Heart Attack Analysis & Prediction

Install Required Libs (If not installed already)

In [ ]:

```
#!pip install pandas
#!pip install NumPy
```

In [ ]:

```
#!pip install matplotlib
#!pip install seaborn
```

In [ ]:

```
#!pip install sklearn
```

In [ ]:

```
#!pip install xgboost
```

In [ ]:

```
#!pip install yellowbrick
```

Import Required Lib

In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import re

from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier
from sklearn.metrics import confusion_matrix, plot_confusion_matrix, classification_report,
from sklearn.metrics import recall_score, accuracy_score,roc_curve, auc
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler, OneHotEncoder, LabelEncoder
from sklearn.compose import ColumnTransformer
from sklearn.decomposition import TruncatedSVD
from sklearn.impute import SimpleImputer
from sklearn.pipeline import Pipeline
from xgboost import XGBClassifier
```

In [2]:

```
# Apply the default theme
sns.set_theme()
sns.set_style("whitegrid")
```

In [3]:

```
# Plot should appear inside the jupyter notebook
%matplotlib inline
```

In [4]:

```
plt.rcParams["figure.figsize"] = (10,6)
plt.rcParams['figure.dpi'] = 100
```

In [5]:

```
pd.options.display.max_rows = 10
pd.options.display.max_columns = 40
```

In [6]:

```
import warnings
warnings.filterwarnings("ignore")
```

Importing Data for analysis

In [7]:

```
ds_heart = pd.read_csv("Data/heart.csv")
```

In [8]:

```
#Printing Dataset Shape
print("\nDateset Shape is : ",ds_heart.shape)
```

```

Dateset Shape is :  (303, 14)
```

Let's Understand Our Data

In [9]:

```
ds_heart.sample()
```

Out[9]:

	age	sex	cp	trtbps	chol	fbs	restecg	thalachh	exng	oldpeak	slp	caa	thall	output
300	68	1	0	144	193	1	1	141	0	3.4	1	2	3	0

In [10]:

```
ds_heart.describe()
```

Out[10]:

	age	sex	cp	trtbps	chol	fbs	restecg	
count	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	30
mean	54.366337	0.683168	0.966997	131.623762	246.264026	0.148515	0.528053	14
std	9.082101	0.466011	1.032052	17.538143	51.830751	0.356198	0.525860	2
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	7
25%	47.500000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000	13
50%	55.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000	15
75%	61.000000	1.000000	2.000000	140.000000	274.500000	0.000000	1.000000	16
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000	20

In [11]:

```
#Columns List
ds_heart.columns
```

Out[11]:

```
Index(['age', 'sex', 'cp', 'trtbps', 'chol', 'fbs', 'restecg', 'thalachh',
       'exng', 'oldpeak', 'slp', 'caa', 'thall', 'output'],
      dtype='object')
```

In [12]:

```
#List of Numeric Columns
numeric_columns = [column for column in ds_heart.columns if (ds_heart[column].dtype == 'flo
print(numeric_columns)
```

```
['age', 'sex', 'cp', 'trtbps', 'chol', 'fbs', 'restecg', 'thalachh', 'exng',
'oldpeak', 'slp', 'caa', 'thall', 'output']
```

In [13]:

```
#Duplicate Values
ds_heart.duplicated().sum()
```

Out[13]:

```
1
```

Data Cleaning and Manupulation using Function & RegEx

In [14]:

```
#Removing duplicate value
ds_heart.drop_duplicates(inplace=True)
```

In [15]:

```
#Total Records 303 unique records 302
#Printing Dataset Shape
print("\nDateset Shape is : ",ds_heart.shape,"(Unqiue Records)\n")
```

```

Dateset Shape is :  (302, 14) (Unqiue Records)

```

In [16]:

```
ds_heart.columns
```

Out[16]:

```
Index(['age', 'sex', 'cp', 'trtbps', 'chol', 'fbs', 'restecg', 'thalachh',
       'exng', 'oldpeak', 'slp', 'caa', 'thall', 'output'],
      dtype='object')
```

In [17]:

```
## Rename few columns to understand
ds_heart.rename(columns={'output': 'attack',
                         'thall': 'stresstest',
                         'caa':'numberofmajorvessels',
                         'cp':'chestpaintype',
                         'exng':'exerciseinducedangina',
                         'restecg':'restingecg',
                         'fbs':'fastingbloodsugar',
                         'trtbps':'restingbloodpressure',
                         'thalachh':'maxheartrateachieved',
                         'slp':'slope',
                         'chol':'cholestoral'}, inplace=True)
ds_heart.columns
```

Out[17]:

```
Index(['age', 'sex', 'chestpaintype', 'restingbloodpressure', 'cholestoral',
       'fastingbloodsugar', 'restingecg', 'maxheartrateachieved',
       'exerciseinducedangina', 'oldpeak', 'slope', 'numberofmajorvessels',
       'stresstest', 'attack'],
      dtype='object')
```

In [18]:

```
#finding Missing Values
pd.options.display.max_rows = 15
print(ds_heart.isnull().sum())
pd.options.display.max_rows = 5
```

```
age                      0
sex                      0
chestpaintype            0
restingbloodpressure     0
cholestoral              0
fastingbloodsugar        0
restingecg               0
maxheartrateachieved     0
exerciseinducedangina    0
oldpeak                  0
slope                    0
numberofmajorvessels     0
stresstest               0
attack                   0
dtype: int64
```

In [19]:

```
#chest pain type: chest pain type
# 0: typical angina
# 1: atypical angina
# 2: non-anginal pain
# 3: asymptomatic
#Validating Values
ds_heart.groupby(['chestpaintype'])['chestpaintype'].count()
```

Out[19]:

```
chestpaintype
0    143
1     50
2     86
3     23
Name: chestpaintype, dtype: int64
```

In [20]:

```
#fasting blood sugar > 120 mg/dl
#1 = true;
#0 = false
#Validating Values
ds_heart.groupby(['fastingbloodsugar'])['fastingbloodsugar'].count()
```

Out[20]:

```
fastingbloodsugar
0    257
1     45
Name: fastingbloodsugar, dtype: int64
```

In [21]:

```
# Heart Attack Count out of 303
#0 = No Hard Attack
#1 = Had Heart Attack
#Validating Values
ds_heart.groupby(['attack'])['attack'].count()
# 164 Had Heart Attack out of 303
```

Out[21]:

```
attack
0    138
1    164
Name: attack, dtype: int64
```

In [22]:

```
#Thalium Stress Test result ~ (0,3)
# 0 : Normal blood flow
# 1 : Abnormal blood flow during exercise - coronary artery disease
# 2 : Low blood flow during both rest and exercise -  severe blockage
# 3 : No thallium visible in parts of the heart - sign of damage from a heart attack
ds_heart.groupby(['stresstest'])['stresstest'].count()
```

Out[22]:

```
stresstest
0      2
1     18
2    165
3    117
Name: stresstest, dtype: int64
```

In [23]:

```
# Number of major vessels
# Valid Values 0,1,2,3
ds_heart.groupby(['numberofmajorvessels'])['numberofmajorvessels'].count()
```

Out[23]:

```
numberofmajorvessels
0    175
1     65
2     38
3     20
4      4
Name: numberofmajorvessels, dtype: int64
```

In [24]:

```
# Found 4 Invalid record for Number of major vessels
# Either Defaulting with meanvalue , max values or
# Removing record with Invalid Values
# To demostrate the concept of filling Missing Value we will use option 1
```

In [25]:

```
#Code to remove Invalid values (Not used)
#ds_heart=ds_heart[ds_heart.numberofmajorvessels!=4]
```

In [26]:

```
ds_heart['numberofmajorvessels'] = ds_heart['numberofmajorvessels'].replace(4,np.nan)
```

In [27]:

```
np.unique(ds_heart['numberofmajorvessels'])
```

Out[27]:

```
array([ 0.,  1.,  2.,  3., nan])
```

In [28]:

```
ds_heart['numberofmajorvessels'] = ds_heart['numberofmajorvessels'].fillna(ds_heart['number
```

In [29]:

```
ds_heart = ds_heart.astype({'numberofmajorvessels':'int64'})
ds_heart.groupby(['numberofmajorvessels'])['numberofmajorvessels'].count()
```

Out[29]:

```
numberofmajorvessels
0    175
1     65
2     38
3     24
Name: numberofmajorvessels, dtype: int64
```

In [30]:

```
ds_heart.shape
```

Out[30]:

```
(302, 14)
```

In [31]:

```
#Exercise induced angina
# 1 = Yes,
# 0 = No,
# Validating
ds_heart.groupby(['exerciseinducedangina'])['exerciseinducedangina'].count()
```

Out[31]:

```
exerciseinducedangina
0    203
1     99
Name: exerciseinducedangina, dtype: int64
```

In [32]:

```
#Resting electrocardiographic results
# 0 = Normal
# 1 = ST-T wave normality
# 2 = Left ventricular hypertrophy
# Validating
ds_heart.groupby(['restingecg'])['restingecg'].count()
```

Out[32]:

```
restingecg
0    147
1    151
2      4
Name: restingecg, dtype: int64
```

In [33]:

```
#Max Heart Rate Achieved
#ds_heart.groupby(['maxheartrateachieved'])['maxheartrateachieved'].count()
np.unique(ds_heart['maxheartrateachieved'])
```

Out[33]:

```
array([ 71,  88,  90,  95,  96,  97,  99, 103, 105, 106, 108, 109, 111,
       112, 113, 114, 115, 116, 117, 118, 120, 121, 122, 123, 124, 125,
       126, 127, 128, 129, 130, 131, 132, 133, 134, 136, 137, 138, 139,
       140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152,
       153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165,
       166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 177, 178, 179,
       180, 181, 182, 184, 185, 186, 187, 188, 190, 192, 194, 195, 202],
      dtype=int64)
```

In [34]:

