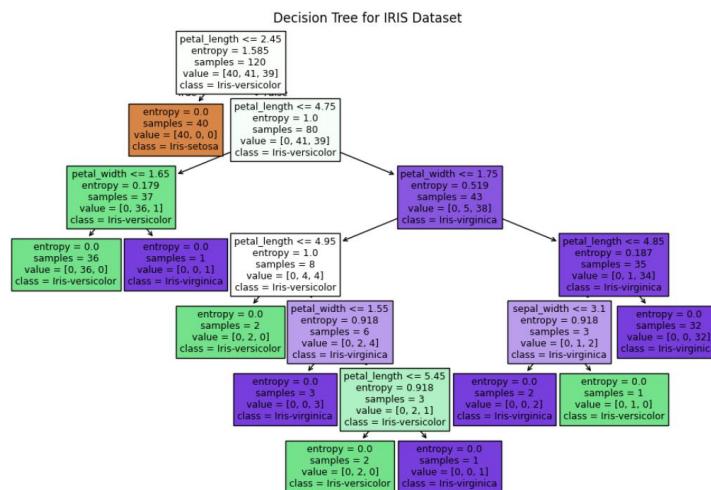
print("IRIS Dataset Decision Tree Classifier")
print("Accuracy:", accuracy_iris)
print("Confusion Matrix:\n", conf_matrix_iris)
print("Classification Report:\n", classification_report(y_test, y_pred_iris))

# Visualize the decision tree
plt.figure(figsize=(12, 8))
plot_tree(clf_iris, filled=True, feature_names=X.columns, class_names=clf_iris.classes_)
plt.title("Decision Tree for IRIS Dataset")
plt.show()

```

IRIS Dataset Decision Tree Classifier  
 Accuracy: 1.0  
 Confusion Matrix:  
 [[10 0 0]  
 [ 0 9 0]  
 [ 0 0 11]]  
 Classification Report:  

	precision	recall	f1-score	support
Iris-setosa	1.00	1.00	1.00	10
Iris-versicolor	1.00	1.00	1.00	9
Iris-virginica	1.00	1.00	1.00	11
accuracy			1.00	30
macro avg	1.00	1.00	1.00	30
weighted avg	1.00	1.00	1.00	30



```

import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report
import matplotlib.pyplot as plt
from sklearn.tree import plot_tree

# Load the drug dataset (make sure drug.csv is in the working directory)
drug = pd.read_csv("drug.csv")

```

```

# Since the target column is 'Drug', drop it from the features
X_drug = drug.drop('Drug', axis=1)
y_drug = drug['Drug']

```

```

# If there are categorical features, perform necessary encoding
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
# Encode features that are categorical
for col in X_drug.select_dtypes(include='object').columns:
    X_drug[col] = le.fit_transform(X_drug[col])
# Also encode the target variable if necessary
y_drug = le.fit_transform(y_drug)

```

```

# Split the data (80% training, 20% testing)
X_train_d, X_test_d, y_train_d, y_test_d = train_test_split(X_drug, y_drug, test_size=0.2, random_state=42)

# Initialize and train the Decision Tree classifier using entropy criterion
clf_drug = DecisionTreeClassifier(criterion='entropy', random_state=42)
clf_drug.fit(X_train_d, y_train_d)

# Make predictions and evaluate the model
y_pred_drug = clf_drug.predict(X_test_d)
accuracy_drug = accuracy_score(y_test_d, y_pred_drug)
conf_matrix_drug = confusion_matrix(y_test_d, y_pred_drug)

print("Drug Dataset Decision Tree Classifier")
print("Accuracy:", accuracy_drug)
print("Confusion Matrix:\n", conf_matrix_drug)
print("Classification Report:\n", classification_report(y_test_d, y_pred_drug))

# Visualize the decision tree
plt.figure(figsize=(12, 8))
plot_tree(clf_drug, filled=True, feature_names=X_drug.columns,
          class_names=[str(cls) for cls in clf_drug.classes_])
plt.title("Decision Tree for Drug Dataset")
plt.show()

```

Drug Dataset Decision Tree Classifier

Accuracy: 1.0

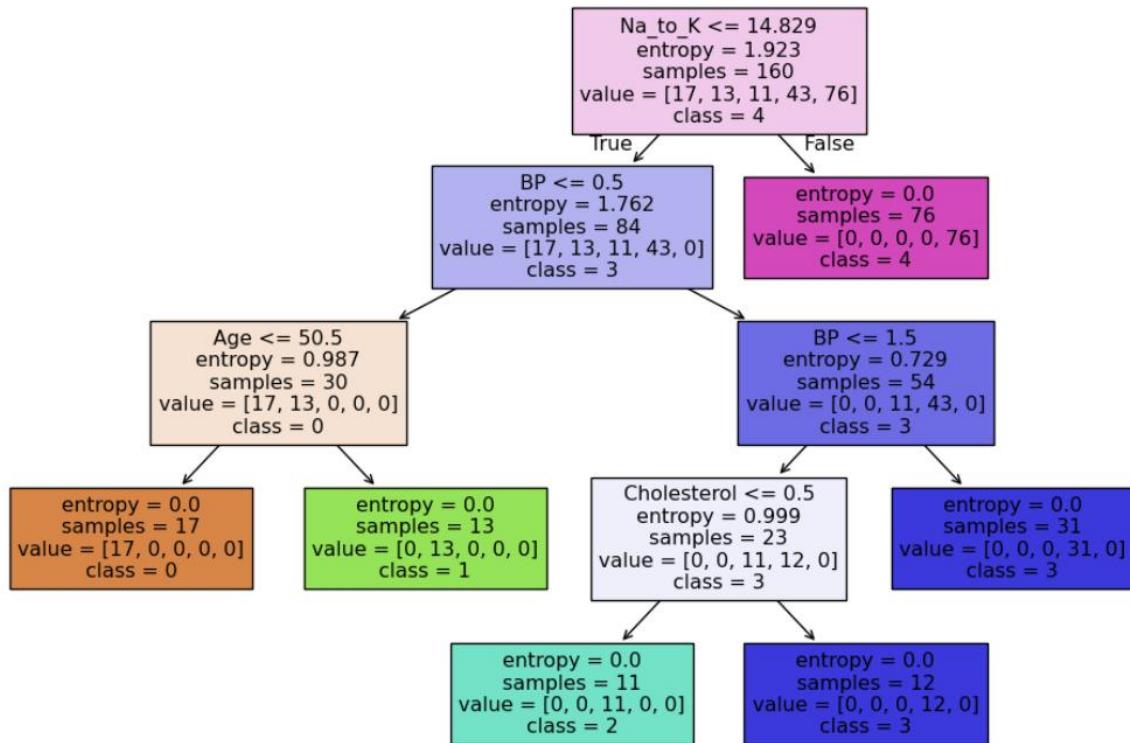
Confusion Matrix:

```
[[ 6  0  0  0  0]
 [ 0  3  0  0  0]
 [ 0  0  5  0  0]
 [ 0  0  0  11  0]
 [ 0  0  0  0  15]]
```

Classification Report:

	precision	recall	f1-score	support
0	1.00	1.00	1.00	6
1	1.00	1.00	1.00	3
2	1.00	1.00	1.00	5
3	1.00	1.00	1.00	11
4	1.00	1.00	1.00	15
accuracy			1.00	40
macro avg	1.00	1.00	1.00	40
weighted avg	1.00	1.00	1.00	40

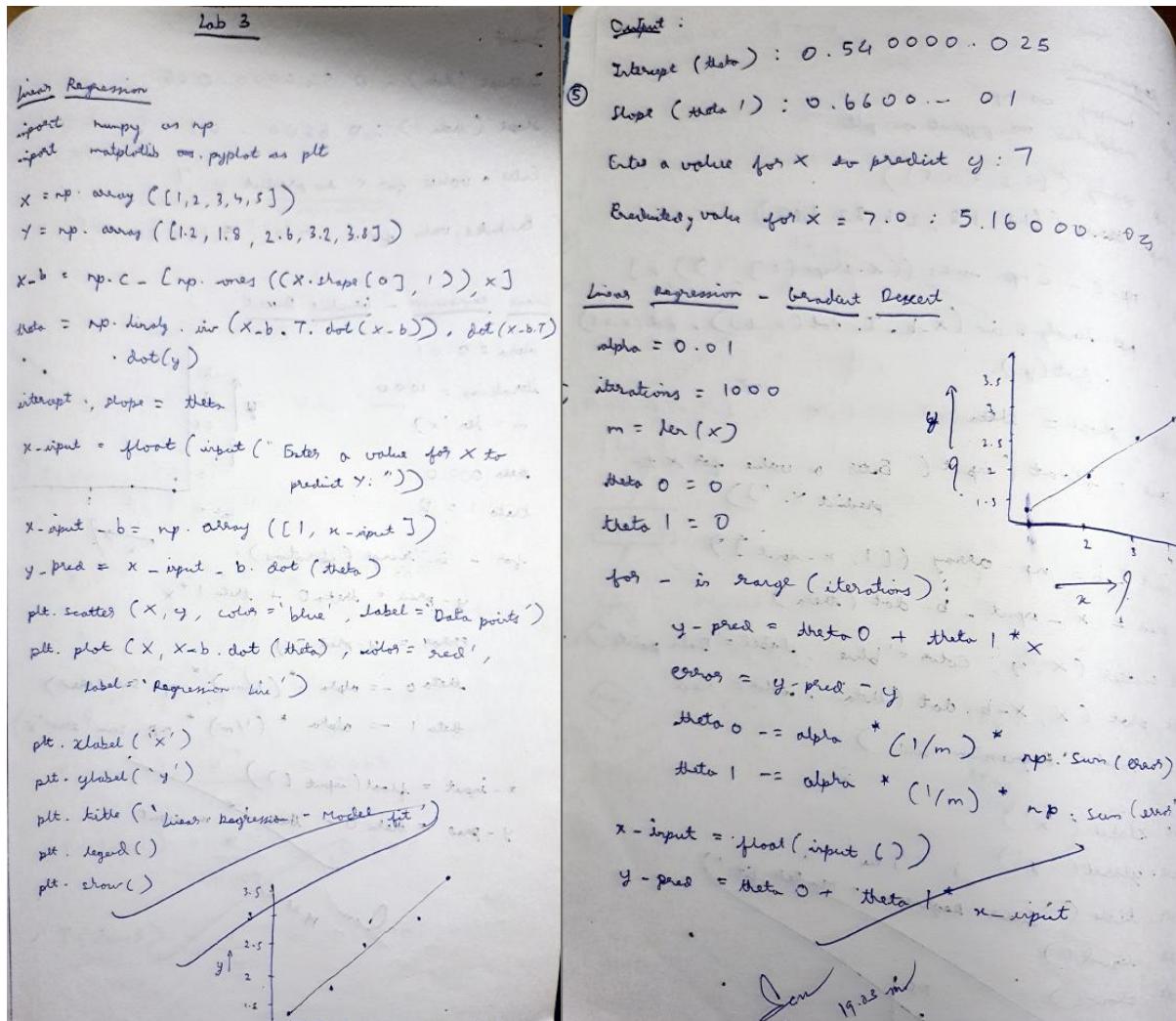
Decision Tree for Drug Dataset



## LABORATORY PROGRAM – 4

### Implement Linear and Multi-Linear Regression algorithm using appropriate dataset

#### OBSERVATION BOOK



#### CODE WITH OUTPUT

