In [2]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
```

In [22]:
```
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler, LabelEncoder
from sklearn.metrics import classification_report, confusion_matrix, accuracy_score
```

In [3]:
```
aq_=pd.read_csv(r"C:\Users\siddh\Downloads\updated_pollution_dataset.csv")
aq_
```

Out[3]:

	Temperature	Humidity	PM2.5	PM10	NO2	SO2	CO	Proximity_to_Industrial_Areas	Population_Density	Air Quality
0	29.8	59.1	5.2	17.9	18.9	9.2	1.72	6.3	319	Moderate
1	28.3	75.6	2.3	12.2	30.8	9.7	1.64	6.0	611	Moderate
2	23.1	74.7	26.7	33.8	24.4	12.6	1.63	5.2	619	Moderate
3	27.1	39.1	6.1	6.3	13.5	5.3	1.15	11.1	551	Good
4	26.5	70.7	6.9	16.0	21.9	5.6	1.01	12.7	303	Good
...	...	...	...	...	...	...	...	...	...	...
4995	40.6	74.1	116.0	126.7	45.5	25.7	2.11	2.8	765	Hazardous
4996	28.1	96.9	6.9	25.0	25.3	10.8	1.54	5.7	709	Moderate
4997	25.9	78.2	14.2	22.1	34.8	7.8	1.63	9.6	379	Moderate
4998	25.3	44.4	21.4	29.0	23.7	5.7	0.89	11.6	241	Good
4999	24.1	77.9	81.7	94.3	23.2	10.5	1.38	8.3	461	Moderate

5000 rows × 10 columns

In [5]:
```
aq_.shape
```

Out[5]:
```
(5000, 10)
```

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

Out[4]:

	Temperature	Humidity	PM2.5	PM10	NO2	SO2	CO	Proximity_to_Industrial_Areas	Popu
count	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	
mean	30.029020	70.056120	20.142140	30.218360	26.412100	10.014820	1.500354	8.425400	
std	6.720661	15.863577	24.554546	27.349199	8.895356	6.750303	0.546027	3.610944	
min	13.400000	36.000000	0.000000	-0.200000	7.400000	-6.200000	0.650000	2.500000	
