Heart Disease-

January 20, 2024

0.1 Import Libraries

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

0.2 Load the dataset

[3]:
```
df=pd.read_csv("Heart.csv")
```

0.3 Analyze the dataset

[4]:
```
df.head()
```

[4]:

	Age	Sex	ChestPainType	RestingBP	Cholesterol	FastingBS	RestingECG	MaxHR	\
0	40	M	ATA	140.0	289.0	0.0	Normal	172.0	
1	49	F	NAP	160.0	180.0	0.0	Normal	156.0	
2	37	M	ATA	130.0	283.0	0.0	ST	98.0	
3	48	F	ASY	NaN	214.0	0.0	Normal	108.0	
4	54	M	NAP	150.0	195.0	0.0	Normal	122.0	

	ExerciseAngina	Oldpeak	ST_Slope	HeartDisease
0	N	0.0	Up	0
1	N	1.0	Flat	1
2	N	0.0	Up	0
3	Y	1.5	Flat	1
4	N	0.0	Up	0

[5]:
```
df.tail()
```

[5]:

	Age	Sex	ChestPainType	RestingBP	Cholesterol	FastingBS	RestingECG	\
913	45	M	TA	110.0	264.0	0.0	Normal	
914	68	M	ASY	144.0	193.0	1.0	Normal	
915	57	M	ASY	130.0	131.0	0.0	Normal	
916	57	F	ATA	130.0	236.0	0.0	LVH	
917	38	M	NAP	138.0	175.0	0.0	Normal	

```
     MaxHR ExerciseAngina  Oldpeak ST_Slope  HeartDisease
913  132.0              N      1.2     Flat             1
914  141.0              N      3.4     Flat             1
915  115.0              Y      1.2     Flat             1
916  174.0              N      0.0     Flat             1
917  173.0              N      0.0       Up             0
```

0.4 Describe the dataset

[6]:
```
df.describe()
```

[6]:
```
                Age   RestingBP  Cholesterol   FastingBS       MaxHR  \
count   918.000000  917.000000   917.000000  917.000000  917.000000
mean     53.510893  132.390403   199.016358    0.233370  136.801527
std       9.432617   18.523331   109.246330    0.423206   25.473119
min      28.000000    0.000000     0.000000    0.000000   60.000000
25%      47.000000  120.000000   174.000000    0.000000  120.000000
50%      54.000000  130.000000   223.000000    0.000000  138.000000
75%      60.000000  140.000000   267.000000    0.000000  156.000000
max      77.000000  200.000000   603.000000    1.000000  202.000000

           Oldpeak  HeartDisease
count   918.000000    918.000000
mean      0.887364      0.553377
std       1.066570      0.497414
min      -2.600000      0.000000
25%       0.000000      0.000000
50%       0.600000      1.000000
75%       1.500000      1.000000
max       6.200000      1.000000
```

0.5 Checking which columns contain null values

[7]:
```
df.isnull().sum()
```

[7]:
```
Age               0
Sex               0
ChestPainType     0
RestingBP         1
Cholesterol       1
FastingBS         1
RestingECG        0
MaxHR             1
ExerciseAngina    0
Oldpeak           0
ST_Slope          0
```

```
HeartDisease      0
dtype: int64
```

0.6 info()