```

import pandas as pd
from sklearn.linear_model import LinearRegression
# Load the data
income_data = pd.read_csv("canada_per_capita_income.csv")
# Assumed data columns: 'Year' and 'PerCapitaIncome'
print("Canada Income Data Head:")
print(income_data.head())
# Prepare feature and target
X_income = income_data[["year"]] # Predictor variable: Year
y_income = income_data["per capita income (US$)"]
# Build and train the linear regression model

```

```

model_income = LinearRegression()
model_income.fit(X_income, y_income)

# Predict per capita income for the year 2020
predicted_income = model_income.predict([[2020]])

print("\nPredicted per capita income for Canada in 2020:", predicted_income[0])

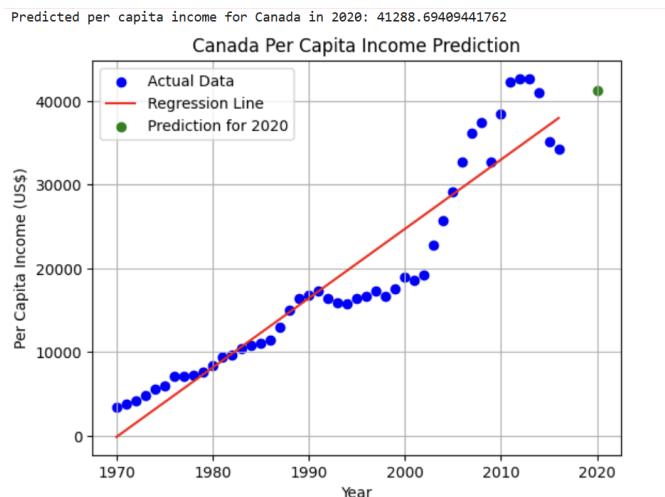
# Plot the data points and the regression line
plt.scatter(X_income, y_income, color='blue', label='Actual Data')
plt.plot(X_income, model_income.predict(X_income), color='red', label='Regression Line')

# Plot the prediction for 2020
plt.scatter(2020, predicted_income[0], color='green', label='Prediction for 2020')

# Customize the plot
plt.xlabel('Year')
plt.ylabel('Per Capita Income (US$)')
plt.title('Canada Per Capita Income Prediction')
plt.legend()
plt.grid(True)

# Display the plot
plt.show()

```



```

import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
from sklearn.linear_model import LinearRegression

# Load the salary data
salary_data = pd.read_csv("salary.csv")
print(salary_data.head())

# Prepare feature and target
X_salary = salary_data[["YearsExperience"]] # Predictor variable: Years of Experience
y_salary = salary_data["Salary"]

# Build and train the linear regression model
model_salary = LinearRegression()
model_salary.fit(X_salary, y_salary)

import matplotlib.pyplot as plt
# Plot the data points and the regression line
plt.scatter(X_salary, y_salary, color='blue', label='Actual Data')
plt.plot(X_salary, model_salary.predict(X_salary), color='red', label='Regression Line')

# Plot the prediction for 12 years of experience

```

```

plt.scatter(12, predicted_salary[0], color='green', label='Prediction for 12 years')

# Customize the plot
plt.xlabel('Years of Experience')
plt.ylabel('Salary')
plt.title('Salary Prediction based on Experience')
plt.legend()
plt.grid(True)

# Display the plot
plt.show()

```

Predicted salary for an employee with 12 years of experience: 139980.88923969213



```

import pandas as pd
import numpy as np
from sklearn.linear_model import LinearRegression

# Read the CSV file (ensure the file is uploaded in your Colab environment)
df = pd.read_csv("hiring.csv")

# Rename columns for convenience
df.columns = ['experience', 'test_score', 'interview_score', 'salary']

print("Original Data:")
print(df)

# Function to convert experience values to numeric
def convert_experience(x):
    try:
        return float(x)
    except:
        x_lower = str(x).strip().lower()
        return num_map.get(x_lower, np.nan)

# Convert the 'experience' column using the mapping
df['experience'] = df['experience'].apply(convert_experience)

# Convert 'test_score', 'interview_score', and 'salary' to numeric (coerce errors to NaN)

```

```

df['test_score'] = pd.to_numeric(df['test_score'], errors='coerce')
df['interview_score'] = pd.to_numeric(df['interview_score'], errors='coerce')
df['salary'] = pd.to_numeric(df['salary'], errors='coerce')

print("\nData After Conversion:")
print(df)

# Fill missing values in numeric columns using the column mean
df['experience'].fillna(df['experience'].mean(), inplace=True)
df['test_score'].fillna(df['test_score'].mean(), inplace=True)
df['interview_score'].fillna(df['interview_score'].mean(), inplace=True)

print("\nData After Filling Missing Values:")
print(df)

# Prepare the feature matrix X and target vector y
X = df[['experience', 'test_score', 'interview_score']]
y = df['salary']

# Build and train the Multiple Linear Regression model
model = LinearRegression()
model.fit(X, y)

# Predict salaries for the given candidate profiles
# Candidate 1: 2 years of experience, 9 test score, 6 interview score
candidate1 = np.array([[2, 9, 6]])
predicted_salary1 = model.predict(candidate1)

# Candidate 2: 12 years of experience, 10 test score, 10 interview score
candidate2 = np.array([[12, 10, 10]])
predicted_salary2 = model.predict(candidate2)

print("\nPredicted Salary for Candidate (2 yrs, 9 test, 6 interview): $", round(predicted_salary1[0], 2))
print("Predicted Salary for Candidate (12 yrs, 10 test, 10 interview): $", round(predicted_salary2[0], 2))

import matplotlib.pyplot as plt

# Create the plot
plt.figure(figsize=(10, 6)) # Adjust figure size for better visualization
plt.scatter(df['experience'], y, color='blue', label='Actual Salary') # Plot actual salary against years of experience

# Plot the regression line (this is an approximation since it's a multi-variable regression)
# You can visualize a single feature against the predicted salary
plt.plot(df['experience'], model.predict(X), color='red', label='Regression Line')

# Highlight predictions
plt.scatter(candidate1[0, 0], predicted_salary1, color='green', label='Candidate 1 Prediction')
plt.scatter(candidate2[0, 0], predicted_salary2, color='purple', label='Candidate 2 Prediction')

# Add labels and title
plt.xlabel("Years of Experience")
plt.ylabel("Salary")
plt.title("Salary Prediction based on Experience, Test Score, Interview Score")

# Add a legend
plt.legend()
plt.grid(True)
plt.show()

```



## LABORATORY PROGRAM – 5

### Build Logistic Regression Model for a given dataset

#### OBSERVATION BOOK

02-04-25      Lab 4 - Logistic Regression

① Solution:

a)  $a_0 = -5$   
 $a_1 = 0.8$

$$P(\text{pass}) = \frac{1}{1 + e^{-(a_0 + a_1 \cdot 7)}} = \frac{1}{1 + e^{-( -5 + 0.8 \cdot 7)}} = 0.645$$

b)  $a_0 + a_1 \cdot 7 = -5 + 0.8 \cdot 7 = 0.6$

$$P(\text{pass}) = 0.645$$

c)  $P(\text{pass}) > 0.5 \rightarrow \text{Here "pass"}$

②  $P(\text{class } i) = \frac{e^{z_i}}{\sum_j e^{z_j}}, z = [2, 1, 0]$

$$\sum_j e^{z_j} = e^2 + e^1 + e^0 \approx 11.107$$

$$e^{z_1} = e^2 = 7.389$$

$$e^{z_2} = e^1 = 2.718$$

$$e^{z_3} = e^0 = 1$$

$$P(\text{class 1}) = \frac{e^2}{11.107} \approx 0.666$$

$$P(\text{class 2}) = \frac{e^1}{11.107} \approx 0.245$$

$$P(\text{class 3}) = \frac{1}{11.107} \approx 0.090$$

i) Satisfaction level has highest import due to highest correlation factor.

ii) It is 77.07%, which is not good because it is not a proper correlation.

iii) Yes, to get all numeric data.

iv) No, but I dropped it from table if was present.

v) It is very accurate, with about no false predictions.

vi) Class label 4 due to inconsistent data & patterns

*Gen*

#### CODE WITH OUTPUT

```

import pandas as pd
from matplotlib import pyplot as plt
#%matplotlib inline
#"%matplotlib inline" will make your plot outputs appear and be stored within the notebook.

df = pd.read_csv("insurance_data.csv")
df.head()

plt.scatter(df.age, df.bought_insurance, marker='+', color='red')

from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(df[['age']], df.bought_insurance, train_size=0.9, random_state=10)
X_train.shape

X_test

from sklearn.linear_model import LogisticRegression
model = LogisticRegression()

model.fit(X_train, y_train)

```

```

X_test
y_test

y_predicted = model.predict(X_test)
y_predicted

model.score(X_test,y_test)

model.predict_proba(X_test)

y_predicted = model.predict([[60]])
y_predicted

#model.coef_ indicates value of m in y=m*x + b equation
model.coef_

#model.intercept_ indicates value of b in y=m*x + b equation
model.intercept_

#Lets defined sigmoid function now and do the math with hand
import math
def sigmoid(x):
    return 1 / (1 + math.exp(-x))

def prediction_function(age):
    z = 0.127 * age - 4.973 # 0.12740563 ~ 0.0127 and -4.97335111 ~ -4.97
    y = sigmoid(z)
    return y