25%	25.100000	58.300000	4.600000	12.300000	20.100000	5.100000	1.030000	5.400000	
50%	29.000000	69.800000	12.000000	21.700000	25.300000	8.000000	1.410000	7.900000	
75%	34.000000	80.300000	26.100000	38.100000	31.900000	13.725000	1.840000	11.100000	
max	58.600000	128.100000	295.000000	315.800000	64.900000	44.900000	3.720000	25.800000	

In [6]:
```
aq_.dtypes
```

Out[6]:
```
Temperature                    float64
Humidity                       float64
PM2.5                          float64
PM10                           float64
NO2                            float64
SO2                            float64
CO                             float64
Proximity_to_Industrial_Areas  float64
Population_Density               int64
Air Quality                     object
dtype: object
```

In [7]:
```
aq_.head(5)
```

Out[7]:

	Temperature	Humidity	PM2.5	PM10	NO2	SO2	CO	Proximity_to_Industrial_Areas	Population_Density	Air Quality
0	29.8	59.1	5.2	17.9	18.9	9.2	1.72	6.3	319	Moderate
1	28.3	75.6	2.3	12.2	30.8	9.7	1.64	6.0	611	Moderate
2	23.1	74.7	26.7	33.8	24.4	12.6	1.63	5.2	619	Moderate
3	27.1	39.1	6.1	6.3	13.5	5.3	1.15	11.1	551	Good
4	26.5	70.7	6.9	16.0	21.9	5.6	1.01	12.7	303	Good

In [67]:
```
aq_.tail(5)
```

Out[67]:

	Temperature	Humidity	PM2.5	PM10	NO2	SO2	CO	Proximity_to_Industrial_Areas	Population_Density	Air Quality
4995	40.6	74.1	116.0	126.7	45.5	25.7	2.11	2.8	765	1
4996	28.1	96.9	6.9	25.0	25.3	10.8	1.54	5.7	709	2
4997	25.9	78.2	14.2	22.1	34.8	7.8	1.63	9.6	379	2
