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

```
filePath = 'heart.csv'
data = pd.read_csv(filePath)

data.head(5)
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2

```
print("(Rows, columns): " + str(data.shape))
data.columns
```

```
(Rows, columns): (303, 14)
Index(['age', 'sex', 'cp', 'trestbps', 'chol', 'fbs', 'restecg', 'thalach',
       'exang', 'oldpeak', 'slope', 'ca', 'thal', 'target'],
      dtype='object')
```

```
data.nunique(axis=0)# returns the number of unique values for each variable
```

```
age          41
sex           2
cp            4
trestbps     49
chol        152
fbs           2
restecg       3
thalach      91
exang         2
oldpeak      40
slope         3
ca            5
thal          4
target        2
dtype: int64
```

```
data.describe()
```

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

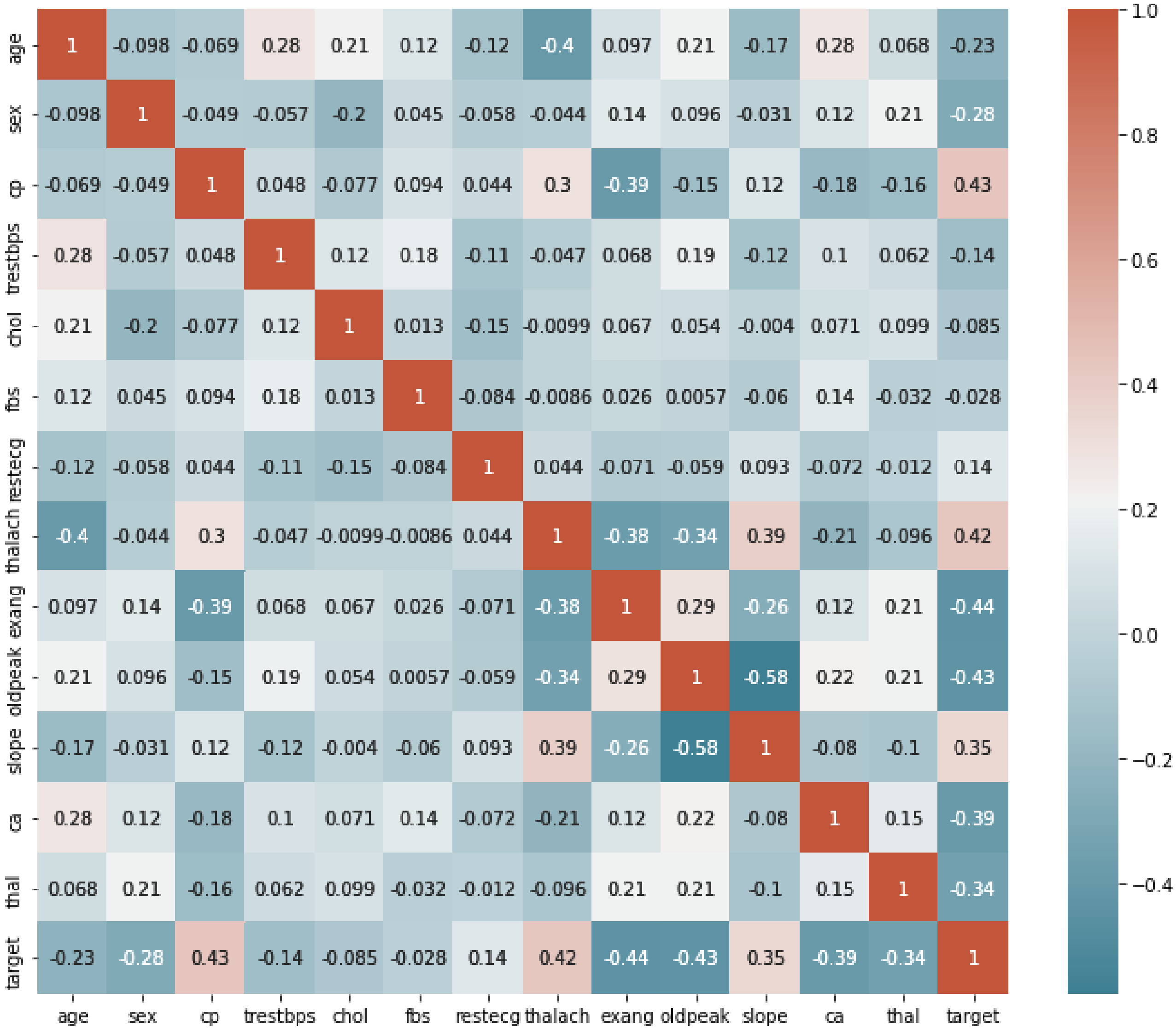
```
print(data.isna().sum())
```