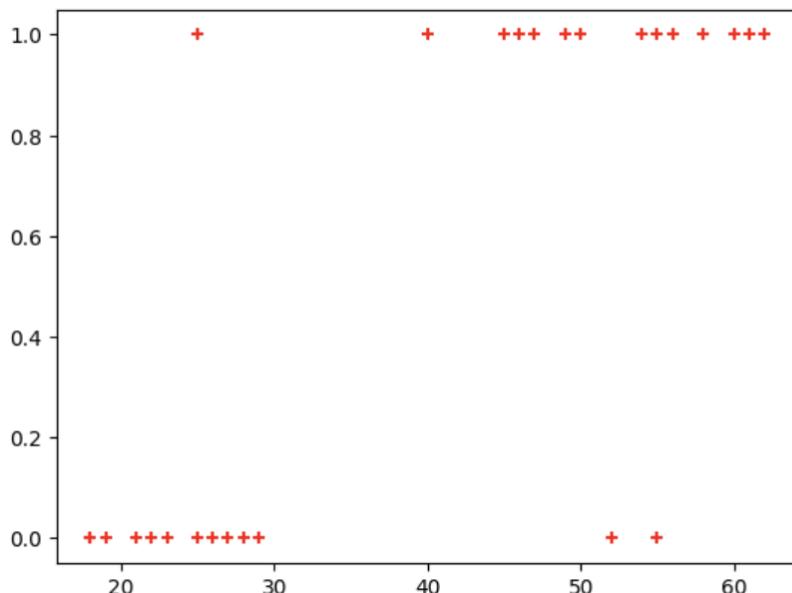
age = 35
prediction_function(age)

```

"""0.37 is less than 0.5 which means person with 35 will not buy the insurance"""

---

'0.37 is less than 0.5 which means person with 35 will not buy the insurance'



```

# Import necessary libraries
import pandas as pd
from sklearn.datasets import load_iris
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score

```

```

from sklearn import metrics
import matplotlib.pyplot as plt

# Load the Iris dataset
iris = pd.read_csv("iris.csv")
iris.head()

X=iris.drop('species',axis='columns')# Features (sepal length, sepal width, petal length, petal width)
y = iris.species # Target labels (0: Setosa, 1: Versicolor, 2: Virginica)

# Split the dataset into 80% training and 20% testing
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Initialize the Multinomial Logistic Regression model
# Use 'multinomial' for multi-class classification and 'lbfgs' solver
model = LogisticRegression(multi_class='multinomial')

# Train the model on the training data
model.fit(X_train, y_train)

# Make predictions on the test data
y_pred = model.predict(X_test)

# Calculate the accuracy of the model on the test data
accuracy = accuracy_score(y_test, y_pred)

# Display the accuracy
print(f"Accuracy of the Multinomial Logistic Regression model on the test set: {accuracy:.2f}")

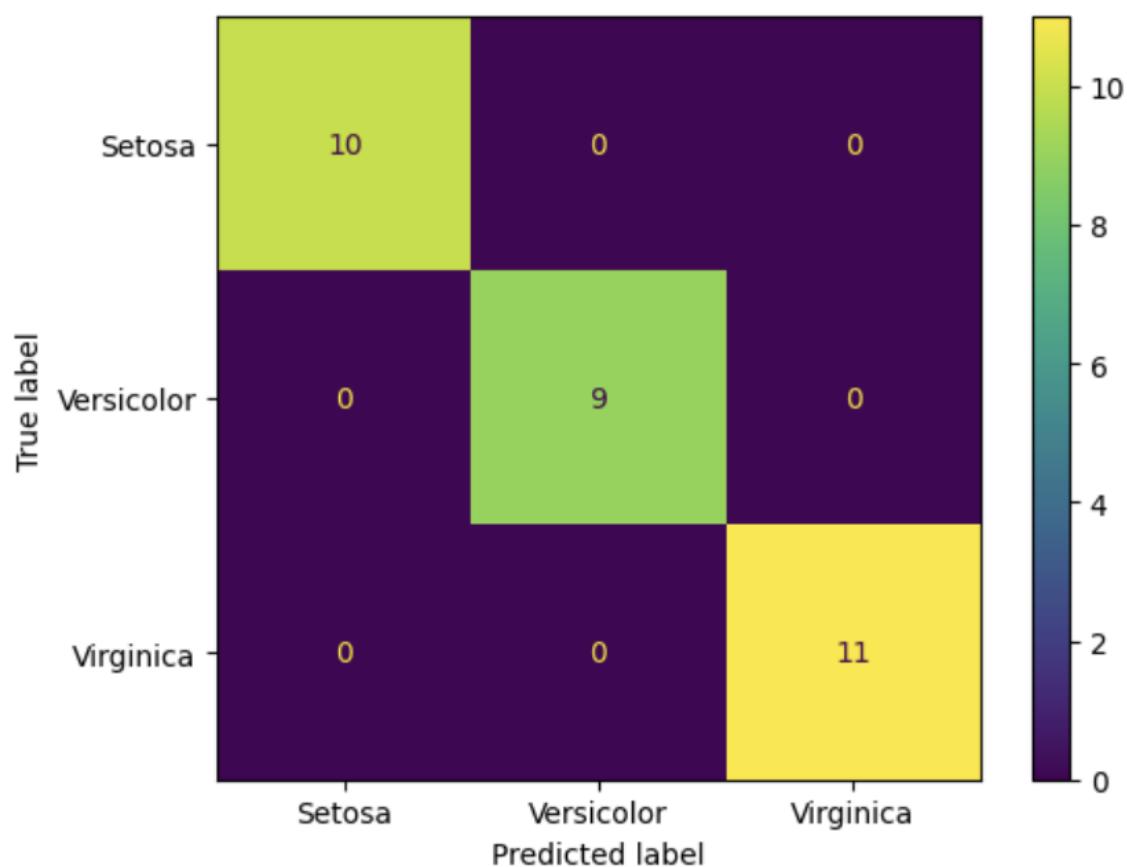
confusion_matrix = metrics.confusion_matrix(y_test, y_pred)

cm_display = metrics.ConfusionMatrixDisplay(confusion_matrix = confusion_matrix, display_labels = ["Setosa",
"Versicolor", "Virginica"])

cm_display.plot()
plt.show()

```

Accuracy of the Multinomial Logistic Regression model on the test set: 1.00



## LABORATORY PROGRAM – 6

**Build KNN Classification model for a given dataset.**

### OBSERVATION BOOK

Lab - 6 - KNN						02-04-25
Customer	Age	Salary	target	Distance	Rank	
A	18	50	N	52.8	5	
B	23	55	N	46.6	4	
C	24	70	N	31.9	2	
D	41	60	Y	40.5	3	
E	43	70	Y	31.1	1	
F	38	40	Y	60.1	6	

$k = 3$ , Closest 3: C, E, D

2Y's card / N  $\rightarrow$   $\therefore$  predicted value  
 $\text{for } X = (35, 100) = Y$

$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$  where  
 $(x_1, y_1) = (35, 100)$

① Iris :

For  $k = 5$ , accuracy  $\approx 0.9667$   
 $k = 3$  error  $\approx 0.0333$

For  $k = 4$ , accuracy  $\approx 1.000$   
error  $\approx 0.000$

For  $k = 6$ , accuracy  $\approx 0.9333$   
error  $\approx 0.0667$

② Diabetes

It is important as it is distance based.  
Otherwise cannot be scaled properly.

Standard Scalar :  $Z = \frac{u - n}{s}$   
 $u = \text{mean}$   
 $s = \text{std.}$   
 $n = \text{feature value}$

Gen

### CODE WITH OUTPUT

```
# Import necessary libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

# For model building and evaluation
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report

# ----- Part 1: IRIS Dataset -----
# Load the iris dataset (ensure iris.csv is in the same directory or provide correct path)
iris_df = pd.read_csv("iris.csv")

# Separate features and target
X_iris = iris_df.drop("species", axis=1)
y_iris = iris_df["species"]
```

```

# Split the data (80% training, 20% testing)
X_train_iris, X_test_iris, y_train_iris, y_test_iris = train_test_split(
    X_iris, y_iris, test_size=0.2, random_state=42
)

# Choose a value for k; here K=3 is used as an example.
knn_iris = KNeighborsClassifier(n_neighbors=3)

# Train the model on training data
knn_iris.fit(X_train_iris, y_train_iris)

# Predict on test data
y_pred_iris = knn_iris.predict(X_test_iris)

# Calculate accuracy score
acc_iris = accuracy_score(y_test_iris, y_pred_iris)
print("IRIS Dataset Accuracy Score:", acc_iris)

# Compute confusion matrix and classification report
cm_iris = confusion_matrix(y_test_iris, y_pred_iris)
print("\nIRIS Dataset Confusion Matrix:\n", cm_iris)

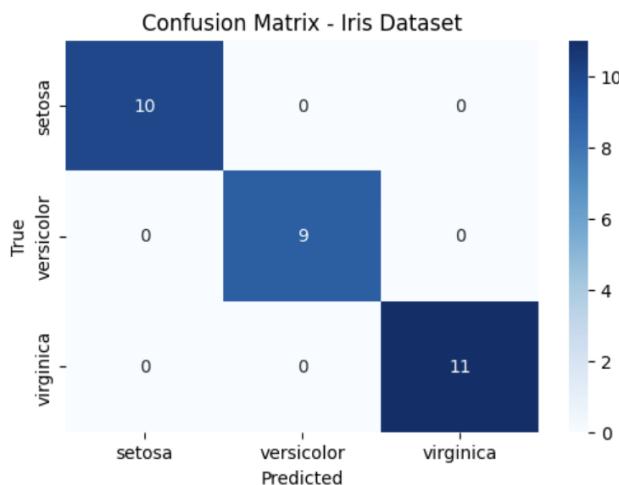
```

```

cr_iris = classification_report(y_test_iris, y_pred_iris)
print("\nIRIS Dataset Classification Report:\n", cr_iris)

```

	precision	recall	f1-score	support
setosa	1.00	1.00	1.00	10
versicolor	1.00	1.00	1.00	9
virginica	1.00	1.00	1.00	11
accuracy			1.00	30
macro avg	1.00	1.00	1.00	30
weighted avg	1.00	1.00	1.00	30



```

# ----- Part 2: Diabetes Dataset ----- #
# Load the diabetes dataset (ensure diabetes.csv is in the same directory or provide correct path)
diabetes_df = pd.read_csv("diabetes.csv")

# Separate features and target (Outcome column is assumed to be the target)
X_diabetes = diabetes_df.drop("Outcome", axis=1)
y_diabetes = diabetes_df["Outcome"]

# Perform feature scaling on the features
scaler = StandardScaler()
X_scaled_diabetes = scaler.fit_transform(X_diabetes)

# Split the scaled data (80% training, 20% testing)

```

```

X_train_diab, X_test_diab, y_train_diab, y_test_diab = train_test_split(
    X_scaled_diabetes, y_diabetes, test_size=0.2, random_state=42
)

# Choose a value for k; here K=5 is used as an example.
knn_diabetes = KNeighborsClassifier(n_neighbors=5)

# Train the model on training data
knn_diabetes.fit(X_train_diab, y_train_diab)

# Predict on test data
y_pred_diab = knn_diabetes.predict(X_test_diab)

# Calculate accuracy score
acc_diab = accuracy_score(y_test_diab, y_pred_diab)
print("Diabetes Dataset Accuracy Score:", acc_diab)

# Compute confusion matrix and classification report
cm_diab = confusion_matrix(y_test_diab, y_pred_diab)
print("\nDiabetes Dataset Confusion Matrix:\n", cm_diab)

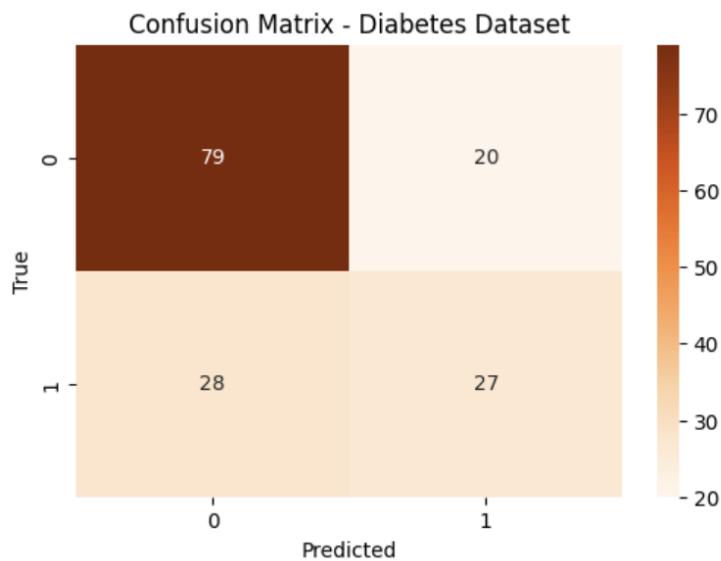
```

```

cr_diab = classification_report(y_test_diab, y_pred_diab)
print("\nDiabetes Dataset Classification Report:\n", cr_diab)

```

	precision	recall	f1-score	support
0	0.74	0.80	0.77	99
1	0.57	0.49	0.53	55
accuracy			0.69	154
macro avg	0.66	0.64	0.65	154
weighted avg	0.68	0.69	0.68	154



```

# ----- Load the Dataset ----- #
# Load heart.csv (make sure the file is in your working directory)
heart_df = pd.read_csv("heart.csv")

# Display the first few rows to check the data
heart_df.head()

# ----- Data Preparation ----- #
# Separate features and target

```

```

X_heart = heart_df.drop("target", axis=1)
y_heart = heart_df["target"]

# Perform feature scaling (important for distance-based algorithms like KNN)
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X_heart)

# Split data into training and testing sets (80% train, 20% test)
X_train, X_test, y_train, y_test = train_test_split(X_scaled, y_heart, test_size=0.2, random_state=42)
# ----- Finding the Best k ----- #
# We will try a range of k values (neighbors) and select the one with maximum accuracy.
k_range = range(1, 21)
accuracy_scores = []

for k in k_range:
    knn = KNeighborsClassifier(n_neighbors=k)
    knn.fit(X_train, y_train)
    y_pred = knn.predict(X_test)
    acc = accuracy_score(y_test, y_pred)
    accuracy_scores.append(acc)
    print(f"K = {k} --> Accuracy: {acc:.4f}")

    k = 1 --> Accuracy: 0.8525
    k = 2 --> Accuracy: 0.8197
    k = 3 --> Accuracy: 0.8689
    k = 4 --> Accuracy: 0.8852
    k = 5 --> Accuracy: 0.9180
    k = 6 --> Accuracy: 0.9344
    k = 7 --> Accuracy: 0.9180
    k = 8 --> Accuracy: 0.8525
    k = 9 --> Accuracy: 0.8852
    k = 10 --> Accuracy: 0.8852
    k = 11 --> Accuracy: 0.8852
    k = 12 --> Accuracy: 0.8689
    k = 13 --> Accuracy: 0.8852
    k = 14 --> Accuracy: 0.8689
    k = 15 --> Accuracy: 0.9016
    k = 16 --> Accuracy: 0.8852
    k = 17 --> Accuracy: 0.8852
    k = 18 --> Accuracy: 0.9016
    k = 19 --> Accuracy: 0.8852
    k = 20 --> Accuracy: 0.8852

    |: # Determine the best k value
    best_k = k_range[np.argmax(accuracy_scores)]
    print("\nBest k value:", best_k)

Best k value: 6

```

```
# ----- Train Final Model with Best k ----- #
best_knn = KNeighborsClassifier(n_neighbors=best_k)
best_knn.fit(X_train, y_train)
y_pred_best = best_knn.predict(X_test)
```

```
# Compute final accuracy, confusion matrix and classification report
final_accuracy = accuracy_score(y_test, y_pred_best)
cm = confusion_matrix(y_test, y_pred_best)
cr_text = classification_report(y_test, y_pred_best)
print("\nFinal Accuracy Score:", final_accuracy)
print("\nConfusion Matrix:\n", cm)
print("\nClassification Report:\n", cr_text)
```

Final Accuracy Score: 0.9344262295081968

Confusion Matrix:

```
[[28  1]
 [ 3 29]]
```

Classification Report:

	precision	recall	f1-score	support
0	0.90	0.97	0.93	29
1	0.97	0.91	0.94	32
accuracy			0.93	61
macro avg	0.93	0.94	0.93	61
weighted avg	0.94	0.93	0.93	61

## LABORATORY PROGRAM – 7

### Build Support vector machine model for a given dataset

#### CODE WITH OUTPUT

```
import numpy as np
import matplotlib.pyplot as plt
from sklearn.svm import SVC

# Data points
X = np.array([[4, 1], [4, -1], [6, 0], [1, 0], [0, 1], [0, -1]])
y = np.array([1, 1, 1, -1, -1, -1])

# Fit linear SVM with a very large C to approximate hard-margin
clf = SVC(kernel='linear', C=1e6)
clf.fit(X, y)

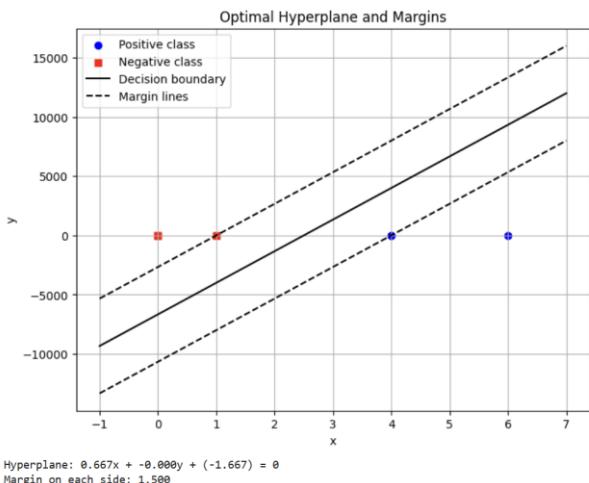
# Extract model parameters
w = clf.coef_[0]
b = clf.intercept_[0]

# Compute decision boundary and margins
xx = np.linspace(-1, 7, 500)
yy = -(w[0] * xx + b) / w[1]

# Margin offset: distance = 1/||w||
margin = 1 / np.linalg.norm(w)
yy_down = yy - np.sqrt(1 + (w[0] / w[1])**2) * margin
yy_up = yy + np.sqrt(1 + (w[0] / w[1])**2) * margin

# Plotting
plt.figure(figsize=(8, 6))
plt.scatter(X[y == 1, 0], X[y == 1, 1], c='blue', marker='o', label='Positive class')
plt.scatter(X[y == -1, 0], X[y == -1, 1], c='red', marker='s', label='Negative class')
plt.plot(xx, yy, 'k-', label='Decision boundary')
plt.plot(xx, yy_down, 'k--', label='Margin lines')
plt.plot(xx, yy_up, 'k--')
plt.xlabel('x')
plt.ylabel('y')
plt.legend()
plt.title('Optimal Hyperplane and Margins')
plt.grid(True)
plt.show()

# Print hyperplane equation
print(f"Hyperplane: {w[0]:.3f}x + {w[1]:.3f}y + ({b:.3f}) = 0")
print(f"Margin on each side: {margin:.3f}")
```



```

import pandas as pd

# Load both datasets
iris_df = pd.read_csv("/content/iris.csv")
# 1. IRIS DATASET - SVM with RBF and Linear Kernels
X_iris = iris_df.drop("species", axis=1)
y_iris = iris_df["species"]

# Encode labels
le_iris = LabelEncoder()
y_iris_encoded = le_iris.fit_transform(y_iris)

# Split dataset
X_train_iris, X_test_iris, y_train_iris, y_test_iris = train_test_split(X_iris, y_iris_encoded, test_size=0.2, random_state=42)

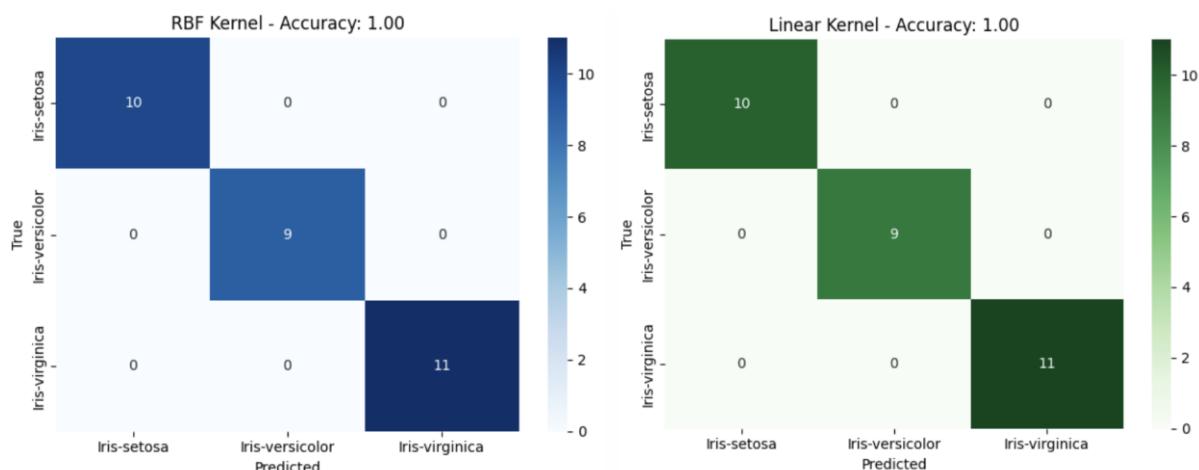
# Train models
svm_rbf = SVC(kernel='rbf')
svm_linear = SVC(kernel='linear')

svm_rbf.fit(X_train_iris, y_train_iris)
svm_linear.fit(X_train_iris, y_train_iris)

# Predictions
y_pred_rbf = svm_rbf.predict(X_test_iris)
y_pred_linear = svm_linear.predict(X_test_iris)

# Accuracy and Confusion Matrix
acc_rbf = accuracy_score(y_test_iris, y_pred_rbf)
acc_linear = accuracy_score(y_test_iris, y_pred_linear)
cm_rbf = confusion_matrix(y_test_iris, y_pred_rbf)
cm_linear = confusion_matrix(y_test_iris, y_pred_linear)

```



```

# Load dataset
letter_df = pd.read_csv("/content/letter-recognition.csv") # Update path if needed
letter_df['letter'] = LabelEncoder().fit_transform(letter_df['letter'])

# Split features and labels
X = letter_df.drop('letter', axis=1)
y = letter_df['letter']

# Train-test split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Standardize
scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)

# Train SVM
svm = SVC(kernel='rbf', probability=True)
svm.fit(X_train, y_train)
y_pred = svm.predict(X_test)
y_prob = svm.predict_proba(X_test)

# Accuracy and Confusion Matrix
print("Accuracy:", accuracy_score(y_test, y_pred))
print("Confusion Matrix:\n", confusion_matrix(y_test, y_pred))

# ROC and AUC (one-vs-rest)
y_test_bin = label_binarize(y_test, classes=np.unique(y))
n_classes = y_test_bin.shape[1]

fpr = dict()
tpr = dict()
roc_auc = dict()

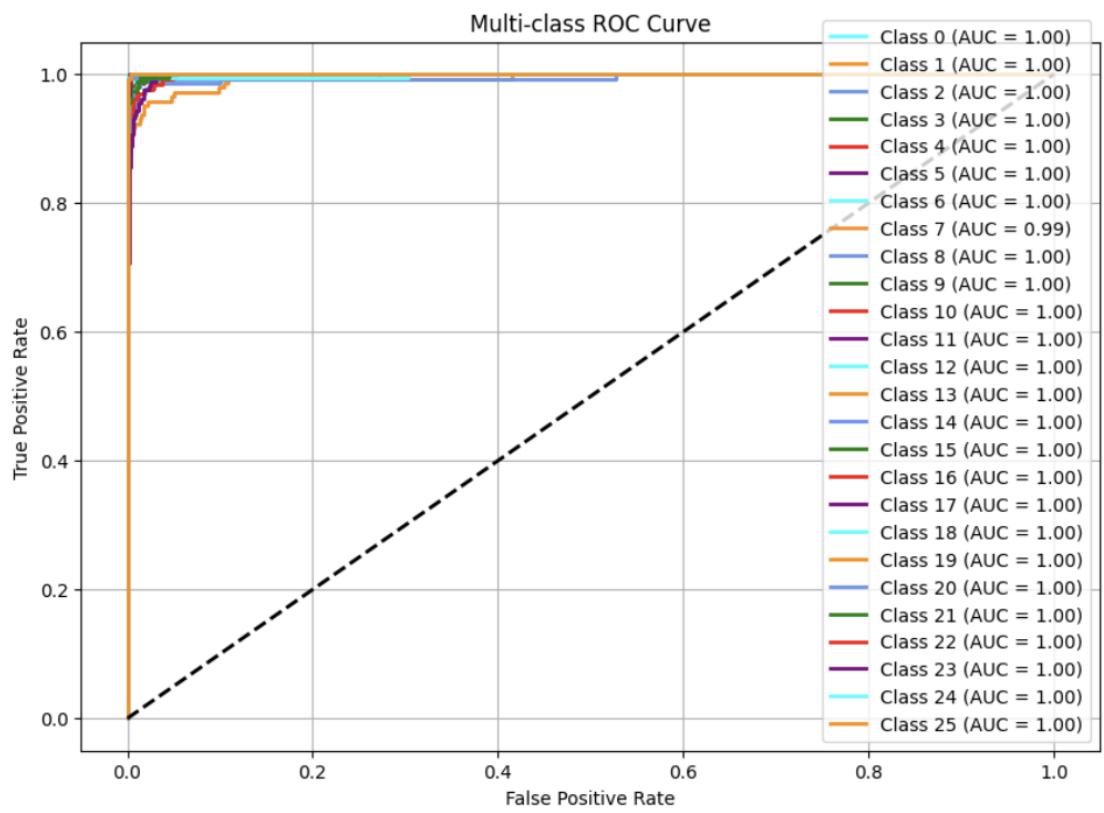
for i in range(n_classes):
    fpr[i], tpr[i], _ = roc_curve(y_test_bin[:, i], y_prob[:, i])
    roc_auc[i] = auc(fpr[i], tpr[i])

# Plot ROC Curve
plt.figure(figsize=(10, 7))
colors = cycle(['aqua', 'darkorange', 'cornflowerblue', 'green', 'red', 'purple'])

for i, color in zip(range(n_classes), colors):
    plt.plot(fpr[i], tpr[i], color=color, lw=2,
             label=f'Class {i} (AUC = {roc_auc[i]:0.2f})')

plt.plot([0, 1], [0, 1], 'k--', lw=2)
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("Multi-class ROC Curve")
plt.legend(loc="lower right")
plt.grid()
plt.show()

```



## LABORATORY PROGRAM – 8

Implement Random forest ensemble method on a given dataset.

### OBSERVATION BOOK

16/04/25      Lab - 7 : Random Forest

S1: Build a Random Forest

a) If no of examples in the train set is  $N$ , take a sample of  $n$ -examples of random but with replacement, from original data. This sample will be training set for generating the tree

Again out of 100, choose next 30 examples randomly for 2<sup>nd</sup> p & put them back.

S2: If there are  $M$  i/p vars.,  $m$  vars. are selected at random, out of  $M$ , the best split on those  $m$ , used to split node. The value of ' $m$ ' is held constant during the generation of various trees in forest

Ex: 10 i/p vars  $\rightarrow$  3  
subset of these vars. randomly to build tree

S3: Each tree is grown to the largest extent for new data, print final prediction of each branch & assign new data point to category part with majority votes, i.e. wherever a new data pt. is given, give that DP to the particular DT

Cart 18.04

## CODE WITH OUTPUT

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, confusion_matrix
import matplotlib.pyplot as plt

# Load the dataset
df = pd.read_csv("iris.csv") # Adjust filename if needed

# Prepare data
X = df.drop(columns=["species"]) # Assuming 'species' is the target column
y = df["species"]

# Split dataset
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Default Random Forest with 10 trees
rf_default = RandomForestClassifier(n_estimators=10, random_state=42)
rf_default.fit(X_train, y_train)
y_pred_default = rf_default.predict(X_test)
acc_default = accuracy_score(y_test, y_pred_default)
conf_matrix_default = confusion_matrix(y_test, y_pred_default)

print(f"Default RF (10 trees) Accuracy: {acc_default}")
print("Confusion Matrix:\n", conf_matrix_default)

# Try different numbers of trees to find the best
best_acc = 0
best_n = 10
acc_list = []

for n in range(1, 101):
    rf = RandomForestClassifier(n_estimators=n, random_state=42)
    rf.fit(X_train, y_train)
    y_pred = rf.predict(X_test)
    acc = accuracy_score(y_test, y_pred)
    acc_list.append((n, acc))
    if acc > best_acc:
        best_acc = acc
        best_n = n
        best_conf_matrix = confusion_matrix(y_test, y_pred)

print(f"\nBest Accuracy: {best_acc} using {best_n} trees")
print("Best Confusion Matrix:\n", best_conf_matrix)
# Plot accuracy vs number of trees
x_vals, y_vals = zip(*acc_list)
plt.plot(x_vals, y_vals, marker='o')
plt.title("Accuracy vs Number of Trees")
plt.xlabel("Number of Trees")
plt.ylabel("Accuracy")
plt.grid(True)
plt.show()
```

```
Default RF (10 trees) Accuracy: 1.0
```

```
Confusion Matrix:
```

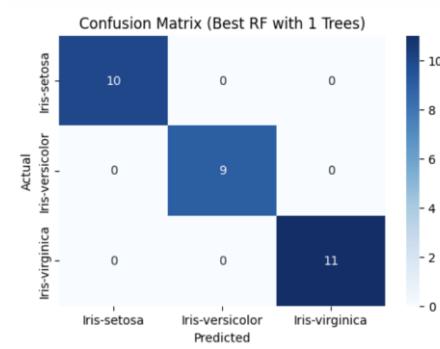
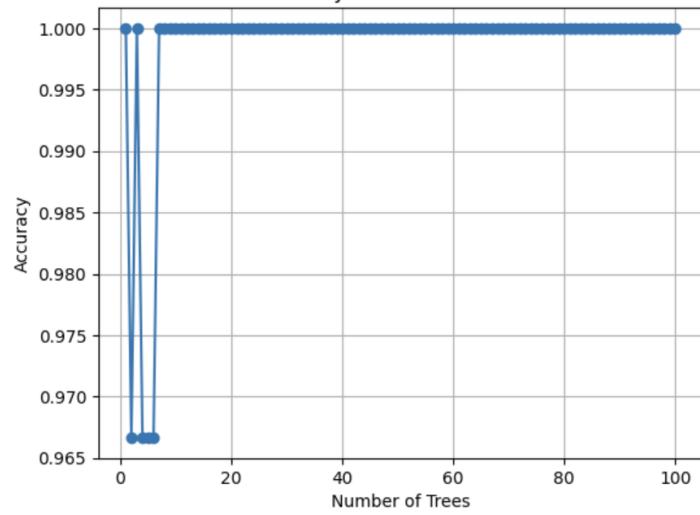
```
[[10  0  0]
 [ 0  9  0]
 [ 0  0 11]]
```

```
Best Accuracy: 1.0 using 1 trees
```

```
Best Confusion Matrix:
```

```
[[10  0  0]
 [ 0  9  0]
 [ 0  0 11]]
```

Accuracy vs Number of Trees



## **LABORATORY PROGRAM – 9**

**Implement Boosting ensemble method on a given dataset.**

## OBSERVATION BOOK

$$wt(d_j)_{j+1} = \frac{1}{6} \times e^{0.349} = 0.2501$$

0.9428

<u>Interactions</u>		Bridited	Actual	Weight
Yes	No	Job Offer	Job Offer	
Yes	No	Yes	Yes	0.1249
No	Yes	No	Yes	0.2501
No	No	No	No	0.2501
No	No	No	No	0.1249
Yes	Yes	Yes	Yes	0.1249
Yes	Yes	Yes	No	0.1249

$$E_{\text{Interest}} = 1 \times 0.2501 = 0.2501$$

$$\alpha_{\text{Interest}} = \frac{1}{2} \ln \frac{(1 - 0.2501)}{0.2501} = 0.5490$$

$$Z_{\text{Interest}} = 0.1249 + 4 \times e^{-0.549} + 0.2501 + e^{-0.549}$$

$$= 0.1249 + 4 \times e^{-0.549} + 0.2501 + e^{-0.549}$$

$$= 0.866$$

$$wt(d_j)_{j+1} = \frac{0.1249 \times e^{-0.549}}{0.866} = 0.0832$$

$$wt(d_j)_{j+1} = \frac{0.2501 \times e^{-0.549}}{0.866} = 0.1667$$

$$wt(d_j)_{j+1} = \frac{0.2501 \times e^{-0.549}}{0.866} = 0.5001$$

### Brakite knowledge

Good → Yes  
Moderate → No  
Awful →

No instances misclassified,  
no need decision stump

<u>Communication</u>		Bridited	Actual	Weight
Low	High	Job Offer	Job Offer	
Low	High	Yes	Yes	0.0832
Moderate	Low	No	Yes	0.5001
Moderate	High	No	No	0.1667
Good	High	No	No	0.0832
Moderate	Low	Yes	Yes	0.0832
Moderate	High	No	Yes	0.0832

$$\epsilon_{cs} = 1 \times 0.5001 + 3 \times 0.0832 = 0.7497$$

$$\alpha_{cs} = \frac{1}{2} \ln \frac{(1 - 0.7497)}{0.7497} = -0.5485$$

$$Z_{cs} = 0.0832 \times 1 \times e^{-(-0.5485)} + 0.1667 \times 1 \times e^{-(-0.5485)} + 0.5001 \times 1 \times e^{-0.5485} + 0.0832 \times 3 \times e^{-(-0.5485)}$$

$$Z_{cs} = 0.866$$

$$wt(d_j) = \frac{0.0832 \times e^{-(-0.5485)}}{0.866} = 0.1663$$

~~$$wt(d_j)_{j+1} = \frac{0.1667 \times e^{-(-0.5485)}}{0.866} = 0.3331$$~~

$$w(\delta_i)_{i+1} = \frac{0.5001 \times e^{(-0.5485)}}{0.866} = 0.3337$$

$$w(\delta_i)_{i+1} = \frac{0.0822 \times e^{(-0.5485)}}{0.866} = 0.0555$$

Final

$$\begin{aligned} H_F(\delta_i) &= \alpha_{COPA} \times \text{Yes} + \alpha_{\text{Interact}} \times \text{Yes} + \alpha_{CS} \times \text{Yes} \\ &= 0.347 \times 1 + 0.5490 \times 1 - 0.5485 \times 1 = 0.34 \end{aligned}$$

	$\alpha_{COPA} = 0.347$	$\alpha_{\text{Interact}} = 0.5490$	$\alpha_{CS} = -0.5485$	Weight avg.	Final Prediction
1	Yes	Yes	Yes	0.3475	Yes
2	No	No	No	0.0	No
3	Yes	No	No	0.347	Yes
4	No	No	Yes	-0.5485	No
5	Yes	Yes	No	0.896	Yes
6	Yes	Yes	No	0.896	Yes

① Best accuracy = 0.83 or 83%.

Nur. of trees = 160.

$$\text{Confusion matrix} = \begin{bmatrix} 10658 & 451 \\ 2023 & 1521 \end{bmatrix}$$

## CODE WITH OUTPUT

```
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split, cross_val_score
from sklearn.preprocessing import OneHotEncoder, StandardScaler
from sklearn.compose import ColumnTransformer
from sklearn.pipeline import Pipeline
from sklearn.ensemble import AdaBoostClassifier
```

```

from sklearn.metrics import accuracy_score, confusion_matrix, ConfusionMatrixDisplay

# Load dataset
data = pd.read_csv('income.csv')

# Display basic info
print("First five rows:")
print(data.head())
print(f"\nDataset shape: {data.shape}")

# Define features and target
target_column = 'income_level'
y = data[target_column]
X = data.drop(columns=[target_column])

# Identify categorical vs numerical columns
categorical_cols = X.select_dtypes(include=['object', 'category']).columns.tolist()
numerical_cols = X.select_dtypes(include=['int64', 'float64']).columns.tolist()
print(f"\nNumerical columns: {numerical_cols}")
print(f"Categorical columns: {categorical_cols}")

# Preprocessor: scale numericals, one-hot encode categoricals
preprocessor = ColumnTransformer(
    transformers=[
        ('num', StandardScaler(), numerical_cols),
        ('cat', OneHotEncoder(handle_unknown='ignore'), categorical_cols)
    ]
)

# Initial AdaBoost model with 10 estimators
pipeline = Pipeline([
    ('preprocess', preprocessor),
    ('clf', AdaBoostClassifier(n_estimators=10, random_state=42))
])

# Split into train/test sets
X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, random_state=42, stratify=y
)

# Train and evaluate initial model
pipeline.fit(X_train, y_train)
y_pred = pipeline.predict(X_test)
initial_acc = accuracy_score(y_test, y_pred)
print(f"Initial test accuracy (n_estimators=10): {initial_acc:.4f}")

# Hyperparameter tuning: find best n_estimators
tree_counts = list(range(10, 201, 10)) # 10,20,...,200
cv_scores = []
for n in tree_counts:
    model = Pipeline([
        ('preprocess', preprocessor),
        ('clf', AdaBoostClassifier(n_estimators=n, random_state=42))
    ])
    scores = cross_val_score(
        model, X_train, y_train, cv=5, scoring='accuracy', n_jobs=-1
    )
    mean_score = scores.mean()
    cv_scores.append(mean_score)
    print(f"n_estimators={n}: CV mean accuracy={mean_score:.4f}")

# Plot CV accuracy vs. number of estimators
plt.figure()
plt.plot(tree_counts, cv_scores, marker='o')
plt.title('AdaBoost CV Accuracy vs. n_estimators')
plt.xlabel('Number of Estimators')
plt.ylabel('CV Mean Accuracy')

```

```

plt.grid(True)
plt.tight_layout()
plt.show()

# Determine optimal number of trees
best_score = max(cv_scores)
best_n = tree_counts[cv_scores.index(best_score)]
print(f"\nBest CV accuracy={best_score:.4f} with n_estimators={best_n}")

# Retrain and evaluate best model
best_model = Pipeline([
    ('preprocess', preprocess),
    ('clf', AdaBoostClassifier(n_estimators=best_n, random_state=42))
])
best_model.fit(X_train, y_train)
y_best = best_model.predict(X_test)
best_test_acc = accuracy_score(y_test, y_best)
print(f"Test accuracy with best n_estimators ({best_n}): {best_test_acc:.4f}")

# Plot comparison of initial vs. best test accuracy
plt.figure()
plt.bar(['n=10', f'n={best_n}'], [initial_acc, best_test_acc])
plt.title('Test Accuracy: Initial vs. Optimized')
plt.ylabel('Accuracy')
plt.ylim(0, 1)
plt.tight_layout()
plt.show()

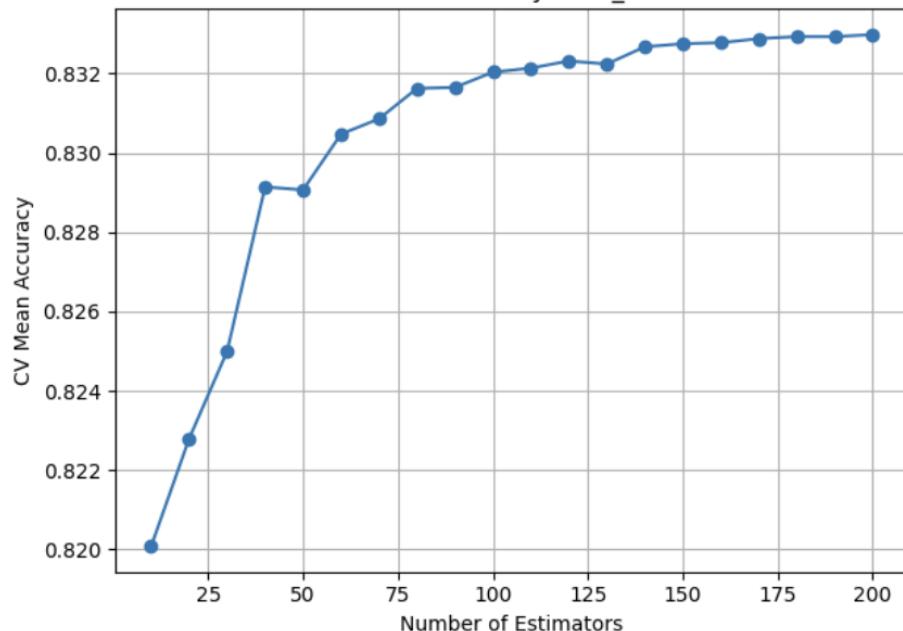
# Plot confusion matrix for best model
cm = confusion_matrix(y_test, y_best)
labels = best_model.named_steps['clf'].classes_
disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=labels)
plt.figure()
disp.plot(cmap=plt.cm.Blues)
plt.title('Confusion Matrix for Best AdaBoost Model')
plt.tight_layout()
plt.show()

```

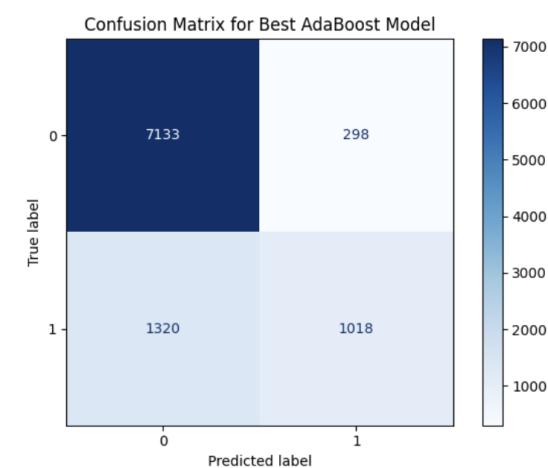
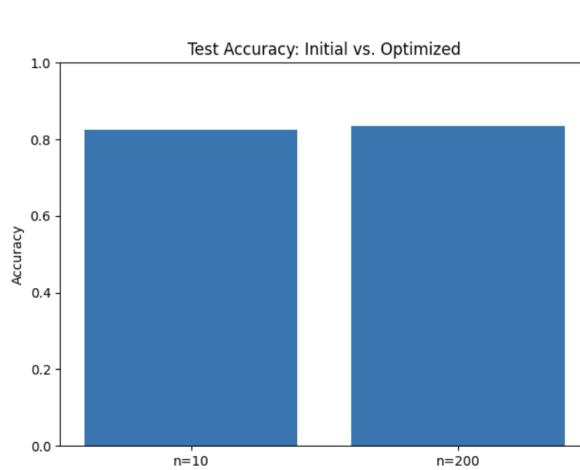
Dataset shape: (48842, 7)

Numerical columns: ['age', 'fnlwgt', 'education\_num', 'capital\_gain', 'capital\_loss', 'hours\_per\_week']  
Categorical columns: []  
Initial test accuracy (n\_estimators=10): 0.8257  
n\_estimators=10: CV mean accuracy=0.8201  
n\_estimators=20: CV mean accuracy=0.8228  
n\_estimators=30: CV mean accuracy=0.8250  
n\_estimators=40: CV mean accuracy=0.8291  
n\_estimators=50: CV mean accuracy=0.8291  
n\_estimators=60: CV mean accuracy=0.8305  
n\_estimators=70: CV mean accuracy=0.8309  
n\_estimators=80: CV mean accuracy=0.8316  
n\_estimators=90: CV mean accuracy=0.8316  
n\_estimators=100: CV mean accuracy=0.8320  
n\_estimators=110: CV mean accuracy=0.8321  
n\_estimators=120: CV mean accuracy=0.8323  
n\_estimators=130: CV mean accuracy=0.8322  
n\_estimators=140: CV mean accuracy=0.8327  
n\_estimators=150: CV mean accuracy=0.8327  
n\_estimators=160: CV mean accuracy=0.8328  
n\_estimators=170: CV mean accuracy=0.8329  
n\_estimators=180: CV mean accuracy=0.8329  
n\_estimators=190: CV mean accuracy=0.8329  
n\_estimators=200: CV mean accuracy=0.8330

AdaBoost CV Accuracy vs. n\_estimators



Best CV accuracy=0.8330 with n\_estimators=200  
Test accuracy with best n\_estimators (200): 0.8344



## LABORATORY PROGRAM – 10

**Build k-Means algorithm to cluster a set of data stored in a .CSV file.**

### OBSERVATION BOOK

		<u>Lab 9 - k-means clustering</u>	
		A	B
①	Dataset		
R1		1.0	1.0
R2		1.5	2.0
R3		2.0	4.0
R4		3.0	7.0
R5		3.5	5.0
R6		4.5	6.0
R7		3.5	4.5

$k = 2$ , centroid for  $C_1 = (1, 1)$ ,  
           "    "     $C_2 = (5, 7)$

Iteration 1

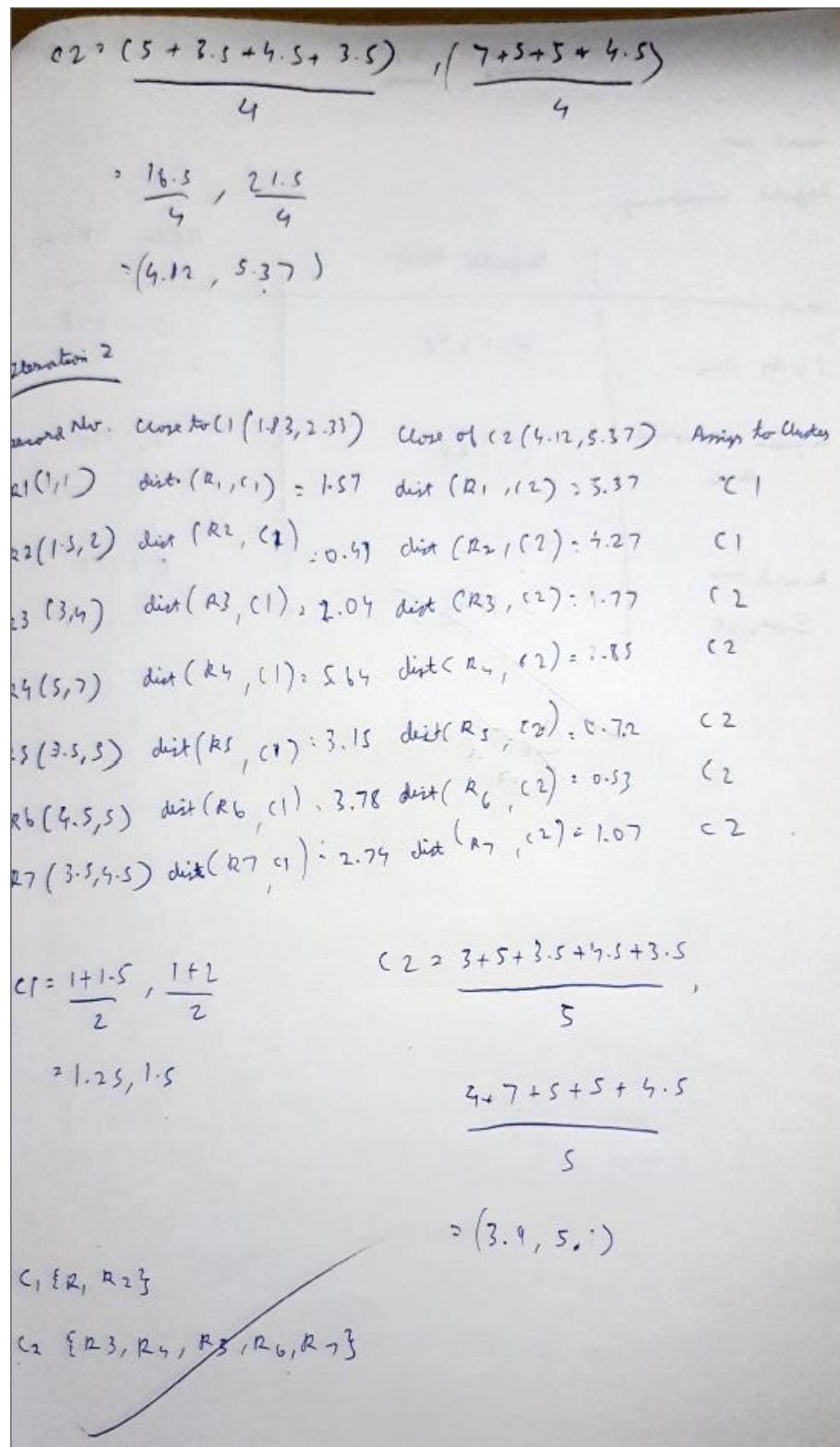
Point No.	Close to $C_1(1, 1)$	Close to $C_2(5, 7)$	Assignment
R1(1, 1)	$dist(R1, C1) = 0.0$	$dist(R1, C2) = 7.21$	C1
R2(2.5, 2)	$dist(R2, C1) = 1.12$	$dist(R2, C2) = 6.12$	C1
R3(3, 4)	$dist(R3, C1) = 3.61$	$dist(R3, C2) = 3.61$	C1
R4(3, 7)	$dist(R4, C1) = 7.21$	$dist(R4, C2) = 0.0$	C1
R5(3.5, 5)	$dist(R5, C1) = 4.12$	$dist(R5, C2) = 2.5$	C2
R6(4.5, 6)	$dist(R6, C1) = 5.31$	$dist(R6, C2) = 2.06$	C2
R7(3.5, 4.5)	$dist(R7, C1) = 4.30$	$dist(R7, C2) = 2.92$	C2

$$C_1 \{R1, R2, R3\} = \overbrace{\frac{1+1.5+3}{3}}, \quad \overbrace{\frac{1+2+4}{3}}$$

$$= \frac{5.5}{3}, \quad \frac{7.0}{3}$$

$$= (1.83, 2.33)$$



## CODE WITH OUTPUT

```

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import load_iris
from sklearn.preprocessing import StandardScaler

```

```

from sklearn.cluster import KMeans
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay

def load_data(csv_path='iris.csv'):
    """
    Try loading from csv_path; if not found, load via sklearn.
    Expects columns: sepal_length, sepal_width, petal_length, petal_width, species.
    Returns DataFrame with a 'species' column.
    """
    try:
        df = pd.read_csv(csv_path)
        # Fixed typo here: use c.strip().replace, not ace()
        df.columns = [c.strip().replace(' ', '_') for c in df.columns]
    except FileNotFoundError:
        iris = load_iris()
        df = pd.DataFrame(
            data=np.c_[iris['data'], iris['target']],
            columns=iris['feature_names'] + ['target']
        )
        df.columns = [c.strip().replace(' (cm)', "").replace(' ', '_')
                     for c in df.columns]
        df['species'] = df['target'].map(lambda x: iris['target_names'][int(x)])
    return df

def preprocess(df):
    """
    Select only petal_length & petal_width, then standard-scale.
    Returns scaled numpy array.
    """
    X = df[['petal_length', 'petal_width']].values
    scaler = StandardScaler()
    X_scaled = scaler.fit_transform(X)
    return X_scaled, scaler

def plot_elbow(X_scaled, max_k=10):
    """
    Compute KMeans inertia for k=1..max_k and plot the elbow curve.
    Returns list of inertias.
    """
    inertias = []
    ks = range(1, max_k + 1)
    for k in ks:
        km = KMeans(n_clusters=k, random_state=42)
        km.fit(X_scaled)
        inertias.append(km.inertia_)
    plt.figure(figsize=(6, 4))
    plt.plot(ks, inertias, 'o-', linewidth=2)
    plt.xlabel('Number of clusters (k)')
    plt.ylabel('Inertia')
    plt.title('Elbow Method for Optimal k')
    plt.xticks(ks)
    plt.grid(True, linestyle='--', alpha=0.5)
    plt.tight_layout()
    plt.show()
    return inertias

def run_kmeans(X_scaled, k):
    """
    Fit KMeans with k clusters, return labels and fitted model.
    """
    km = KMeans(n_clusters=k, random_state=42)
    labels = km.fit_predict(X_scaled)
    return km, labels

def plot_confusion(df, labels, k):
    """
    Builds and displays a confusion matrix comparing true species vs. cluster.
    """

```

```

"""
species_names = df['species'].unique()
species_to_num = {name: idx for idx, name in enumerate(species_names)}
true_nums = df['species'].map(species_to_num)

cm = confusion_matrix(true_nums, labels)
disp = ConfusionMatrixDisplay(
    confusion_matrix=cm,
    display_labels=[f"Cluster {i}" for i in range(k)])
)
fig, ax = plt.subplots(figsize=(6, 6))
disp.plot(ax=ax, cmap='Blues', colorbar=True)
ax.set_xlabel('Predicted Cluster')
ax.set_ylabel('True Species')
plt.title('K-Means Clustering Confusion Matrix')
plt.tight_layout()
plt.show()

cm_df = pd.DataFrame(
    cm,
    index=[f"True: {name}" for name in species_names],
    columns=[f"Cluster {i}" for i in range(k)])
)
print("\nConfusion Matrix (counts):")
print(cm_df)

def main():
    # 1) Load data
    df = load_data('iris.csv')
    if 'species' not in df.columns:
        print("Error: 'species' column not found.")
        return

    # 2) Preprocess
    X_scaled, scaler = preprocess(df)

    # 3) Elbow plot to decide k
    print("Generating elbow plot to find optimal k...")
    inertias = plot_elbow(X_scaled, max_k=10)

    # 4) From the elbow you'll typically see a bend at k=3
    optimal_k = 3
    print(f"Choosing k = {optimal_k} (you can adjust this based on the plot).")

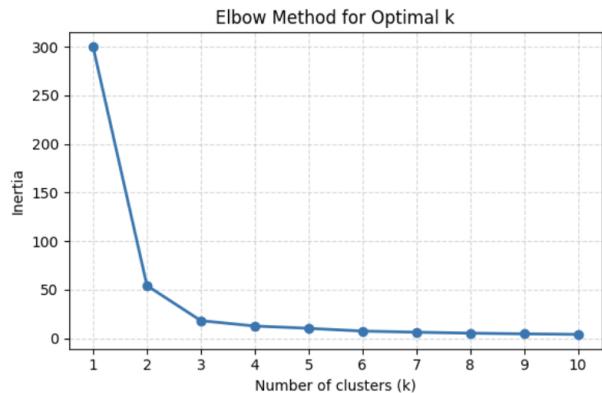
    # 5) Run K-Means and assign clusters
    km_model, labels = run_kmeans(X_scaled, optimal_k)
    df['cluster'] = labels

    # 6) Visualize clusters in feature space
    plt.figure(figsize=(6, 4))
    plt.scatter(
        X_scaled[:, 0], X_scaled[:, 1],
        c=labels, cmap='viridis', edgecolor='k', s=50
    )
    centroids = km_model.cluster_centers_
    plt.scatter(
        centroids[:, 0], centroids[:, 1],
        marker='X', c='red', s=200, label='Centroids'
    )
    plt.xlabel('Scaled Petal Length')
    plt.ylabel('Scaled Petal Width')
    plt.title(f'K-Means Clusters (k={optimal_k})')
    plt.legend()
    plt.grid(True, linestyle='--', alpha=0.5)
    plt.tight_layout()
    plt.show()

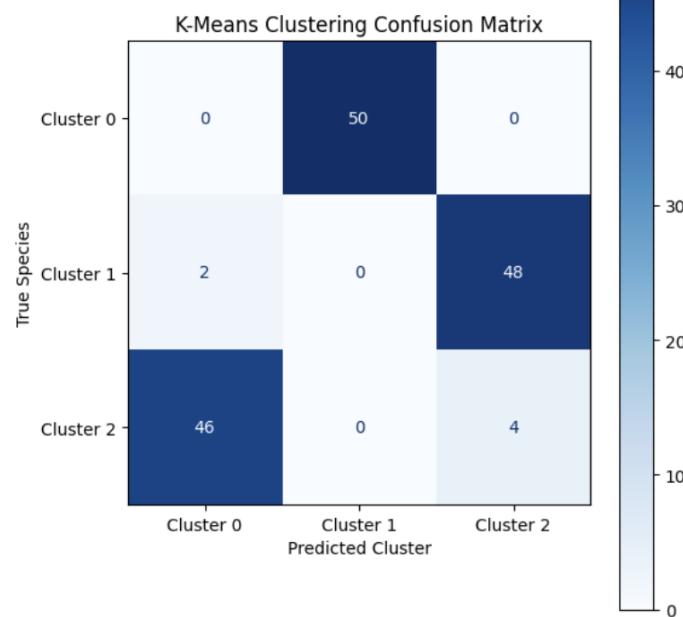
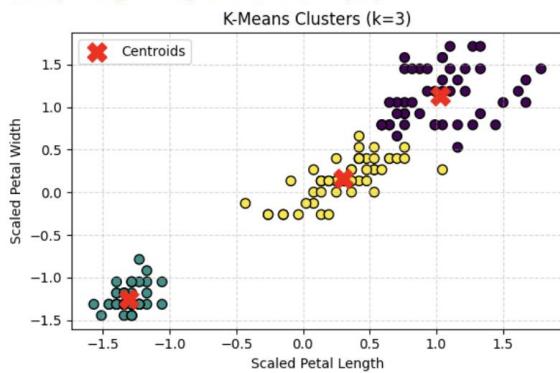
```

```
# 7) Confusion matrix vs. true species
plot_confusion(df, labels, optimal_k)
```

```
if __name__ == "__main__":
    main()
```



Choosing k = 3 (you can adjust this based on the plot).



## LABORATORY PROGRAM – 11

### Implement Dimensionality reduction using Principle Component Analysis (PCA) method.

#### OBSERVATION BOOK

		Before PCA	After PCA
heart.csv			
Report accuracy :			
SVM Acc.	0.1648	0.1848	
Logistic regression acc	0.1685	0.1739	
Random Forest	0.1848	0.1738	
	<i>Surpassed</i>		

#### CODE WITH OUTPUT

```
import pandas as pd

df = pd.read_csv("heart.csv")

# Step 3: Split Features and Target
X = df.drop("target", axis=1)
y = df["target"]

# Step 4: Preprocessing
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler, OneHotEncoder
from sklearn.compose import ColumnTransformer
from sklearn.pipeline import Pipeline

categorical_features = ["cp", "thal", "slope"]
numerical_features = [col for col in X.columns if col not in categorical_features]
```

```

preprocessor = ColumnTransformer(transformers=[  

    ("num", StandardScaler(), numerical_features),  

    ("cat", OneHotEncoder(), categorical_features)  

])
# Step 5: Train/Test Split  

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Step 6: Models  

from sklearn.linear_model import LogisticRegression  

from sklearn.svm import SVC  

from sklearn.ensemble import RandomForestClassifier  

from sklearn.metrics import accuracy_score

models = {  

    "Logistic Regression": LogisticRegression(max_iter=1000),  

    "SVM": SVC(),  

    "Random Forest": RandomForestClassifier()  

}

# Step 7: Train and Evaluate Models (Before PCA)  

print("Accuracy Before PCA:")  

results = {}  

for name, model in models.items():  

    pipeline = Pipeline(steps=[  

        ("preprocessor", preprocessor),  

        ("classifier", model)  

    ])  

    pipeline.fit(X_train, y_train)  

    y_pred = pipeline.predict(X_test)  

    acc = accuracy_score(y_test, y_pred)  

    results[name] = acc  

    print(f"{name}: {acc:.4f}")

from sklearn.decomposition import PCA

print("\nAccuracy After PCA (n_components=5):")  

pca_results = {}

for name, model in models.items():  

    pipeline_pca = Pipeline(steps=[  

        ("preprocessor", preprocessor),  

        ("pca", PCA(n_components=5)),  

        ("classifier", model)  

    ])  

    pipeline_pca.fit(X_train, y_train)  

    y_pred_pca = pipeline_pca.predict(X_test)  

    acc_pca = accuracy_score(y_test, y_pred_pca)  

    pca_results[name] = acc_pca  

    print(f"{name}: {acc_pca:.4f}")

```

→  Accuracy Before PCA:  
Logistic Regression: 0.9016  
SVM: 0.8525  
Random Forest: 0.8361

 Accuracy After PCA (n\_components=5):  
Logistic Regression: 0.8689  
SVM: 0.8689  
Random Forest: 0.8852