[8]:
```
df.info()
```

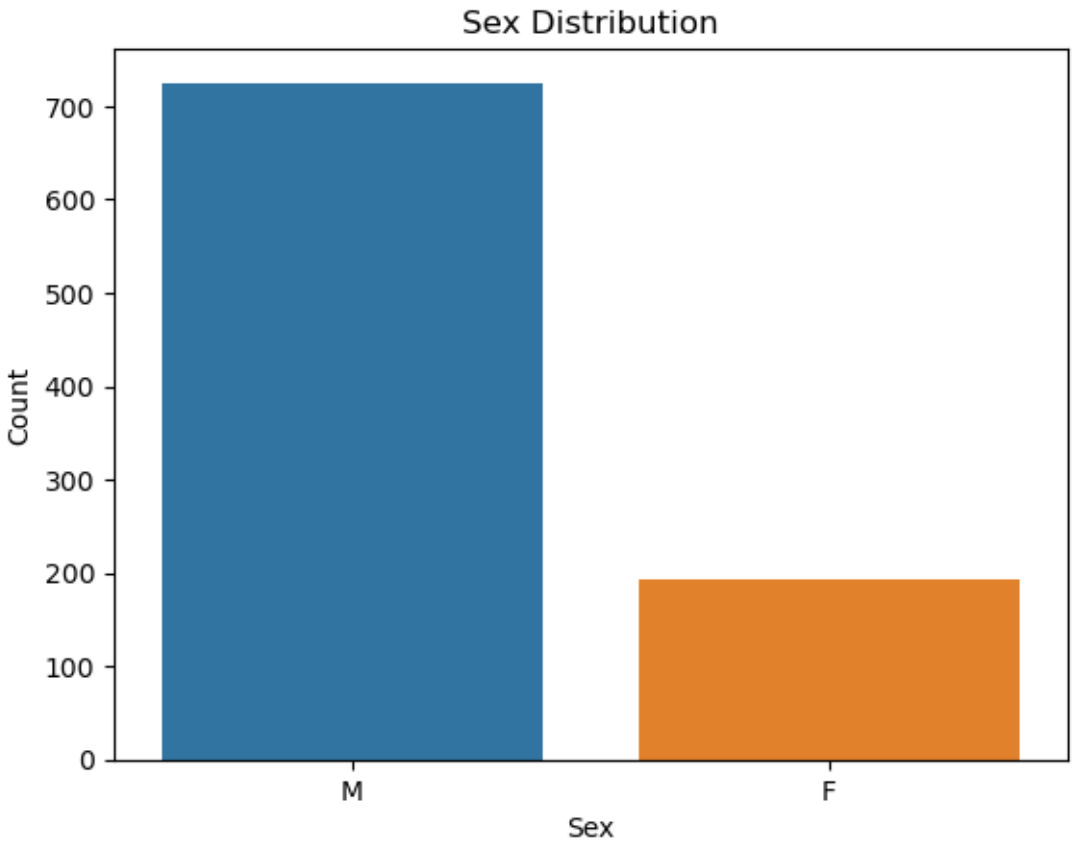
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 918 entries, 0 to 917
Data columns (total 12 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   Age             918 non-null    int64
 1   Sex             918 non-null    object
 2   ChestPainType   918 non-null    object
 3   RestingBP       917 non-null    float64
 4   Cholesterol     917 non-null    float64
 5   FastingBS       917 non-null    float64
 6   RestingECG      918 non-null    object
 7   MaxHR           917 non-null    float64
 8   ExerciseAngina  918 non-null    object
 9   Oldpeak         918 non-null    float64
 10  ST_Slope        918 non-null    object
 11  HeartDisease    918 non-null    int64
dtypes: float64(5), int64(2), object(5)
memory usage: 86.2+ KB
```

[9]:
```
df.shape
```

[9]:
```
(918, 12)
```

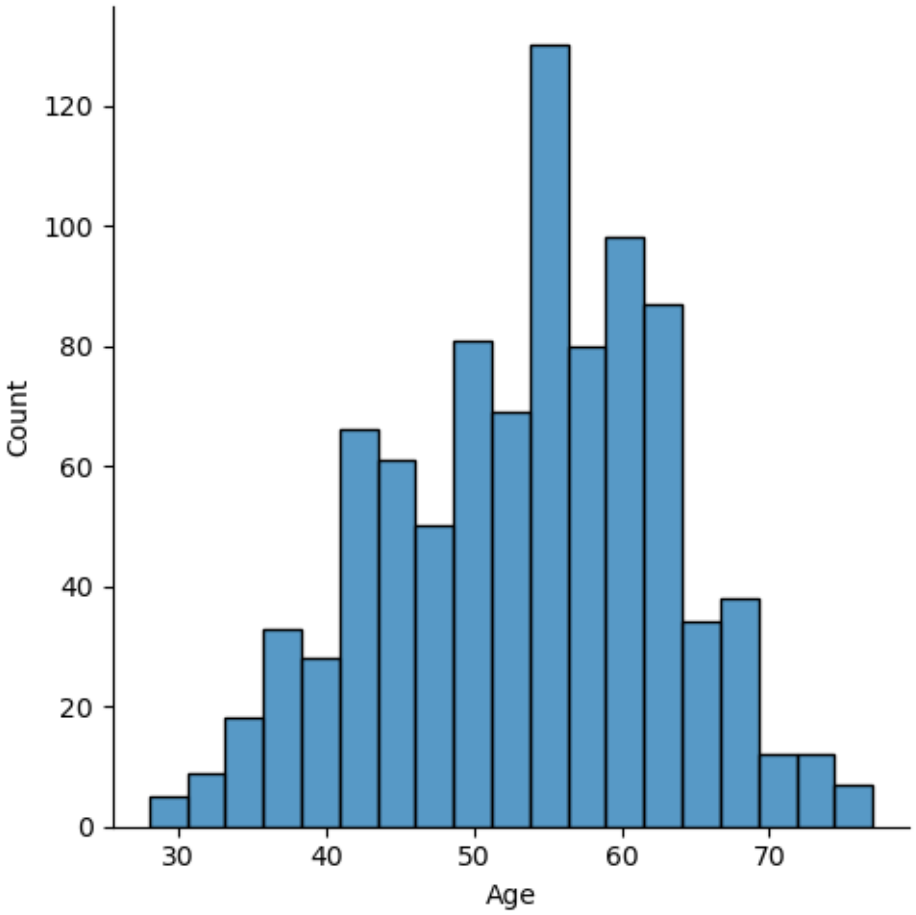
[10]:
```
sns.countplot(data=df,x='Sex');
plt.title('Sex Distribution')
plt.xlabel('Sex')
plt.ylabel('Count')
```

[10]:
```
Text(0, 0.5, 'Count')
```



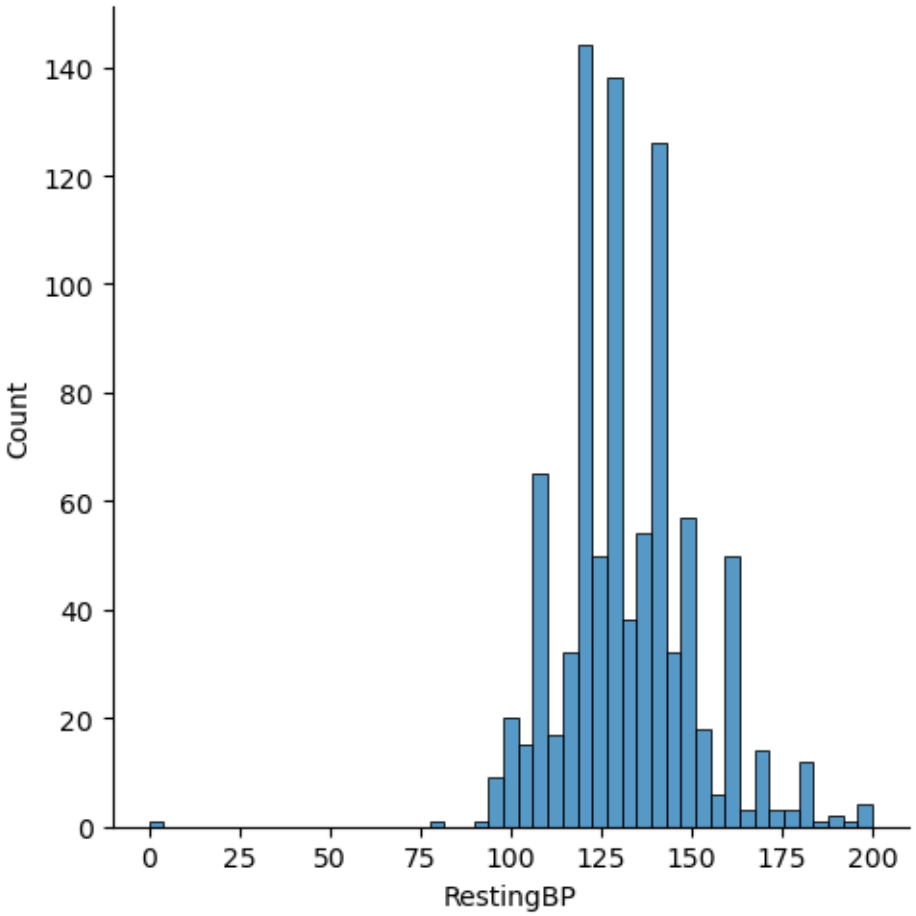
[11]:
```
sns.displot(df['Age'])
```

[11]: <seaborn.axisgrid.FacetGrid at 0x1c75f9fdc90>



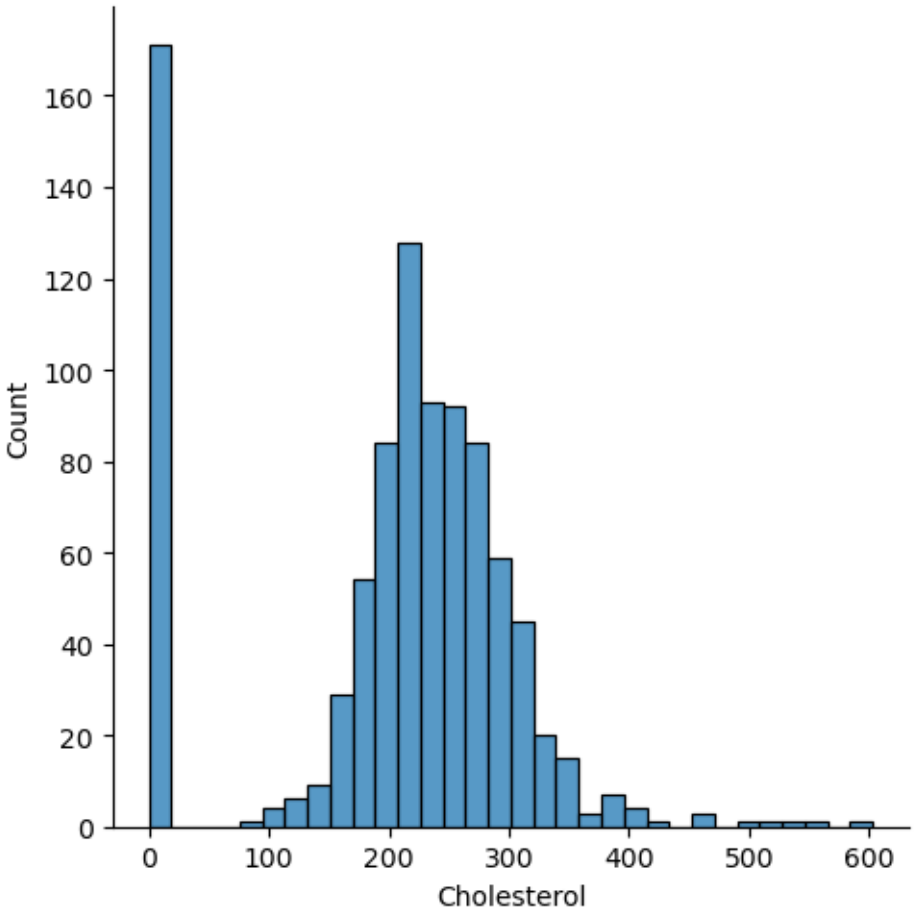
[12]:
```
sns.displot(df['RestingBP'])
```

[12]: <seaborn.axisgrid.FacetGrid at 0x1c75f9e3310>



[13]:
```
sns.displot(df['Cholesterol'])
```

[13]:
```
<seaborn.axisgrid.FacetGrid at 0x1c765848c10>
```



0.7 Duplicate Values

[14]:
```
df_data=df.duplicated().any()
```

[15]:
```
df_data
```

[15]:
```
False
```

0.7.1 label

[16]:
```
df.HeartDisease.value_counts()
```

[16]:
```
1    508
0    410
Name: HeartDisease, dtype: int64
```

1 completing missing values & outlier

[17]:
```
from sklearn.impute import SimpleImputer
numImputer=SimpleImputer(missing_values=np.nan, strategy="most_frequent")
numImputer=numImputer.fit(df[["RestingBP","Cholesterol","FastingBS","MaxHR"]])
new_df=numImputer.transform(df[["RestingBP","Cholesterol","FastingBS","MaxHR"]])
new_df
```