```
#Resting Blood Pressure
# 0 : downsloping
# 1 : flat
# 2 : upsloping
ds_heart.groupby(['slope'])['slope'].count()
```

Out[34]:

```
slope
0     21
1    140
2    141
Name: slope, dtype: int64
```

In [35]:

```
#cholestoral < 200 means healthy individual
#ds_heart.groupby(['cholestoral'])['cholestoral'].count()
np.unique(ds_heart['cholestoral'])
```

Out[35]:

```
array([126, 131, 141, 149, 157, 160, 164, 166, 167, 168, 169, 172, 174,
       175, 176, 177, 178, 180, 182, 183, 184, 185, 186, 187, 188, 192,
       193, 195, 196, 197, 198, 199, 200, 201, 203, 204, 205, 206, 207,
       208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220,
       221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233,
       234, 235, 236, 237, 239, 240, 241, 242, 243, 244, 245, 246, 247,
       248, 249, 250, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261,
       262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 273, 274, 275,
       276, 277, 278, 281, 282, 283, 284, 286, 288, 289, 290, 293, 294,
       295, 298, 299, 300, 302, 303, 304, 305, 306, 307, 308, 309, 311,
       313, 315, 318, 319, 321, 322, 325, 326, 327, 330, 335, 340, 341,
       342, 353, 354, 360, 394, 407, 409, 417, 564], dtype=int64)
```

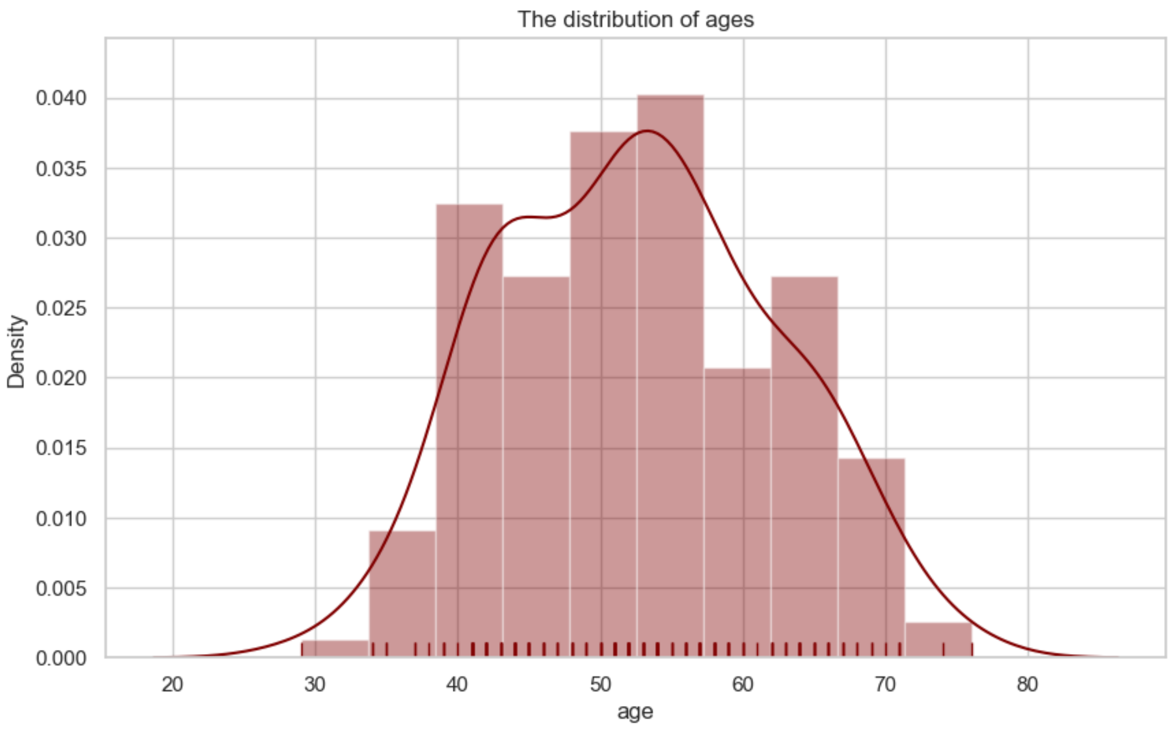
Generating insights

In [36]:

```
ds_attack = ds_heart[ds_heart.attack==1]
```

In [37]:

```
ax= sns.distplot(ds_attack.age, rug=True, color="maroon")
plt.title("The distribution of ages")
plt.show()
```



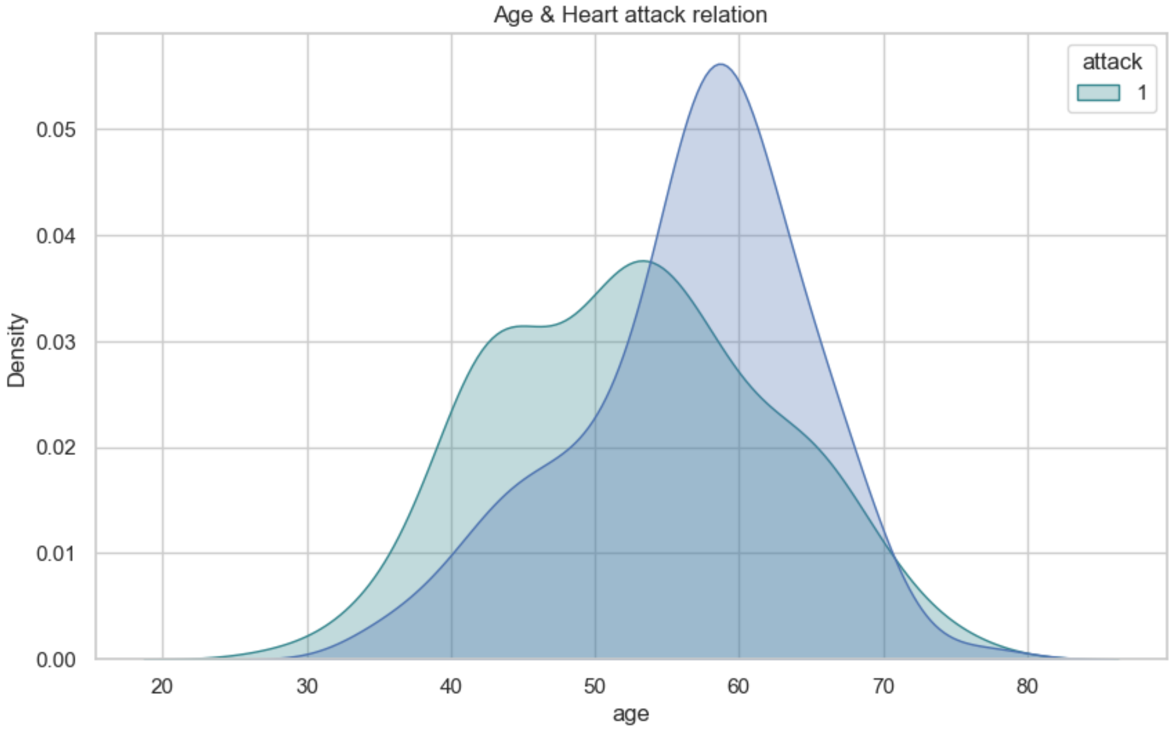
Age V/s Probability of Heart Attack

In [38]:

```
def graphanalysis(x,y,z):
    fig1 = plt.figure()
    ax1 = fig1.add_subplot(1, 1, 1)
    plt.title(x)
    sns.kdeplot(data=ds_heart[ds_heart.attack==1], x=y, hue = z, shade=True, palette="crest
    sns.kdeplot(data=ds_heart[ds_heart.attack==0], x=y, shade=True, ax=ax1, palette="crest"
    plt.show()
```

In [39]:

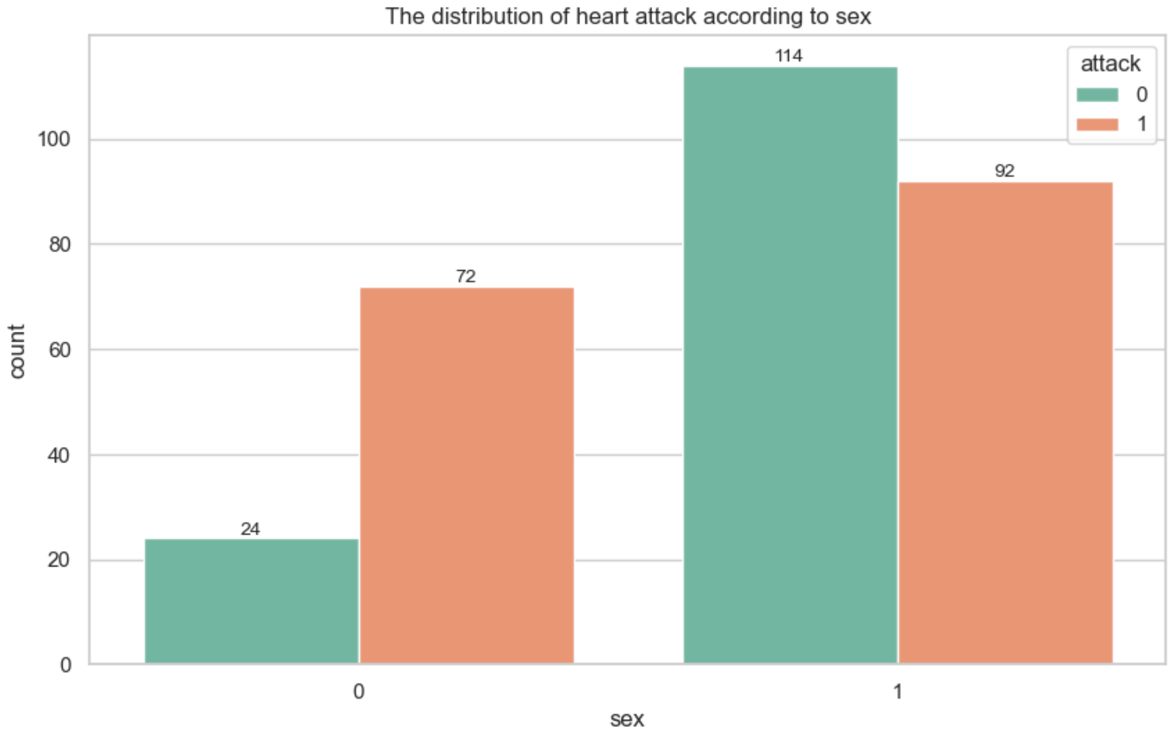
```
graphanalysis("Age & Heart attack relation","age","attack")
```



Gender V/s Probability of Heart Attack

In [40]:

```
ax= sns.countplot(ds_heart.sex, hue=ds_heart.attack, palette="Set2")
plt.title("The distribution of heart attack according to sex")
for p in ax.containers:
    ax.bar_label(p)
```



In [41]:

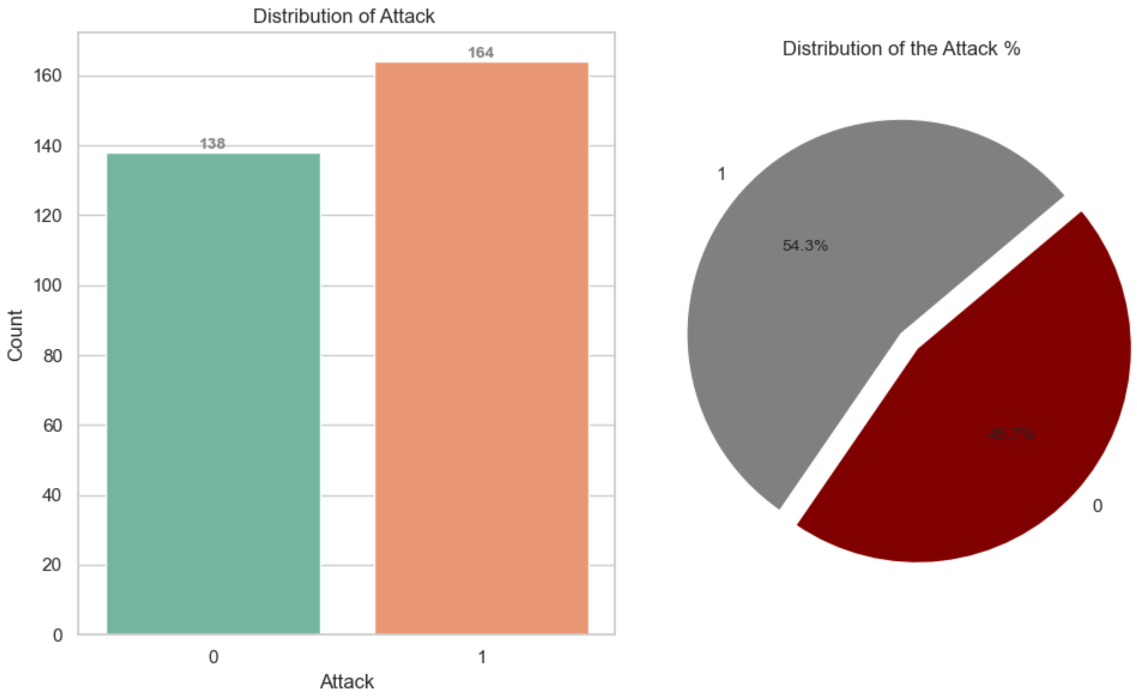
```
# the average heart attack risk percentage according to sex
# 1 --> male
# 0 --> female
ds_heart.groupby('sex').attack.apply(lambda x: x.sum()/x.size * 100)
```

Out[41]:

```
sex
0    75.000000
1    44.660194
Name: attack, dtype: float64
```

In [42]:

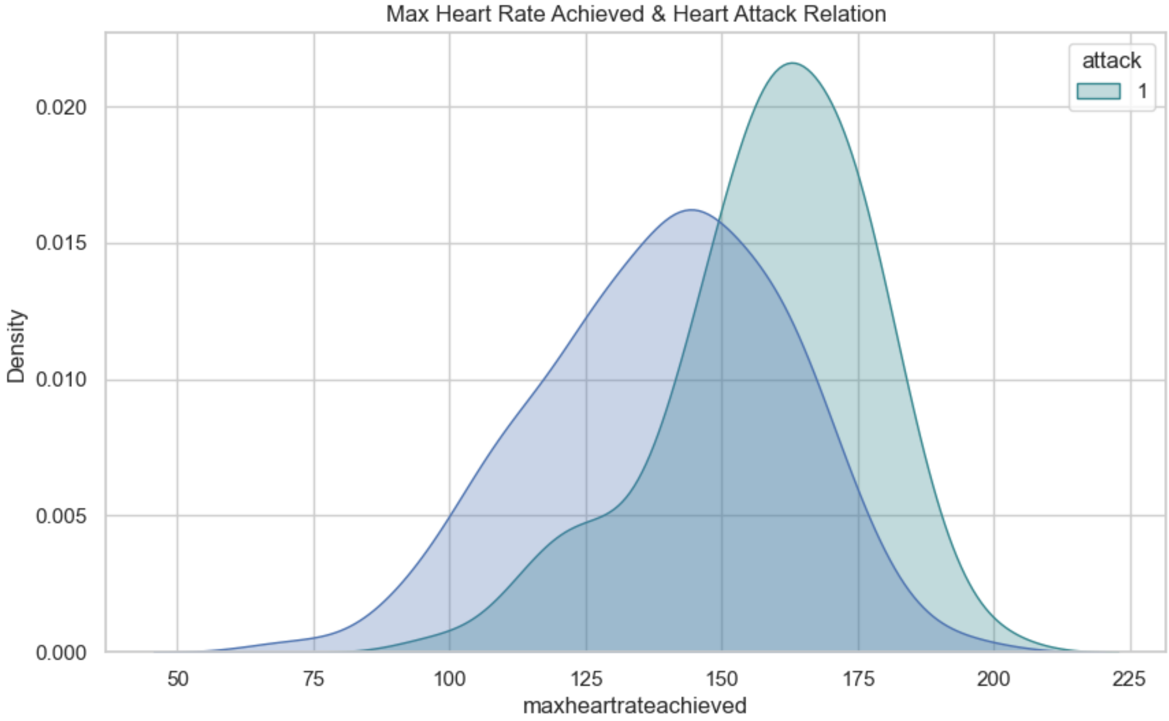
```
plt.subplot(1,2,1)
ax = sns.countplot(x='attack', data=ds_heart, palette="Set2")
plt.title('Distribution of Attack ')
plt.xlabel('Attack')
plt.ylabel('Count')
ax.bar_label(ax.containers[0], fontsize=10, color='grey', fontweight='bold')
plt.subplot(1,2,2)
plt.pie(ds_heart.attack.value_counts(), labels = ds_heart.attack.value_counts().index, auto
plt.title('Distribution of the Attack %')
plt.tight_layout()
plt.show()
```



Max Heart Rate Achieved V/s Probability of Heart Attack

In [43]:

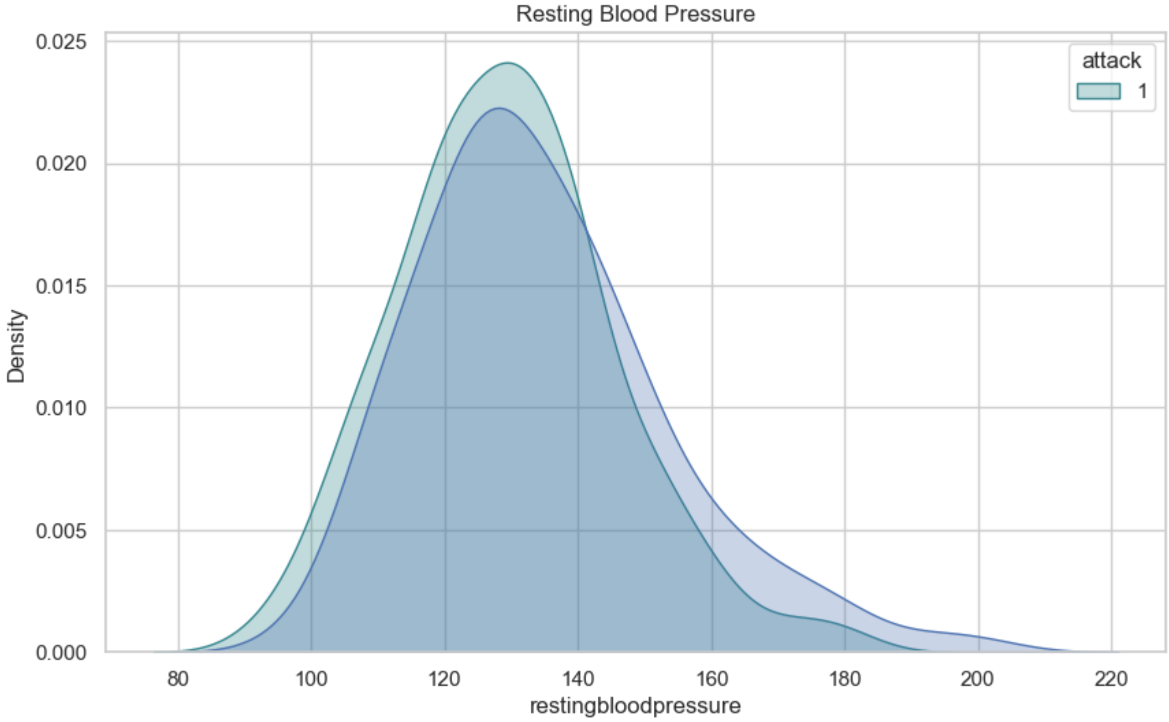
```
graphanalysis("Max Heart Rate Achieved & Heart Attack Relation","maxheartrateachieved","att
```



Resting Blood Pressure V/s Probability of Heart Attack

In [44]:

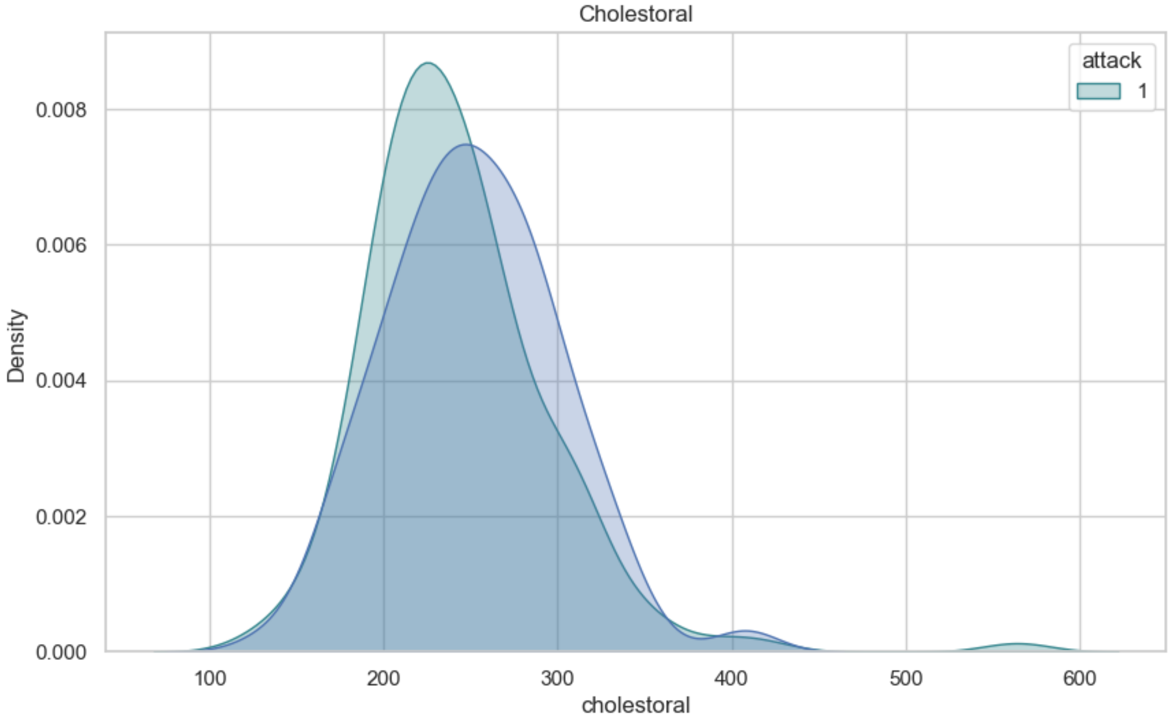
```
graphanalysis('Resting Blood Pressure','restingbloodpressure','attack')
```



Cholestoral Level in Blood V/s Probability of Heart Attack

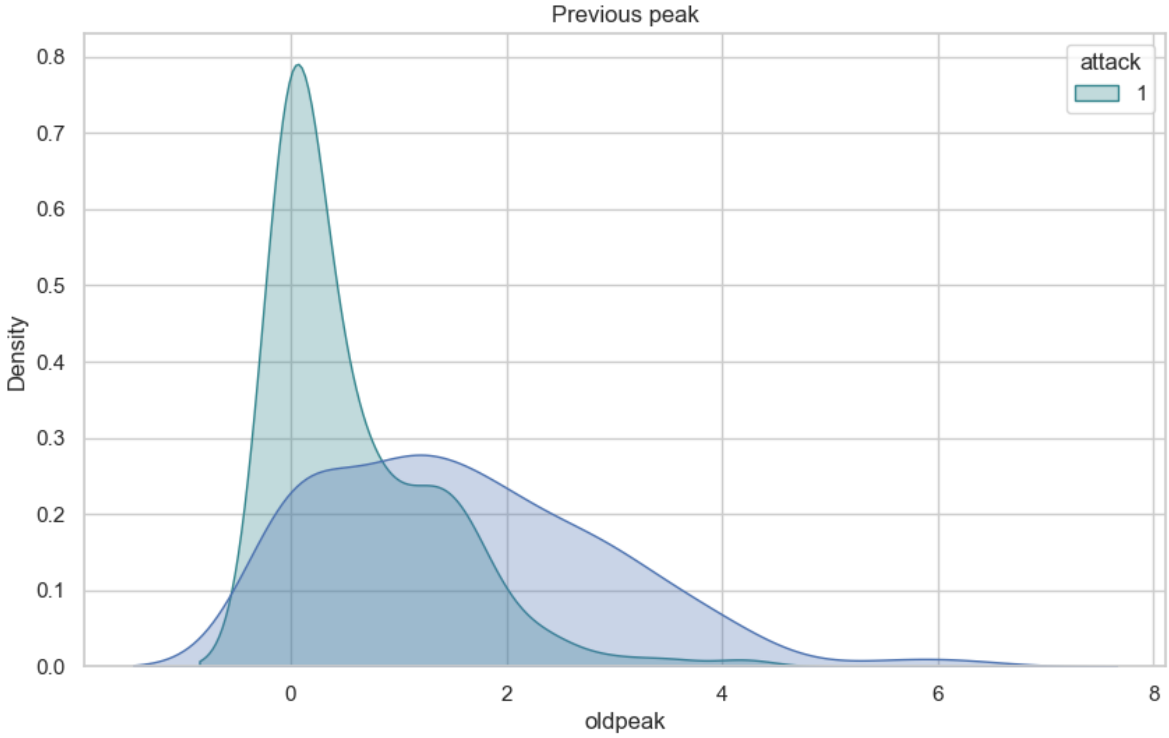
In [45]:

```
graphanalysis('Cholestoral','cholestoral','attack')
```



In [46]:

```
graphanalysis('Previous peak','oldpeak','attack')
```



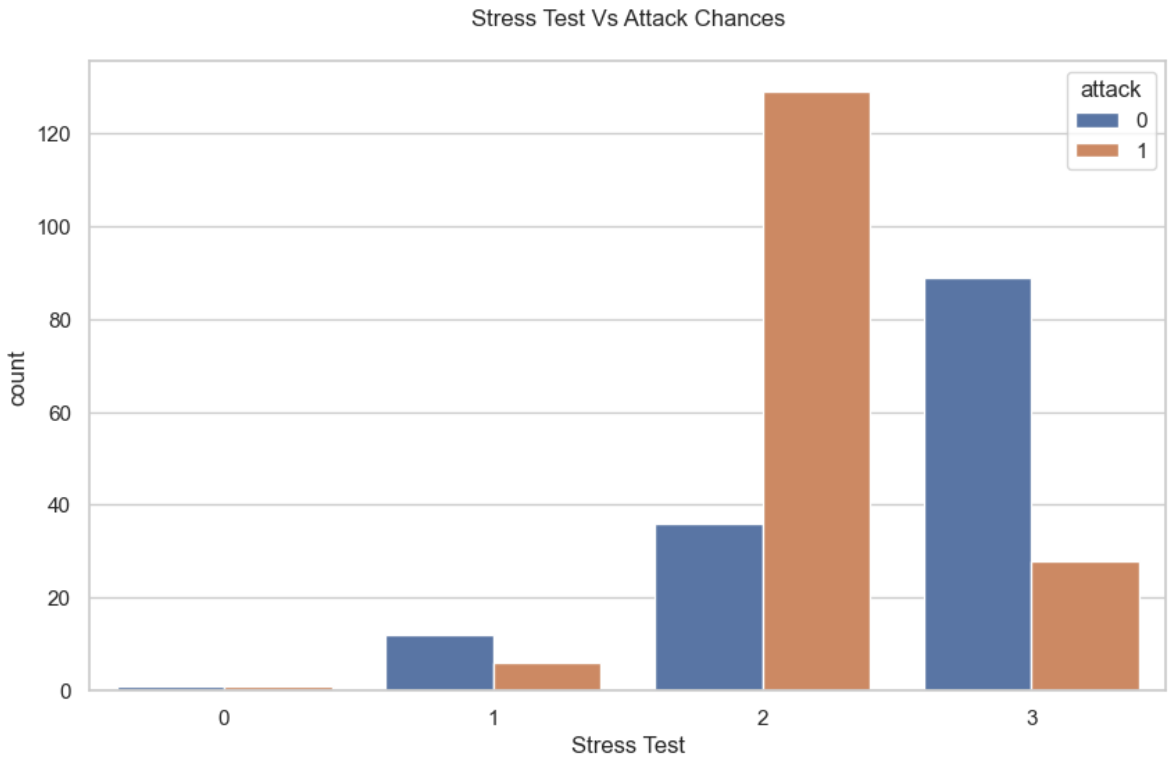
Analysis other Varriable Result in Heart Attack

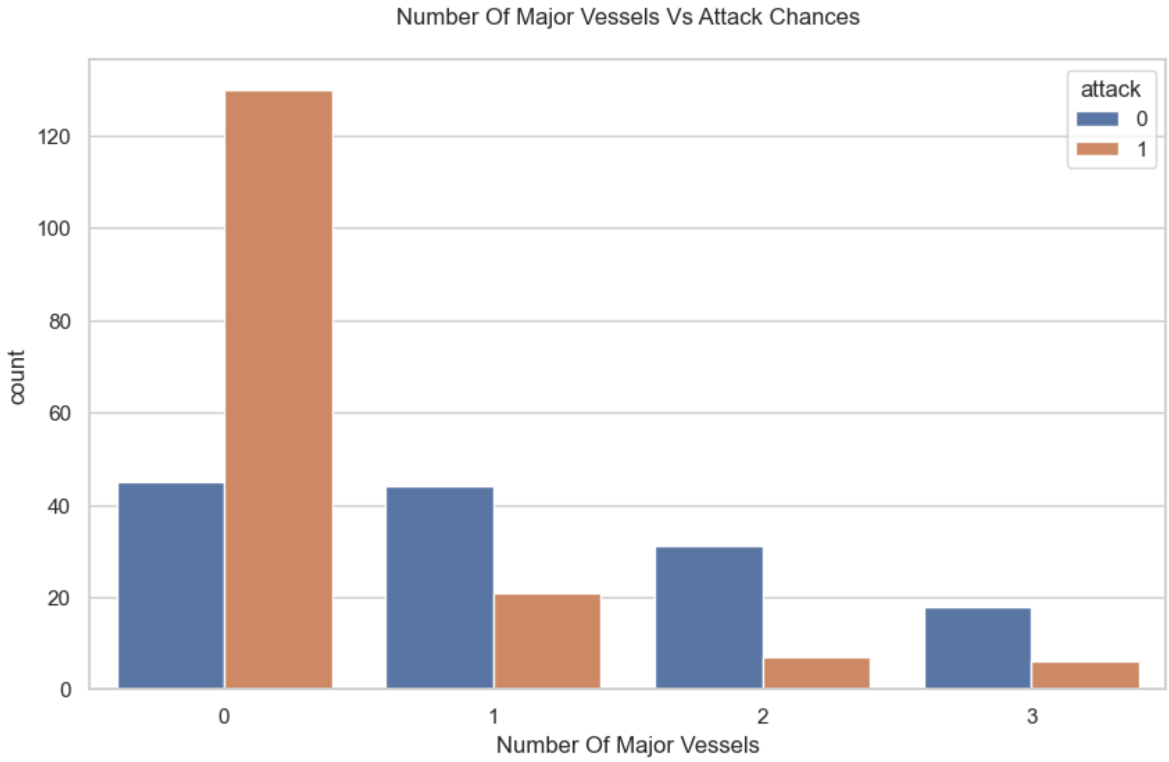
In [47]:

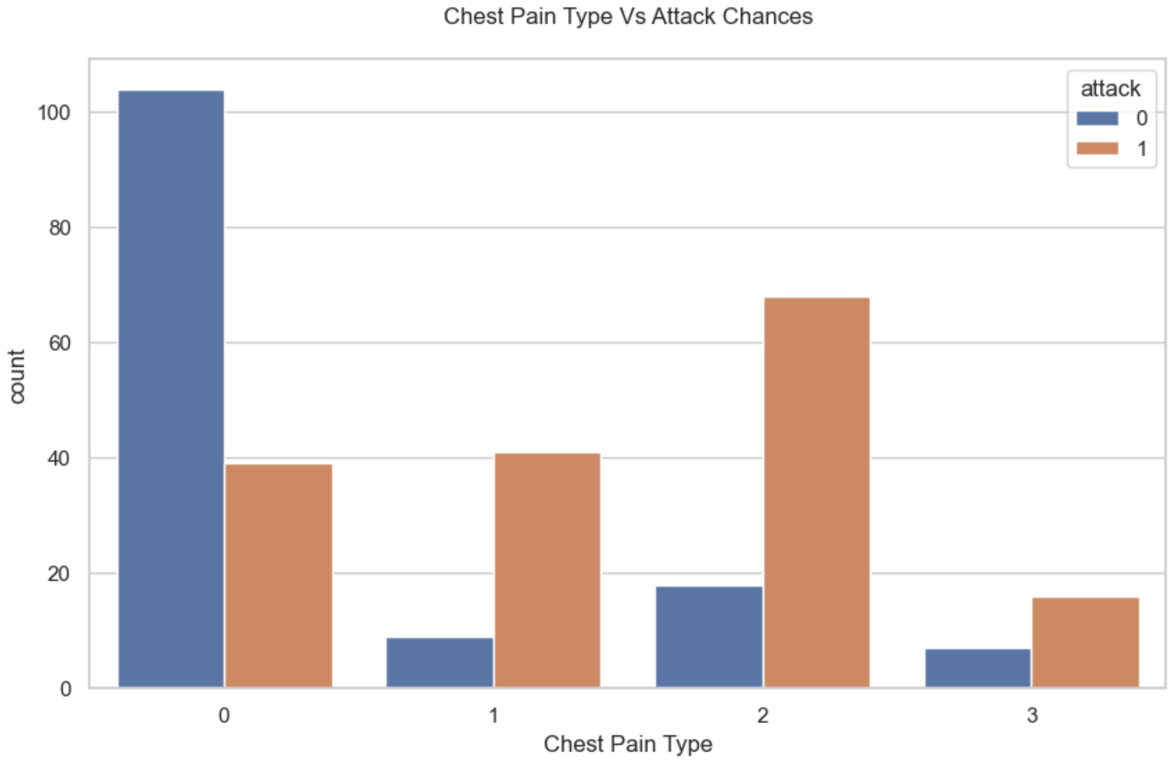
```
def graphshow(x,y,z):
    sns.countplot(data=ds_heart, x=y, hue=z)
    title=('{} Vs Attack Chances\n').format(x)
    plt.title(title)
    plt.xlabel(x)
    plt.show()
```

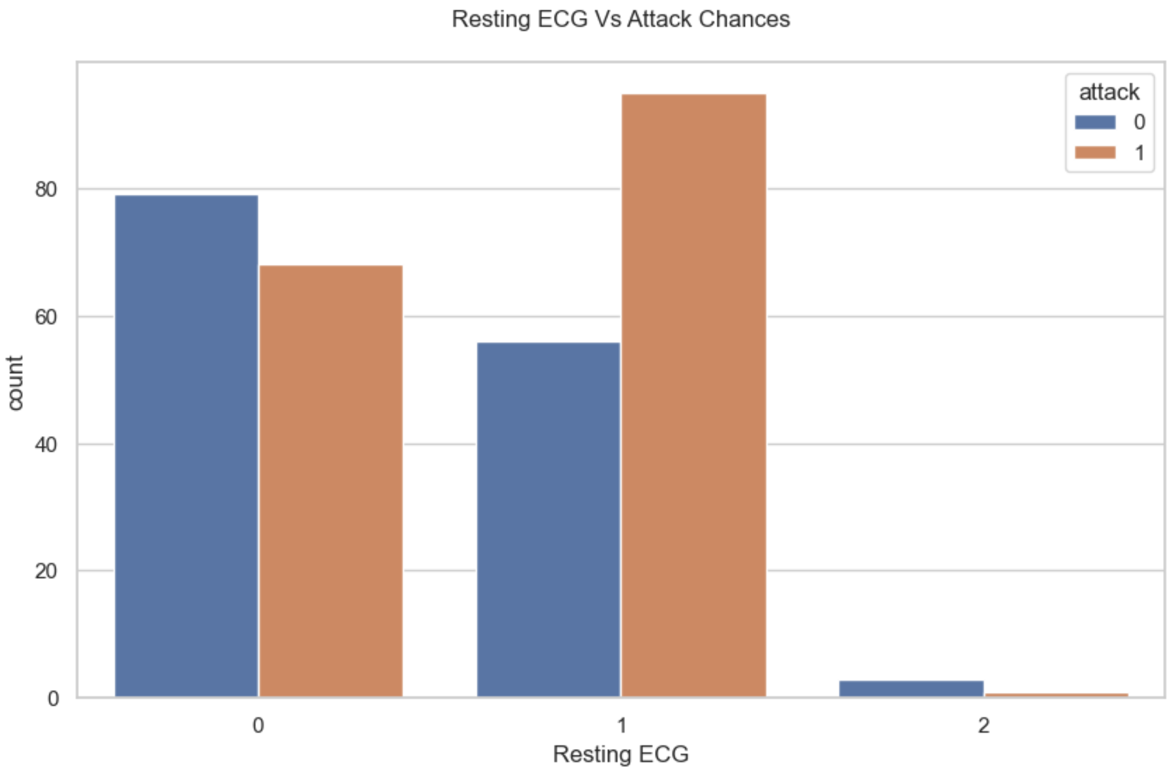
In [48]:

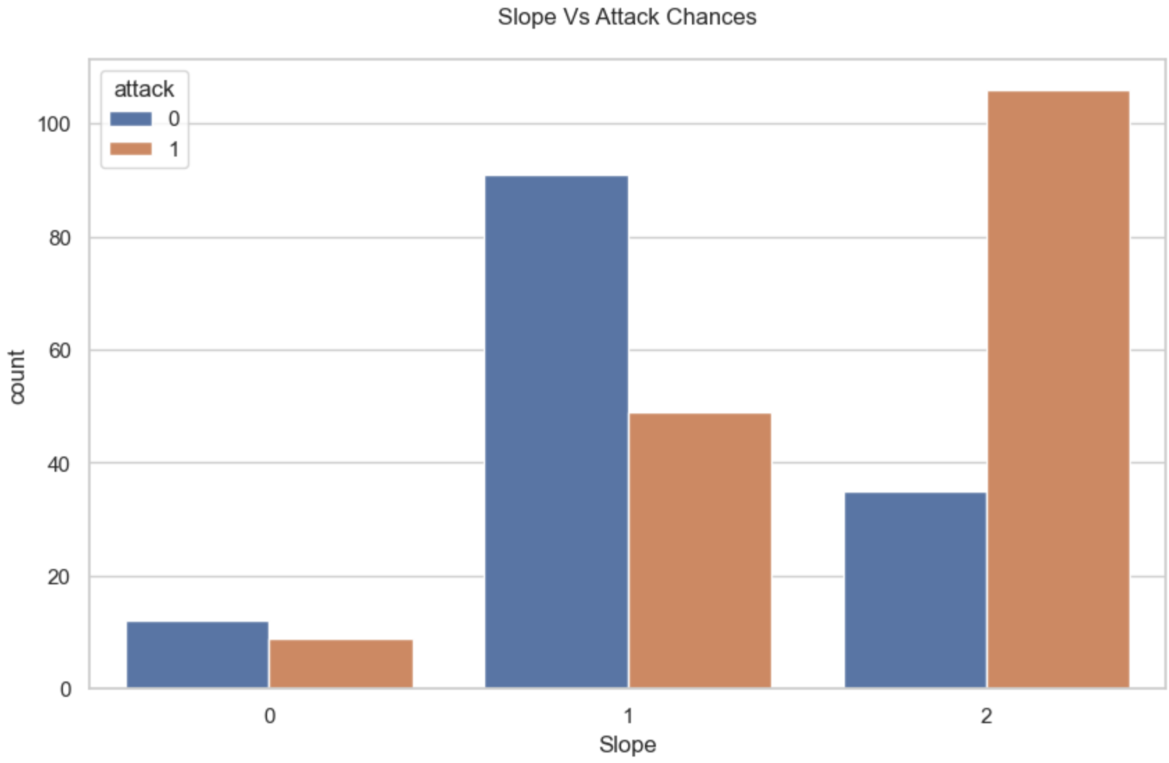
```
graphshow('Stress Test','stresstest','attack')
graphshow('Number Of Major Vessels','numberofmajorvessels','attack')
graphshow('Chest Pain Type','chestpaintype','attack')
graphshow('Resting ECG','restingecg','attack')
graphshow('Slope','slope','attack')
graphshow('Exercise Induced Angina','exerciseinducedangina','attack')
graphshow('Fasting Blood Sugar','fastingbloodsugar','attack')
```

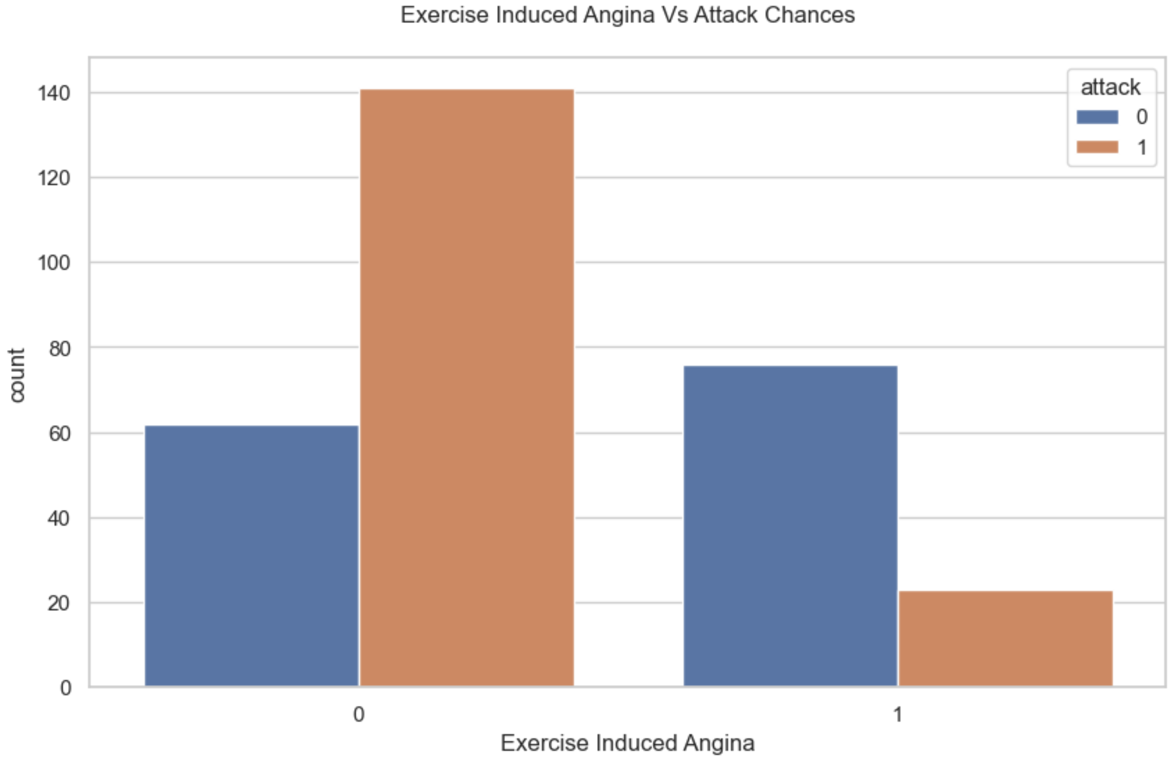


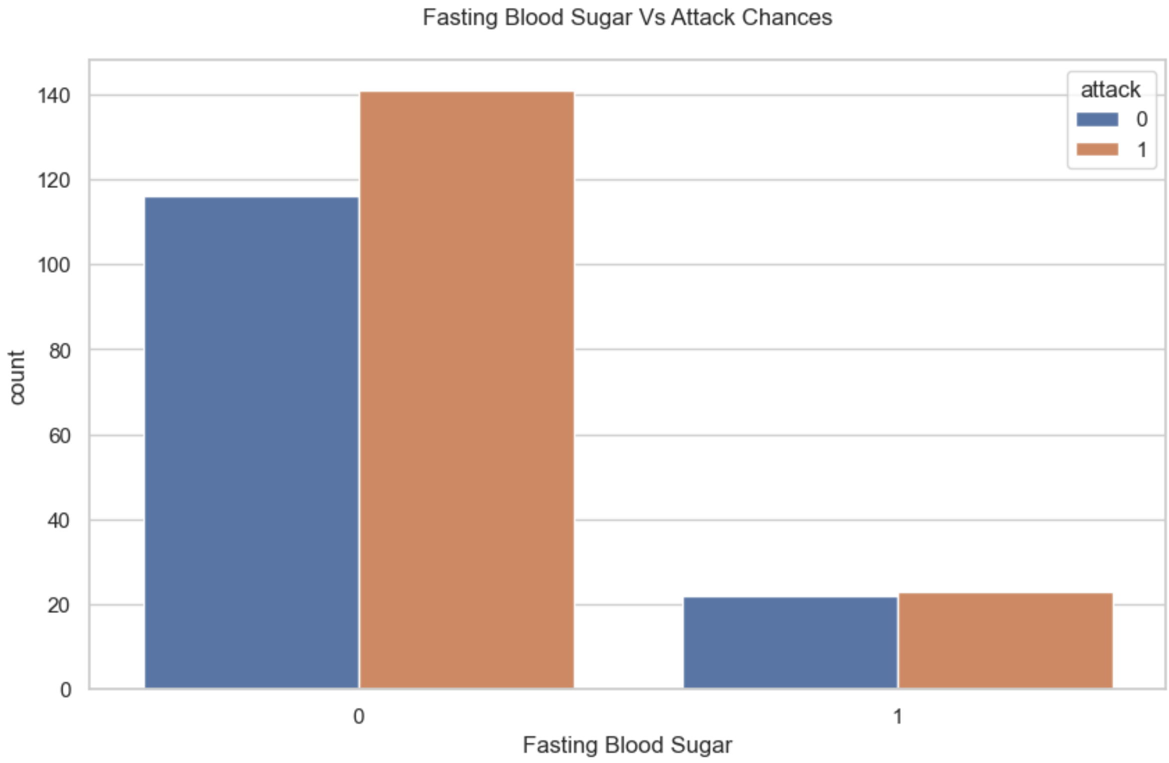

Number Of Major Vessels Vs Attack Chances
attack
0
1
count
0
20
40
60
80
100
120
0
1
2
3
Number Of Major Vessels


Chest Pain Type Vs Attack Chances
attack
0
1
count
0
20
40
60
80
100
0
1
2
3
Chest Pain Type


Resting ECG Vs Attack Chances
attack
0
1
count
0
20
40
60
80
0
1
2
Resting ECG


Slope Vs Attack Chances
attack
0
1
count
0
20
40
60
80
100
0
1
2
Slope

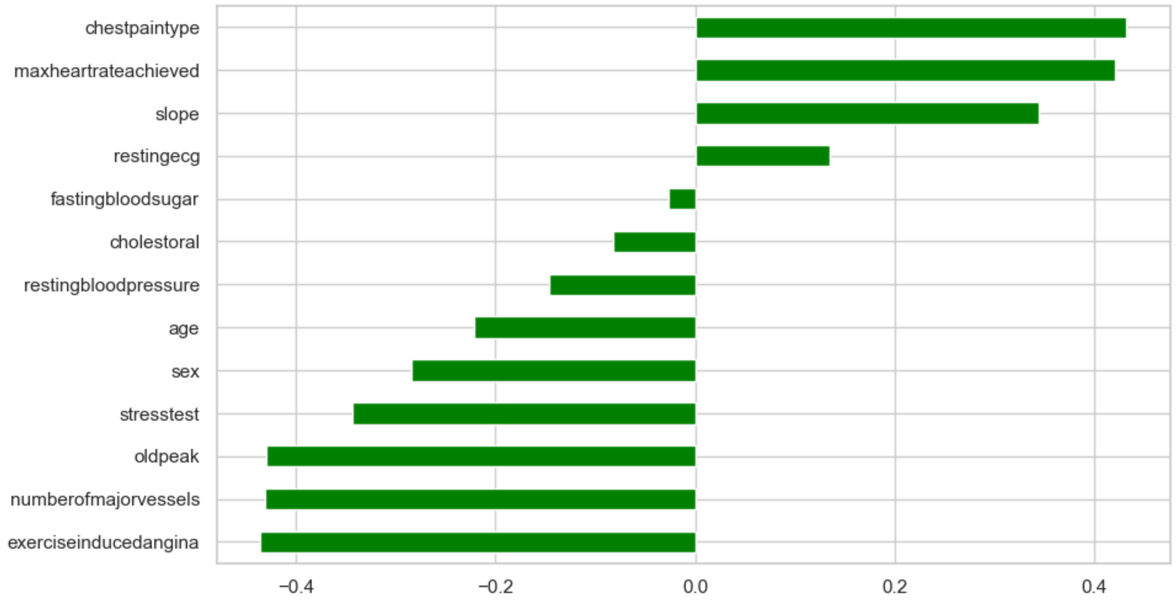

Exercise Induced Angina Vs Attack Chances
attack
0
1
count
0
20
40
60
80
100
120
140
0
1
Exercise Induced Angina



Fasting Blood Sugar Vs Attack Chances

In [49]:

```
ds_heart.corr()['attack'].sort_values().drop('attack').plot(kind = 'barh', color="green");
# Correlation of the target column with other columns
```



Modelling

In [50]:

```
# Split 75:25
x_train=ds_heart.drop(columns=["attack"])
y_train=ds_heart["attack"]
x_train, x_test, y_train, y_test = train_test_split(x_train, y_train, test_size=0.25)
```

In [51]:

```
print('Train dataset shape:',x_train.shape)
print('Test dataset shape', y_train.shape)
```

```
Train dataset shape: (226, 13)
Test dataset shape (226,)
```

In [52]:

```
numeric_columns = [column for column in x_train.columns if (ds_heart[column].dtype == 'floa
print(numeric_columns)
print('#'*99)
categorical_columns = x_train.select_dtypes(include='object').columns
print(categorical_columns)
```

```
['age', 'sex', 'chestpaintype', 'restingbloodpressure', 'cholestoral', 'fast
ingbloodsugar', 'restingecg', 'maxheartrateachieved', 'exerciseinducedangin
a', 'oldpeak', 'slope', 'numberofmajorvessels', 'stresstest']
############################################################################
#######################
Index([], dtype='object')
```

In [53]:

```
numeric_features = Pipeline([
    ('handlingmissingvalues',SimpleImputer(strategy='median')),
    ('scaling',StandardScaler(with_mean=True))
])
print(numeric_features)
```

```
Pipeline(steps=[('handlingmissingvalues', SimpleImputer(strategy='median')),
                ('scaling', StandardScaler())])
```

In [54]:

```
categorical_features = Pipeline([
    ('handlingmissingvalues',SimpleImputer(strategy='most_frequent')),
    ('encoding', OneHotEncoder()),
    ('scaling', StandardScaler(with_mean=False))
])
print(categorical_features)
```

```
Pipeline(steps=[('handlingmissingvalues',
                 SimpleImputer(strategy='most_frequent')),
                ('encoding', OneHotEncoder()),
                ('scaling', StandardScaler(with_mean=False))])
```

In [55]:

```
processing = ColumnTransformer([
                                ('numeric', numeric_features, numeric_columns),
                                ('categorical', categorical_features, categorical_columns)
                               ])
print(processing)
```

```
ColumnTransformer(transformers=[('numeric',
                                 Pipeline(steps=[('handlingmissingvalues',
                                                  SimpleImputer(strategy='me
dian')),
                                                 ('scaling',
                                                  StandardScaler())]),
                                 ['age', 'sex', 'chestpaintype',
                                  'restingbloodpressure', 'cholestoral',
                                  'fastingbloodsugar', 'restingecg',
                                  'maxheartrateachieved',
                                  'exerciseinducedangina', 'oldpeak', 'slop
e',
                                  'numberofmajorvessels', 'stresstest']),
                                ('categorical',
                                 Pipeline(steps=[('handlingmissingvalues',
                                                  SimpleImputer(strategy='mo
st_frequent')),
                                                 ('encoding', OneHotEncoder
()),
                                                 ('scaling',
                                                  StandardScaler(with_mean=F
alse))]),
                                 Index([], dtype='object'))])
```

Model Preparation & Model Evaluation

In [56]:

```
def prepare_model(algorithm):
    model = Pipeline(steps= [
                             ('processing',processing),
                             ('pca', TruncatedSVD(n_components=3, random_state=12)),
                             ('modeling', algorithm)
                            ])
    model.fit(x_train, y_train)
    return model
```

In [58]:

```
def prepare_confusion_matrix(algo, model):
    print(algo)
    plt.figure(figsize=(6,3))
    pred = model.predict(x_test)
    cm = confusion_matrix(y_test, pred)
    ax= plt.subplot()
    sns.heatmap(cm, annot=True, ax=ax)
    plt.show()

    # labels, title and ticks
    ax.set_xlabel('Predicted Labels');ax.set_ylabel('True Labels');
    ax.set_title('Confusion Matrix');
```

In [59]:

```
def prepare_classification_report(algo, model):
    print(algo+' Report :')
    pred = model.predict(x_test)
    print(classification_report(y_test, pred))
```

In [60]:

```
def prepare_roc_curve(algo, model):
    print(algo)
    y_pred_proba = model.predict_proba(x_test)[::,1]
    fpr, tpr, thresholds = roc_curve(y_test,  y_pred_proba)
    roc_auc = auc(fpr, tpr)
    curve = RocCurveDisplay(fpr=fpr, tpr=tpr, roc_auc=roc_auc)
    curve.plot()
    plt.show()
```

In [61]:

```
algorithms = [('Random Forest calssifier', RandomForestClassifier()),
              ('Gradientboot classifier',GradientBoostingClassifier()),
              ('XGBClassifier', XGBClassifier())
             ]
```

In [64]:

```
trained_models = []
model_and_score = {}

for index, tup in enumerate(algorithms):
    model = prepare_model(tup[1])
    model_and_score[tup[0]] = str(model.score(x_train,y_train)*100)+"%"
    trained_models.append((tup[0],model))
```

Evaluation Metrics

In [65]:

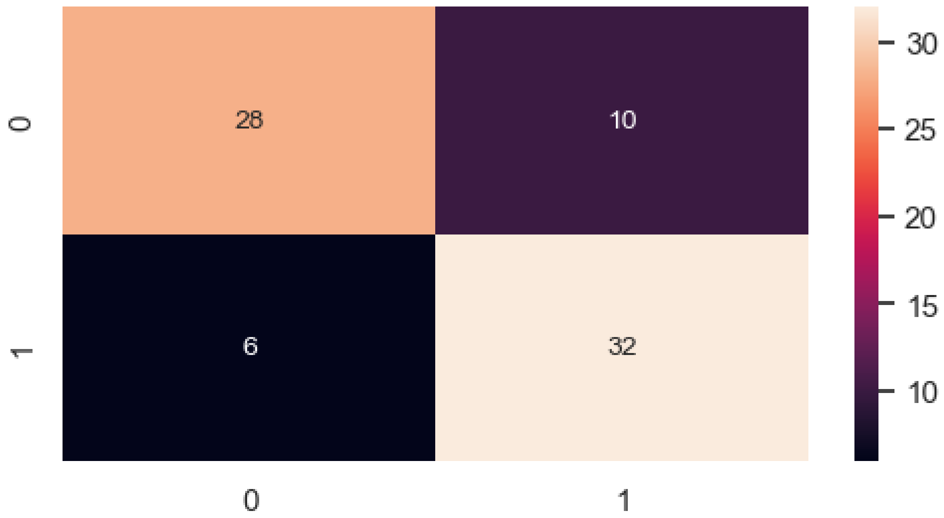
```
print(model_and_score)
```

```
{'Random Forest calssifier': '100.0%', 'Gradientboot classifier': '99.557522
1238938%', 'XGBClassifier': '100.0%'}
```

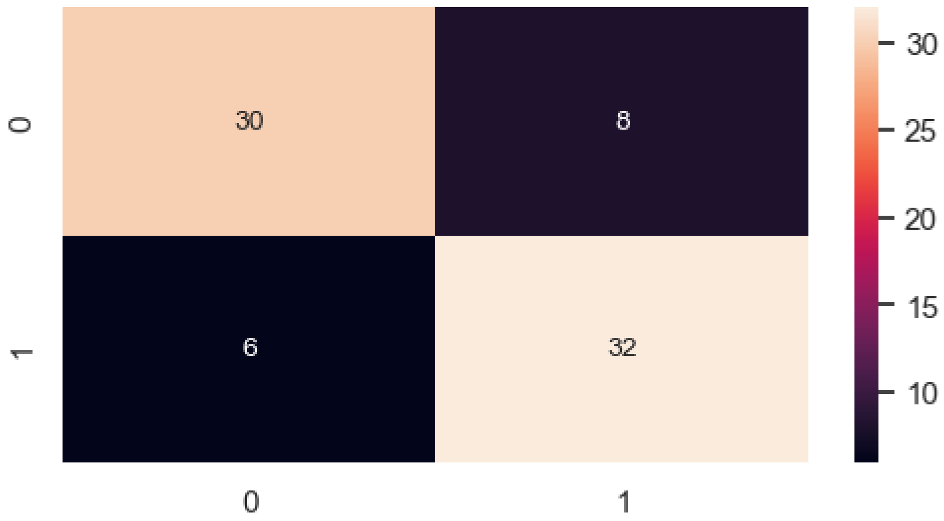
In [66]:

```python
for index, tup in enumerate(trained_models):
    prepare_confusion_matrix(tup[0], tup[1])
```

```
Random Forest calssifier
```



```
Gradientboot classifier
```



```
XGBClassifier
```

0
25
13
30
25
20

In [67]:

```
for index, tup in enumerate(trained_models):
    prepare_classification_report(tup[0], tup[1])
    print("\n")
```

```
Random Forest calssifier Report :
              precision    recall  f1-score   support

           0       0.82      0.74      0.78        38
           1       0.76      0.84      0.80        38

    accuracy                           0.79        76
   macro avg       0.79      0.79      0.79        76
weighted avg       0.79      0.79      0.79        76



Gradientboot classifier Report :
              precision    recall  f1-score   support

           0       0.83      0.79      0.81        38
           1       0.80      0.84      0.82        38

    accuracy                           0.82        76
   macro avg       0.82      0.82      0.82        76
weighted avg       0.82      0.82      0.82        76



XGBClassifier Report :
              precision    recall  f1-score   support

           0       0.81      0.66      0.72        38
           1       0.71      0.84      0.77        38

    accuracy                           0.75        76
   macro avg       0.76      0.75      0.75        76
weighted avg       0.76      0.75      0.75        76
```

In [68]:

```
print('Test dataset shape:',x_test.shape)
print('Tes dataset shape', y_test.shape)
```

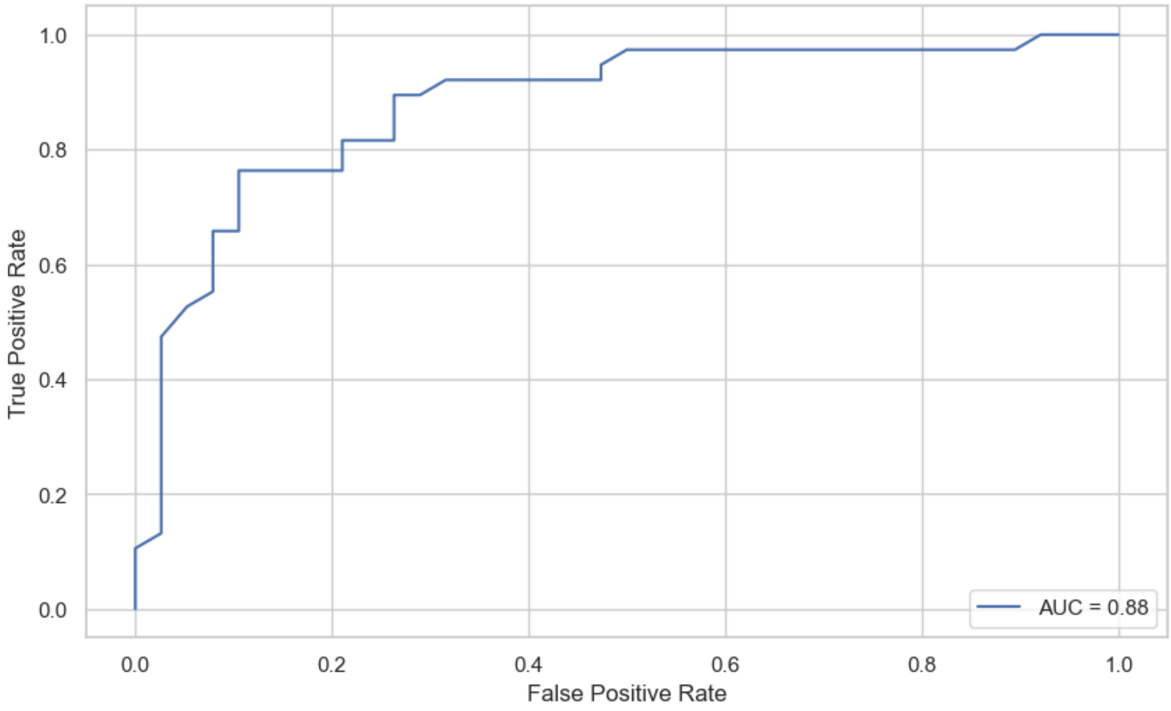
```
Test dataset shape: (76, 13)
Tes dataset shape (76,)
```

In [69]:

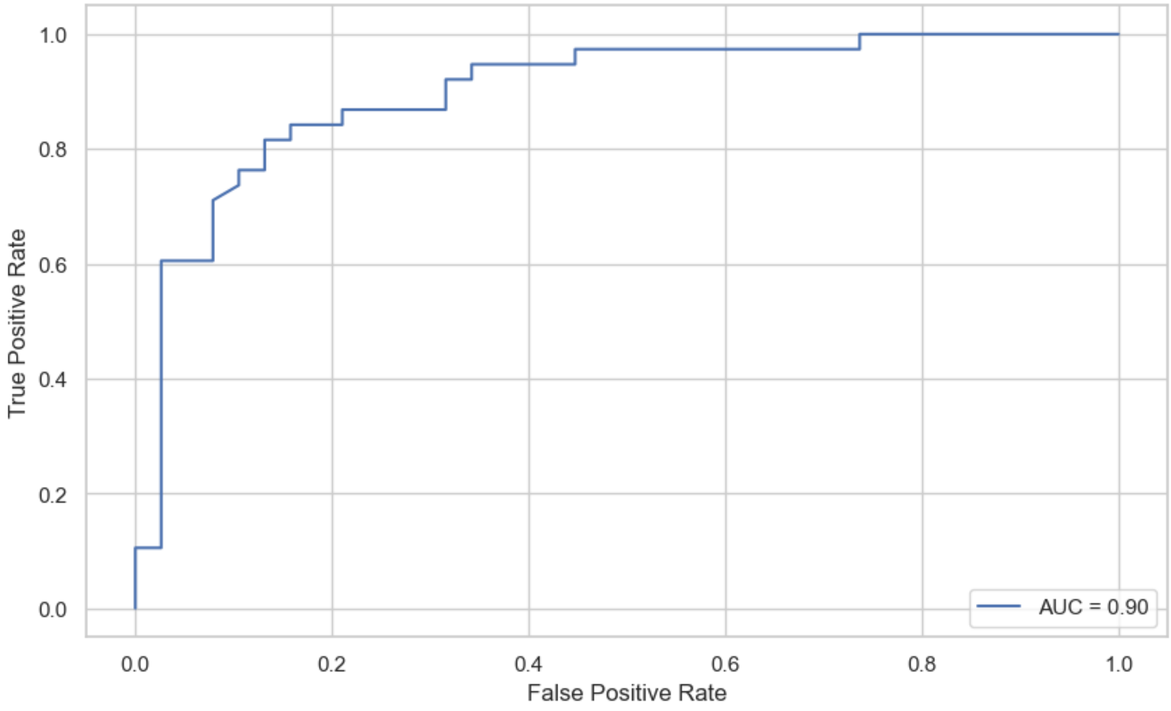
```
encoder = LabelEncoder()
y_test = encoder.fit_transform(y_test)

for index, tup in enumerate(trained_models):
    prepare_roc_curve(tup[0], tup[1])
```

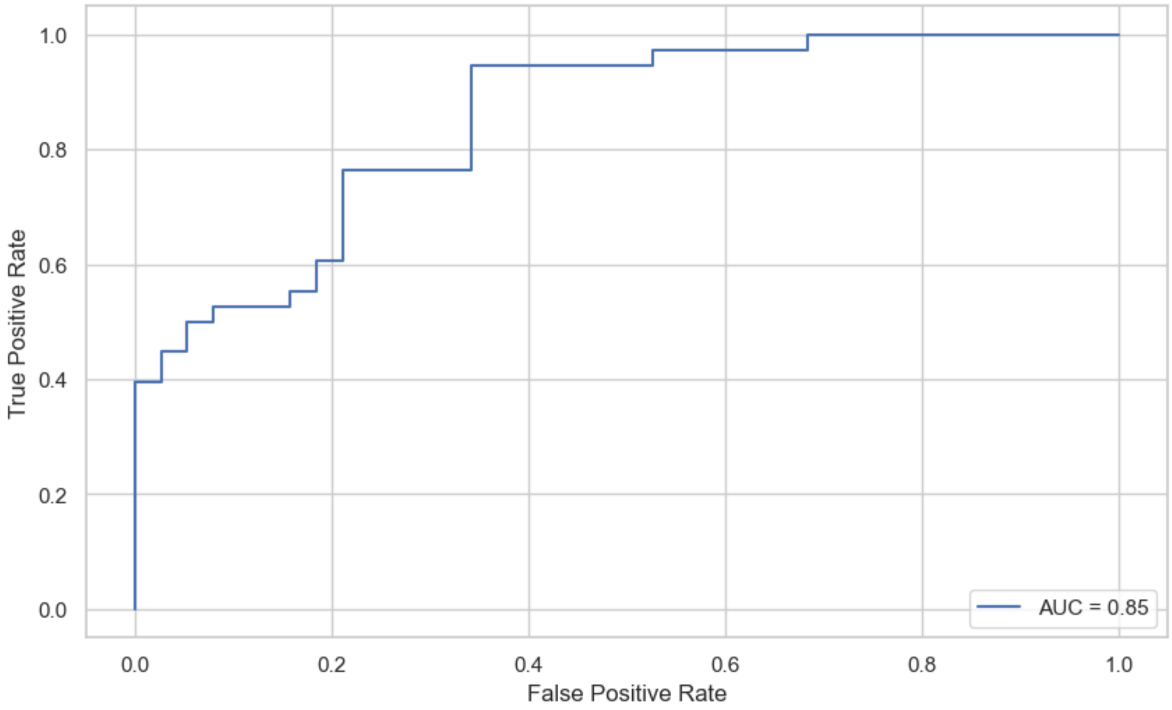
```
Random Forest calssifier
```



```
Gradientboot classifier
```



```
XGBClassifier
```



In [70]:

```
x = pd.DataFrame([
    ["Random Forest calssifier","100","0.86"],
    ["Gradientboot classifier","99.56","0.86"],
    ["XGB Classifier","100","0.84"]],
    columns=["Model", "Train Accuracy", "AUC SCORE"]
)
print(x)
```

```
                      Model Train Accuracy AUC SCORE
0  Random Forest calssifier            100      0.86
1   Gradientboot classifier          99.56      0.86
2            XGB Classifier            100      0.84
```