4998	25.3	44.4	21.4	29.0	23.7	5.7	0.89	11.6	241	0
4999	24.1	77.9	81.7	94.3	23.2	10.5	1.38	8.3	461	2

In [10]:
```
aq_.columns
```

Out[10]:
```
Index(['Temperature', 'Humidity', 'PM2.5', 'PM10', 'NO2', 'SO2', 'CO',
       'Proximity_to_Industrial_Areas', 'Population_Density', 'Air Quality'],
      dtype='object')
```

In [11]:
```
aq_.isna()
```

Out[11]:

	Temperature	Humidity	PM2.5	PM10	NO2	SO2	CO	Proximity_to_Industrial_Areas	Population_Density	Air Quality
0	False	False	False	False	False	False	False	False	False	False
1	False	False	False	False	False	False	False	False	False	False
2	False	False	False	False	False	False	False	False	False	False
3	False	False	False	False	False	False	False	False	False	False
4	False	False	False	False	False	False	False	False	False	False
...	...	...	...	...	...	...	...	...	...	...
4995	False	False	False	False	False	False	False	False	False	False
4996	False	False	False	False	False	False	False	False	False	False
4997	False	False	False	False	False	False	False	False	False	False
4998	False	False	False	False	False	False	False	False	False	False
4999	False	False	False	False	False	False	False	False	False	False

5000 rows × 10 columns

In [12]:
```
aq_.isnull().sum()
```

Out[12]:
```
Temperature                    0
Humidity                       0
PM2.5                          0
PM10                           0
NO2                            0
SO2                            0
CO                             0
Proximity_to_Industrial_Areas  0
Population_Density             0
Air Quality                    0
dtype: int64
```

In [13]:
```
aq_.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 10 columns):
 #   Column                         Non-Null Count  Dtype  
---  ------                         --------------  -----  
 0   Temperature                    5000 non-null   float64
 1   Humidity                       5000 non-null   float64
 2   PM2.5                          5000 non-null   float64
 3   PM10                           5000 non-null   float64
 4   NO2                            5000 non-null   float64
 5   SO2                            5000 non-null   float64
 6   CO                             5000 non-null   float64
 7   Proximity_to_Industrial_Areas  5000 non-null   float64
 8   Population_Density             5000 non-null   int64  
 9   Air Quality                    5000 non-null   object 
dtypes: float64(8), int64(1), object(1)
memory usage: 390.8+ KB
```

TO FIND THE CATAEGORICAL VALUES

In [14]:
```
categorical_features=[ i for i in aq_.columns if aq_[i].dtype =="Air Quality"]
aq_[categorical_features]
```

Out[14]:

0
1
2
3
4
...
4995
4996
4997
4998
4999

5000 rows × 0 columns

In [18]:
```
label_encoder = LabelEncoder()
aq_['Air Quality'] = label_encoder.fit_transform(aq_['Air Quality'])
aq_
```

Out[18]:

	Temperature	Humidity	PM2.5	PM10	NO2	SO2	CO	Proximity_to_Industrial_Areas	Population_Density	Air Quality
0	29.8	59.1	5.2	17.9	18.9	9.2	1.72	6.3	319	2
1	28.3	75.6	2.3	12.2	30.8	9.7	1.64	6.0	611	2
2	23.1	74.7	26.7	33.8	24.4	12.6	1.63	5.2	619	2
3	27.1	39.1	6.1	6.3	13.5	5.3	1.15	11.1	551	0