[17]:
```
array([[140., 289.,   0., 172.],
       [160., 180.,   0., 156.],
       [130., 283.,   0.,  98.],
       …,
       [130., 131.,   0., 115.],
       [130., 236.,   0., 174.],
       [138., 175.,   0., 173.]])
```

[18]:
```
df[["RestingBP","Cholesterol","FastingBS","MaxHR"]]=new_df
df
```

[18]:

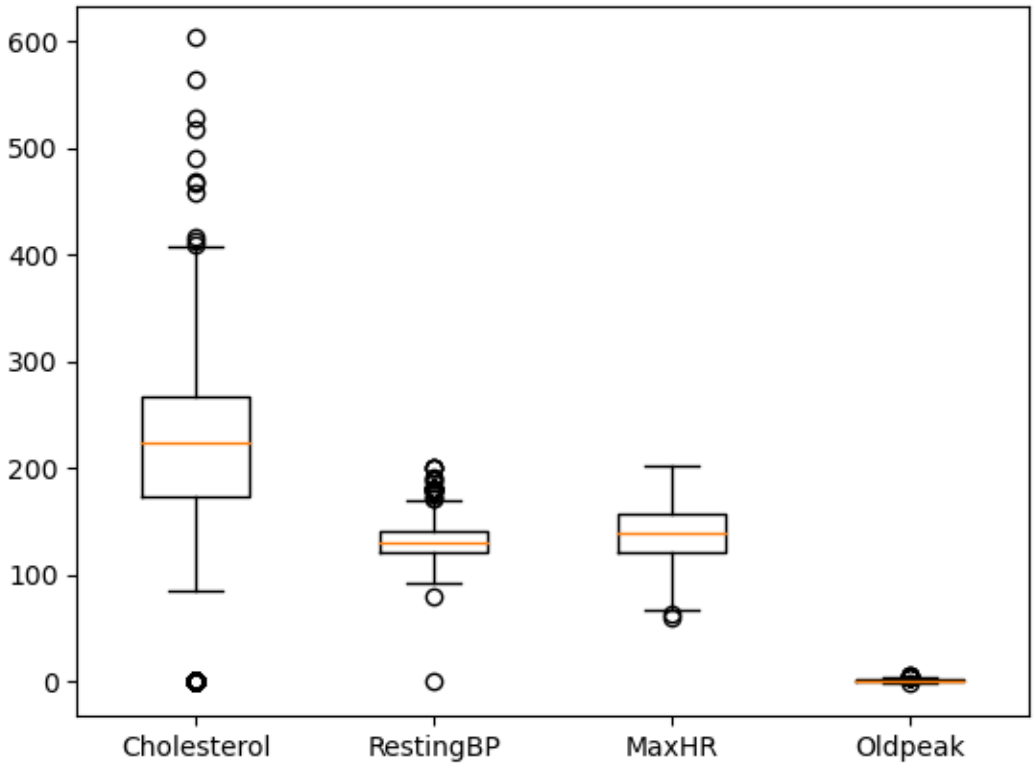
	Age	Sex	ChestPainType	RestingBP	Cholesterol	FastingBS	RestingECG	\
0	40	M	ATA	140.0	289.0	0.0	Normal	
1	49	F	NAP	160.0	180.0	0.0	Normal	
2	37	M	ATA	130.0	283.0	0.0	ST	
3	48	F	ASY	120.0	214.0	0.0	Normal	
4	54	M	NAP	150.0	195.0	0.0	Normal	
..	…	..	…	…	…	…	…	
913	45	M	TA	110.0	264.0	0.0	Normal	
914	68	M	ASY	144.0	193.0	1.0	Normal	
915	57	M	ASY	130.0	131.0	0.0	Normal	
916	57	F	ATA	130.0	236.0	0.0	LVH	
917	38	M	NAP	138.0	175.0	0.0	Normal	

	MaxHR	ExerciseAngina	Oldpeak	ST_Slope	HeartDisease
0	172.0	N	0.0	Up	0
1	156.0	N	1.0	Flat	1
2	98.0	N	0.0	Up	0
3	108.0	Y	1.5	Flat	1
4	122.0	N	0.0	Up	0
..	…	…	…	…	…
913	132.0	N	1.2	Flat	1
914	141.0	N	3.4	Flat	1
915	115.0	Y	1.2	Flat	1
916	174.0	N	0.0	Flat	1
917	173.0	N	0.0	Up	0

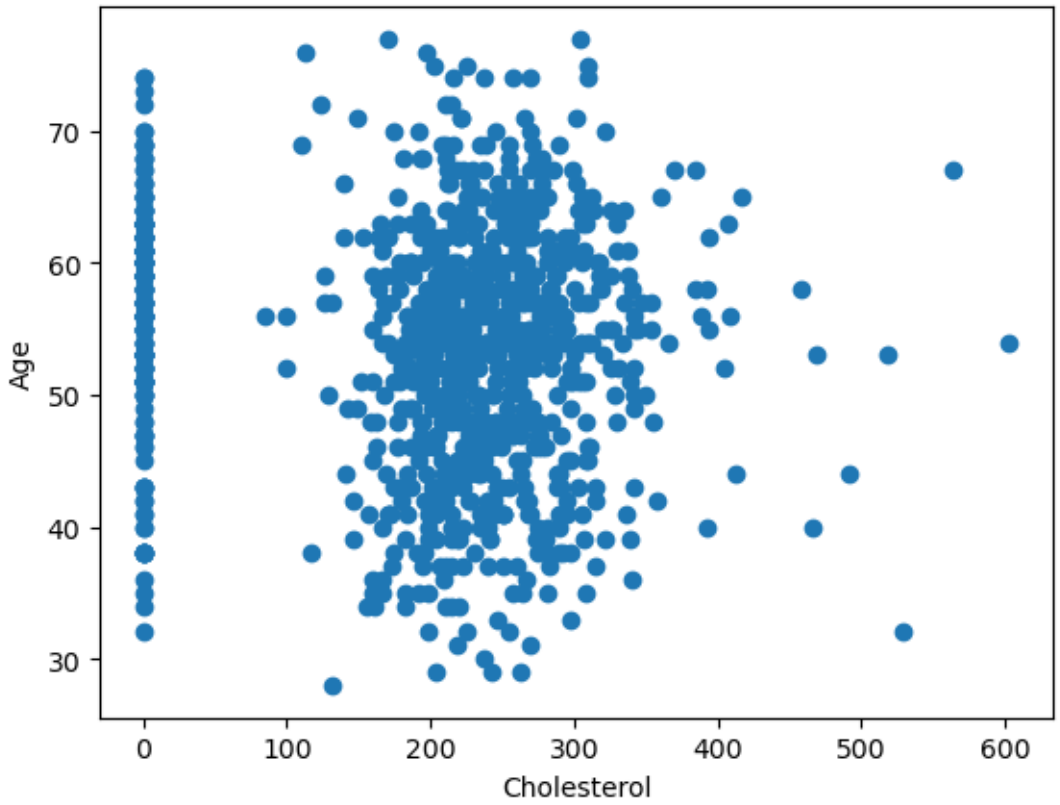
[918 rows x 12 columns]

1.0.1 outlier

[19]:
```
plt.boxplot(x=[df["Cholesterol"],df["RestingBP"],df["MaxHR"],df["Oldpeak"]])
plt.xticks([1,2,3,4],["Cholesterol","RestingBP","MaxHR","Oldpeak"])
plt.show()
```

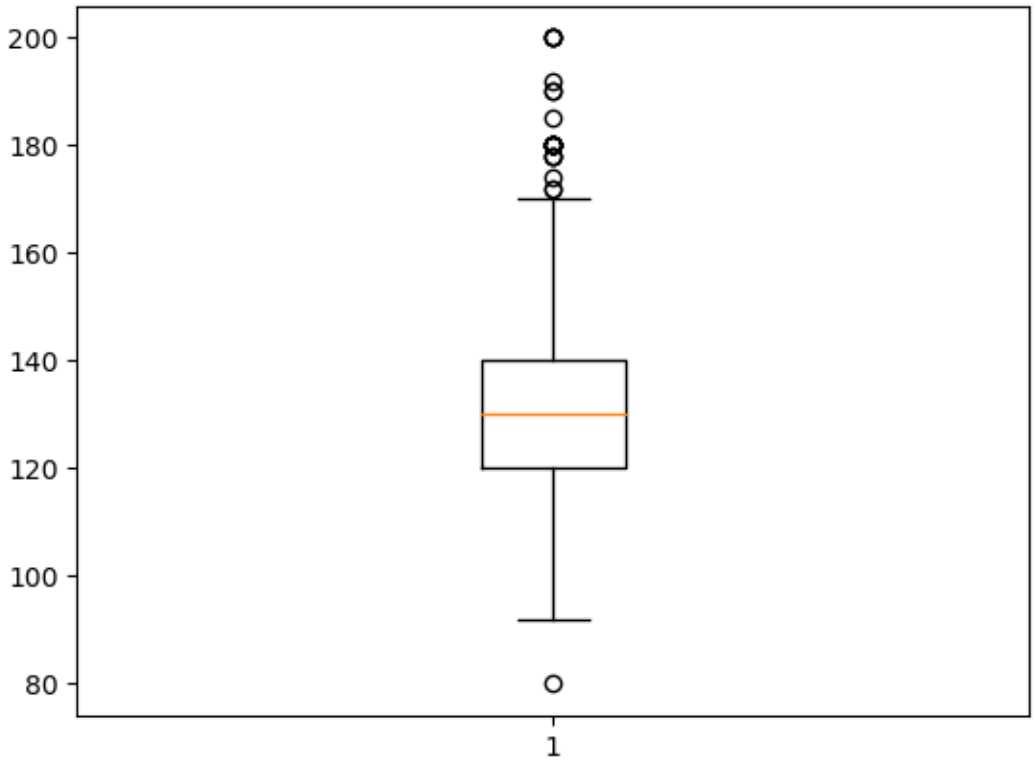


[20]:
```
plt.scatter(df["Cholesterol"],df["Age"])
plt.xlabel("Cholesterol")
plt.ylabel("Age")
plt.show()
```



[21]:
```
df = df.drop(df[(df['RestingBP'] == 0)].index)
```

[22]:
```
plt.boxplot(df["RestingBP"])
plt.show()
```



[23]:
```
df.loc[df['Cholesterol'] == 0,'Cholesterol'] = np.nan
```

[24]:
```
df.isnull().sum()
```

[24]:
```
Age                 0
Sex                 0
ChestPainType       0
RestingBP           0
Cholesterol       171
FastingBS           0
RestingECG          0
MaxHR               0
ExerciseAngina      0
Oldpeak             0
ST_Slope            0
HeartDisease        0
dtype: int64
```

[25]:
```
df["Cholesterol"] = df["Cholesterol"].fillna(df["Cholesterol"].median())
df["Cholesterol"]
```

[25]:
```
0      289.0
1      180.0
2      283.0
3      214.0
4      195.0
       …
913    264.0
914    193.0
915    131.0
916    236.0
917    175.0
Name: Cholesterol, Length: 917, dtype: float64
```

2 encoder

Age

[26]:
```
df["Sex"].value_counts()
```

[26]:
```
M    724
F    193
Name: Sex, dtype: int64
```

[27]:
```
df["Sex"]=df["Sex"].replace(["M","F"],[0,1])
```

ChestPainType

[28]:
```
df["ChestPainType"].value_counts()
```

[28]:
```
ASY    496
NAP    202
ATA    173
TA      46
Name: ChestPainType, dtype: int64
```

[29]:
```
df["ChestPainType"]=df["ChestPainType"].
 ↪replace(["ASY","NAP","ATA","TA"],[0,1,2,3])
```

RestingECG

[30]:
```
df["RestingECG"].value_counts()
```

[30]:
```
Normal    551
LVH       188
ST        178
Name: RestingECG, dtype: int64
```

[31]:
```
df["RestingECG"]=df["RestingECG"].replace(["Normal","LVH","ST"],[0,1,2])
```

ExerciseAngina

[18]:
```
df["ExerciseAngina"].value_counts()
```

[18]:
```
N    546
Y    371
Name: ExerciseAngina, dtype: int64
```

[19]:
```
df["ExerciseAngina"]=df["ExerciseAngina"].replace(["N","Y"],[0,1])
```

ST_Slope

[20]:
```
df["ST_Slope"].value_counts()
```

[20]:
```
Flat    459
Up      395
Down     63
Name: ST_Slope, dtype: int64
```

[21]:
```
df["ST_Slope"]=df["ST_Slope"].replace(["Flat","Up","Down"],[0,1,2])
```

[22]:
```
df
```

[22]:

	Age	Sex	ChestPainType	RestingBP	Cholesterol	FastingBS	RestingECG	\
0	40	0	2	140.0	289.0	0.0	0	
1	49	1	1	160.0	180.0	0.0	0	
2	37	0	2	130.0	283.0	0.0	2	
3	48	1	0	120.0	214.0	0.0	0	
4	54	0	1	150.0	195.0	0.0	0	
..	…	…	…	…	…	…	…	
913	45	0	3	110.0	264.0	0.0	0	
914	68	0	0	144.0	193.0	1.0	0	
915	57	0	0	130.0	131.0	0.0	0	
916	57	1	2	130.0	236.0	0.0	1	
917	38	0	1	138.0	175.0	0.0	0	

	MaxHR	ExerciseAngina	Oldpeak	ST_Slope	HeartDisease
0	172.0	0	0.0	1	0
1	156.0	0	1.0	0	1
2	98.0	0	0.0	1	0
3	108.0	1	1.5	0	1
4	122.0	0	0.0	1	0
..	…	…	…	…	…
913	132.0	0	1.2	0	1
914	141.0	0	3.4	0	1
915	115.0	1	1.2	0	1
