```
import numpy as np
import pandas as pd
import scipy.stats
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
from statsmodels.formula.api import ols
from statsmodels.stats.multicomp import pairwise_tukeyhsd
from scipy.stats import chi2_contingency
```

```
from google.colab import files
uploaded= files.upload()
```

Choose Files No file chosen Upload widget is only available when the cell has been execute

```
Saving Heart_disease_UCI_EDA.csv to Heart_disease_UCI_EDA (1).csv
```

```
df= pd.read_csv("Heart_disease_UCI_EDA.csv")
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
df.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
```

```
df.describe()
```

	age	sex	cp	trestbps	chol	fbs	restec
count	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.00000
mean	54.366337	0.683168	0.528053	131.280528	245.134488	0.148515	0.5148
std	9.082101	0.466011	0.500038	16.582241	47.552910	0.356198	0.5006
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.0000
25%	47.500000	0.000000	0.000000	120.000000	211.000000	0.000000	0.0000
50%	55.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.0000
75%	61.000000	1.000000	1.000000	140.000000	274.500000	0.000000	1.0000
max	77.000000	1.000000	1.000000	170.000000	369.750000	1.000000	1.0000

```
df.shape
```

```
(303, 14)
```

```
df1= df[:]
```

```
df1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
```

```
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
#Creating Dummies of Categorical Variables and dropping 1st dummy variable

Catg_vars =['sex', 'cp', 'fbs', 'restecg', 'exang', 'slope', 'ca', 'thal']


for i in Catg_vars:
    Catg_list = 'var'+'_'+i
    Catg_list = pd.get_dummies(df[i], drop_first=True, prefix = i)
    df1 = df1.join(Catg_list)
    df1
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
df1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 22 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   age        303 non-null    int64  
 1   sex        303 non-null    int64  
 2   cp         303 non-null    int64  
 3   trestbps   303 non-null    int64  
 4   chol       303 non-null    float64
 5   fbs        303 non-null    int64  
 6   restecg    303 non-null    int64  
 7   thalach    303 non-null    float64
 8   exang      303 non-null    int64  
 9   oldpeak    303 non-null    float64
 10  slope      303 non-null    int64
 11  ca         303 non-null    int64
 12  thal       303 non-null    int64
 13  target     303 non-null    int64
 14  sex_1      303 non-null    uint8
 15  cp_1       303 non-null    uint8
 16  fbs_1      303 non-null    uint8
 17  restecg_1  303 non-null    uint8
 18  exang_1    303 non-null    uint8
 19  slope_2    303 non-null    uint8
 20  ca_1       303 non-null    uint8
 21  thal_1     303 non-null    uint8
dtypes: float64(3), int64(11), uint8(8)
memory usage: 35.6 KB
```

```
#After Creating dummies and dropping 1st dummy now drop original variable
Catg_vars = ['sex', 'cp', 'fbs', 'restecg', 'exang', 'slope', 'ca', 'thal']
```

```
df_vars = df1.columns.values.tolist()
```

```
to_keep = [i for i in df_vars if i not in Catg_vars]
# keep only those which are not in the list of data_vars
```

```
df_final = df1[to_keep]
```

```
df_final.columns.values
```

```
array(['age', 'trestbps', 'chol', 'thalach', 'oldpeak', 'target', 'sex_1',
       'cp_1', 'fbs_1', 'restecg_1', 'exang_1', 'slope_2', 'ca_1',
       'thal_1'], dtype=object)
```

```
df_final.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   age        303 non-null    int64
 1   trestbps   303 non-null    int64
 2   chol       303 non-null    float64
 3   thalach    303 non-null    float64
 4   oldpeak    303 non-null    float64
 5   target     303 non-null    int64
 6   sex_1      303 non-null    uint8
 7   cp_1       303 non-null    uint8
 8   fbs_1      303 non-null    uint8
 9   restecg_1  303 non-null    uint8
 10  exang_1    303 non-null    uint8
 11  slope_2    303 non-null    uint8
 12  ca_1       303 non-null    uint8
 13  thal_1     303 non-null    uint8
dtypes: float64(3), int64(3), uint8(8)
memory usage: 16.7 KB
```

```
X = df_final.loc[:, df_final.columns!= 'target']
y = df_final.loc[:, df_final.columns== 'target']
```

```
X.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 13 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   age        303 non-null    int64  
 1   trestbps   303 non-null    int64  
 2   chol       303 non-null    float64
 3   thalach    303 non-null    float64
 4   oldpeak    303 non-null    float64
 5   sex_1      303 non-null    uint8  
 6   cp_1       303 non-null    uint8  
 7   fbs_1      303 non-null    uint8  
 8   restecg_1  303 non-null    uint8  
 9   exang_1    303 non-null    uint8  
 10  slope_2    303 non-null    uint8  
 11  ca_1       303 non-null    uint8  
 12  thal_1     303 non-null    uint8  
dtypes: float64(3), int64(2), uint8(8)
memory usage: 14.3 KB
```

```
y
```

	target
0	1
1	1
2	1
3	1
4	1
...	...
298	0
299	0
300	0
301	0
302	0

303 rows × 1 columns

```
''' Splitting the data into Train & Test (70-30 respectively) '''
```

```
from sklearn.linear_model import LogisticRegression
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)
```

```
train = X_train.join(y_train)
```

```
train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 212 entries, 137 to 172
Data columns (total 14 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   age        212 non-null    int64  
 1   trestbps   212 non-null    int64  
 2   chol       212 non-null    float64
 3   thalach    212 non-null    float64
 4   oldpeak    212 non-null    float64
 5   sex_1      212 non-null    uint8  
 6   cp_1       212 non-null    uint8  
 7   fbs_1      212 non-null    uint8  
 8   restecg_1  212 non-null    uint8  
 9   exang_1    212 non-null    uint8  
 10  slope_2    212 non-null    uint8  
 11  ca_1       212 non-null    uint8  
 12  thal_1     212 non-null    uint8  
 13  target     212 non-null    int64  
dtypes: float64(3), int64(3), uint8(8)
memory usage: 23.2 KB
```

```
no_disease = train[train.target == 0]
len(no_disease)
```

```
94
```

```
yes_disease = train[train.target == 1]
len(yes_disease)
```

```
118
```

```
from sklearn.utils import resample
```

```
# Smote is done - over sampling
no_disease_os = resample(no_disease,
                          replace = True,
                          n_samples = len(yes_disease),
                          random_state = 14)
```

```
train_os = pd.concat([yes_disease, no_disease_os])
```

```
train_os.target.value_counts()
```

```
1    118
0    118
Name: target, dtype: int64
```

```
X_train_os = train_os.loc[:, train_os.columns != 'target']
y_train_os = train_os.loc[:, train_os.columns == 'target']
```

#Recurrsive Feature Elimination

```
from sklearn import datasets
from sklearn.feature_selection import RFE
from sklearn.linear_model import LogisticRegression
```

```
logreg = LogisticRegression(max_iter=10000000)
```

```
rfe = RFE(logreg, n_features_to_select=11)
```

```
rfe = rfe.fit(X_train_os, y_train_os.values.ravel())
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_sag.py:354: ConvergenceW
  ConvergenceWarning,
/usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_sag.py:354: ConvergenceW
  ConvergenceWarning,
/usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_sag.py:354: ConvergenceW
  ConvergenceWarning,
```

```
rfe.n_features_to_select
```

```
11
```

```
X_train_os.columns[rfe.get_support()]
```

```
Index(['trestbps', 'thalach', 'oldpeak', 'sex_1', 'cp_1', 'fbs_1', 'restecg_1',
       'exang_1', 'slope_2', 'ca_1', 'thal_1'],
      dtype='object')
```

```
cols = X_train_os.columns[rfe.get_support()]
```

```
cols.to_list()
```

```
['trestbps',
 'thalach',
 'oldpeak',
 'sex_1',
 'cp_1',
 'fbs_1',
 'restecg_1',
 'exang_1',
 'slope_2',
 'ca_1',
 'thal_1']
```

#Logistic Model by statistic apporach

```
#________________________________sm model to see p_values
x1 = X_train_os[cols]
```

```
x1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 236 entries, 137 to 186
Data columns (total 11 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   trestbps   236 non-null    int64  
 1   thalach    236 non-null    float64
 2   oldpeak    236 non-null    float64
 3   sex_1      236 non-null    uint8  
 4   cp_1       236 non-null    uint8  
 5   fbs_1      236 non-null    uint8  
 6   restecg_1  236 non-null    uint8  
 7   exang_1    236 non-null    uint8  
 8   slope_2    236 non-null    uint8  
 9   ca_1       236 non-null    uint8  
 10  thal_1     236 non-null    uint8  
dtypes: float64(2), int64(1), uint8(8)
memory usage: 9.2 KB
```

```
y_train_os.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 236 entries, 137 to 186
Data columns (total 1 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   target  236 non-null    int64
dtypes: int64(1)
memory usage: 3.7 KB
```

```
y_train_os.value_counts()
```

```
target
1         118
0         118
dtype: int64
```

```
y1 = y_train_os
```

```
y1
```

	target
137	1
106	1
44	1
139	1
156	1
...	...
263	0
257	0
221	0
221	0
186	0

236 rows × 1 columns

```
#____________Stats model
import statsmodels.api as sm
```

```
x1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 236 entries, 137 to 186
Data columns (total 11 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   trestbps   236 non-null    int64  
 1   thalach    236 non-null    float64
 2   oldpeak    236 non-null    float64
 3   sex_1      236 non-null    uint8  
 4   cp_1       236 non-null    uint8  
 5   fbs_1      236 non-null    uint8  
 6   restecg_1  236 non-null    uint8  
 7   exang_1    236 non-null    uint8  
 8   slope_2    236 non-null    uint8  
 9   ca_1       236 non-null    uint8  
 10  thal_1     236 non-null    uint8  
dtypes: float64(2), int64(1), uint8(8)
memory usage: 9.2 KB
```

```
y1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 236 entries, 137 to 186
Data columns (total 1 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   target  236 non-null    int64
```

```
dtypes: int64(1)
memory usage: 3.7 KB
```

```
logit_model = sm.Logit(y1,x1)
```

```
result = logit_model.fit(method='bfgs')
```

```
Warning: Maximum number of iterations has been exceeded.
         Current function value: 0.290243
         Iterations: 35
         Function evaluations: 39
         Gradient evaluations: 39
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:512: ConvergenceWarr
  "Check mle_retvals", ConvergenceWarning)
```

```
print(result.summary2())
```

```
                         Results: Logit
=================================================================
Model:              Logit            Pseudo R-squared: 0.581
Dependent Variable: target           AIC:              158.9947
Date:               2021-11-27 07:59 BIC:              197.0969
No. Observations:   236              Log-Likelihood:   -68.497
Df Model:           10               LL-Null:          -163.58
Df Residuals:       225              LLR p-value:      1.8016e-35
Converged:          0.0000           Scale:            1.0000
------------------------------------------------------------------
               Coef.   Std.Err.     z     P>|z|    [0.025   0.975]
------------------------------------------------------------------
trestbps      -0.0040    0.0099  -0.4054  0.6852  -0.0233   0.0153
thalach        0.0197    0.0089   2.2180  0.0266   0.0023   0.0371
oldpeak       -0.5144    0.2615  -1.9674  0.0491  -1.0269  -0.0020
sex_1         -1.2426    0.5543  -2.2419  0.0250  -2.3290  -0.1563
cp_1           1.7922    0.5053   3.5467  0.0004   0.8018   2.7825
fbs_1         -0.6882    0.6324  -1.0883  0.2765  -1.9277   0.5513
restecg_1     -0.5831    0.4842  -1.2043  0.2285  -1.5321   0.3659
exang_1       -0.7763    0.4994  -1.5545  0.1201  -1.7551   0.2025
slope_2        0.4471    0.5568   0.8030  0.4220  -0.6442   1.5383
ca_1          -1.8748    0.4714  -3.9773  0.0001  -2.7987  -0.9509
thal_1        -1.1527    0.5104  -2.2587  0.0239  -2.1530  -0.1524
=================================================================
```

#Logistic model by SK learn method

```
from sklearn.linear_model import LogisticRegression
from sklearn import metrics
```

```
logreg= LogisticRegression(solver= 'sag')
logreg.fit(x1, y1)
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/utils/validation.py:985: DataConversic
  y = column_or_1d(y, warn=True)
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_sag.py:354: ConvergenceW
  ConvergenceWarning,
LogisticRegression(solver='sag')
```

```
## X_test should alsso have only 2 columns
X_test2= X_test[cols]
```

```
X_test2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 91 entries, 225 to 238
Data columns (total 11 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   trestbps   91 non-null     int64  
 1   thalach    91 non-null     float64
 2   oldpeak    91 non-null     float64
 3   sex_1      91 non-null     uint8  
 4   cp_1       91 non-null     uint8  
 5   fbs_1      91 non-null     uint8  
 6   restecg_1  91 non-null     uint8  
 7   exang_1    91 non-null     uint8  
 8   slope_2    91 non-null     uint8  
 9   ca_1       91 non-null     uint8  
 10  thal_1     91 non-null     uint8  
dtypes: float64(2), int64(1), uint8(8)
memory usage: 3.6 KB
```

```
y_pred= logreg.predict(X_test2)
```

```
log_score= logreg.score(X_test2, y_test)
```

```
print("Accuracy of logistic regression classifier on test data:{}".format(log_score))
```

```
Accuracy of logistic regression classifier on test data:0.7032967032967034
```

```
from sklearn.metrics import confusion_matrix
```

```
confusion_matrix = confusion_matrix(y_test, y_pred)
print(confusion_matrix)
```

```
[[28 16]
 [11 36]]
```

```
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.72      0.64      0.67        44
```

```
               1       0.69      0.77      0.73        47

        accuracy                           0.70        91
       macro avg       0.71      0.70      0.70        91
    weighted avg       0.70      0.70      0.70        91
```

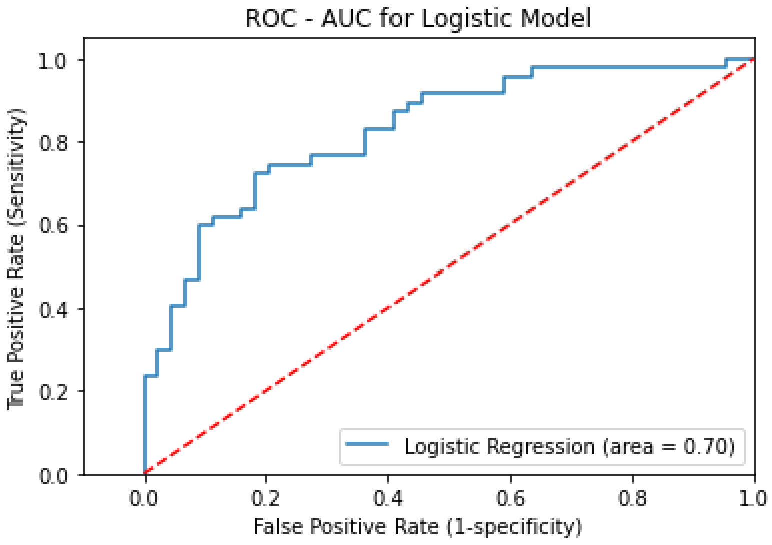
```
from sklearn.metrics import roc_auc_score
from sklearn.metrics import roc_curve
```

```
logit_roc_auc = roc_auc_score(y_test, logreg.predict(X_test2))
logit_roc_auc
```

```
     0.7011605415860734
```

```
""  Area under curve is 0.701   ""
```

```
fpr, tpr, thresholds = roc_curve(y_test, logreg.predict_proba(X_test2)[:,1])
plt.figure()
plt.plot(fpr, tpr, label='Logistic Regression (area = %0.2f)' % logit_roc_auc)
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([-0.1, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate (1-specificity)')
plt.ylabel('True Positive Rate (Sensitivity)')
plt.title('ROC - AUC for Logistic Model')
plt.legend(loc="lower right")
plt.show()
```



# Decision Tree Model

```
df.info()
```

```
     <class 'pandas.core.frame.DataFrame'>
     RangeIndex: 303 entries, 0 to 302
     Data columns (total 14 columns):
```

```
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
df2=df[:]
```

```
df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
from sklearn.preprocessing import LabelEncoder
LE= LabelEncoder()
```

```
df2['sex']= LE.fit_transform(df2['sex'])
df2['cp']= LE.fit_transform(df2['cp'])
df2['fbs']= LE.fit_transform(df2['fbs'])
df2['restecg']= LE.fit_transform(df2['restecg'])
df2['exang']= LE.fit_transform(df2['exang'])
df2['slope']= LE.fit_transform(df2['slope'])
df2['ca']= LE.fit_transform(df2['ca'])
```

```
df2['thal']= LE.fit_transform(df2['thal'])
df2
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca
0	63	1	1	145	233.0	1	0	150.0	0	2.3	0	0
1	37	1	1	130	250.0	0	1	187.0	0	3.5	0	0
2	41	0	1	130	204.0	0	0	172.0	0	1.4	1	0
3	56	1	1	120	236.0	0	1	178.0	0	0.8	1	0
4	57	0	0	120	354.0	0	1	163.0	1	0.6	1	0
...	...	...	...	...	...	...	...	...	...	...	...	...
298	57	0	0	140	241.0	0	1	123.0	1	0.2	0	0
299	45	1	1	110	264.0	0	1	132.0	0	1.2	0	0
300	68	1	0	144	193.0	1	1	141.0	0	3.4	0	1
301	57	1	0	130	131.0	0	1	115.0	1	1.2	0	1
302	57	0	1	130	236.0	0	0	174.0	0	0.0	0	1

303 rows × 14 columns

```
X = df2.loc[:, df2.columns != 'target']
y = df2.loc[:, df2.columns == 'target']
```

```
X.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 13 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
dtypes: float64(3), int64(10)
memory usage: 30.9 KB
```

```
y
```

	target
0	1
1	1
2	1
3	1
4	1
...	...
298	0
299	0
300	0
301	0
302	0

```
'''Fit Tree'''
#train test - split

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)


from sklearn.tree import DecisionTreeClassifier


#fit tree on train data
#model
clf = DecisionTreeClassifier()


#Fit Classifier model on train set
clf.fit(X_train, y_train)
```

```
DecisionTreeClassifier()
```

```
#Predict/estimate_train  X_train
y_pred_train = clf.predict(X_train)


y_pred_train
```

```
array([1, 1, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 0, 0,
       0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1,
       0, 1, 1, 0, 0, 0, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0, 1, 0,
       0, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 0, 1, 0,
       0, 1, 0, 0, 1, 1, 1, 0, 0, 1, 1, 0, 1, 0, 1, 0, 1, 1, 0, 1, 1, 1,
       0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0,
       0, 0, 1, 1, 0, 1, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0,
       0, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 0,
       1, 1, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 0,
       1, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 0])
```

```
#Predict/estimate_test  X_test
y_pred_test = clf.predict(X_test)
```

```
y_pred_test
```

```
array([0, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 1, 1, 1, 0, 1, 0, 0, 0, 0, 1, 0,
       0, 1, 1, 1, 0, 0, 1, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 1, 0, 1, 1, 0, 1, 0, 1, 0, 1,
       0, 1, 0])
```

```
#See the train
from sklearn import tree
```

```
tree.plot_tree(clf.fit(X_train, y_train))
```

```
[Text(180.20117647058825, 206.56799999999998, 'X[12] <= 0.5\ngini = 0.494\nsamples =
 Text(110.28705882352942, 184.824, 'X[9] <= 1.7\ngini = 0.303\nsamples = 118\nvalue =
 Text(78.7764705882353, 163.07999999999998, 'X[11] <= 0.5\ngini = 0.222\nsamples = 1
 Text(47.265882352941176, 141.336, 'X[0] <= 58.5\ngini = 0.139\nsamples = 80\nvalue =
 Text(31.51058823529412, 119.592, 'X[7] <= 156.5\ngini = 0.064\nsamples = 60\nvalue =
 Text(23.632941176470588, 97.848, 'X[3] <= 129.0\ngini = 0.219\nsamples = 16\nvalue =
 Text(15.75529411764706, 76.10399999999998, 'X[1] <= 0.5\ngini = 0.48\nsamples = 5\n
 Text(7.87764705882353, 54.360000000000014, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]
 Text(23.632941176470588, 54.360000000000014, 'gini = 0.0\nsamples = 2\nvalue = [2,
 Text(31.51058823529412, 76.10399999999998, 'gini = 0.0\nsamples = 11\nvalue = [0, 1
 Text(39.38823529411765, 97.848, 'gini = 0.0\nsamples = 44\nvalue = [0, 44]'),
 Text(63.02117647058824, 119.592, 'X[4] <= 243.5\ngini = 0.32\nsamples = 20\nvalue =
 Text(55.14352941176471, 97.848, 'gini = 0.0\nsamples = 9\nvalue = [0, 9]'),
 Text(70.89882352941177, 97.848, 'X[0] <= 64.5\ngini = 0.463\nsamples = 11\nvalue = |
 Text(63.02117647058824, 76.10399999999998, 'X[7] <= 170.5\ngini = 0.5\nsamples = 8\n
 Text(55.14352941176471, 54.360000000000014, 'X[3] <= 165.0\ngini = 0.444\nsamples =
 Text(47.265882352941176, 32.615999999999985, 'X[4] <= 352.375\ngini = 0.32\nsamples
 Text(39.38823529411765, 10.872000000000014, 'gini = 0.0\nsamples = 4\nvalue = [4, 0
 Text(55.14352941176471, 10.872000000000014, 'gini = 0.0\nsamples = 1\nvalue = [0, 1
 Text(63.02117647058824, 32.615999999999985, 'gini = 0.0\nsamples = 1\nvalue = [0, 1
 Text(70.89882352941177, 54.360000000000014, 'gini = 0.0\nsamples = 2\nvalue = [0, 2
 Text(78.7764705882353, 76.10399999999998, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'
 Text(110.28705882352942, 141.336, 'X[2] <= 0.5\ngini = 0.434\nsamples = 22\nvalue =
 Text(94.53176470588235, 119.592, 'X[1] <= 0.5\ngini = 0.32\nsamples = 5\nvalue = [4
 Text(86.65411764705883, 97.848, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(102.40941176470588, 97.848, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
 Text(126.04235294117647, 119.592, 'X[4] <= 172.0\ngini = 0.291\nsamples = 17\nvalue
 Text(118.16470588235295, 97.848, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(133.92000000000002, 97.848, 'X[4] <= 279.5\ngini = 0.219\nsamples = 16\nvalue =
 Text(126.04235294117647, 76.10399999999998, 'gini = 0.0\nsamples = 9\nvalue = [0, 9
 Text(141.79764705882354, 76.10399999999998, 'X[4] <= 285.0\ngini = 0.408\nsamples =
 Text(133.92000000000002, 54.360000000000014, 'gini = 0.0\nsamples = 1\nvalue = [1,
 Text(149.67529411764707, 54.360000000000014, 'X[7] <= 154.5\ngini = 0.278\nsamples =
 Text(141.79764705882354, 32.615999999999985, 'X[0] <= 54.5\ngini = 0.5\nsamples = 2
 Text(133.92000000000002, 10.872000000000014, 'gini = 0.0\nsamples = 1\nvalue = [0,
 Text(149.67529411764707, 10.872000000000014, 'gini = 0.0\nsamples = 1\nvalue = [1,
 Text(157.5529411764706, 32.615999999999985, 'gini = 0.0\nsamples = 4\nvalue = [0, 4
 Text(141.79764705882354, 163.07999999999998, 'X[0] <= 45.5\ngini = 0.492\nsamples =
 Text(133.92000000000002, 141.336, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(149.67529411764707, 141.336, 'X[0] <= 63.5\ngini = 0.426\nsamples = 13\nvalue =
 Text(141.79764705882354, 119.592, 'gini = 0.0\nsamples = 8\nvalue = [8, 0]'),
 Text(157.5529411764706, 119.592, 'X[7] <= 111.5\ngini = 0.32\nsamples = 5\nvalue = |
 Text(149.67529411764707, 97.848, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(165.43058823529412, 97.848, 'gini = 0.0\nsamples = 4\nvalue = [0, 4]'),
 Text(250.11529411764707, 184.824, 'X[2] <= 0.5\ngini = 0.359\nsamples = 94\nvalue =
 Text(208.75764705882352, 163.07999999999998, 'X[9] <= 0.5\ngini = 0.19\nsamples = 6
 Text(181.18588235294118, 141.336, 'X[7] <= 117.0\ngini = 0.43\nsamples = 16\nvalue =
 Text(173.30823529411765, 119.592, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(189.0635294117647, 119.592, 'X[4] <= 217.0\ngini = 0.337\nsamples = 14\nvalue =
 Text(181.18588235294118, 97.848, 'X[11] <= 0.5\ngini = 0.5\nsamples = 6\nvalue = [3
 Text(173.30823529411765, 76.10399999999998, 'X[6] <= 0.5\ngini = 0.375\nsamples = 4
 Text(165.43058823529412, 54.360000000000014, 'gini = 0.0\nsamples = 1\nvalue = [1,
 Text(181.18588235294118, 54.360000000000014, 'gini = 0.0\nsamples = 3\nvalue = [0,
 Text(189.0635294117647, 76.10399999999998, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]
 Text(196.94117647058823, 97.848, 'gini = 0.0\nsamples = 8\nvalue = [8, 0]'),
 Text(236.3294117647059, 141.336, 'X[0] <= 65.5\ngini = 0.077\nsamples = 50\nvalue =
 Text(220.57411764705884, 119.592, 'X[3] <= 112.0\ngini = 0.042\nsamples = 47\nvalue
#Model has learnt unneccesaary things
#Need to optimize
```

```
from sklearn.metrics import accuracy_score
```

```
print(round(accuracy_score(y_train,y_pred_train), 2))
```

```
     1.0
```

```
print(round(accuracy_score(y_test,y_pred_test), 2))
```

```
     0.66
```

```
# Accuracy of train data is 1
# Accuracy of test data is 0.66
```

```
from sklearn import tree
```

```
path = clf.cost_complexity_pruning_path(X_train, y_train)
```

```
path
```

```
     {'ccp_alphas': array([0.        , 0.00393082, 0.00408805, 0.0043239 , 0.0045283 ,
             0.00581761, 0.00628931, 0.0067086 , 0.006798  , 0.00707547,
             0.00754717, 0.00754717, 0.00808625, 0.00825472, 0.00934166,
             0.01027254, 0.01189882, 0.01479953, 0.01782345, 0.02469498,
             0.03423776, 0.16576779]),
      'impurities': array([0.        , 0.00786164, 0.02421384, 0.03286164, 0.05097484,
             0.10333333, 0.10962264, 0.11633124, 0.12312924, 0.13728018,
             0.14482735, 0.15237452, 0.16046078, 0.16871549, 0.18739882,
             0.19767136, 0.22146899, 0.25106805, 0.2688915 , 0.29358648,
             0.32782424, 0.49359203])}
```

```
alphas = path['ccp_alphas']
```

```
alphas
```

```
     array([0.        , 0.00393082, 0.00408805, 0.0043239 , 0.0045283 ,
            0.00581761, 0.00628931, 0.0067086 , 0.006798  , 0.00707547,
            0.00754717, 0.00754717, 0.00808625, 0.00825472, 0.00934166,
            0.01027254, 0.01189882, 0.01479953, 0.01782345, 0.02469498,
            0.03423776, 0.16576779])
```

```
acrcy_train, acrcy_test = [],[]

for i in alphas:
    clf = DecisionTreeClassifier(ccp_alpha=i)

    clf.fit(X_train, y_train)
    y_pred_train = clf.predict(X_train)
    y_pred_test = clf.predict(X_test)

    acrcy_train.append(accuracy_score(y_train, y_pred_train))
    acrcy_test.append(accuracy_score(y_test,y_pred_test))
```

```
acrcy_train
```

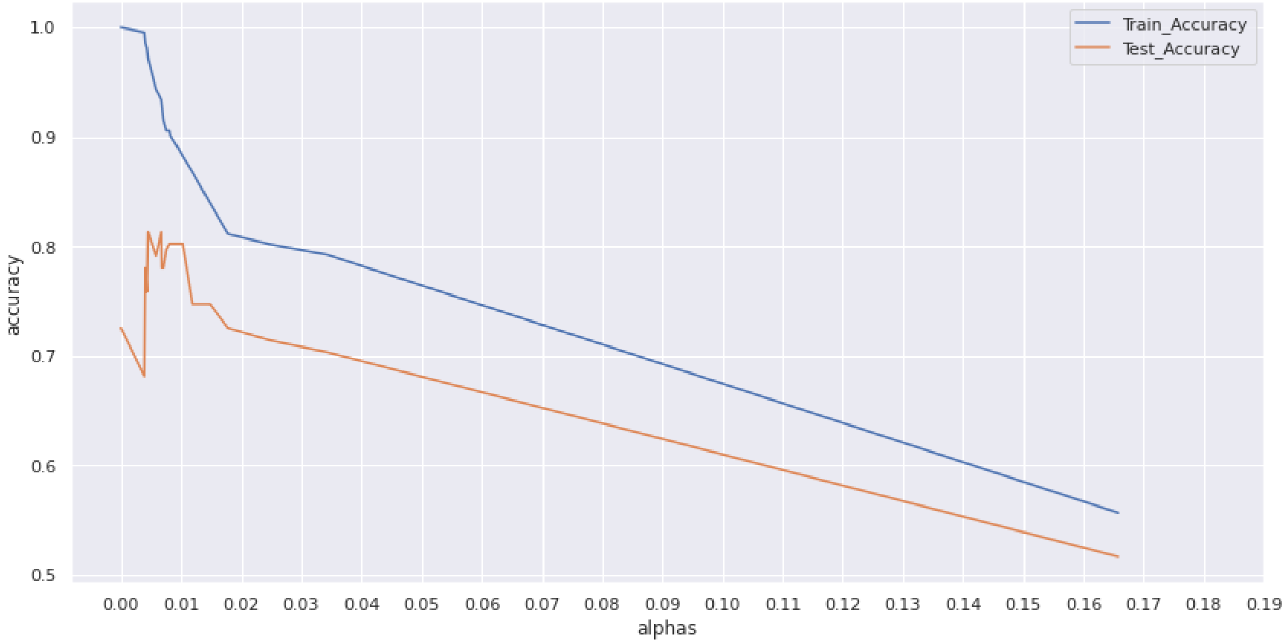
```
[1.0,
 0.9952830188679245,
 0.9858490566037735,
 0.9811320754716981,
 0.9716981132075472,
 0.9433962264150944,
 0.9386792452830188,
 0.9339622641509434,
 0.9292452830188679,
 0.9150943396226415,
 0.9056603773584906,
 0.9056603773584906,
 0.9056603773584906,
 0.9009433962264151,
 0.8915094339622641,
 0.8820754716981132,
 0.8679245283018868,
 0.839622641509434,
 0.8113207547169812,
 0.8018867924528302,
 0.7924528301886793,
 0.5566037735849056]
```

```
acrcy_test
```

```
[0.7252747252747253,
 0.6813186813186813,
 0.7802197802197802,
 0.7582417582417582,
 0.8131868131868132,
 0.7912087912087912,
 0.8021978021978022,
 0.8131868131868132,
 0.7802197802197802,
 0.7802197802197802,
 0.7912087912087912,
 0.8021978021978022,
 0.8021978021978022,
 0.8021978021978022,
 0.8021978021978022,
 0.8021978021978022,
 0.7472527472527473,
 0.7472527472527473,
 0.7252747252747253,
 0.7142857142857143,
 0.7032967032967034,
 0.5164835164835165]
```

```
# now we have scores
# lets, plot

sns.set()
plt.figure(figsize = (14,7))
sns.lineplot(y =acrcy_train, x = alphas, label = 'Train_Accuracy')
sns.lineplot(y =acrcy_test, x = alphas, label = 'Test_Accuracy')
plt.xticks(ticks=np.arange(0.00,0.2,0.01))
plt.xlabel('alphas')
plt.ylabel('accuracy')
plt.show()
```



```
#_________with ccp = 0.015
clf = DecisionTreeClassifier(ccp_alpha=0.015, random_state = 14)
```

```
clf.fit(X_train,y_train)
```

```
     DecisionTreeClassifier(ccp_alpha=0.015, random_state=14)
```

```
y_pred_train = clf.predict(X_train)
```

```
y_pred_test = clf.predict(X_test)
```

```
from sklearn.metrics import accuracy_score
print(round(accuracy_score(y_train,y_pred_train), 2))
```

```
     0.84
```

```
print(round(accuracy_score(y_test,y_pred_test), 2))
```

```
     0.75
```

```
### Confusion Matrix
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report


confusion_matrix = confusion_matrix(y_test, y_pred_test)
print(confusion_matrix)
```

```
     [[27 17]
      [ 6 41]]
```

```
### Classification Report
from sklearn.metrics import classification_report


print(classification_report(y_test, y_pred_test))
```

```
                  precision    recall  f1-score   support

               0       0.82      0.61      0.70        44
               1       0.71      0.87      0.78        47

        accuracy                           0.75        91
       macro avg       0.76      0.74      0.74        91
    weighted avg       0.76      0.75      0.74        91
```

```
###########################  ROC AUC Curve

from sklearn.metrics import roc_auc_score
from sklearn.metrics import roc_curve
from sklearn.metrics import roc_curve, auc, roc_auc_score


predictedProbability = clf.predict_proba(X_test)[:, 1]
fpr,tpr, thresholds = metrics.roc_curve(y_test, predictedProbability)
```

```
fpr
```

```
     array([0.        , 0.27272727, 0.38636364, 0.45454545, 0.52272727,
            1.        ])
```

```
tpr
```

```
     array([0.        , 0.70212766, 0.87234043, 0.91489362, 0.93617021,
            1.        ])
```

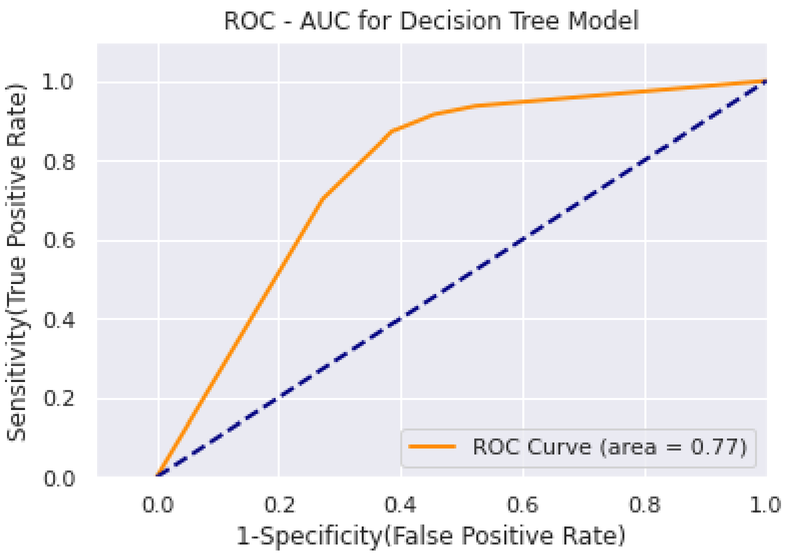
```
thresholds
```

```
array([1.87254902, 0.87254902, 0.7       , 0.4375    , 0.125     ,
       0.10606061])
```

```
dff = pd.DataFrame(dict(fpr = fpr,tpr = tpr))
auc = auc(fpr,tpr)
auc
```

```
0.7712765957446808
```

```
plt.figure()
lw = 2
plt.plot(fpr, tpr, color = 'darkorange',
         lw =lw, label = 'ROC Curve (area = %0.2f)' %auc)
plt.plot([0,1],[0,1], color='navy', lw = lw, linestyle = '--')
plt.xlim([-0.1, 1.0])
plt.ylim([0.0, 1.1])
plt.xlabel('1-Specificity(False Positive Rate)')
plt.ylabel('Sensitivity(True Positive Rate)')
plt.title("ROC - AUC for Decision Tree Model")
plt.legend(loc = "lower right")
plt.show()
```



# Random Forest

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
df2=df[:]
```

```
df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
from sklearn.preprocessing import LabelEncoder
LE= LabelEncoder()
```

```
df2['sex']= LE.fit_transform(df2['sex'])
df2['cp']= LE.fit_transform(df2['cp'])
df2['fbs']= LE.fit_transform(df2['fbs'])
df2['restecg']= LE.fit_transform(df2['restecg'])
df2['exang']= LE.fit_transform(df2['exang'])
df2['slope']= LE.fit_transform(df2['slope'])
df2['ca']= LE.fit_transform(df2['ca'])
df2['thal']= LE.fit_transform(df2['thal'])
df2
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca
0	63	1	1	145	233.0	1	0	150.0	0	2.3	0	0
1	37	1	1	130	250.0	0	1	187.0	0	3.5	0	0
2	41	0	1	130	204.0	0	0	172.0	0	1.4	1	0
3	56	1	1	120	236.0	0	1	178.0	0	0.8	1	0
4	57	0	0	120	354.0	0	1	163.0	1	0.6	1	0
...	...	...	...	...	...	...	...	...	...	...	...	...
298	57	0	0	140	241.0	0	1	123.0	1	0.2	0	0
299	45	1	1	110	264.0	0	1	132.0	0	1.2	0	0
300	68	1	0	144	193.0	1	1	141.0	0	3.4	0	1
302	57	0	1	130	236.0	0	0	174.0	0	0.0	0	1

```
X = df2.loc[:, df2.columns != 'target']
y = df2.loc[:, df2.columns == 'target']
```

```
X.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 13 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
dtypes: float64(3), int64(10)
memory usage: 30.9 KB
```

```
y
```

	target
0	1
1	1
2	1
3	1
4	1
...	...
301	0

```
'''Fit Tree'''
#train test - split

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)


#import the classifier
from sklearn.ensemble import RandomForestClassifier


#Create Classifier object
#in our previous experiment, we found ccp_alphas = 0.015 has the best accuarcy
clf_rf = RandomForestClassifier(n_estimators =100, ccp_alpha= 0.015, random_state = 14)


#fit the classifier with x and y  data = train
mod_rf = clf_rf.fit(X_train, y_train)
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:2: DataConversionWarning
```

```
#Prediction
y_train_pred = mod_rf.predict(X_train)
y_train_pred
```

```
array([1, 1, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 0, 0,
       0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1,
       0, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 0,
       0, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 0, 1, 0,
       1, 1, 0, 0, 1, 1, 0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 0, 1, 1, 1,
       0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0,
       0, 1, 1, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0,
       0, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 0,
       1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 0,
       1, 1, 1, 0, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1])
```

```
#Prediction
y_test_pred = mod_rf.predict(X_test)
y_test_pred
```

```
     array([0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0,
            0, 0, 1, 0, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1, 0, 0, 1, 1, 1, 0,
            1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
            1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 0, 1, 0, 1,
            1, 1, 0])
```

```
from sklearn.metrics import accuracy_score

print(round(accuracy_score(y_train,y_train_pred), 2))
```

```
     0.9
```

```
print(round(accuracy_score(y_test,y_test_pred), 2))
```

```
     0.81
```

```
#_____________________________ Extract Feature Importance
fi = pd.DataFrame({'feature': list(X_train.columns),
                  'importance': mod_rf.feature_importances_}).\
    sort_values('importance', ascending = False)
```

```
fi.head()
```

	feature	importance
12	thal	0.203829
11	ca	0.156076
9	oldpeak	0.115380
2	cp	0.113929
8	exang	0.100628

```
# Accuarcy 2 cells above is 0.9 & 0.81 for Train & test (respectively)
# This accuracy is for having all columns as features in our model
# Lets build a model keeping 5 best features
# that is keeping 'cp', 'exang', 'oldpeak', 'ca', 'thal' only
from sklearn.ensemble import RandomForestClassifier
```

```
#Create Classifier object
#in our previous experiment Decision Tree model,
#we found ccp_alphas = 0.035 has the best accuarcy
clf_rf1 = RandomForestClassifier(n_estimators =100, ccp_alpha= 0.015, random_state = 14)
```

```
# fit the classifier with x and y data=TRAIN,
#this time with Failure_Type only
X_train.info()
```

```
     <class 'pandas.core.frame.DataFrame'>
```

```
Int64Index: 212 entries, 137 to 172
Data columns (total 13 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       212 non-null    int64  
 1   sex       212 non-null    int64  
 2   cp        212 non-null    int64  
 3   trestbps  212 non-null    int64  
 4   chol      212 non-null    float64
 5   fbs       212 non-null    int64  
 6   restecg   212 non-null    int64  
 7   thalach   212 non-null    float64
 8   exang     212 non-null    int64  
 9   oldpeak   212 non-null    float64
 10  slope     212 non-null    int64  
 11  ca        212 non-null    int64  
 12  thal      212 non-null    int64  
dtypes: float64(3), int64(10)
memory usage: 23.2 KB
```

```
X_train1 = X_train.iloc[ : ,[2,8,9,11,12]]
X_train1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 212 entries, 137 to 172
Data columns (total 5 columns):
 #   Column   Non-Null Count  Dtype  
---  ------   --------------  -----  
 0   cp       212 non-null    int64  
 1   exang    212 non-null    int64  
 2   oldpeak  212 non-null    float64
 3   ca       212 non-null    int64  
 4   thal     212 non-null    int64  
dtypes: float64(1), int64(4)
memory usage: 9.9 KB
```

```
mod_rf1 = clf_rf1.fit(X_train1, y_train)
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:1: DataConversionWarning
  """Entry point for launching an IPython kernel.
```

```
#Prediction
y_train_pred1 = mod_rf1.predict(X_train1)
y_train_pred1
```

```
array([1, 1, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 0, 0,
       0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1,
       0, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 0, 0, 1, 0,
       0, 0, 1, 1, 1, 0, 1, 0, 0, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 0, 1, 0,
       1, 1, 0, 0, 1, 1, 0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 0, 1, 1, 1,
       0, 0, 1, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0,
       0, 1, 1, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 0, 1, 0, 1, 1, 1, 1, 1, 0,
       0, 1, 1, 0, 1, 0, 0, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 0,
       1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 0, 0, 0, 0, 1, 0,
       1, 1, 1, 0, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1])
```

```
X_test.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 91 entries, 225 to 238
Data columns (total 13 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       91 non-null     int64  
 1   sex       91 non-null     int64  
 2   cp        91 non-null     int64  
 3   trestbps  91 non-null     int64  
 4   chol      91 non-null     float64
 5   fbs       91 non-null     int64  
 6   restecg   91 non-null     int64  
 7   thalach   91 non-null     float64
 8   exang     91 non-null     int64  
 9   oldpeak   91 non-null     float64
 10  slope     91 non-null     int64  
 11  ca        91 non-null     int64  
 12  thal      91 non-null     int64  
dtypes: float64(3), int64(10)
memory usage: 10.0 KB
```

```
X_test1 = X_test.iloc[ : ,[2,8,9,11,12]]
X_test1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 91 entries, 225 to 238
Data columns (total 5 columns):
 #   Column   Non-Null Count  Dtype  
---  ------   --------------  -----  
 0   cp       91 non-null     int64  
 1   exang    91 non-null     int64  
 2   oldpeak  91 non-null     float64
 3   ca       91 non-null     int64  
 4   thal     91 non-null     int64  
dtypes: float64(1), int64(4)
memory usage: 4.3 KB
```

```
#Prediction
y_test_pred1 = mod_rf1.predict(X_test1)
y_test_pred1
```

```
array([0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0,
       0, 1, 1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1, 0, 0, 1, 1, 1, 0,
       1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1,
       1, 1, 1])
```

```
from sklearn.metrics import accuracy_score
```

```
print(round(accuracy_score(y_train,y_train_pred1), 2))
```

```
     0.86
```

```
print(round(accuracy_score(y_test,y_test_pred1), 2))
```

```
     0.81
```

```
### There is no much difference in accuarcy
#Earlier train accuracy = 0.9 now with 4 features its 0.86
#Earlier test accuracy = 0.81 now with 4 features its 0.81
```

```
### Confusion Matrix
from sklearn.metrics import confusion_matrix
```

```
confusion_matrix = confusion_matrix(y_test, y_test_pred1)
print(confusion_matrix)
```

```
     [[31 13]
      [ 4 43]]
```

```
### Classification Report
print(classification_report(y_test, y_test_pred1))
```

```
                   precision    recall  f1-score   support

                0       0.89      0.70      0.78        44
                1       0.77      0.91      0.83        47

         accuracy                           0.81        91
        macro avg       0.83      0.81      0.81        91
     weighted avg       0.82      0.81      0.81        91
```

```
###########################  ROC AUC Curve

from sklearn.metrics import roc_auc_score
from sklearn.metrics import roc_curve
from sklearn.metrics import roc_curve, auc, roc_auc_score
```

```
predictedProbability1 = mod_rf1.predict_proba(X_test1)[:, 1]
fpr,tpr, thresholds = metrics.roc_curve(y_test, predictedProbability1)
```

```
fpr
```

```
     array([0.        , 0.        , 0.        , 0.        , 0.        ,
            0.        , 0.02272727, 0.06818182, 0.06818182, 0.09090909,
            0.09090909, 0.13636364, 0.13636364, 0.13636364, 0.15909091,
            0.15909091, 0.18181818, 0.18181818, 0.20454545, 0.20454545,
            0.22727273, 0.25      , 0.29545455, 0.29545455, 0.34090909,
            0.36363636, 0.56818182, 0.56818182, 0.63636364, 0.65909091,
            0.75      , 0.79545455, 0.84090909, 0.88636364, 0.93181818,
            0.97727273, 1.        ])
```

```
tpr
```

```
array([0.        , 0.34042553, 0.36170213, 0.40425532, 0.46808511,
       0.4893617 , 0.5106383 , 0.55319149, 0.57446809, 0.59574468,
       0.61702128, 0.63829787, 0.68085106, 0.72340426, 0.72340426,
       0.76595745, 0.76595745, 0.78723404, 0.80851064, 0.85106383,
       0.87234043, 0.91489362, 0.91489362, 0.93617021, 0.93617021,
       0.95744681, 0.95744681, 0.9787234 , 0.9787234 , 1.        ,
       1.        , 1.        , 1.        , 1.        , 1.        ,
       1.        , 1.        ])
```

```
thresholds
```

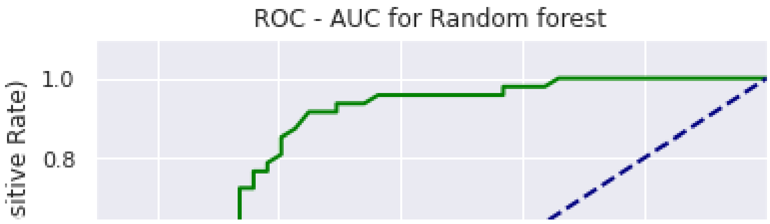
```
array([1.89541299, 0.89541299, 0.87927376, 0.87323944, 0.86817101,
       0.85796746, 0.84706323, 0.83106041, 0.82920144, 0.78756654,
       0.77792825, 0.76811059, 0.72797353, 0.71908852, 0.71394146,
       0.69817409, 0.69024108, 0.67850108, 0.66600645, 0.61190299,
       0.60839611, 0.51014379, 0.5002123 , 0.4982503 , 0.45813156,
       0.42562654, 0.28671954, 0.27201602, 0.20334771, 0.17894051,
       0.11768904, 0.11394835, 0.10070404, 0.09012524, 0.08501373,
       0.082074  , 0.081574  ])
```

```
dff1 = pd.DataFrame(dict(fpr = fpr,tpr = tpr))
auc1 = auc(fpr,tpr)
auc1
```

```
0.9008704061895552
```

```
''' Area Under Curve is 0.9 '''
```

```
plt.figure()
lw = 2
plt.plot(fpr, tpr, color = 'green',
         lw =lw, label = 'ROC Curve (area = %0.2f)' %auc1)
plt.plot([0,1],[0,1], color='navy', lw = lw, linestyle = '--')
plt.xlim([-0.1, 1.0])
plt.ylim([0.0, 1.1])
plt.xlabel('1-Specificity(False Positive Rate)')
plt.ylabel('Sensitivity(True Positive Rate)')
plt.title("ROC - AUC for Random forest")
plt.legend(loc = "lower right")
plt.show()
```



# Gradient Boosting Model

```
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.model_selection import GridSearchCV
```

```
df.info()
```

```
     <class 'pandas.core.frame.DataFrame'>
     RangeIndex: 303 entries, 0 to 302
     Data columns (total 14 columns):
      #   Column    Non-Null Count  Dtype  
     ---  ------    --------------  -----  
      0   age       303 non-null    int64  
      1   sex       303 non-null    int64  
      2   cp        303 non-null    int64  
      3   trestbps  303 non-null    int64  
      4   chol      303 non-null    float64
      5   fbs       303 non-null    int64  
      6   restecg   303 non-null    int64  
      7   thalach   303 non-null    float64
      8   exang     303 non-null    int64  
      9   oldpeak   303 non-null    float64
      10  slope     303 non-null    int64  
      11  ca        303 non-null    int64  
      12  thal      303 non-null    int64  
      13  target    303 non-null    int64  
     dtypes: float64(3), int64(11)
     memory usage: 33.3 KB
```

```
df2=df[:]
```

```
df2.info()
```

```
     <class 'pandas.core.frame.DataFrame'>
     RangeIndex: 303 entries, 0 to 302
     Data columns (total 14 columns):
      #   Column    Non-Null Count  Dtype  
     ---  ------    --------------  -----  
      0   age       303 non-null    int64  
      1   sex       303 non-null    int64  
      2   cp        303 non-null    int64  
      3   trestbps  303 non-null    int64  
      4   chol      303 non-null    float64
      5   fbs       303 non-null    int64  
      6   restecg   303 non-null    int64  
      7   thalach   303 non-null    float64
      8   exang     303 non-null    int64  
```

```
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64
 11  ca        303 non-null    int64
 12  thal      303 non-null    int64
 13  target    303 non-null    int64
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
from sklearn.preprocessing import LabelEncoder
LE= LabelEncoder()
```

```
df2['sex']= LE.fit_transform(df2['sex'])
df2['cp']= LE.fit_transform(df2['cp'])
df2['fbs']= LE.fit_transform(df2['fbs'])
df2['restecg']= LE.fit_transform(df2['restecg'])
df2['exang']= LE.fit_transform(df2['exang'])
df2['slope']= LE.fit_transform(df2['slope'])
df2['ca']= LE.fit_transform(df2['ca'])
df2['thal']= LE.fit_transform(df2['thal'])
df2
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca
0	63	1	1	145	233.0	1	0	150.0	0	2.3	0	0
1	37	1	1	130	250.0	0	1	187.0	0	3.5	0	0
2	41	0	1	130	204.0	0	0	172.0	0	1.4	1	0
3	56	1	1	120	236.0	0	1	178.0	0	0.8	1	0
4	57	0	0	120	354.0	0	1	163.0	1	0.6	1	0
...	...	...	...	...	...	...	...	...	...	...	...	...
298	57	0	0	140	241.0	0	1	123.0	1	0.2	0	0
299	45	1	1	110	264.0	0	1	132.0	0	1.2	0	0
300	68	1	0	144	193.0	1	1	141.0	0	3.4	0	1
301	57	1	0	130	131.0	0	1	115.0	1	1.2	0	1
302	57	0	1	130	236.0	0	0	174.0	0	0.0	0	1

303 rows × 14 columns

```
X = df2.loc[:, df2.columns != 'target']
y = df2.loc[:, df2.columns == 'target']
```

```
X.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 13 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
```

```
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
dtypes: float64(3), int64(10)
memory usage: 30.9 KB
```

```
y
```

	target
0	1
1	1
2	1
3	1
4	1
...	...
298	0
299	0
300	0
301	0
302	0

303 rows × 1 columns

```
'''Fit Tree'''
#train test - split

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)
```

```
GB = GradientBoostingClassifier()
```

```
GB_mod = GB.fit(X_train, y_train)
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/ensemble/_gb.py:494: DataConversionWar
  y = column_or_1d(y, warn=True)
```

```
# Prediction
y_train_GB = GB_mod.predict(X_train)
y_train_GB
```

```
     array([1, 1, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 0, 0,
            0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1,
            0, 1, 1, 0, 0, 0, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0, 1, 0,
            0, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 0, 1, 0,
            0, 1, 0, 0, 1, 1, 1, 0, 0, 1, 1, 0, 1, 0, 1, 0, 1, 1, 0, 1, 1, 1,
            0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0,
            0, 0, 1, 1, 0, 1, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0,
            0, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 0,
            1, 1, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 0,
            1, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 0])
```

```
# Prediction
y_test_GB = GB_mod.predict(X_test)
y_test_GB
```

```
     array([0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0,
            0, 0, 1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1, 0, 0, 1, 1, 1, 0,
            0, 1, 1, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
            1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 1,
            1, 1, 1])
```

```
print(round(accuracy_score(y_train, y_train_GB), 2))
```

```
     1.0
```

```
print(round(accuracy_score(y_test, y_test_GB), 2))
```

```
     0.81
```

```
### Confusion Matrix
from sklearn.metrics import confusion_matrix
```

```
confusion_matrix = confusion_matrix(y_test, y_test_GB)
print(confusion_matrix)
```

```
     [[33 11]
      [ 6 41]]
```

```
### Classification Report
from sklearn.metrics import classification_report
```

```
print(classification_report(y_test, y_test_GB))
```

```
                   precision    recall  f1-score   support
```

```
           0       0.85      0.75      0.80        44
           1       0.79      0.87      0.83        47

    accuracy                           0.81        91
   macro avg       0.82      0.81      0.81        91
weighted avg       0.82      0.81      0.81        91
```

# Knowing your Nearest Neighbours(KNN)

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
df2=df[:]
```

```
df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
from sklearn.preprocessing import LabelEncoder
LE= LabelEncoder()
```

```
df2['sex']= LE.fit_transform(df2['sex'])
df2['cp']= LE.fit_transform(df2['cp'])
df2['fbs']= LE.fit_transform(df2['fbs'])
df2['restecg']= LE.fit_transform(df2['restecg'])
df2['exang']= LE.fit_transform(df2['exang'])
df2['slope']= LE.fit_transform(df2['slope'])
df2['ca']= LE.fit_transform(df2['ca'])
df2['thal']= LE.fit_transform(df2['thal'])
df2
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca
0	63	1	1	145	233.0	1	0	150.0	0	2.3	0	0
1	37	1	1	130	250.0	0	1	187.0	0	3.5	0	0
2	41	0	1	130	204.0	0	0	172.0	0	1.4	1	0
3	56	1	1	120	236.0	0	1	178.0	0	0.8	1	0
4	57	0	0	120	354.0	0	1	163.0	1	0.6	1	0
...	...	...	...	...	...	...	...	...	...	...	...	...
298	57	0	0	140	241.0	0	1	123.0	1	0.2	0	0
299	45	1	1	110	264.0	0	1	132.0	0	1.2	0	0
300	68	1	0	144	193.0	1	1	141.0	0	3.4	0	1
301	57	1	0	130	131.0	0	1	115.0	1	1.2	0	1
302	57	0	1	130	236.0	0	0	174.0	0	0.0	0	1

303 rows × 14 columns

```
df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
X = df2.loc[:, df2.columns != 'target']
y = df2.loc[:, df2.columns == 'target']
```

```
X.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 13 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
dtypes: float64(3), int64(10)
memory usage: 30.9 KB
```

```
y
```

	target
0	1
3	1
298	0

```
from sklearn.linear_model import LogisticRegression
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)
```

```
from sklearn.neighbors import KNeighborsClassifier
```

```
#Building Model @ n_neighbors = 9

knn = KNeighborsClassifier(n_neighbors = 9)
print(knn)
mpm_knn = knn.fit(X_train, y_train)
print(mpm_knn)
```

```
KNeighborsClassifier(n_neighbors=9)
KNeighborsClassifier(n_neighbors=9)
/usr/local/lib/python3.7/dist-packages/sklearn/neighbors/_classification.py:198: Data
  return self._fit(X, y)
```

```
#Applying on Test data for prediction
y_pred_KNN = mpm_knn.predict(X_test)
print(y_pred_KNN)
```

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

```
#Prediction Score
mpm_knn.score(X_test, y_test)
```

```
0.7142857142857143
```

```
#Accuracy Score
from sklearn.metrics import accuracy_score
accuracy_score(y_test, y_pred_KNN)
```

```
0.7142857142857143
```

```
# creating a confusion matrix
from sklearn.metrics import confusion_matrix
knn_predictions = knn.predict(X_test)
cm = confusion_matrix(y_test, knn_predictions)
cm
```

```
     array([[27, 17],
            [ 9, 38]])
```

```
### Classification Report
from sklearn.metrics import classification_report
print(classification_report(y_test, knn_predictions))
```

```
                   precision    recall  f1-score   support

                0       0.75      0.61      0.67        44
                1       0.69      0.81      0.75        47

         accuracy                           0.71        91
        macro avg       0.72      0.71      0.71        91
     weighted avg       0.72      0.71      0.71        91
```

# SVM

```
df.info()
```

```
     <class 'pandas.core.frame.DataFrame'>
     RangeIndex: 303 entries, 0 to 302
     Data columns (total 14 columns):
      #   Column    Non-Null Count  Dtype  
     ---  ------    --------------  -----  
      0   age       303 non-null    int64  
      1   sex       303 non-null    int64  
      2   cp        303 non-null    int64  
      3   trestbps  303 non-null    int64  
      4   chol      303 non-null    float64
      5   fbs       303 non-null    int64  
      6   restecg   303 non-null    int64  
      7   thalach   303 non-null    float64
      8   exang     303 non-null    int64  
      9   oldpeak   303 non-null    float64
      10  slope     303 non-null    int64  
      11  ca        303 non-null    int64  
      12  thal      303 non-null    int64  
      13  target    303 non-null    int64  
     dtypes: float64(3), int64(11)
     memory usage: 33.3 KB
```

```
df2= df[:]
```

```
df2.info()
```

```
     <class 'pandas.core.frame.DataFrame'>
     RangeIndex: 303 entries, 0 to 302
     Data columns (total 14 columns):
      #   Column    Non-Null Count  Dtype  
     ---  ------    --------------  -----  
      0   age       303 non-null    int64  
      1   sex       303 non-null    int64  
      2   cp        303 non-null    int64  
```

```
 3   trestbps  303 non-null    int64
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64
 6   restecg   303 non-null    int64
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64
 11  ca        303 non-null    int64
 12  thal      303 non-null    int64
 13  target    303 non-null    int64
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
from sklearn.preprocessing import LabelEncoder
LE= LabelEncoder()
```

```
df2['sex']= LE.fit_transform(df2['sex'])
df2['cp']= LE.fit_transform(df2['cp'])
df2['fbs']= LE.fit_transform(df2['fbs'])
df2['restecg']= LE.fit_transform(df2['restecg'])
df2['exang']= LE.fit_transform(df2['exang'])
df2['slope']= LE.fit_transform(df2['slope'])
df2['ca']= LE.fit_transform(df2['ca'])
df2['thal']= LE.fit_transform(df2['thal'])
df2
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca
0	63	1	1	145	233.0	1	0	150.0	0	2.3	0	0
1	37	1	1	130	250.0	0	1	187.0	0	3.5	0	0
2	41	0	1	130	204.0	0	0	172.0	0	1.4	1	0
3	56	1	1	120	236.0	0	1	178.0	0	0.8	1	0
4	57	0	0	120	354.0	0	1	163.0	1	0.6	1	0
...	...	...	...	...	...	...	...	...	...	...	...	...
298	57	0	0	140	241.0	0	1	123.0	1	0.2	0	0
299	45	1	1	110	264.0	0	1	132.0	0	1.2	0	0
300	68	1	0	144	193.0	1	1	141.0	0	3.4	0	1
301	57	1	0	130	131.0	0	1	115.0	1	1.2	0	1
302	57	0	1	130	236.0	0	0	174.0	0	0.0	0	1

303 rows × 14 columns

```
df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

```
X = df2.loc[:, df2.columns != 'target']
y = df2.loc[:, df2.columns == 'target']
```

```
X.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 13 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    float64
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    float64
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
dtypes: float64(3), int64(10)
memory usage: 30.9 KB
```

```
y
```

	target
0	1
1	1
2	1
3	1
4	1
...	...
298	0
301	0

```
# splitting
from sklearn.linear_model import LogisticRegression
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)
```

```
from sklearn import svm
from sklearn.svm import SVC
```

```
svm_model= svm.SVC(kernel='linear', C=1, gamma='auto', probability= True).fit(X_train, y_t
```

```
    /usr/local/lib/python3.7/dist-packages/sklearn/utils/validation.py:985: DataConversi
      y = column_or_1d(y, warn=True)
```

```
y_pred_SVM = svm_model.predict(X_test)
```

```
# model accuracy for X_test
accuracy = svm_model.score(X_test, y_test)
print(accuracy)

    0.8241758241758241
```

```
# creating a confusion matrix
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_test, y_pred_SVM)
cm

    array([[34, 10],
           [ 6, 41]])
```

```
### Classification Report
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred_SVM))
```

```
              precision    recall  f1-score   support

           0       0.85      0.77      0.81        44
           1       0.80      0.87      0.84        47

    accuracy                           0.82        91
   macro avg       0.83      0.82      0.82        91
weighted avg       0.83      0.82      0.82        91
```

# Naive Bayes

```
from sklearn.naive_bayes import GaussianNB
gnb = GaussianNB().fit(X_train, y_train)
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/utils/validation.py:985: DataConversi
  y = column_or_1d(y, warn=True)
```

```
gnb_predictions = gnb.predict(X_test)
```

```
# accuracy on X_test
accuracy = gnb.score(X_test, y_test)
print(accuracy)
```

```
0.8131868131868132
```

```
# creating a confusion matrix
cm = confusion_matrix(y_test, gnb_predictions)
cm
```

```
array([[35,  9],
       [ 8, 39]])
```

```
### Classification Report
from sklearn.metrics import classification_report
print(classification_report(y_test, gnb_predictions))
```

```
              precision    recall  f1-score   support

           0       0.81      0.80      0.80        44
           1       0.81      0.83      0.82        47

    accuracy                           0.81        91
   macro avg       0.81      0.81      0.81        91
weighted avg       0.81      0.81      0.81        91
```