4	26.5	70.7	6.9	16.0	21.9	5.6	1.01	12.7	303	0
...	...	...	...	...	...	...	...	...	...	...
4995	40.6	74.1	116.0	126.7	45.5	25.7	2.11	2.8	765	1
4996	28.1	96.9	6.9	25.0	25.3	10.8	1.54	5.7	709	2
4997	25.9	78.2	14.2	22.1	34.8	7.8	1.63	9.6	379	2
4998	25.3	44.4	21.4	29.0	23.7	5.7	0.89	11.6	241	0
4999	24.1	77.9	81.7	94.3	23.2	10.5	1.38	8.3	461	2

5000 rows × 10 columns

In [35]:
```
print(aq_['Air Quality'].unique())
```

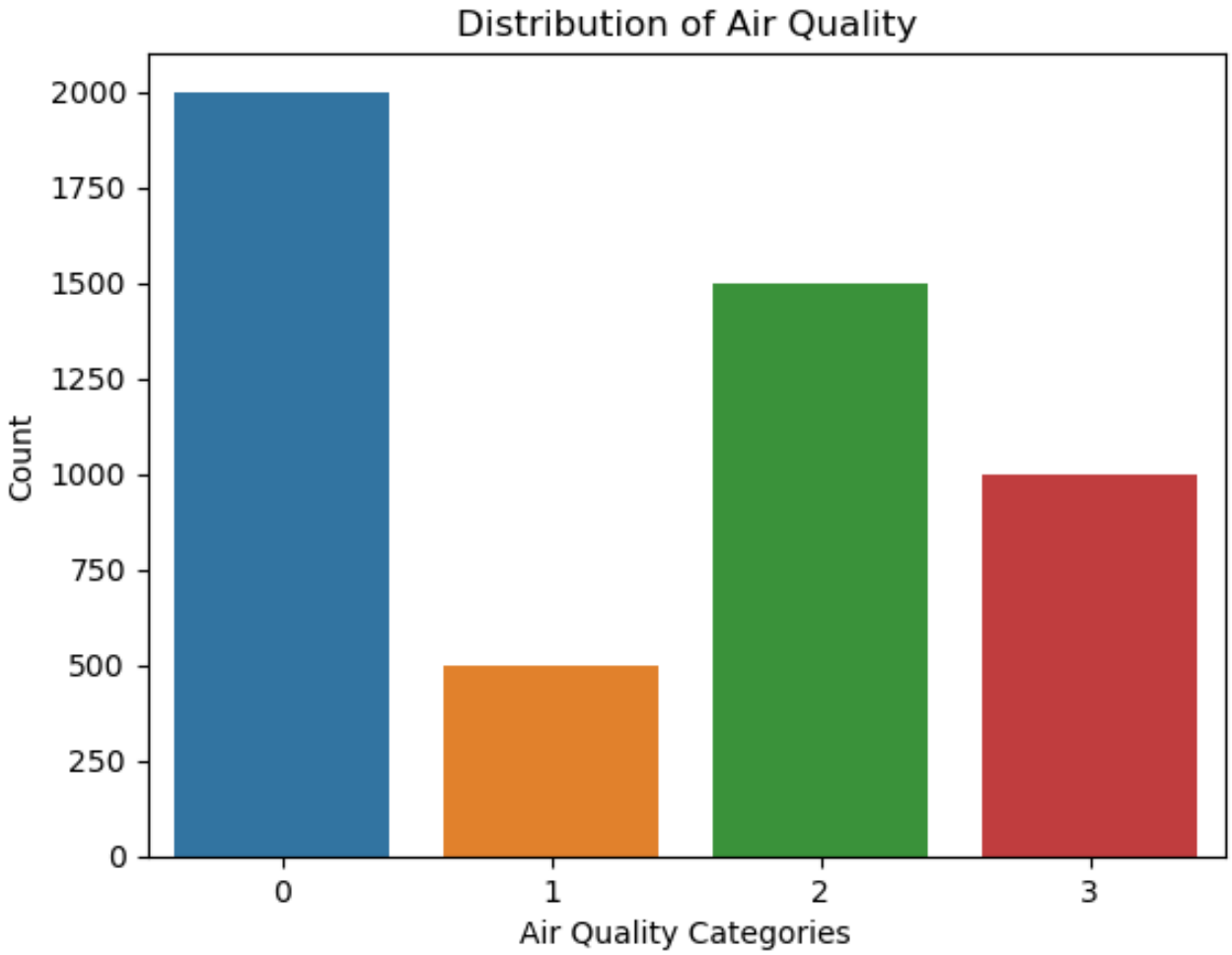
```
[2 0 1 3]
```

In [19]:
```
aq_.index
```

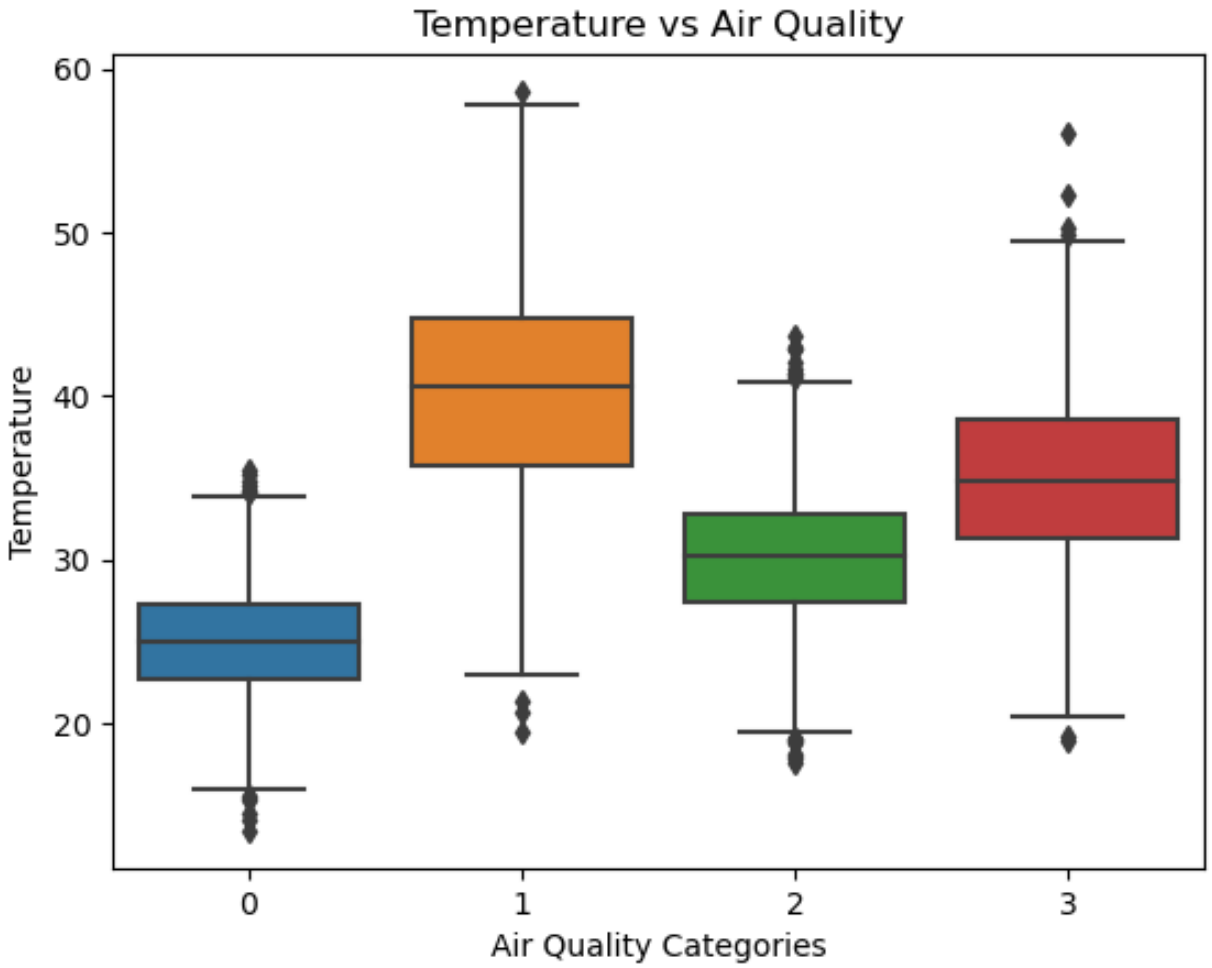
Out[19]:
```
RangeIndex(start=0, stop=5000, step=1)
```

EDA CHART

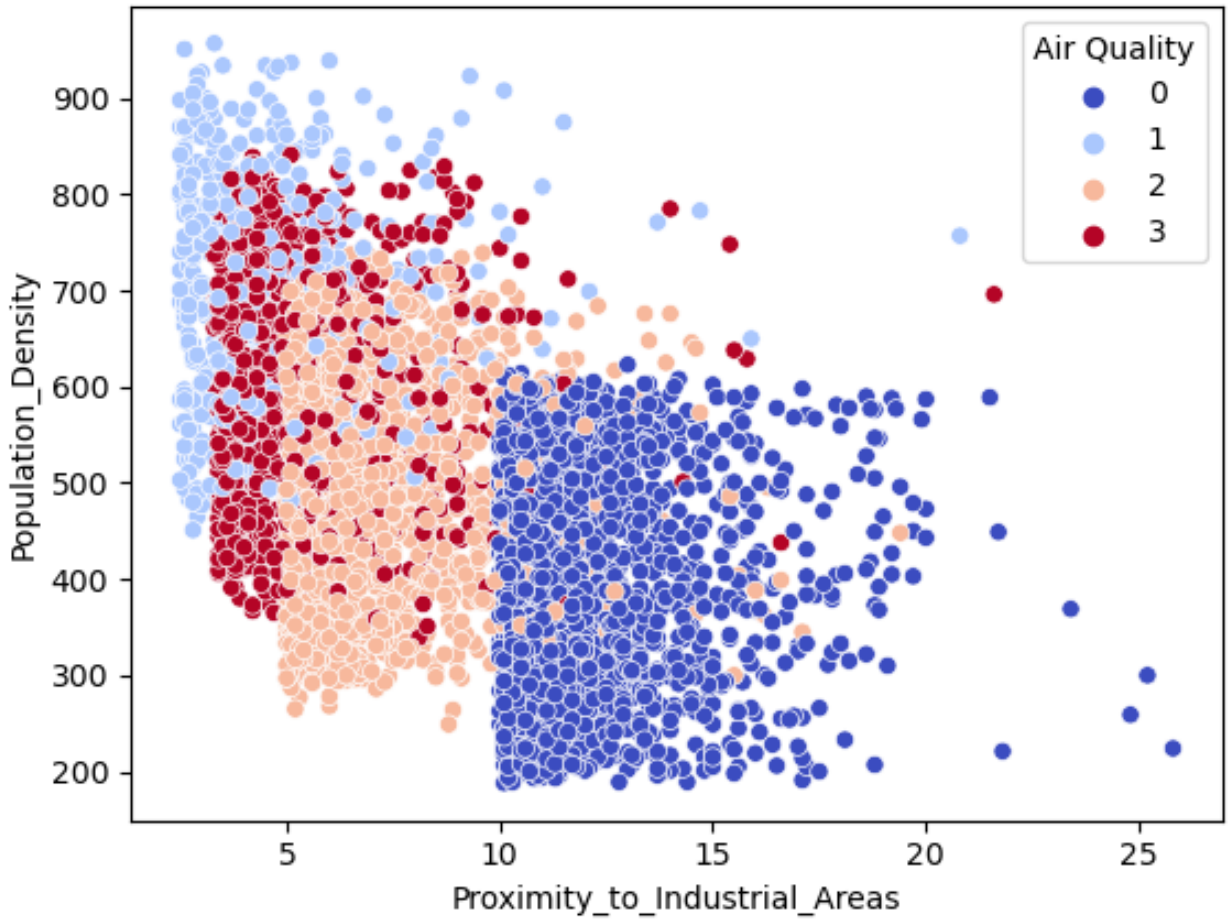
In [57]:
```
sns.countplot(x='Air Quality', data=aq_)
plt.title('Distribution of Air Quality')
plt.xlabel('Air Quality Categories')
plt.ylabel('Count')
plt.show();
```



In [58]:
```
sns.boxplot(x='Air Quality', y='Temperature', data=aq_)
plt.title('Temperature vs Air Quality')
plt.xlabel('Air Quality Categories')
plt.ylabel('Temperature')
plt.show();
```



In [66]:
```
sns.scatterplot(
    x='Proximity_to_Industrial_Areas',
    y='Population_Density',
    hue='Air Quality',
    palette='coolwarm',
    data=aq_
)
plt.show;
```



LOGISTIC REGRESSION MODEL

In [28]:
```
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score
```

In [30]:
```
# Define features and target
X = aq_.drop(columns=['Air Quality'])
y = aq_['Air Quality']
```

to identify the x test and x test columns and values

In [41]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42)
```