```
age         0
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
slope       0
ca          0
thal        0
target      0
dtype: int64
```

EDA

```
corr = data.corr()
plt.subplots(figsize=(15,10))
sns.heatmap(corr, xticklabels=corr.columns, yticklabels=corr.columns, annot=True, cmap=sns.di
sns.heatmap(corr, xticklabels=corr.columns,
            yticklabels=corr.columns,
            annot=True,
            cmap=sns.diverging_palette(220, 20, as_cmap=True))
```

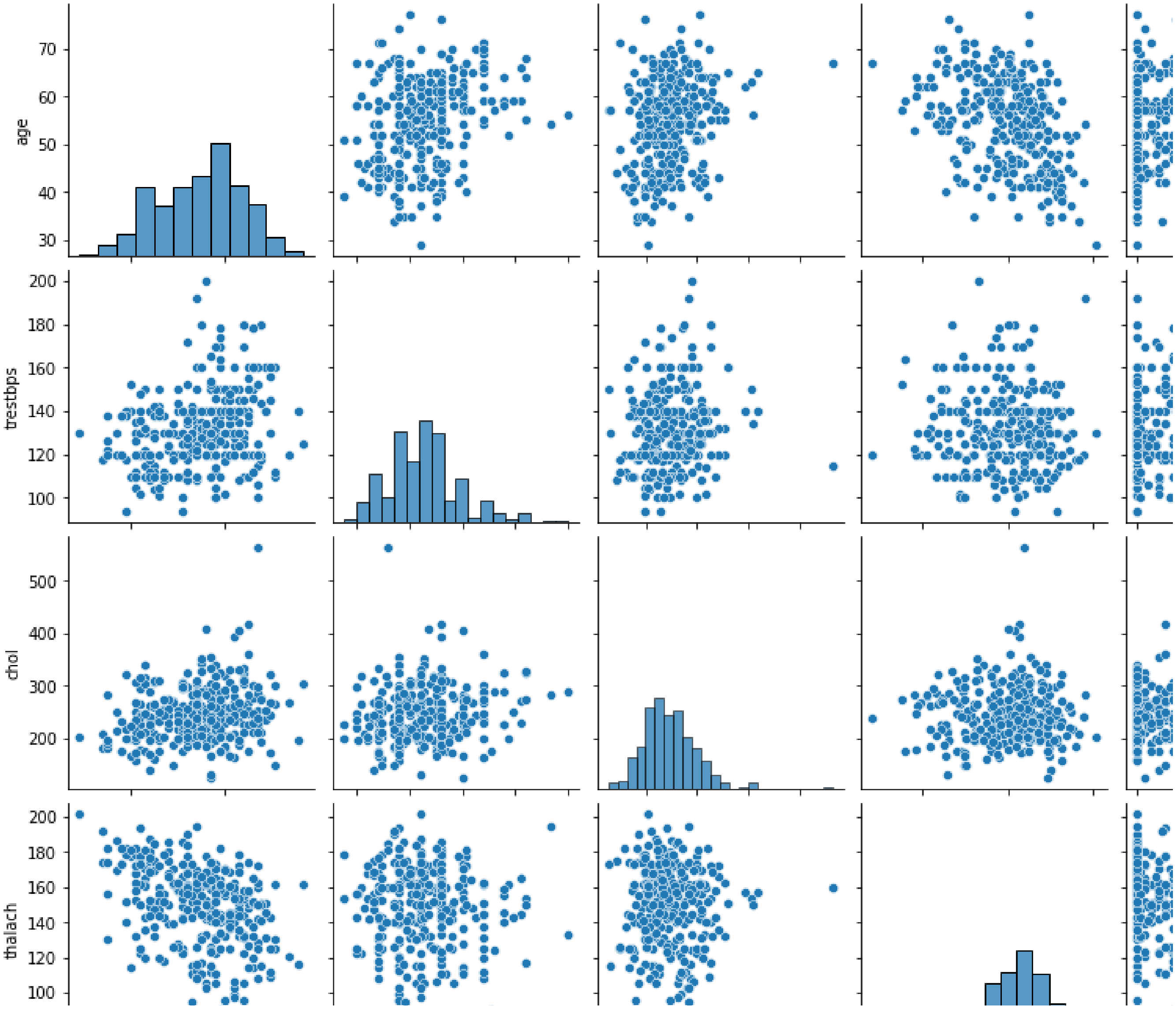
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb6eaa3a910>
```



	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
age	1	-0.098	-0.069	0.28	0.21	0.12	-0.12	-0.4	0.097	0.21	-0.17	0.28	0.068	-0.23
sex	-0.098	1	-0.049	-0.057	-0.2	0.045	-0.058	-0.044	0.14	0.096	-0.031	0.12	0.21	-0.28
cp	-0.069	-0.049	1	0.048	-0.077	0.094	0.044	0.3	-0.39	-0.15	0.12	-0.18	-0.16	0.43
trestbps	0.28	-0.057	0.048	1	0.12	0.18	-0.11	-0.047	0.068	0.19	-0.12	0.1	0.062	-0.14
chol	0.21	-0.2	-0.077	0.12	1	0.013	-0.15	-0.0099	0.067	0.054	-0.004	0.071	0.099	-0.085
fbs	0.12	0.045	0.094	0.18	0.013	1	-0.084	-0.0086	0.026	0.0057	-0.06	0.14	-0.032	-0.028
restecg	-0.12	-0.058	0.044	-0.11	-0.15	-0.084	1	0.044	-0.071	-0.059	0.093	-0.072	-0.012	0.14
thalach	-0.4	-0.044	0.3	-0.047	-0.0099	-0.0086	0.044	1	-0.38	-0.34	0.39	-0.21	-0.096	0.42
exang	0.097	0.14	-0.39	0.068	0.067	0.026	-0.071	-0.38	1	0.29	-0.26	0.12	0.21	-0.44
oldpeak	0.21	0.096	-0.15	0.19	0.054	0.0057	-0.059	-0.34	0.29	1	-0.58	0.22	0.21	-0.43
slope	-0.17	-0.031	0.12	-0.12	-0.004	-0.06	0.093	0.39	-0.26	-0.58	1	-0.08	-0.1	0.35
ca	0.28	0.12	-0.18	0.1	0.071	0.14	-0.072	-0.21	0.12	0.22	-0.08	1	0.15	-0.39
thal	0.068	0.21	-0.16	0.062	0.099	-0.032	-0.012	-0.096	0.21	0.21	-0.1	0.15	1	-0.34
target	-0.23	-0.28	0.43	-0.14	-0.085	-0.028	0.14	0.42	-0.44	-0.43	0.35	-0.39	-0.34	1

```
subData = data[['age','trestbps','chol','thalach','oldpeak']]
sns.pairplot(subData)
```

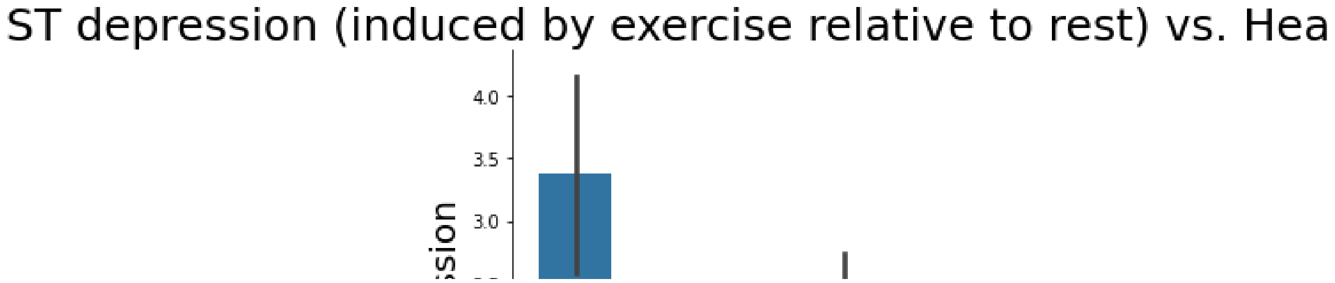
```
<seaborn.axisgrid.PairGrid at 0x7fb6e8006110>
```



```
sns.catplot(x="target", y="oldpeak", hue="slope", kind="bar", data=data);

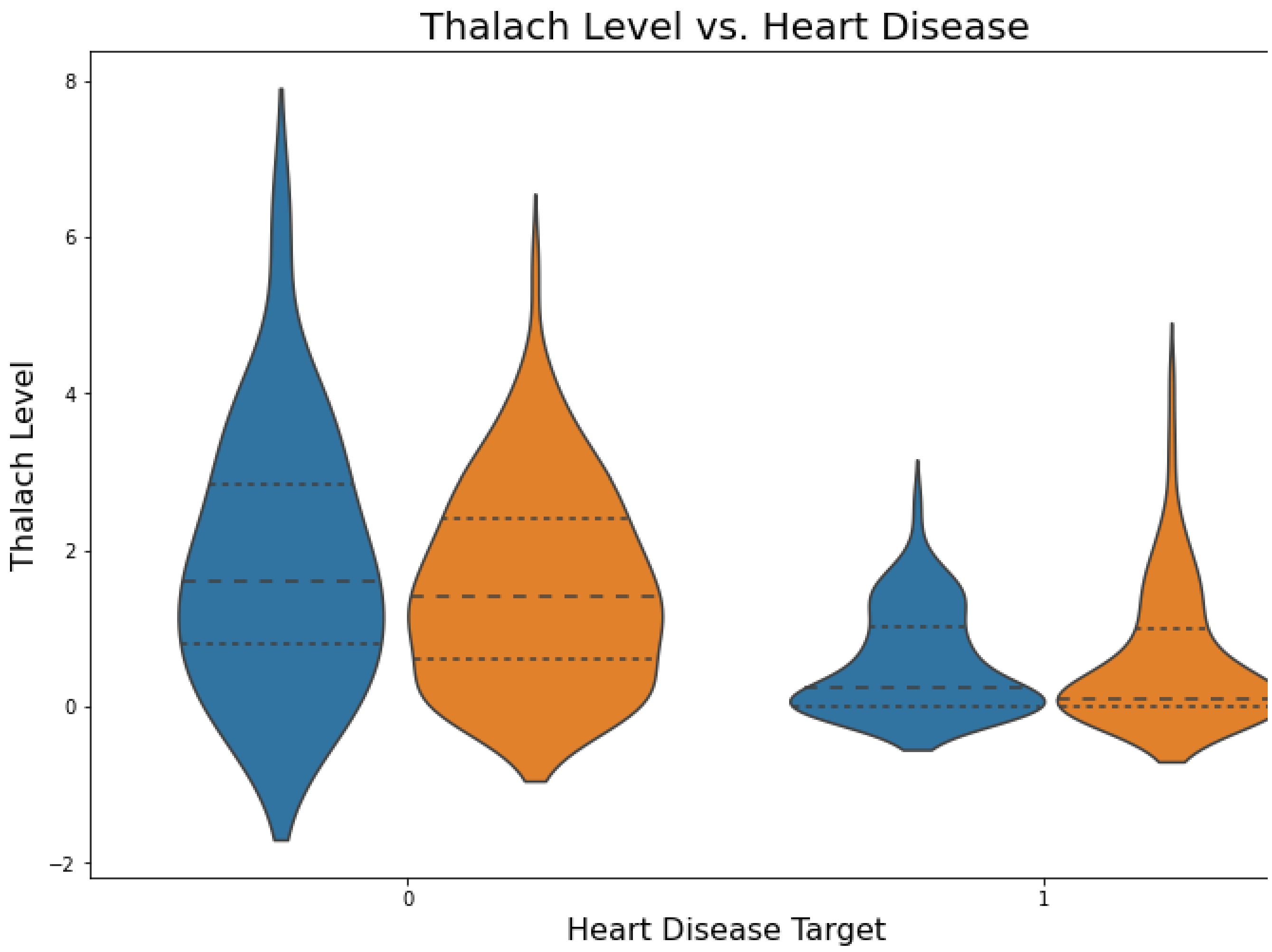
plt.title('ST depression (induced by exercise relative to rest) vs. Heart Disease',size=25)
plt.xlabel('Heart Disease',size=20)
plt.ylabel('ST depression',size=20)
```

```
    Text(26.426458333333343, 0.5, 'ST depression')
```



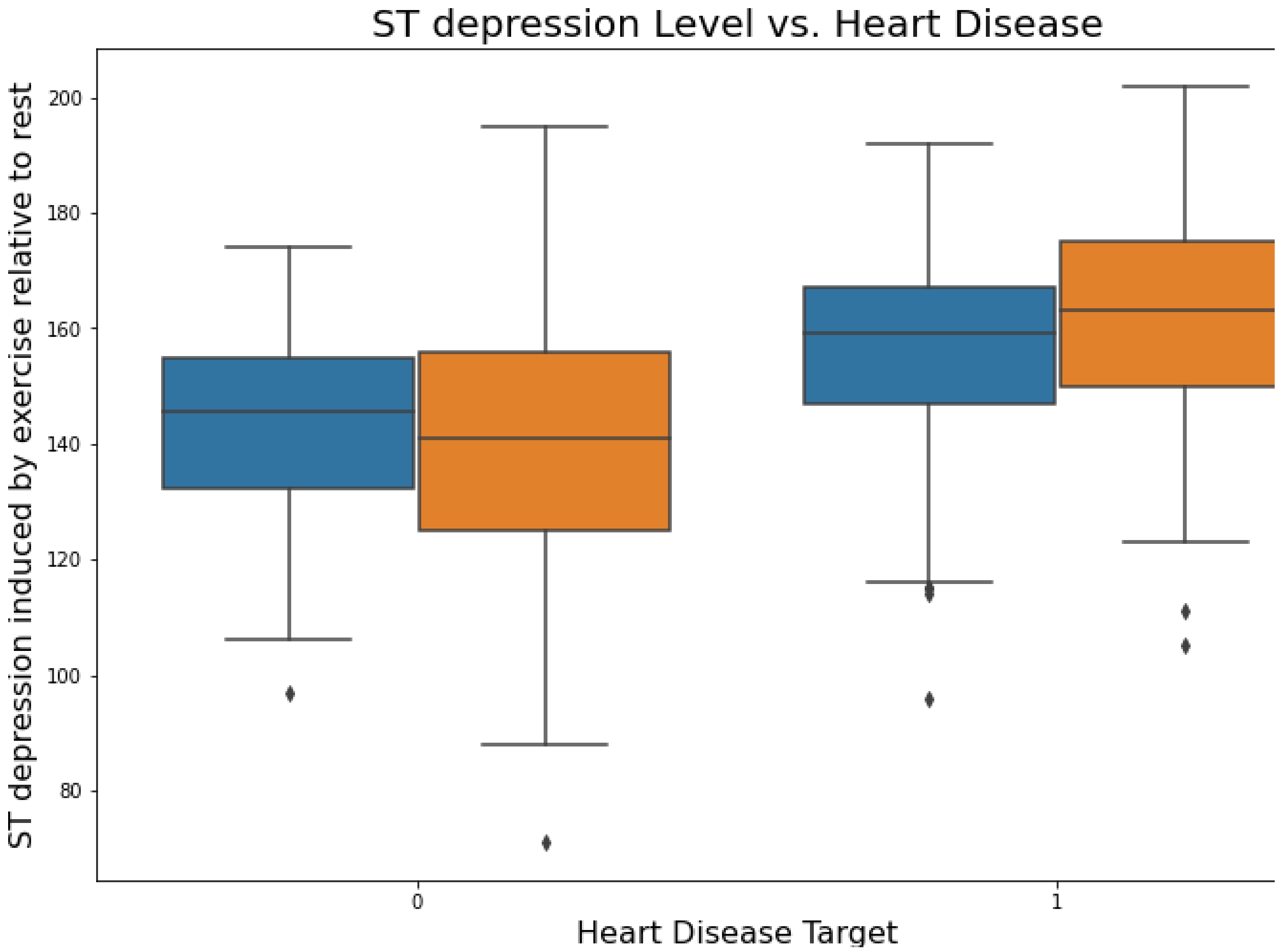
```
plt.figure(figsize=(12,8))
sns.violinplot(x= 'target', y= 'oldpeak',hue="sex", inner='quartile',data= data )
plt.title("Thalach Level vs. Heart Disease",fontsize=20)
plt.xlabel("Heart Disease Target", fontsize=16)
plt.ylabel("Thalach Level", fontsize=16)
```

```
    Text(0, 0.5, 'Thalach Level')
```



```
plt.figure(figsize=(12,8))
sns.boxplot(x= 'target', y= 'thalach',hue="sex", data=data )
plt.title("ST depression Level vs. Heart Disease", fontsize=20)
plt.xlabel("Heart Disease Target",fontsize=16)
plt.ylabel("ST depression induced by exercise relative to rest", fontsize=16)
```

```
Text(0, 0.5, 'ST depression induced by exercise relative to rest')
```



Filtering data by positive & negative Heart Disease patient

```
# Filtering data by POSITIVE Heart Disease patient
pos_data = data[data['target']==1]
pos_data.describe()
```

	age	sex	cp	trestbps	chol	fbs	restecg
count	165.000000	165.000000	165.000000	165.000000	165.000000	165.000000	165.000000
mean	52.496970	0.563636	1.375758	129.303030	242.230303	0.139394	0.593939
std	9.550651	0.497444	0.952222	16.169613	53.552872	0.347412	0.504818
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000
25%	44.000000	0.000000	1.000000	120.000000	208.000000	0.000000	0.000000
50%	52.000000	1.000000	2.000000	130.000000	234.000000	0.000000	1.000000
75%	59.000000	1.000000	2.000000	140.000000	267.000000	0.000000	1.000000
max	76.000000	1.000000	3.000000	180.000000	564.000000	1.000000	2.000000

```
# Filtering data by NEGATIVE Heart Disease patient
neg_data = data[data['target']==0]
neg_data.describe()
```

	age	sex	cp	trestbps	chol	fbs	restecg
count	138.000000	138.000000	138.000000	138.000000	138.000000	138.000000	138.000000
mean	56.601449	0.826087	0.478261	134.398551	251.086957	0.159420	0.449275
std	7.962082	0.380416	0.905920	18.729944	49.454614	0.367401	0.541321
min	35.000000	0.000000	0.000000	100.000000	131.000000	0.000000	0.000000
25%	52.000000	1.000000	0.000000	120.000000	217.250000	0.000000	0.000000
50%	58.000000	1.000000	0.000000	130.000000	249.000000	0.000000	0.000000
75%	62.000000	1.000000	0.000000	144.750000	283.000000	0.000000	1.000000
max	77.000000	1.000000	3.000000	200.000000	409.000000	1.000000	2.000000

```
print("(Positive Patients ST depression): " + str(pos_data['oldpeak'].mean()))
print("(Negative Patients ST depression): " + str(neg_data['oldpeak'].mean()))
```

```
     (Positive Patients ST depression): 0.5830303030303029
     (Negative Patients ST depression): 1.5855072463768118
```

```
print("(Positive Patients thalach): " + str(pos_data['thalach'].mean()))
print("(Negative Patients thalach): " + str(neg_data['thalach'].mean()))
```

```
     (Positive Patients thalach): 158.46666666666667
     (Negative Patients thalach): 139.1014492753623
```

Machine Learning & predictive analysis

Prepare Data for Modeling

```
X = data.iloc[:, :-1].values
y = data.iloc[:, -1].values
```

```
from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(X,y,test_size = 0.2, random_state = 1)
```

```
from sklearn.preprocessing import StandardScaler
```

```
sc = StandardScaler()
x_train = sc.fit_transform(x_train)
x_test = sc.transform(x_test)
```

Modeling /Training

Random forest

```
from sklearn.metrics import classification_report
from sklearn.ensemble import RandomForestClassifier

model6 = RandomForestClassifier(random_state=1)# get instance of model
model6.fit(x_train, y_train) # Train/Fit model

y_pred6 = model6.predict(x_test) # get y predictions
print(classification_report(y_test, y_pred6)) # output accuracy
```

```
              precision    recall  f1-score   support

           0       0.88      0.70      0.78        30
           1       0.76      0.90      0.82        31

    accuracy                           0.80        61
   macro avg       0.82      0.80      0.80        61
weighted avg       0.81      0.80      0.80        61
```

Making the Confusion Matrix

```
from sklearn.metrics import confusion_matrix, accuracy_score
cm = confusion_matrix(y_test, y_pred6)
print(cm)
accuracy_score(y_test, y_pred6)
```

```
[[21  9]
 [ 3 28]]
0.8032786885245902
```

Feature Importance

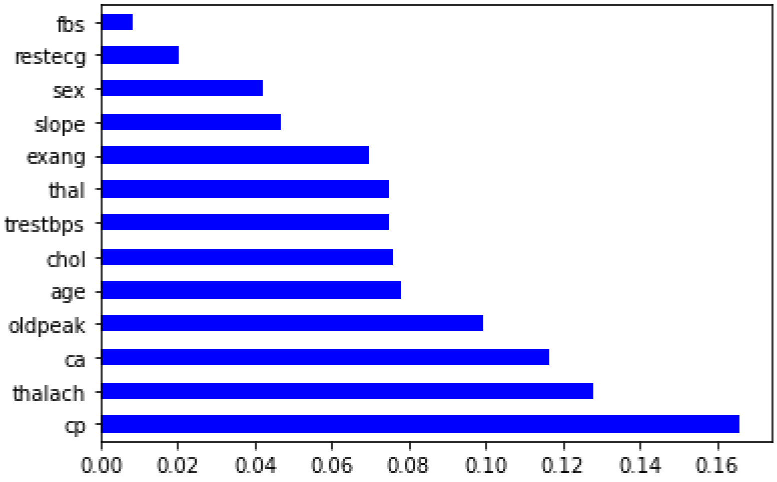
```
# get importance
importance = model6.feature_importances_

# summarize feature importance
for i,v in enumerate(importance):
    print('Feature: %0d, Score: %.5f' % (i,v))
```

```
Feature: 0, Score: 0.07814
Feature: 1, Score: 0.04206
Feature: 2, Score: 0.16580
Feature: 3, Score: 0.07477
Feature: 4, Score: 0.07587
Feature: 5, Score: 0.00828
Feature: 6, Score: 0.02014
Feature: 7, Score: 0.12772
Feature: 8, Score: 0.06950
Feature: 9, Score: 0.09957
Feature: 10, Score: 0.04677
Feature: 11, Score: 0.11667
Feature: 12, Score: 0.07473
```

```
index= data.columns[:-1]
importance = pd.Series(model6.feature_importances_, index=index)
importance.nlargest(13).plot(kind='barh', colormap='winter')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb6d4cc4850>
```



```
print(model6.predict(sc.transform([[20,1,2,110,230,1,1,140,1,2.2,2,0,2]])))
```

```
[1]
```

```
y_pred = model6.predict(x_test)
print(np.concatenate((y_pred.reshape(len(y_pred),1), y_test.reshape(len(y_test),1)),1))
```

```
[[0 0]
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