916	174.0	0	0.0	0	1
917	173.0	0	0.0	1	0

[917 rows x 12 columns]

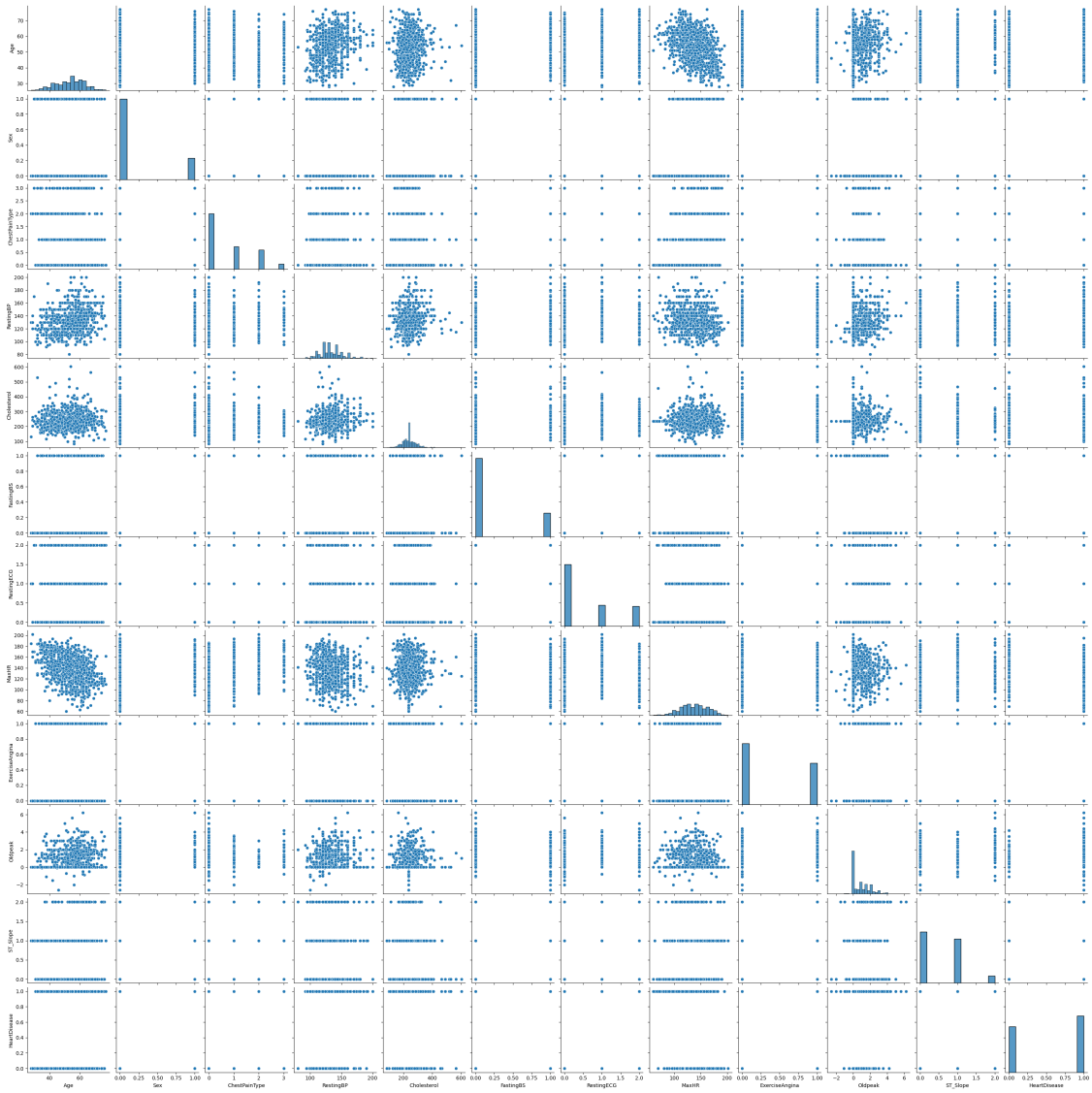
2.0.1 corr

[31]:
```
cor=df.corr()
cor
```

[31]:

	Age	Sex	ChestPainType	RestingBP	Cholesterol	FastingBS	RestingECG	MaxHR	ExerciseAngina	Oldpeak	ST_Slope	HeartDisease
Age	1.000000	-0.055670	-0.165951	0.263665	0.045556	0.198170	0.210694	-0.381982	0.216017	0.258563	-0.093310	0.282012
Sex	-0.055670	1.000000	0.168437	-0.011538	0.111122	-0.120424	-0.038758	0.189516	-0.191226	-0.105444	0.066355	-0.305118
ChestPainType	-0.165951	0.168437	1.000000	-0.019763	-0.062737	-0.116564	-0.064901	0.343310	-0.416553	-0.245250	0.203046	-0.471846
RestingBP	0.263665	-0.011538	-0.019763	1.000000	0.086641	0.068410	0.115449	-0.108317	0.151708	0.173587	-0.092236	0.116984
Cholesterol	0.045556	0.111122	-0.062737	0.086641	1.000000	0.024851	0.010679	-0.001780	0.072751	0.054583	-0.076421	0.076262
FastingBS	0.198170	-0.120424	-0.116564	0.068410	0.024851	1.000000	0.120381	-0.131195	0.059988	0.053062	-0.044113	0.267994
RestingECG	0.210694	-0.038758	-0.064901	0.115449	0.010679	0.120381	1.000000	-0.092709	0.097755	0.100452	-0.020166	0.108440
MaxHR	-0.381982	0.189516	0.343310	-0.108317	-0.001780	-0.131195	-0.092709	1.000000	-0.369673	-0.160445	0.247979	-0.401137
ExerciseAngina	0.216017	-0.191226	-0.416553	0.151708	0.072751	0.059988	0.097755	-0.369673	1.000000	0.409494	-0.254216	0.495490
Oldpeak	0.258563	-0.105444	-0.245250	0.173587	0.054583	0.053062	0.100452	-0.160445	0.409494	1.000000	-0.096810	0.403638
ST_Slope	-0.093310	0.066355	0.203046	-0.092236	-0.076421	-0.044113	-0.020166	0.247979	-0.254216	-0.096810	1.000000	-0.397260
HeartDisease	0.282012	-0.305118	-0.471846	0.116984	0.076262	0.267994	0.108440	-0.401137	0.495490	0.403638	-0.397260	1.000000

[41]:
```
sns.pairplot(df)
plt.show()
```



2.1 Standardization

[31]:
```
from sklearn import preprocessing
X=df.iloc[:,:-1]
Y=df.iloc[:,-1]
```

[32]:
```
X
```

[32]:

	Age	Sex	ChestPainType	RestingBP	Cholesterol	FastingBS	RestingECG	\
0	40	0	2	140.0	289.0	0.0	0	

```
1     49    1              1      160.0        180.0        0.0           0
2     37    0              2      130.0        283.0        0.0           2
3     48    1              0      120.0        214.0        0.0           0
4     54    0              1      150.0        195.0        0.0           0
..   ...  ...            ...      ...          ...          ...         ...
913   45    0              3      110.0        264.0        0.0           0
914   68    0              0      144.0        193.0        1.0           0
915   57    0              0      130.0        131.0        0.0           0
916   57    1              2      130.0        236.0        0.0           1
917   38    0              1      138.0        175.0        0.0           0

     MaxHR  ExerciseAngina  Oldpeak  ST_Slope
0    172.0               0      0.0         1
1    156.0               0      1.0         0
2     98.0               0      0.0         1
3    108.0               1      1.5         0
4    122.0               0      0.0         1
..     ...             ...      ...       ...
913  132.0               0      1.2         0
914  141.0               0      3.4         0
915  115.0               1      1.2         0
916  174.0               0      0.0         0
917  173.0               0      0.0         1

[917 rows x 11 columns]
```

[33]:
```
Y
```

[33]:
```
0      0
1      1
2      0
3      1
4      0
      ..
913    1
914    1
915    1
916    1
917    0
Name: HeartDisease, Length: 917, dtype: int64
```

3 Split data

[34]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test=train_test_split(X,Y, test_size=0.3 ,␣
 ↪random_state=0)
```

```
print("Train set",X_train.shape, y_train.shape)
print("Test set",X_test.shape, y_test.shape)
```

```
Train set (641, 11) (641,)
Test set (276, 11) (276,)
```

[35]:
```
from sklearn.preprocessing import StandardScaler
sc=StandardScaler()
X_train_s=sc.fit_transform(X_train)
X_test_s=sc.transform(X_test)
```

[36]:
```
X_train_s
```

[36]:
```
array([[-2.26099369, -0.51894791, -0.82065891, …, -0.83412661,
        -0.85419772, -0.89779876],
       [-1.84109019, -0.51894791,  0.22932584, …, -0.83412661,
         0.09359653, -0.89779876],
       [-0.26645203, -0.51894791, -0.82065891, …, -0.83412661,
         1.23094963, -0.89779876],
       …,
       [ 1.83306551,  1.92697569, -0.82065891, …, -0.83412661,
         0.66227308, -0.89779876],
       [ 0.0484756 , -0.51894791,  0.22932584, …, -0.83412661,
        -0.66463887,  0.70971243],
       [ 0.78330674, -0.51894791, -0.82065891, …,  1.19885877,
         2.55786158, -0.89779876]])
```

[37]:
```
from sklearn.feature_selection import VarianceThreshold
variance_selector = VarianceThreshold(threshold=0)
X_train_fs = variance_selector.fit_transform(X_train_s)
X_test_fs = variance_selector.transform(X_test_s)
print(f"{X_train.shape[1]-X_train_fs.shape[1]} features have beenremoved,␣
 ↪{X_train_fs.shape[1]} features remain")
```

```
0 features have beenremoved, 11 features remain
```

[38]:
```
from sklearn.feature_selection import SelectKBest, f_classif
selector = SelectKBest(f_classif, k='all')
X_train_fs1 = selector.fit_transform(X_train_s, y_train)
X_test_fs1 = selector.transform(X_test_s)
print(f"{X_train.shape[1]-X_train_fs1.shape[1]} features have beenremoved,␣
 ↪{X_train_fs1.shape[1]} features remain")
```

```
0 features have beenremoved, 11 features remain
```

4 KNN

[39]:
```
from sklearn.neighbors import KNeighborsClassifier
classifier=KNeighborsClassifier(n_neighbors=11, metric="manhattan")
classifier.fit(X_train_fs, y_train)
```

[39]:
```
KNeighborsClassifier(metric='manhattan', n_neighbors=11)
```

[386]:
```
y_pred=classifier.predict(X_test_fs)
print(y_pred)
```

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

[387]:
```
from sklearn import metrics
acc=metrics.accuracy_score(y_test, y_pred)
print("accuracy:%.2f\n\n"%(acc))
cm=metrics.confusion_matrix(y_test,y_pred)
print("confusion Matrix: ")
print(cm,"\n\n")
print("-----------------------------------------")
result=metrics.classification_report(y_test, y_pred)
print("Classification Report:\n")
print(result)
```

```
accuracy:0.87


confusion Matrix:
[[103  18]
 [ 19 136]]


-----------------------------------------
Classification Report:

              precision    recall  f1-score   support

           0       0.84      0.85      0.85       121
           1       0.88      0.88      0.88       155

    accuracy                           0.87       276
   macro avg       0.86      0.86      0.86       276
```

```
weighted avg       0.87      0.87      0.87       276
```