In [42]:
```
X_train
```

Out[42]:

	Temperature	Humidity	PM2.5	PM10	NO2	SO2	CO	Proximity_to_Industrial_Areas	Population_Density
1840	39.1	82.9	56.7	69.3	39.7	8.2	2.00	3.6	543
2115	22.1	83.0	0.7	9.3	32.5	11.4	1.60	6.3	512
4437	34.5	77.7	6.2	7.1	25.6	8.9	1.71	8.1	500
1146	23.8	65.2	9.9	14.2	14.6	4.9	0.97	10.7	331
2486	34.6	81.4	21.9	32.1	29.6	1.9	1.19	6.9	512
...	...	...	...	...	...	...	...	...	...
4426	30.0	59.7	59.3	68.8	22.1	7.4	1.39	5.1	412
466	27.7	54.0	17.6	23.2	24.6	11.1	1.27	7.8	638
3092	24.2	67.6	19.4	35.1	24.2	9.6	1.91	6.2	422
3772	21.4	76.4	15.3	22.1	12.4	3.4	0.96	16.3	420
860	34.4	103.1	29.2	42.2	54.4	23.6	3.37	3.7	614

3500 rows × 9 columns

In [45]:
```
X_test
```

Out[45]:

	Temperature	Humidity	PM2.5	PM10	NO2	SO2	CO	Proximity_to_Industrial_Areas	Population_Density
1501	31.3	73.4	72.8	88.8	54.1	17.1	2.54	2.6	755
2586	24.0	68.8	0.8	8.6	20.9	2.4	1.16	10.5	235
2653	25.4	78.6	4.1	6.7	21.3	9.1	1.40	10.1	543
1055	30.7	102.0	7.9	26.1	41.6	26.1	2.31	4.8	765
705	26.5	54.1	12.3	15.3	20.3	5.3	0.99	12.7	374
...	...	...	...	...	...	...	...	...	...
3563	20.9	58.2	17.5	23.6	18.8	3.9	0.94	10.9	420
1538	20.6	88.6	47.9	57.9	28.9	12.3	1.94	5.4	412
1837	34.7	75.8	2.7	6.4	33.2	6.3	1.50	7.8	335
2380	22.2	98.7	13.2	35.8	24.0	12.6	1.54	3.8	471
1912	22.7	73.6	8.2	13.6	21.8	5.2	1.14	12.2	472

1500 rows × 9 columns

to identify the y test and y test columns and values

In [47]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42)
```

In [53]:
```
y_train
```

Out[53]:
```
1840    3
2115    2
4437    2
1146    0
2486    2
       ..
4426    2
466     2
3092    3
3772    0
860     1
Name: Air Quality, Length: 3500, dtype: int32
```

In [49]:
```
y_test
```

Out[49]:
```
1501    1
2586    0
2653    2
1055    1
705     0
       ..
3563    0
1538    2
1837    2
2380    3
1912    0
Name: Air Quality, Length: 1500, dtype: int32
```

In [33]:
```python
# Split dataset (70% training, 30% testing)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42)

# Standardize features (important for regularization)
scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)

# Model with regularization (L2 penalty)
model = LogisticRegression(penalty='l2', C=0.1)

# Train the model
model.fit(X_train, y_train)

# Evaluate performance
y_train_pred = model.predict(X_train)
y_test_pred = model.predict(X_test)

train_acc = accuracy_score(y_train, y_train_pred)
test_acc = accuracy_score(y_test, y_test_pred)

print(f"Training Accuracy: {train_acc:.2f}")
print(f"Testing Accuracy: {test_acc:.2f}")

# Corrected accuracy calculation
print(" Accuracy:", round(test_acc * 100, 2))
```

```
Training Accuracy: 0.94
Testing Accuracy: 0.93
 Accuracy: 93.2
```

In [54]:
```
from sklearn.metrics import classification_report

# Generate classification report
report =classification_report(y_test, y_test_pred)

print(report)
```

```
              precision    recall  f1-score   support

           0       0.99      1.00      1.00       618
           1       0.88      0.78      0.83       148
           2       0.94      0.94      0.94       452
           3       0.82      0.85      0.83       282

    accuracy                           0.93      1500
   macro avg       0.91      0.89      0.90      1500
weighted avg       0.93      0.93      0.93      1500
```

In [55]:
```
print(y_test_pred[:10])  # Shows first 10 predictions
print(y_test[:10].values)  # Shows actual values for comparison
```

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

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]: