VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

Machine Learning (23CS6PCMAL)

Submitted by

Rushi Hundiwala (1BM22CS224)

in partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
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B.M.S. College of Engineering,

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 **Rushi Hundiwala(1BM22CS224),** who is bonafide student of **B.M.S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum. The Lab report has been approved as it satisfies the academic requirements in respect of an Machine Learning (23CS6PCMAL) work prescribed for the said degree.

Lab Faculty Incharge Name: **Ms. Saritha A N** Assistant Professor Department of CSE, BMSCE	 **Dr. Kavitha Sooda** Professor & HOD Department of CSE, BMSCE

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Github Link:https://github.com/RishiHundiwala344/ML-lab/tree/main

Program 1

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

Code:

```
import pandas as pd

# ---- IMPORTING DATA ----

# Read data from a CSV file
input_file = 'input_data.csv'  # Make sure this file exists in your working directory
try:
    data = pd.read_csv(input_file)
    print("Imported Data:")
    print(data)
except FileNotFoundError:
    print(f"File '{input_file}' not found.")

# ---- EXPORTING DATA ----

# Modify or process the data (optional) - Example: Add a new column
if 'data' in locals():
    data['Processed'] = data.iloc[:, 0].apply(lambda x: x)  # Just copying the first column for example

    # Export the modified data to a new CSV file
    output_file = 'output_data.csv'
    data.to_csv(output_file, index=False)
    print(f"\nData exported successfully to '{output_file}'")
```

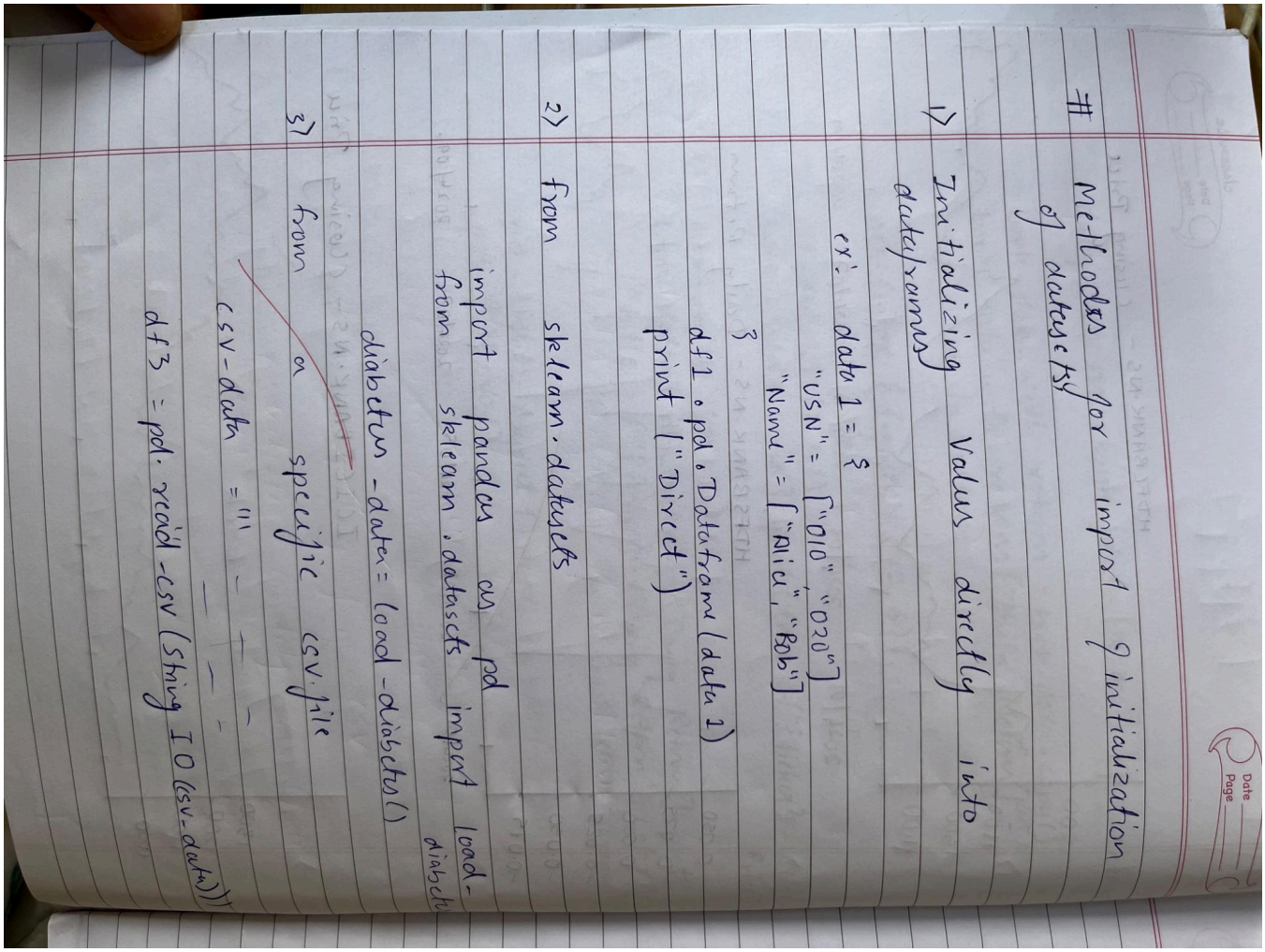
OUTPUT:

```
Name,Age,Country
Alice,30,USA
Bob,25,Canada
Charlie,35,UK
```

Program 2

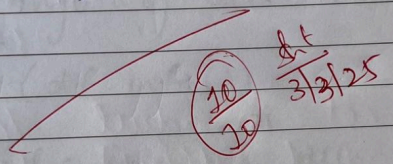
Demonstrate various data pre-processing techniques for a given dataset

SCREENSHOT:



Method - 4

	Passenger Id	Survived	Pclass
0	1	0	3
1	2	1	1
2	3	1	3
3	4	1	1
4	5	0	3



4) Downloading & Using online databases.

ex-code

```
url = "https://raw.githubusercontent"

try :
    _ _ _

except :
    _ _ _
```

like Kaggle etc.

Code :

```
csv_data = """Product ID, Quantity
1001,10
1002,5
1003,20
1004,15
1005,8
"""
df3 = pd.read_csv(StringIO(csv_data))
```

method 4

```
url = "https://raw.githubusercontent.com"
try :
    response = requests.get(url)
    response.raise_for_status()
except:
    requests.exceptions.RequestException as e:
    print(f"\nError downloading dataset: {e}")
```

CODE:

```
import pandas as pd

from sklearn.preprocessing import LabelEncoder, StandardScaler


# Sample dataset

data = {

    'CustomerID': [1, 2, 3, 4, 5],

    'Gender': ['Male', 'Female', 'Female', 'Male', 'Female'],

    'Age': [25, 30, None, 35, 40],

    'Salary': [50000, 60000, 52000, None, 58000],
```

```
    'Purchased': ['No', 'Yes', 'No', 'Yes', 'Yes']
}

# Create DataFrame
df = pd.DataFrame(data)

# --------------------------------------
# 1. Handling Missing Values
# --------------------------------------

# Fill missing 'Age' with mean age
df['Age'].fillna(df['Age'].mean(), inplace=True)

# Fill missing 'Salary' with mean salary
df['Salary'].fillna(df['Salary'].mean(), inplace=True)

# --------------------------------------
# 2. Encoding Categorical Variables
# --------------------------------------

# Convert 'Gender' to numeric (Male: 0, Female: 1)
df['Gender'] = df['Gender'].map({'Male': 0, 'Female': 1})

# Encode 'Purchased' column (No: 0, Yes: 1)
```

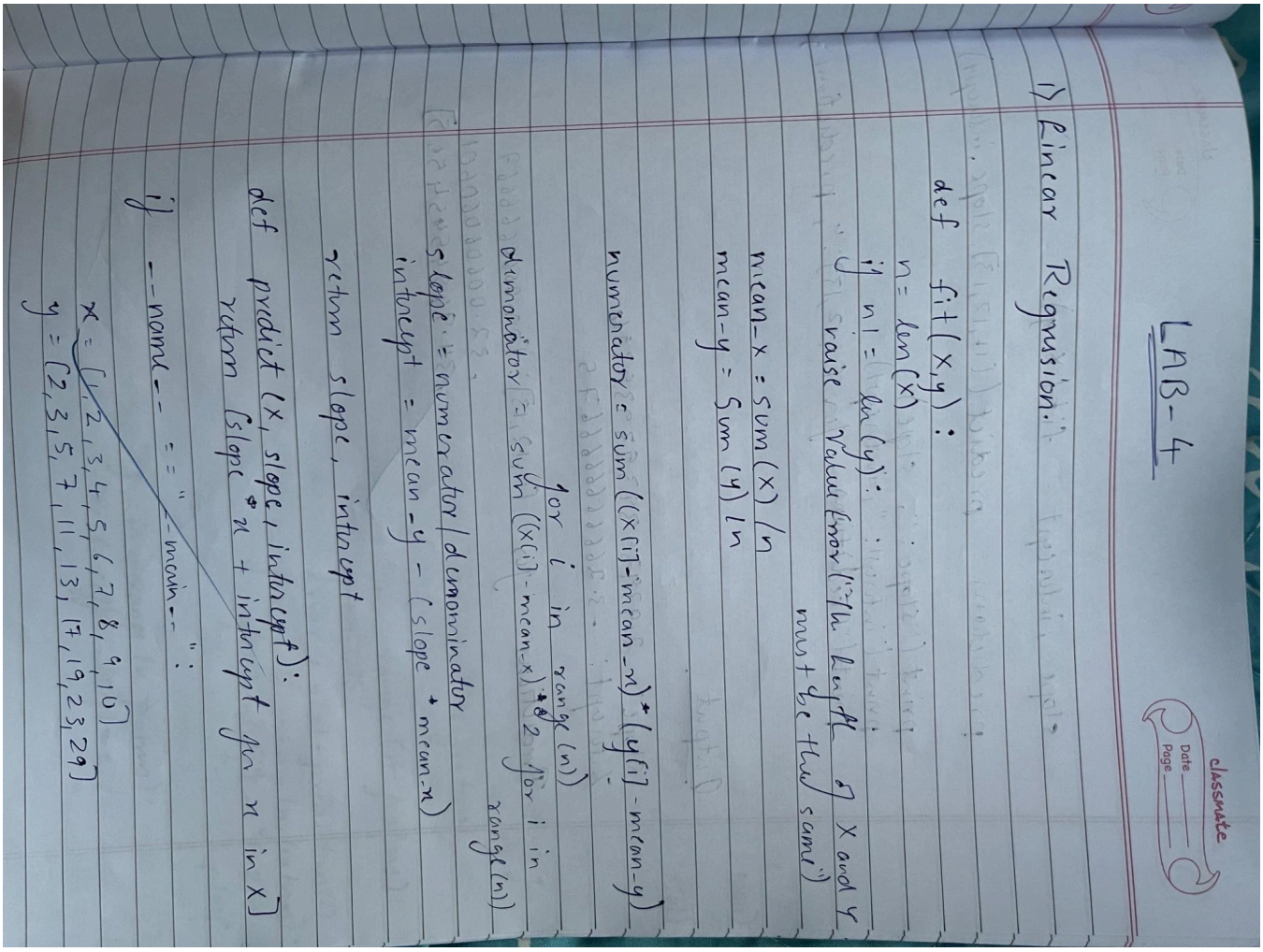
```
le = LabelEncoder()
df['Purchased'] = le.fit_transform(df['Purchased'])

# ---------------------------------------
# 3. Feature Scaling
# ---------------------------------------

# Scale 'Age' and 'Salary' using StandardScaler
scaler = StandardScaler()
df[['Age', 'Salary']] = scaler.fit_transform(df[['Age', 'Salary']])

# ---------------------------------------
# 4. Feature Engineering
# ---------------------------------------

# Create a new feature: Age to Salary ratio
df['Age_Salary_Ratio'] = df['Age'] / (df['Salary'] + 1e-6)  # add epsilon to avoid division by zero

# ---------------------------------------
# 5. Drop Irrelevant Columns
# ---------------------------------------

# Drop 'CustomerID' as it's just an identifier
df.drop(columns=['CustomerID'], inplace=True)
```

```
# ------------------------------------

# Final Output

# ------------------------------------


print(df)
```

Program 3

Implement Linear and Multi-Linear Regression algorithm using appropriate dataset

Screenshot:



Code:

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

# --- Simulated Weather Dataset ---
data = {
    'Temperature': [30, 35, 40, 45, 50, 55, 60, 65, 70, 75],
    'Humidity':    [90, 85, 80, 78, 70, 65, 60, 55, 50, 45],
    'WindSpeed':   [5, 7, 6, 8, 10, 9, 11, 12, 13, 15],
    'Rainfall':    [20, 18, 15, 12, 10, 8, 5, 3, 2, 1]
}
df = pd.DataFrame(data)

# --- Helper: Normal Equation ---
def normal_equation(X, y):
    XTX = X.T @ X
    XTy = X.T @ y
```

```
    beta = np.linalg.inv(XTX) @ XTy
    return beta

# === LINEAR REGRESSION: Rainfall ~ Temperature ===
X_lin = df[['Temperature']].values
y = df['Rainfall'].values.reshape(-1, 1)

# Add intercept term (bias) to X
X_lin_b = np.hstack((np.ones((X_lin.shape[0], 1)), X_lin))  # [1, Temperature]

# Compute coefficients
theta_lin = normal_equation(X_lin_b, y)

# Predictions
y_pred_lin = X_lin_b @ theta_lin

# === MULTIPLE LINEAR REGRESSION: Rainfall ~ Temperature + Humidity + WindSpeed ===
X_multi = df[['Temperature', 'Humidity', 'WindSpeed']].values
X_multi_b = np.hstack((np.ones((X_multi.shape[0], 1)), X_multi))  # [1, T, H, W]

# Compute coefficients
theta_multi = normal_equation(X_multi_b, y)

# Predictions
y_pred_multi = X_multi_b @ theta_multi

# --- Print Results ---
print("== Linear Regression ==")
print(f"Intercept: {theta_lin[0][0]:.2f}")
print(f"Coefficient (Temperature): {theta_lin[1][0]:.2f}")
print()

print("== Multiple Linear Regression ==")
print(f"Intercept: {theta_multi[0][0]:.2f}")
print(f"Coefficients:")
print(f"  Temperature: {theta_multi[1][0]:.2f}")
print(f"  Humidity: {theta_multi[2][0]:.2f}")
print(f"  WindSpeed: {theta_multi[3][0]:.2f}")
print()

# --- Visualization: Linear Regression ---
plt.figure(figsize=(10, 5))
plt.scatter(X_lin, y, color='blue', label='Actual')
plt.plot(X_lin, y_pred_lin, color='red', label='Predicted')
plt.xlabel('Temperature (°F)')
plt.ylabel('Rainfall (mm)')
plt.title('Linear Regression: Rainfall vs Temperature')
plt.legend()
```

```
plt.grid(True)
plt.show()
```

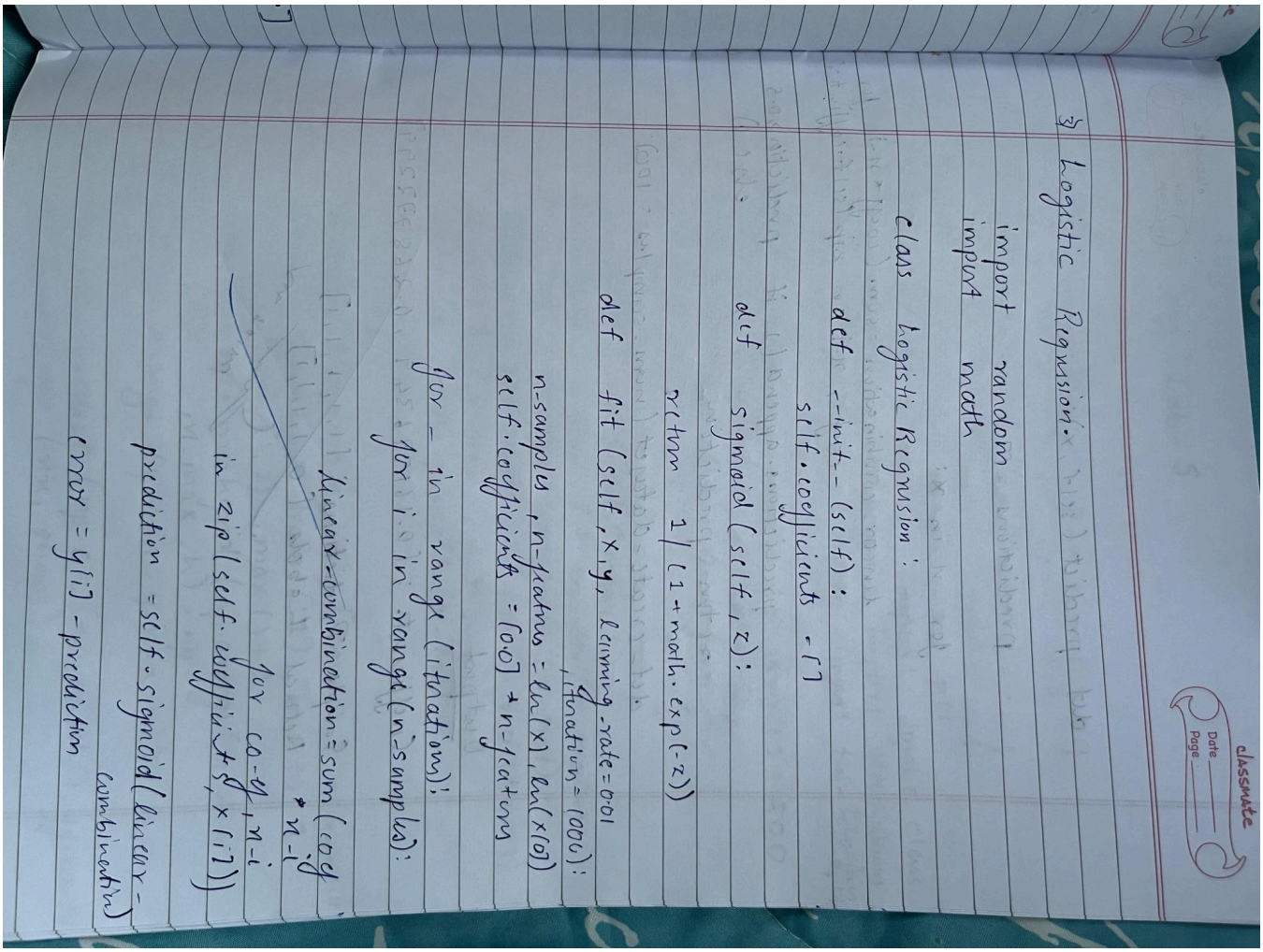
OUTPUT:

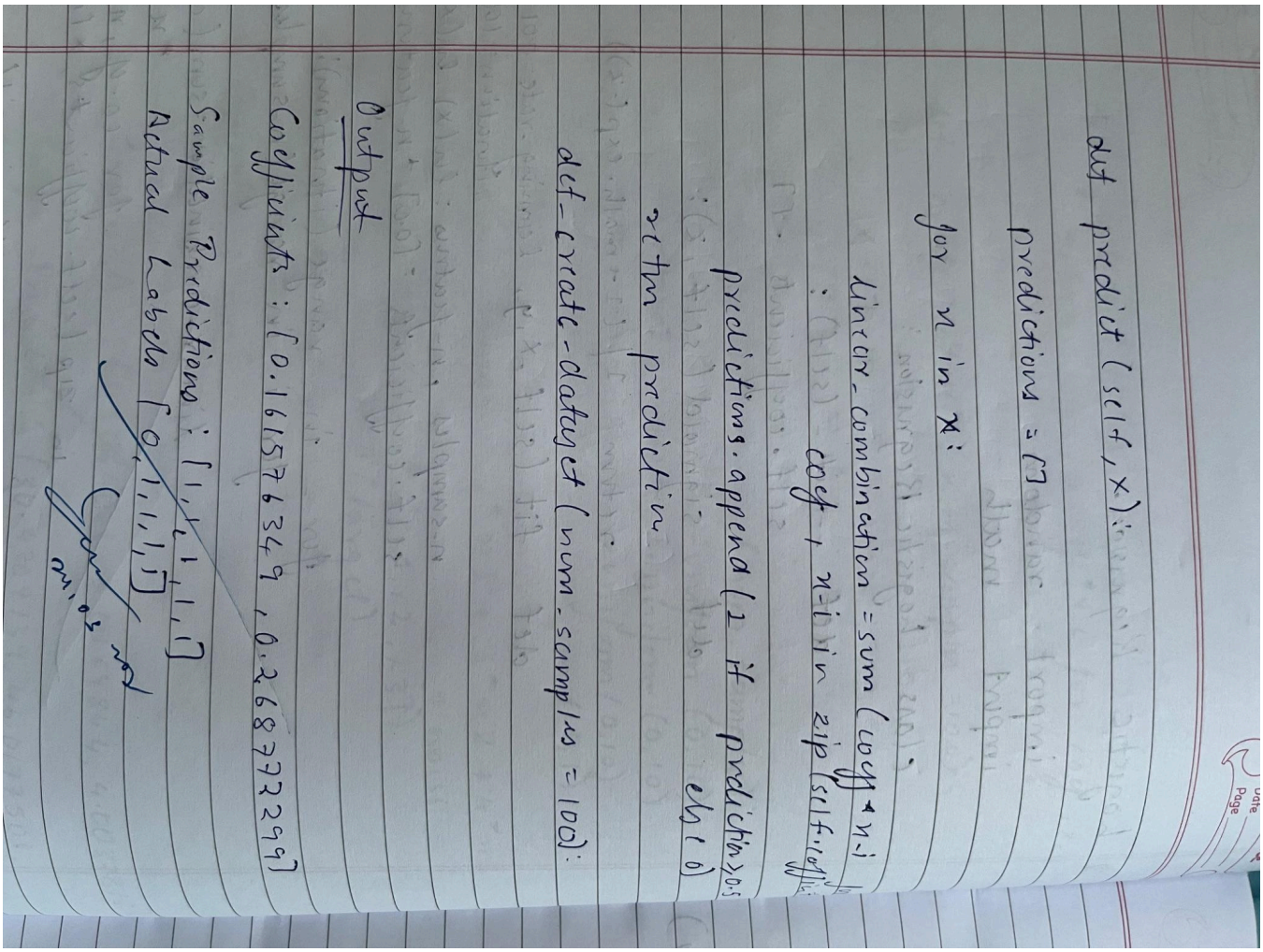
```
== Linear Regression ==
Intercept: 36.00
Coefficient (Temperature): -0.48

== Multiple Linear Regression ==
Intercept: 27.93
Coefficients:
  Temperature: -0.32
  Humidity: 0.16
  WindSpeed: -0.66
```

Program 4

Build Logistic Regression Model for a given dataset

SCREENSHOT:





CODE:

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

# ------------------------------
# 1. Simulated Dataset
# ------------------------------
# Binary classification: Predict if it will rain (1) or not (0) based on weather conditions
data = {
    'Temperature': [30, 35, 40, 45, 50, 55, 60, 65, 70, 75],
    'Humidity':    [90, 85, 80, 78, 70, 65, 60, 55, 50, 45],
    'RainToday':   [1, 1, 1, 1, 0, 0, 0, 0, 0, 0]
}
df = pd.DataFrame(data)

# Features and target
X = df[['Temperature', 'Humidity']].values
y = df['RainToday'].values.reshape(-1, 1)

# ------------------------------
# 2. Preprocessing: Add Bias Term
```

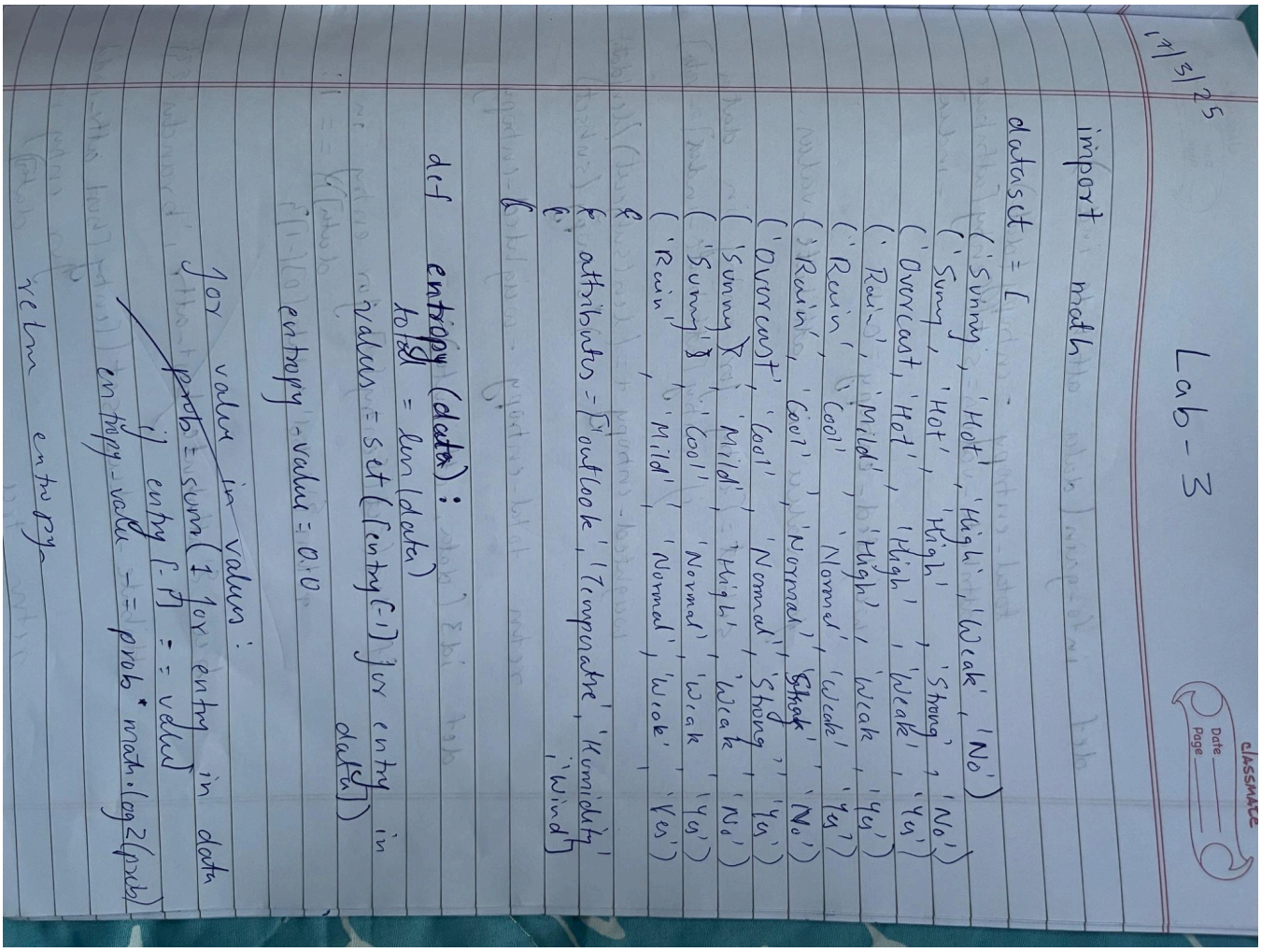
```
# ------------------------------
X = np.hstack((np.ones((X.shape[0], 1)), X))  # Add column of 1s

# ------------------------------
# 3. Define Logistic Functions
# ------------------------------
def sigmoid(z):
    return 1 / (1 + np.exp(-z))

def compute_cost(X, y, theta):
    m = len(y)
    h = sigmoid(X @ theta)
    cost = -(1/m) * (y.T @ np.log(h + 1e-10) + (1 - y).T @ np.log(1 - h + 1e-10))
    return cost.item()

def gradient_descent(X, y, theta, lr, iterations):
    m = len(y)
    cost_history = []

    for i in range(iterations):
        h = sigmoid(X @ theta)
        gradient = (1/m) * (X.T @ (h - y))
        theta -= lr * gradient
        cost = compute_cost(X, y, theta)
        cost_history.append(cost)

    return theta, cost_history

# ------------------------------
# 4. Training the Model
# ------------------------------
theta_init = np.zeros((X.shape[1], 1))  # [bias, temp, humidity]
learning_rate = 0.01
iterations = 1000

theta_final, cost_history = gradient_descent(X, y, theta_init, learning_rate, iterations)

# ------------------------------
# 5. Prediction
# ------------------------------
def predict(X, theta):
    return (sigmoid(X @ theta) >= 0.5).astype(int)

y_pred = predict(X, theta_final)

# ------------------------------
# 6. Print Results
# ------------------------------
print("== Logistic Regression ==")
print("Final Coefficients (theta):")
print(f"  Intercept  : {theta_final[0][0]:.2f}")
print(f"  Temperature: {theta_final[1][0]:.2f}")
```

```
print(f"  Humidity   : {theta_final[2][0]:.2f}")
print()
print("Predictions:", y_pred.ravel())
print("Actual     :", y.ravel())
print(f"Accuracy   : {np.mean(y_pred == y) * 100:.2f}%")

# ----------------------------
# 7. Visualization (Cost over Time)
# ----------------------------
plt.plot(cost_history)
plt.title('Cost Function over Iterations')
plt.xlabel('Iteration')
plt.ylabel('Cost')
plt.grid(True)
plt.show()
```

Program 5

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

SCREENSHOT:



CODE:

```
import pandas as pd
import math
from collections import Counter

# ----------------------------
# 1. Sample Weather Dataset
# ----------------------------
data = [
    ['Sunny', 'Hot', 'High', False, 'No'],
    ['Sunny', 'Hot', 'High', True, 'No'],
    ['Overcast', 'Hot', 'High', False, 'Yes'],
    ['Rain', 'Mild', 'High', False, 'Yes'],
    ['Rain', 'Cool', 'Normal', False, 'Yes'],
    ['Rain', 'Cool', 'Normal', True, 'No'],
    ['Overcast', 'Cool', 'Normal', True, 'Yes'],
    ['Sunny', 'Mild', 'High', False, 'No'],
    ['Sunny', 'Cool', 'Normal', False, 'Yes'],
    ['Rain', 'Mild', 'Normal', False, 'Yes'],
    ['Sunny', 'Mild', 'Normal', True, 'Yes'],
```

```
    ['Overcast', 'Mild', 'High', True, 'Yes'],
    ['Overcast', 'Hot', 'Normal', False, 'Yes'],
    ['Rain', 'Mild', 'High', True, 'No']
]

columns = ['Outlook', 'Temperature', 'Humidity', 'Windy', 'PlayTennis']
df = pd.DataFrame(data, columns=columns)

# ------------------------------
# 2. Entropy and Information Gain
# ------------------------------
def entropy(target_col):
    counts = Counter(target_col)
    total = len(target_col)
    return -sum((count/total) * math.log2(count/total) for count in counts.values())

def info_gain(df, split_attr, target_attr):
    total_entropy = entropy(df[target_attr])
    vals = df[split_attr].unique()
    weighted_entropy = 0

    for val in vals:
        subset = df[df[split_attr] == val]
        weighted_entropy += (len(subset)/len(df)) * entropy(subset[target_attr])

    return total_entropy - weighted_entropy

# ------------------------------
# 3. ID3 Algorithm (Recursive Tree Builder)
# ------------------------------
def id3(df, target_attr, attributes):
    labels = df[target_attr]
    if len(labels.unique()) == 1:
        return labels.iloc[0]
    if len(attributes) == 0:
        return labels.mode()[0]

    gains = {attr: info_gain(df, attr, target_attr) for attr in attributes}
    best_attr = max(gains, key=gains.get)

    tree = {best_attr: {}}
    for val in df[best_attr].unique():
        subset = df[df[best_attr] == val]
        subtree = id3(subset, target_attr, [a for a in attributes if a != best_attr])
        tree[best_attr][val] = subtree
    return tree

# ------------------------------
# 4. Train the Tree
# ------------------------------
attributes = ['Outlook', 'Temperature', 'Humidity', 'Windy']
tree = id3(df, 'PlayTennis', attributes)
```

```
# ------------------------------
# 5. Classification Function
# ------------------------------
def classify(tree, sample):
    if not isinstance(tree, dict):
        return tree
    attr = next(iter(tree))
    value = sample[attr]
    if value in tree[attr]:
        return classify(tree[attr][value], sample)
    else:
        return 'Unknown'  # For unseen feature values

# ------------------------------
# 6. Predict on New Sample
# ------------------------------
new_sample = {
    'Outlook': 'Sunny',
    'Temperature': 'Cool',
    'Humidity': 'High',
    'Windy': True
}

prediction = classify(tree, new_sample)

# ------------------------------
# 7. Output
# ------------------------------
import pprint
print("== ID3 Decision Tree ==")
pprint.pprint(tree)
print("\n== New Sample Classification ==")
print("Input Sample:", new_sample)
print("Predicted Class:", prediction)
```

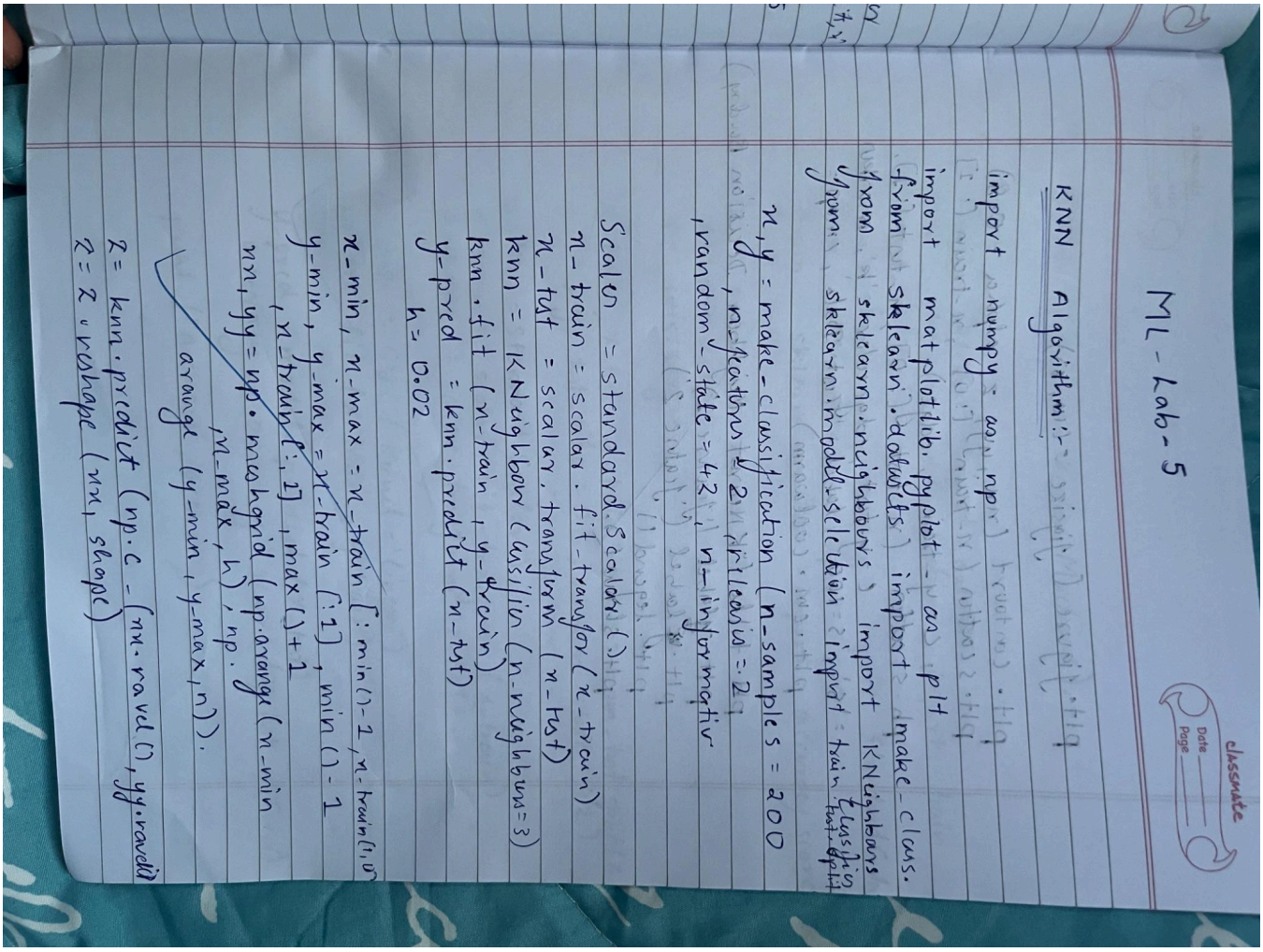
OUTPUT:

```
== ID3 Decision Tree ==
{'Outlook': {
    'Overcast': 'Yes',
    'Rain': {'Windy': {False: 'Yes', True: 'No'}},
    'Sunny': {'Humidity': {'High': 'No', 'Normal': 'Yes'}}
}}

== New Sample Classification ==
Input Sample: {'Outlook': 'Sunny', 'Temperature': 'Cool', 'Humidity': 'High', 'Windy': True}
Predicted Class: No
```

Program 6

Build KNN Classification model for a given dataset

SCREENSHOT:



CODE:

```
import numpy as np
import pandas as pd
from collections import Counter

# ------------------------------
# 1. Sample Dataset
# ------------------------------
data = {
   'Temperature': [30, 35, 40, 45, 50, 55, 60, 65, 70, 75],
   'Humidity':    [90, 85, 80, 78, 70, 65, 60, 55, 50, 45],
   'RainToday':   ['Yes', 'Yes', 'Yes', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No']
}

df = pd.DataFrame(data)

# Encode target labels
df['RainToday'] = df['RainToday'].map({'Yes': 1, 'No': 0})

# ------------------------------
```

```
# 2. Euclidean Distance Function
# ------------------------------
def euclidean_distance(x1, x2):
    return np.sqrt(np.sum((x1 - x2)**2))

# ------------------------------
# 3. KNN Classifier Function
# ------------------------------
def knn_predict(X_train, y_train, x_test, k=3):
    distances = []
    for i in range(len(X_train)):
        dist = euclidean_distance(X_train[i], x_test)
        distances.append((dist, y_train[i]))

    # Sort by distance and get k nearest labels
    distances.sort(key=lambda x: x[0])
    k_labels = [label for _, label in distances[:k]]

    # Majority vote
    vote = Counter(k_labels).most_common(1)[0][0]
    return vote

# ------------------------------
# 4. Train and Predict
# ------------------------------
X = df[['Temperature', 'Humidity']].values
y = df['RainToday'].values

# New sample to classify
new_sample = np.array([48, 66])  # 48°F and 66% humidity

# Predict with k=3
prediction = knn_predict(X, y, new_sample, k=3)

# ------------------------------
# 5. Output
# ------------------------------
print("== KNN Classification ==")
print("New Sample:", new_sample)
print(f"Predicted Class (RainToday): {'Yes' if prediction == 1 else 'No'}")
```

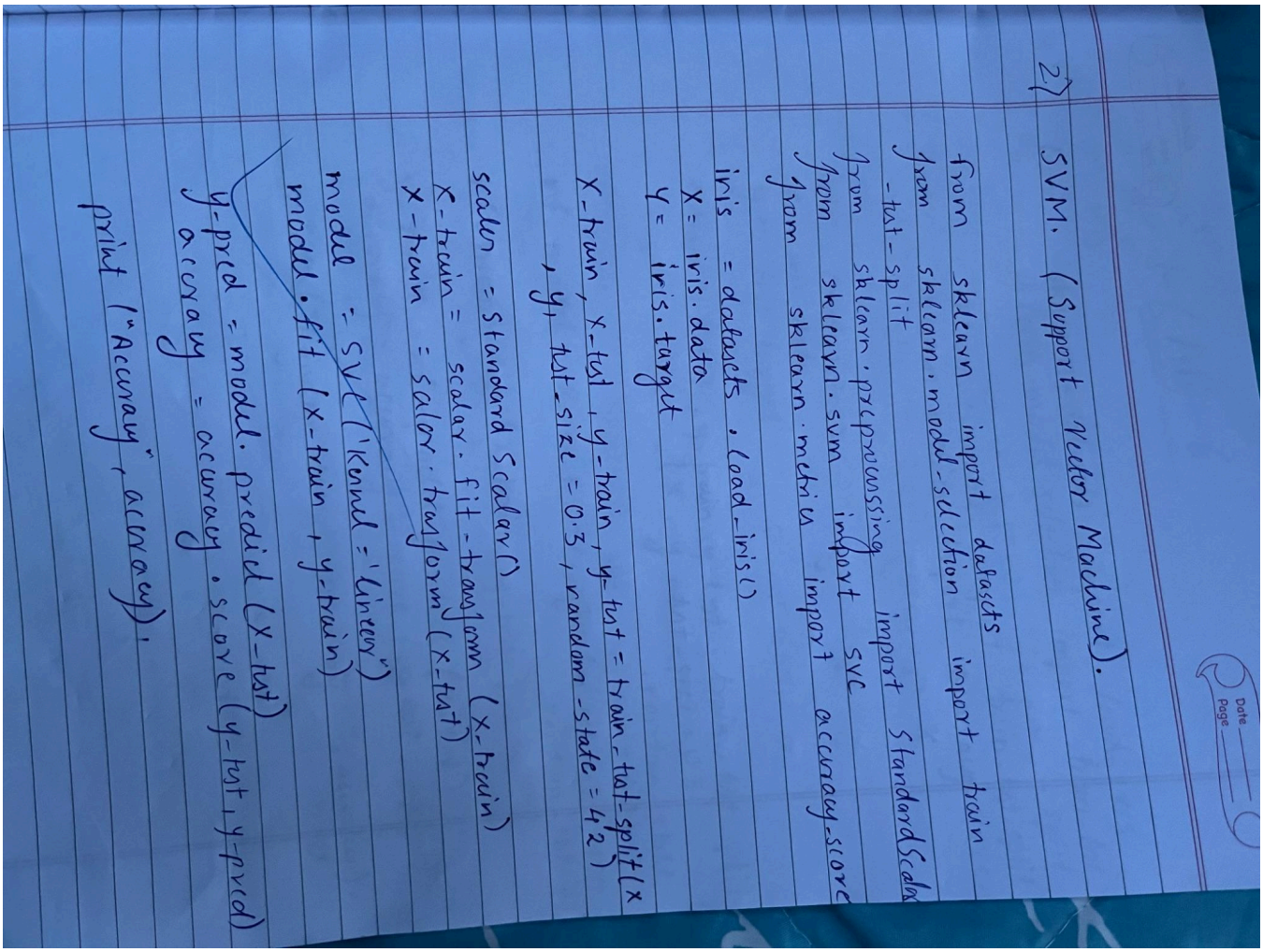
OUTPUT:

```
== KNN Classification ==

New Sample: [48 66]
Predicted Class (RainToday): No
```

Program 7

Build Support vector machine model for a given dataset

SCREENSHOT:



CODE:

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

# ------------------------------
# 1. Sample Dataset
# ------------------------------
data = {
    'Temperature': [30, 35, 40, 45, 50, 55, 60, 65, 70, 75],
    'Humidity':    [90, 85, 80, 78, 70, 65, 60, 55, 50, 45],
    'RainToday':   [1, 1, 1, 1, 0, 0, 0, 0, 0, 0]  # 1 = Yes, 0 = No
}
```

```
df = pd.DataFrame(data)

# Features and labels
X = df[['Temperature', 'Humidity']].values
y = df['RainToday'].values

# Convert labels to -1 and 1 for SVM
y = np.where(y == 1, 1, -1)

# ------------------------------
# 2. SVM Training Function
# ------------------------------
class SVM:
    def __init__(self, lr=0.001, lambda_param=0.01, n_iters=1000):
        self.lr = lr
        self.lambda_param = lambda_param
        self.n_iters = n_iters
        self.w = None
        self.b = None

    def fit(self, X, y):
        n_samples, n_features = X.shape
        self.w = np.zeros(n_features)
        self.b = 0

        for _ in range(self.n_iters):
            for idx, x_i in enumerate(X):
                condition = y[idx] * (np.dot(x_i, self.w) + self.b) >= 1
                if condition:
                    self.w -= self.lr * (2 * self.lambda_param * self.w)
                else:
                    self.w -= self.lr * (2 * self.lambda_param * self.w - np.dot(x_i, y[idx]))
                    self.b -= self.lr * y[idx]

    def predict(self, X):
        linear_output = np.dot(X, self.w) + self.b
        return np.where(linear_output >= 0, 1, 0)

# ------------------------------
# 3. Train the SVM Model
# ------------------------------
svm = SVM()
svm.fit(X, y)

# ------------------------------
# 4. Predict New Sample
# ------------------------------
new_sample = np.array([[48, 66]])  # Example: Temp=48°F, Humidity=66%
prediction = svm.predict(new_sample)[0]

# ------------------------------
# 5. Output
```

```
# ----------------------------
print("== SVM Classification ==")
print("New Sample:", new_sample[0])
print("Predicted Class (RainToday):", 'Yes' if prediction == 1 else 'No')

# ----------------------------
# 6. Visualization
# ----------------------------
def plot_svm(X, y, model):
    def get_line(w, b, x):
        return (-w[0]*x - b) / w[1]

    plt.figure(figsize=(8,6))
    for idx, label in enumerate(y):
        plt.scatter(X[idx][0], X[idx][1], color='blue' if label == 1 else 'red')

    ax = plt.gca()
    x_vals = np.linspace(np.min(X[:,0]), np.max(X[:,0]), 100)
    y_vals = get_line(model.w, model.b, x_vals)

    plt.plot(x_vals, y_vals, 'k--', label='Decision boundary')
    plt.xlabel('Temperature')
    plt.ylabel('Humidity')
    plt.title('SVM Decision Boundary')
    plt.grid(True)
    plt.legend()
    plt.show()

plot_svm(X, y, svm)
```

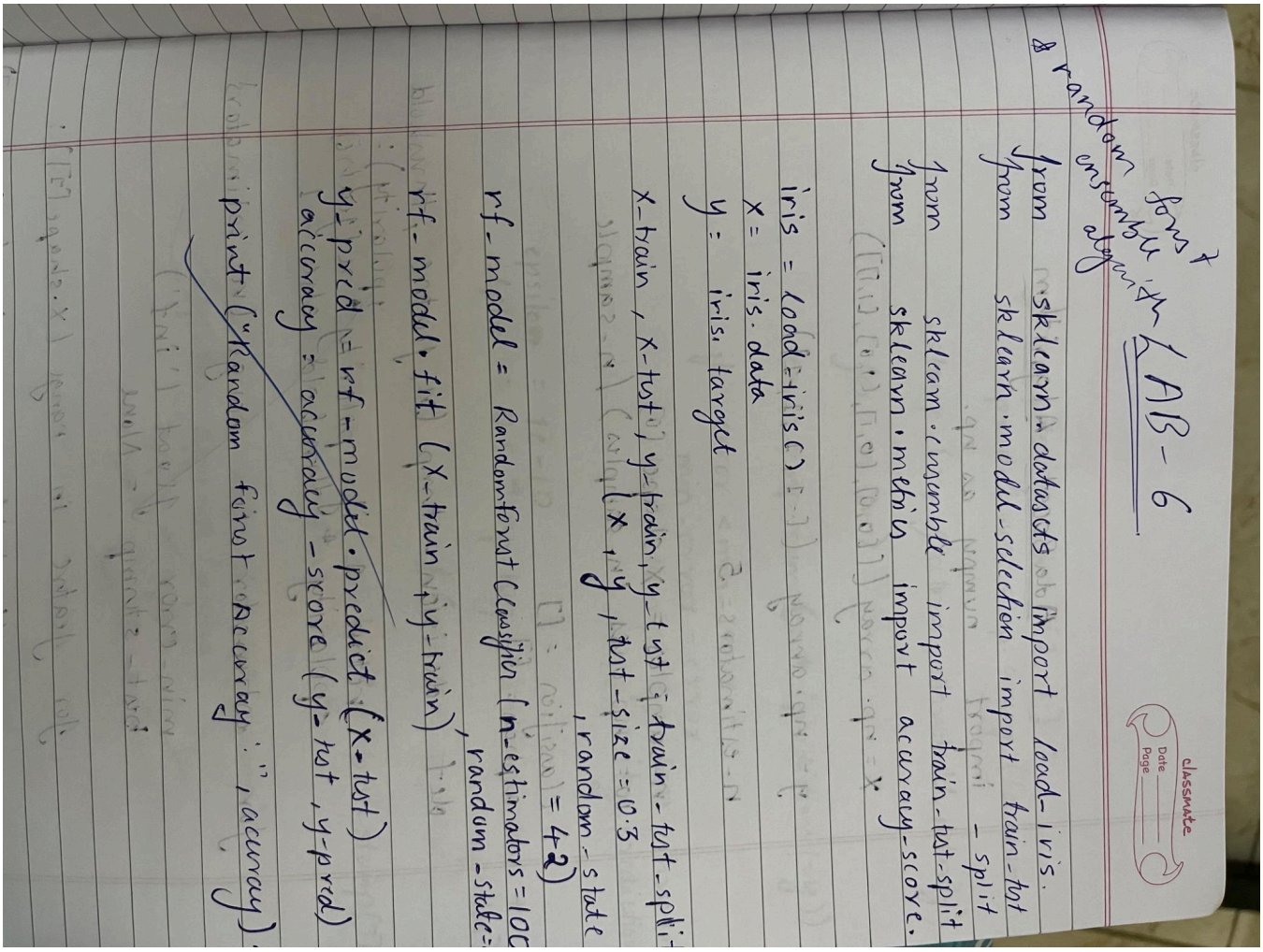
OUTPUT:

```
== SVM Classification ==
New Sample: [48 66]
Predicted Class (RainToday): No
```

Program 8

Implement Random forest ensemble method on a given dataset

SCREENSHOT:



CODE:

```
import numpy as np
import pandas as pd
import math
from collections import Counter
import random

# ----------------------------
# 1. Dataset (Play Tennis)
# ----------------------------
data = [
    ['Sunny', 'Hot', 'High', False, 'No'],
    ['Sunny', 'Hot', 'High', True, 'No'],
    ['Overcast', 'Hot', 'High', False, 'Yes'],
    ['Rain', 'Mild', 'High', False, 'Yes'],
```

```
    ['Rain', 'Cool', 'Normal', False, 'Yes'],
    ['Rain', 'Cool', 'Normal', True, 'No'],
    ['Overcast', 'Cool', 'Normal', True, 'Yes'],
    ['Sunny', 'Mild', 'High', False, 'No'],
    ['Sunny', 'Cool', 'Normal', False, 'Yes'],
    ['Rain', 'Mild', 'Normal', False, 'Yes'],
    ['Sunny', 'Mild', 'Normal', True, 'Yes'],
    ['Overcast', 'Mild', 'High', True, 'Yes'],
    ['Overcast', 'Hot', 'Normal', False, 'Yes'],
    ['Rain', 'Mild', 'High', True, 'No']
]

columns = ['Outlook', 'Temperature', 'Humidity', 'Windy', 'PlayTennis']
df = pd.DataFrame(data, columns=columns)

# ----------------------------
# 2. Entropy & Info Gain Functions
# ----------------------------
def entropy(target_col):
    counts = Counter(target_col)
    total = len(target_col)
    return -sum((count/total) * math.log2(count/total) for count in counts.values())

def info_gain(df, split_attr, target_attr):
    total_entropy = entropy(df[target_attr])
    vals = df[split_attr].unique()
    weighted_entropy = 0
    for val in vals:
        subset = df[df[split_attr] == val]
        weighted_entropy += (len(subset)/len(df)) * entropy(subset[target_attr])
    return total_entropy - weighted_entropy

# ----------------------------
# 3. ID3 Tree Builder with Feature Bagging
# ----------------------------
def id3(df, target_attr, attributes):
    labels = df[target_attr]
    if len(labels.unique()) == 1:
        return labels.iloc[0]
    if len(attributes) == 0:
        return labels.mode()[0]

    # Select subset of attributes randomly (sqrt of total)
    subset_size = max(1, int(math.sqrt(len(attributes))))
    selected_attrs = random.sample(attributes, subset_size)

    gains = {attr: info_gain(df, attr, target_attr) for attr in selected_attrs}
    best_attr = max(gains, key=gains.get)

    tree = {best_attr: {}}
    for val in df[best_attr].unique():
        subset = df[df[best_attr] == val]
```

```
        subtree = id3(subset, target_attr, [a for a in attributes if a != best_attr])
        tree[best_attr][val] = subtree
    return tree

# ----------------------------
# 4. Bootstrap Sampling
# ----------------------------
def bootstrap_sample(df):
    n_samples = len(df)
    indices = np.random.choice(n_samples, size=n_samples, replace=True)
    return df.iloc[indices]

# ----------------------------
# 5. Random Forest Class
# ----------------------------
class RandomForest:
    def __init__(self, n_trees=5):
        self.n_trees = n_trees
        self.trees = []
        self.attributes = None
        self.target = None

    def fit(self, df, target_attr, attributes):
        self.target = target_attr
        self.attributes = attributes
        for _ in range(self.n_trees):
            sample = bootstrap_sample(df)
            tree = id3(sample, target_attr, attributes)
            self.trees.append(tree)

    def classify_tree(self, tree, sample):
        if not isinstance(tree, dict):
            return tree
        attr = next(iter(tree))
        value = sample.get(attr)
        if value not in tree[attr]:
            # If unseen feature value, return mode of subtree (or 'Unknown')
            return 'Unknown'
        return self.classify_tree(tree[attr][value], sample)

    def predict(self, samples):
        results = []
        for sample in samples:
            votes = []
            for tree in self.trees:
                pred = self.classify_tree(tree, sample)
                votes.append(pred)
            # Majority vote ignoring 'Unknown'
            votes = [v for v in votes if v != 'Unknown']
            if votes:
                final_pred = Counter(votes).most_common(1)[0][0]
            else:
```

```
                final_pred = 'Unknown'
            results.append(final_pred)
        return results

# ----------------------------
# 6. Train Random Forest
# ----------------------------
attributes = ['Outlook', 'Temperature', 'Humidity', 'Windy']
target = 'PlayTennis'

rf = RandomForest(n_trees=10)
rf.fit(df, target, attributes)

# ----------------------------
# 7. Predict New Samples
# ----------------------------
new_samples = [
    {'Outlook': 'Sunny', 'Temperature': 'Cool', 'Humidity': 'High', 'Windy': True},
    {'Outlook': 'Rain', 'Temperature': 'Mild', 'Humidity': 'Normal', 'Windy': False},
]

predictions = rf.predict(new_samples)

# ----------------------------
# 8. Output
# ----------------------------
print("== Random Forest Predictions ==")
for sample, pred in zip(new_samples, predictions):
    print(f"Input: {sample} => Predicted: {pred}")
```

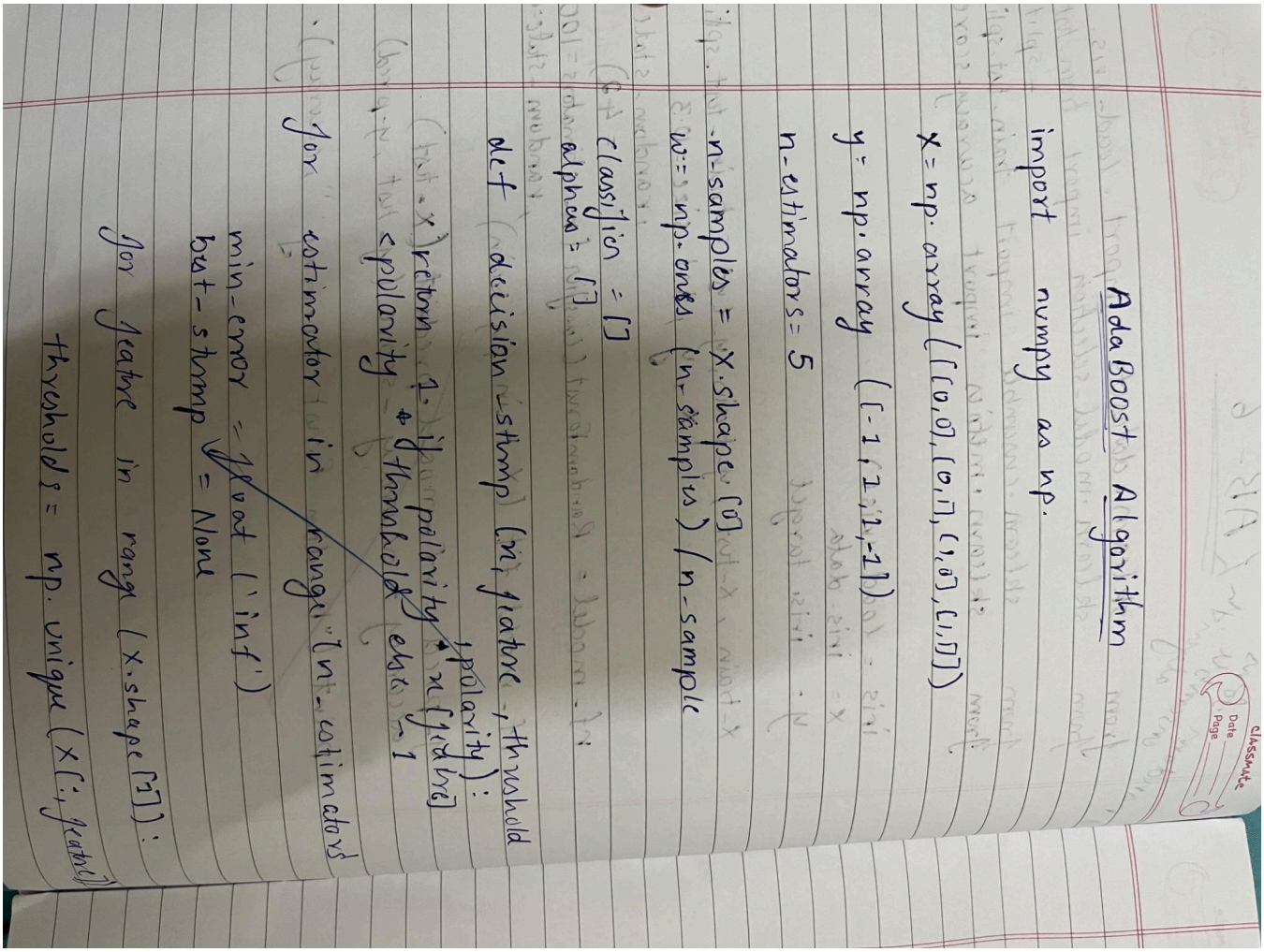
OUTPUT:

```
== Random Forest Predictions ==
Input: {'Outlook': 'Sunny', 'Temperature': 'Cool', 'Humidity': 'High', 'Windy': True} => Predicted: No
Input: {'Outlook': 'Rain', 'Temperature': 'Mild', 'Humidity': 'Normal', 'Windy': False} => Predicted: Yes
```

Program 9

Implement Boosting ensemble (Adaboost) method on a given dataset

SCREENSHOT:



CODE:

```
import numpy as np
import pandas as pd

# ------------------------------
# 1. Sample Dataset (Binary Classification)
# ------------------------------
data = {
    'Temperature': [30, 35, 40, 45, 50, 55, 60, 65],
    'Humidity':    [90, 85, 80, 78, 70, 65, 60, 55],
    'RainToday':   [1, 1, 1, 1, 0, 0, 0, 0]  # 1 = Yes, 0 = No
}

df = pd.DataFrame(data)
X = df[['Temperature', 'Humidity']].values
y = df['RainToday'].values
y = np.where(y == 1, 1, -1)  # Convert labels to -1 and 1

# ------------------------------
# 2. Decision Stump Weak Learner
# ------------------------------
```

```
class DecisionStump:
    def __init__(self):
        self.feature_index = None
        self.threshold = None
        self.polarity = 1

    def predict(self, X):
        n_samples = X.shape[0]
        X_column = X[:, self.feature_index]
        preds = np.ones(n_samples)
        if self.polarity == 1:
            preds[X_column < self.threshold] = -1
        else:
            preds[X_column > self.threshold] = -1
        return preds

# ------------------------------
# 3. AdaBoost Implementation
# ------------------------------
class AdaBoost:
    def __init__(self, n_clf=5):
        self.n_clf = n_clf

    def fit(self, X, y):
        n_samples, n_features = X.shape

        # Initialize weights to 1/N
        w = np.full(n_samples, (1 / n_samples))

        self.clfs = []
        self.alphas = []

        for _ in range(self.n_clf):
            clf = DecisionStump()
            min_error = float('inf')

            # Find best decision stump
            for feature_i in range(n_features):
                X_column = X[:, feature_i]
                thresholds = np.unique(X_column)
                for threshold in thresholds:
                    for polarity in [1, -1]:
                        preds = np.ones(n_samples)
                        if polarity == 1:
                            preds[X_column < threshold] = -1
                        else:
                            preds[X_column > threshold] = -1

                        # Calculate weighted error
                        misclassified = w[y != preds]
                        error = sum(misclassified)
```

```
                    if error < min_error:
                        min_error = error
                        clf.polarity = polarity
                        clf.threshold = threshold
                        clf.feature_index = feature_i

            # Compute alpha (model weight)
            EPS = 1e-10
            alpha = 0.5 * np.log((1.0 - min_error) / (min_error + EPS))

            # Update weights
            preds = clf.predict(X)
            w *= np.exp(-alpha * y * preds)
            w /= np.sum(w)  # Normalize

            # Save classifier and alpha
            self.clfs.append(clf)
            self.alphas.append(alpha)

    def predict(self, X):
        clf_preds = [alpha * clf.predict(X) for clf, alpha in zip(self.clfs, self.alphas)]
        y_pred = np.sum(clf_preds, axis=0)
        return np.where(y_pred >= 0, 1, 0)

# ------------------------------
# 4. Train and Predict
# ------------------------------
ada = AdaBoost(n_clf=5)
ada.fit(X, y)

new_samples = np.array([
    [48, 66],  # New sample to predict
    [60, 55],
])

predictions = ada.predict(new_samples)

# ------------------------------
# 5. Output
# ------------------------------
print("== AdaBoost Predictions ==")
for sample, pred in zip(new_samples, predictions):
    print(f"Input: {sample} => Predicted Class (RainToday): {'Yes' if pred == 1 else 'No'}")
```

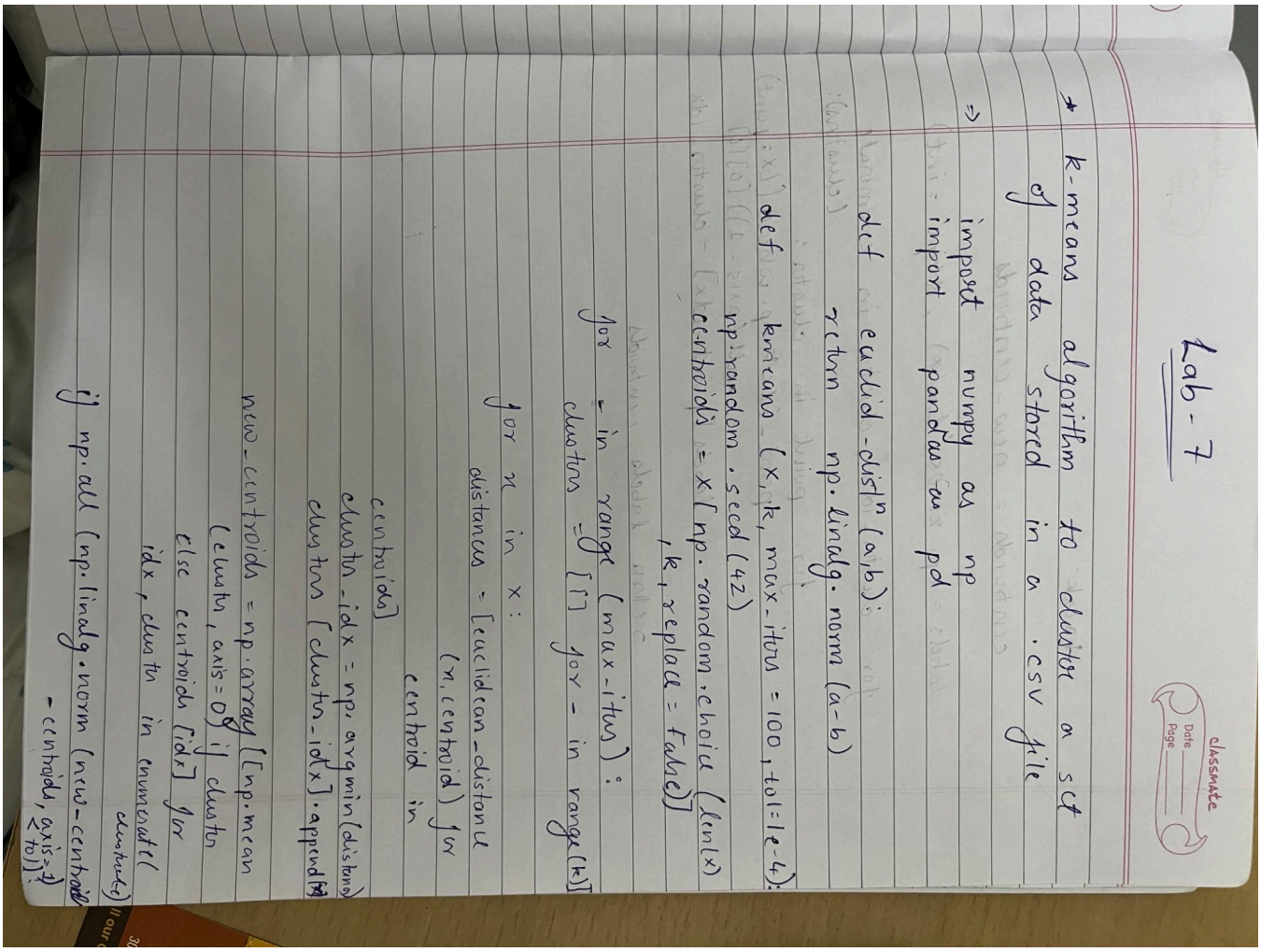
OUTPUT:

```
== AdaBoost Predictions ==
Input: [48 66] => Predicted Class (RainToday): No
Input: [60 55] => Predicted Class (RainToday): No
```

Program 10

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

SCREENSHOT:



CODE:

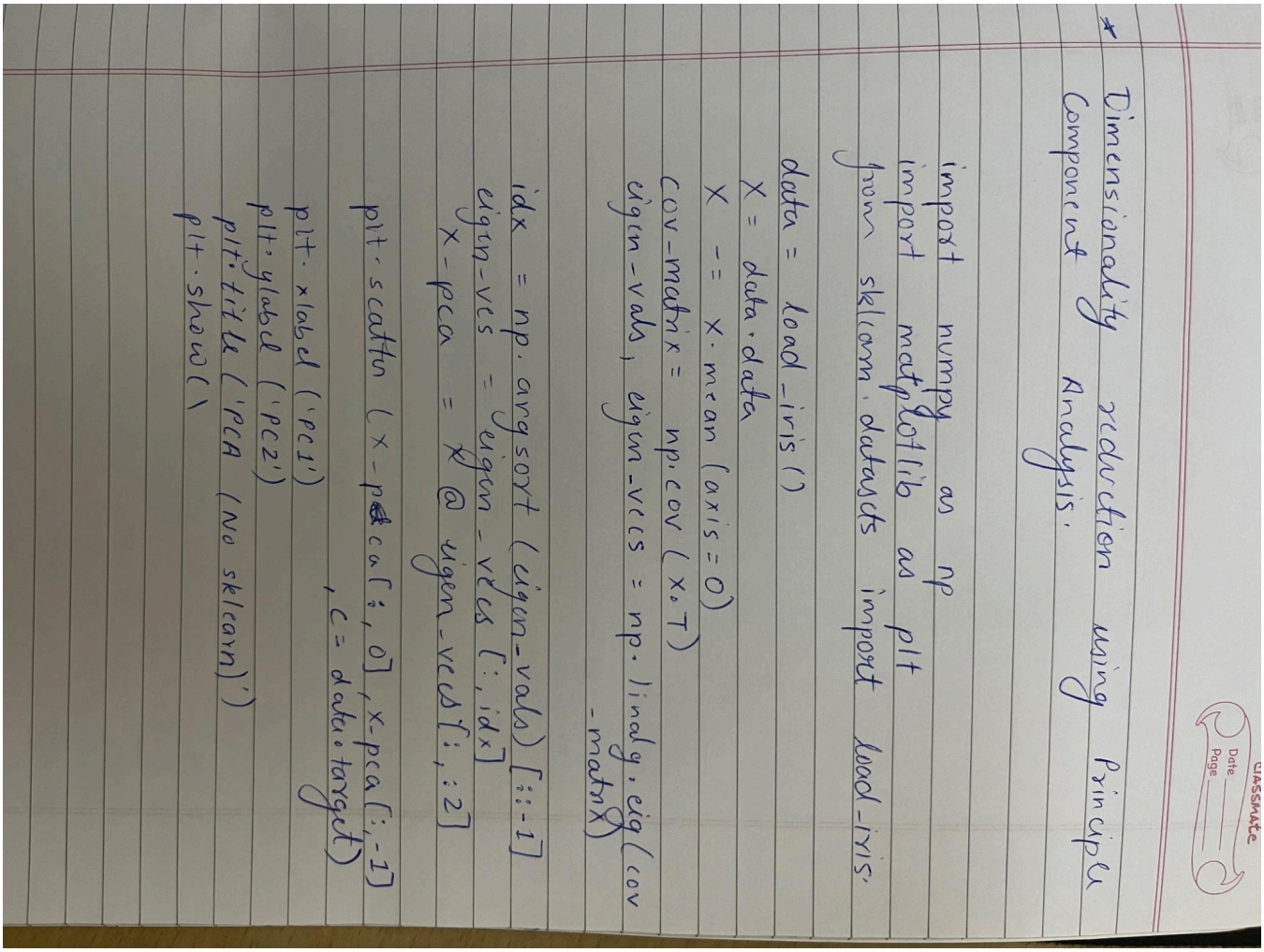
```
import numpy as np
import pandas as pd

def euclidean_distance(a, b):
    return np.linalg.norm(a - b)

def kmeans(X, k, max_iters=100, tol=1e-4):
    # Randomly initialize centroids by selecting k random points from data
    np.random.seed(42)
    centroids = X[np.random.choice(len(X), k, replace=False)]

    for _ in range(max_iters):
```

```
        clusters = [[] for _ in range(k)]

        # Assign points to nearest centroid
        for x in X:
            distances = [euclidean_distance(x, centroid) for centroid in centroids]
            cluster_idx = np.argmin(distances)
            clusters[cluster_idx].append(x)

        new_centroids = np.array([np.mean(cluster, axis=0) if cluster else centroids[idx]
                                  for idx, cluster in enumerate(clusters)])

        # Check convergence (if centroids do not change more than tol)
        if np.all(np.linalg.norm(new_centroids - centroids, axis=1) < tol):
            break

        centroids = new_centroids

    # Prepare cluster labels
    labels = np.zeros(len(X), dtype=int)
    for cluster_idx, cluster in enumerate(clusters):
        for point in cluster:
            point_idx = np.where((X == point).all(axis=1))[0][0]
            labels[point_idx] = cluster_idx

    return labels, centroids

# ------------------------------
# Load dataset from CSV
# Replace 'data.csv' with your CSV filename
# ------------------------------
df = pd.read_csv('data.csv')  # Make sure CSV has only numerical columns or select subset
X = df.values

# ------------------------------
# Run k-Means
# ------------------------------
k = 3  # number of clusters
labels, centroids = kmeans(X, k)

# ------------------------------
# Output results
# ------------------------------
print("Cluster assignments for each data point:")
print(labels)
print("\nCentroids:")
print(centroids)
```

Program 11

Implement Dimensionality reduction using Principal Component Analysis (PCA) method

SCREENSHOT:



CODE:

```
import numpy as np
import pandas as pd

def standardize(X):
    """Standardize features to zero mean and unit variance"""
    return (X - np.mean(X, axis=0)) / np.std(X, axis=0)

def pca(X, n_components):
    # Step 1: Standardize data
    X_std = standardize(X)

    # Step 2: Compute covariance matrix
    cov_matrix = np.cov(X_std, rowvar=False)
```

```
    # Step 3: Compute eigenvalues and eigenvectors
    eigenvalues, eigenvectors = np.linalg.eigh(cov_matrix)

    # Step 4: Sort eigenvectors by descending eigenvalues
    sorted_idx = np.argsort(eigenvalues)[::-1]
    eigenvalues = eigenvalues[sorted_idx]
    eigenvectors = eigenvectors[:, sorted_idx]

    # Step 5: Select top n_components eigenvectors (principal components)
    components = eigenvectors[:, :n_components]

    # Step 6: Project data
    X_pca = np.dot(X_std, components)

    return X_pca, eigenvalues, components

# ----------------------------
# Example Usage with Sample Data
# ----------------------------
# Create example dataset or load your own CSV file
data = {
    'Feature1': [2.5, 0.5, 2.2, 1.9, 3.1, 2.3, 2, 1, 1.5, 1.1],
    'Feature2': [2.4, 0.7, 2.9, 2.2, 3, 2.7, 1.6, 1.1, 1.6, 0.9],
    'Feature3': [1, 3, 2, 4, 5, 1, 2, 1, 3, 2]
}
df = pd.DataFrame(data)

X = df.values
n_components = 2

X_reduced, eigenvalues, components = pca(X, n_components)

print("Reduced data (first 2 principal components):")
print(X_reduced)

print("\nEigenvalues:")
print(eigenvalues)

print("\nPrincipal Components (eigenvectors):")
print(components)
```

OUTPUT:

```
Reduced data (first 2 principal components):
[[-1.33464313  0.18236219]
 [-2.74540499 -0.03668303]
 [-0.80719059 -0.27982202]
 [-0.60117914 -0.24580249]
 [-1.51377843  0.45088336]
```

```
 [-1.08458099 -0.01252943]
 [-1.5563464  -0.09316944]
 [-2.28299081 -0.37639029]
 [-1.71419074 -0.19499621]
 [-2.3510216  -0.38885353]]

Eigenvalues:
[2.22135779 1.45080258 0.32619848]

Principal Components (eigenvectors):
[[ 0.6764725   0.65370205  0.33974892]
 [ 0.73517866 -0.67392404 -0.07898289]
 [ 0.02637013  0.34399291 -0.93884852]]
```