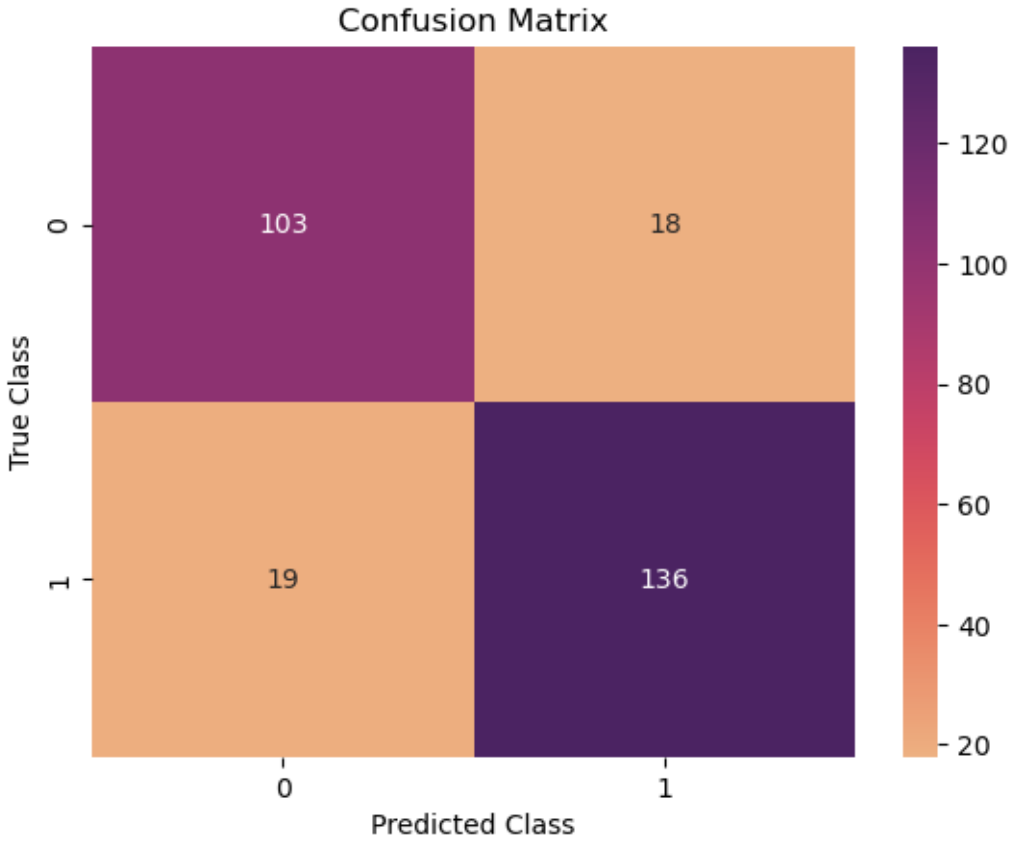
4.1 other k

[362]:
```
for k in range(1, 12):
    classifier = KNeighborsClassifier(n_neighbors=k, metric="manhattan")
    classifier.fit(X_train_s, y_train)

    y_pred_train = classifier.predict(X_train_s)
    accuracy_train = metrics.accuracy_score(y_train, y_pred_train)

    y_pred=classifier.predict(X_test_fs)
    accuracy_test = metrics.accuracy_score(y_test, y_pred)

    print(f"n_neighbors = {k},Train Accuracy = {accuracy_train:.2f}")
    print(f"n_neighbors = {k}, Test Accuracy = {accuracy_test:.2f}")
    print("")
```

```
n_neighbors = 1,Train Accuracy = 1.00
n_neighbors = 1, Test Accuracy = 0.84

n_neighbors = 2,Train Accuracy = 0.90
n_neighbors = 2, Test Accuracy = 0.79

n_neighbors = 3,Train Accuracy = 0.91
n_neighbors = 3, Test Accuracy = 0.85

n_neighbors = 4,Train Accuracy = 0.90
n_neighbors = 4, Test Accuracy = 0.83

n_neighbors = 5,Train Accuracy = 0.90
n_neighbors = 5, Test Accuracy = 0.84

n_neighbors = 6,Train Accuracy = 0.88
n_neighbors = 6, Test Accuracy = 0.85

n_neighbors = 7,Train Accuracy = 0.90
n_neighbors = 7, Test Accuracy = 0.84

n_neighbors = 8,Train Accuracy = 0.89
n_neighbors = 8, Test Accuracy = 0.83

n_neighbors = 9,Train Accuracy = 0.89
n_neighbors = 9, Test Accuracy = 0.84

n_neighbors = 10,Train Accuracy = 0.88
n_neighbors = 10, Test Accuracy = 0.86
```

```
n_neighbors = 11,Train Accuracy = 0.88
n_neighbors = 11, Test Accuracy = 0.87
```

[407]:
```
ax=sns.heatmap(cm, annot=True, fmt='d', cmap='flare')
plt.title('Confusion Matrix')
plt.xlabel('Predicted Class')
plt.ylabel('True Class')
plt.show()
```



5 Decision Tree

[40]:
```
from sklearn.tree import DecisionTreeClassifier
tree_classifier=DecisionTreeClassifier(criterion="gini", random_state=0)
tree_classifier.fit(X_train_fs, y_train)
```

[40]:
```
DecisionTreeClassifier(random_state=0)
```

[393]:
```
tree_y_pred=tree_classifier.predict(X_test_fs)
print(tree_y_pred)
```

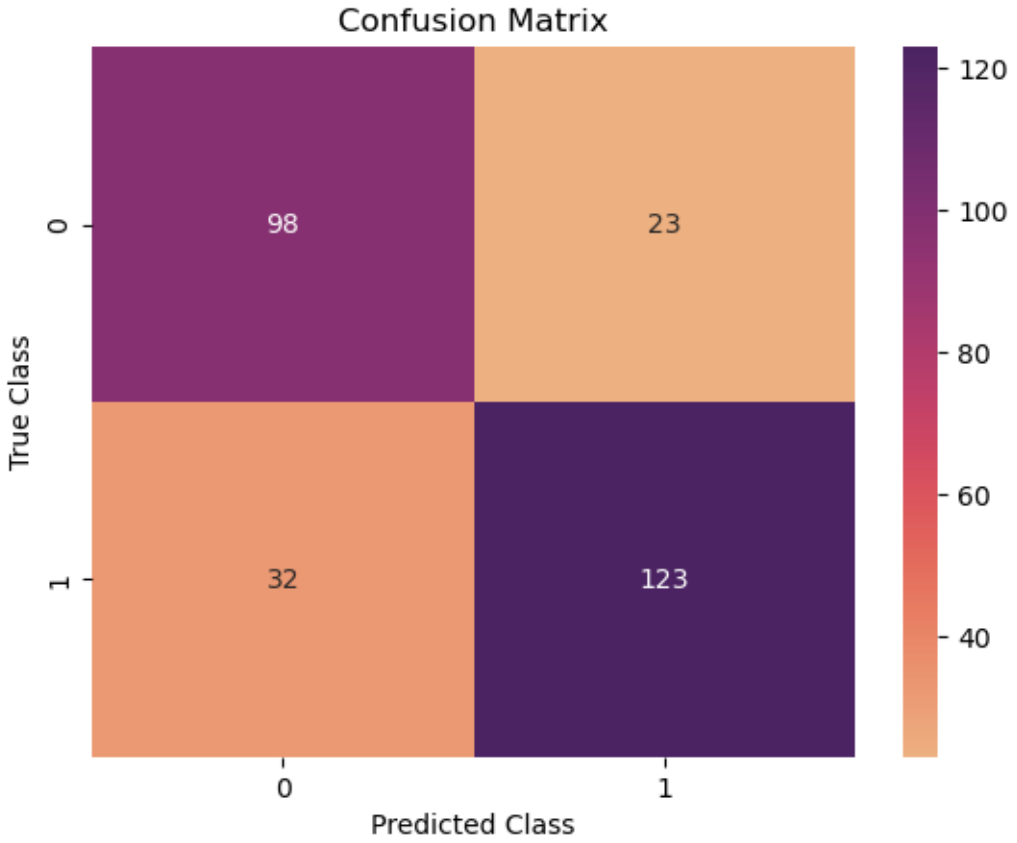
```
[1 1 1 0 1 0 1 0 0 0 1 1 1 1 0 1 1 1 1 0 1 1 0 0 0 0 1 1 1 1 1 0 0 0 1 0 0
 0 0 0 0 1 1 1 1 0 0 1 0 1 1 0 0 1 1 0 0 0 0 0 1 1 1 0 1 1 1 0 1 0 1 1 1 1
 1 0 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 0 0 0 0 1 0 0 0 1 1 1 1 0 1 0 0 0 0 0
 1 1 1 0 1 0 1 1 1 1 1 1 0 1 0 0 1 0 1 1 1 1 1 0 0 1 1 1 0 0 1 0 1 0 0 1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

[394]:
```
from sklearn import metrics
tree_acc=metrics.accuracy_score(y_test, tree_y_pred)
print("accuracy:%.2f\n\n"%(tree_acc))
tree_cm=metrics.confusion_matrix(y_test,tree_y_pred)
print("confusion Matrix: ")
print(tree_cm,"\n\n")
print("-----------------------------------------")
tree_result=metrics.classification_report(y_test, tree_y_pred)
print("Classification Report:\n")
print(tree_result)
```

```
accuracy:0.80


confusion Matrix:
[[ 98  23]
 [ 32 123]]


-----------------------------------------
Classification Report:

              precision    recall  f1-score   support

           0       0.75      0.81      0.78       121
           1       0.84      0.79      0.82       155

    accuracy                           0.80       276
   macro avg       0.80      0.80      0.80       276
weighted avg       0.80      0.80      0.80       276
```

[395]:
```
tree_ax=sns.heatmap(tree_cm, annot=True, fmt='d', cmap='flare')
plt.title('Confusion Matrix')
plt.xlabel('Predicted Class')
plt.ylabel('True Class')
```

```
plt.show()
```



5.1 svm

[41]:
```
from sklearn import svm
svm_classifier=svm.SVC(kernel="rbf")
svm_classifier.fit(X_train_fs, y_train)
```

[41]:
```
SVC()
```

[46]:
```
svm_y_pred=svm_classifier.predict(X_test_fs)
print(svm_y_pred)
```

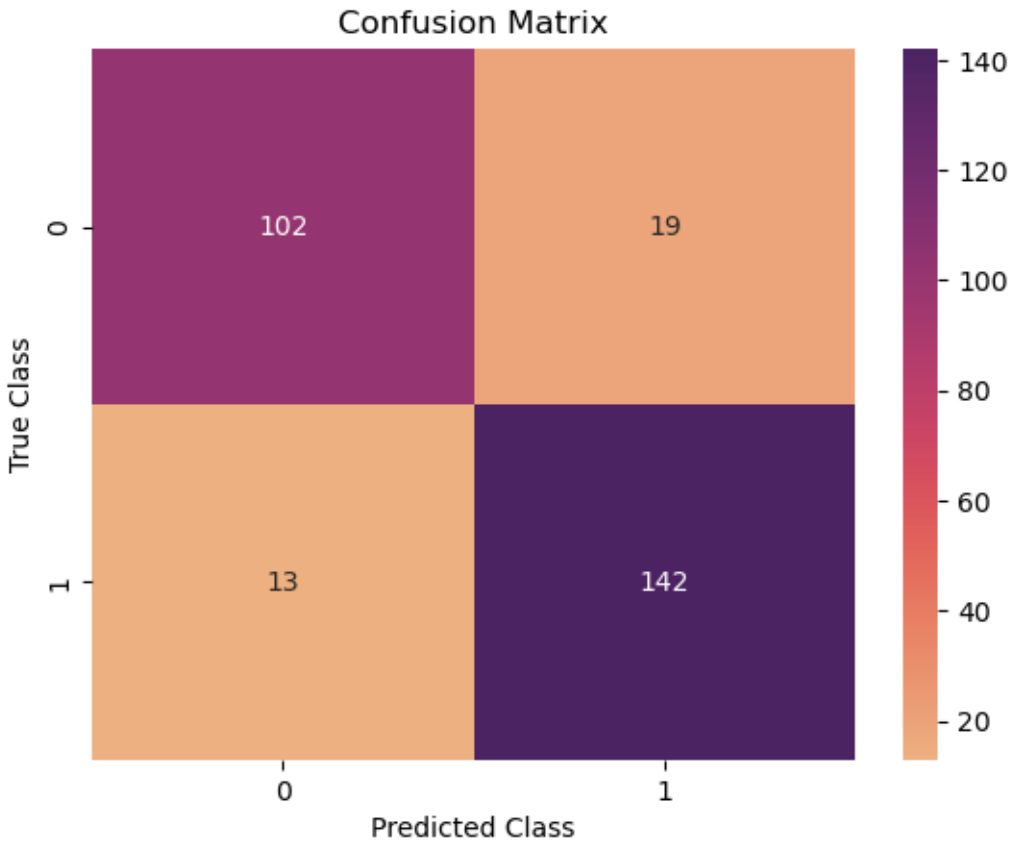
```
[1 1 1 0 0 0 1 0 0 0 1 1 1 1 0 1 1 1 1 0 1 1 1 0 0 0 1 1 1 1 1 0 0 0 1 0 0
 0 1 0 0 1 1 1 1 0 0 1 0 1 1 0 0 1 1 0 0 0 0 0 1 1 1 0 1 1 1 0 1 0 1 1 1 1
 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 1 0 0 0 1 0 1 0 0 0 0 1 1 1 0 1 0 0 0 1 0
 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 0 1 0 1 0 1 1 1 1 1 0 1 1 0 1 1 0 1 0 0 1 1
 1 0 0 1 0 0 1 0 1 1 1 0 1 1 1 0 1 0 1 0 1 0 1 1 0 0 1 1 1 0 0 1 1 1 0 1 1
 1 0 1 1 0 1 0 1 0 1 1 0 0 1 0 1 1 0 1 1 0 0 0 1 0 1 1 0 1 0 0 1 0 1 1 1 1
```

```
 0 1 1 1 0 1 1 1 0 1 1 1 0 1 1 1 0 1 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 0 0
 1 0 1 1 0 0 0 0 0 1 0 0 1 1 1 1 1]
```

[47]:
```
from sklearn import metrics
svm_acc=metrics.accuracy_score(y_test, svm_y_pred)
print("accuracy:%.2f\n\n"%(svm_acc))
svm_cm=metrics.confusion_matrix(y_test,svm_y_pred)
print("confusion Matrix: ")
print(svm_cm,"\n\n")
print("-----------------------------------------")
svm_result=metrics.classification_report(y_test, svm_y_pred)
print("Classification Report:\n")
print(svm_result)
```

```
accuracy:0.88


confusion Matrix:
[[102  19]
 [ 13 142]]


-----------------------------------------
Classification Report:

              precision    recall  f1-score   support

           0       0.89      0.84      0.86       121
           1       0.88      0.92      0.90       155

    accuracy                           0.88       276
   macro avg       0.88      0.88      0.88       276
weighted avg       0.88      0.88      0.88       276
```

[48]:
```
svm_ax=sns.heatmap(svm_cm, annot=True, fmt='d', cmap='flare')
plt.title('Confusion Matrix')
plt.xlabel('Predicted Class')
plt.ylabel('True Class')

plt.show()
```


Confusion Matrix
102
19
13
142
True Class
Predicted Class
0
1
0
1
140
120
100
80
60
40
20

[ ]: