1. import libraries

In [1]:
```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import MinMaxScaler,StandardScaler

from sklearn.linear_model import LogisticRegression
from sklearn.metrics import confusion_matrix, accuracy_score,
classification_report

%matplotlib inline
```

In [2]:
```
df = pd.read_csv('heart.csv')
df
```

Out[2]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	ta
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	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
298	57	0	0	140	241	0	1	123	1	0.2	1	0	3	
299	45	1	3	110	264	0	1	132	0	1.2	1	0	3	
300	68	1	0	144	193	1	1	141	0	3.4	1	2	3	
301	57	1	0	130	131	0	1	115	1	1.2	1	1	3	
302	57	0	1	130	236	0	0	174	0	0.0	1	1	2	

303 rows × 14 columns

In [3]:
```
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    int64  
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    int64  
 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(1), int64(13)
memory usage: 33.3 KB
```

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

Out[4]:

	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

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

Out[5]:
```
(303, 14)
```

In [6]:
```
df.isna().sum()
```

Out[6]:
```
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
```

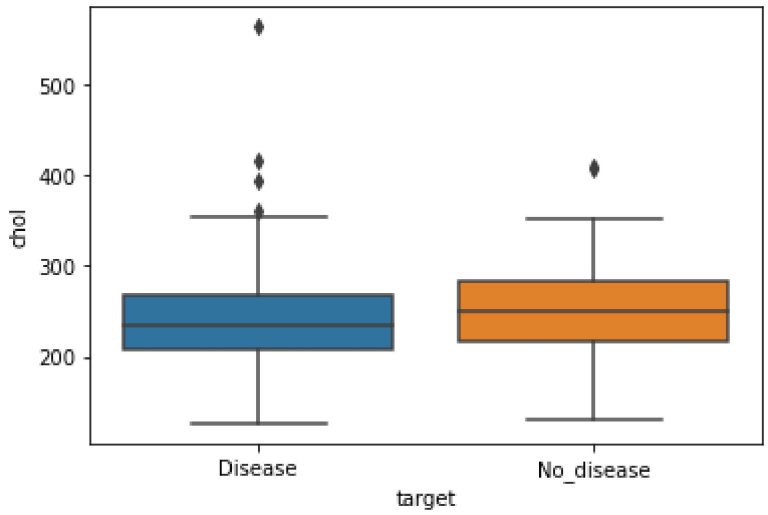
In [7]:
```
df['sex'] = df['sex'].astype('object')
df['cp'] = df['cp'].astype('object')
df['fbs'] = df['fbs'].astype('object')
df['restecg'] = df['restecg'].astype('object')
df['exang'] = df['exang'].astype('object')
df['slope'] = df['slope'].astype('object')
df['ca'] = df['ca'].astype('object')
df['thal'] = df['thal'].astype('object')
df.dtypes
```

Out[7]:
```
age          int64
sex         object
cp          object
trestbps     int64
chol         int64
fbs         object
restecg     object
thalach      int64
exang       object
oldpeak    float64
slope       object
ca          object
thal        object
target       int64
dtype: object
```

In [8]:
```
df['target'] = df.target.replace({1: "Disease", 0: "No_disease"})
df['sex'] = df.sex.replace({1: "Male", 0: "Female"})
df['cp'] = df.cp.replace({0: "typical_angina",1: "atypical_angina",
                          2:"non-anginal pain", 3: "asymtomatic"})
df['exang'] = df.exang.replace({1: "Yes", 0: "No"})
df['fbs'] = df.fbs.replace({1: "True", 0: "False"})
df['slope'] = df.slope.replace({0: "upsloping", 1: "flat",
                                2:"downsloping"})
df['thal'] = df.thal.replace({1: "fixed_defect", 2: "reversable_defect",
                              3:"normal"})
```

In [9]:
```
bxplt = sns.boxplot(df["target"],df["chol"])
plt.show()
```

```
C:\Users\mange\anaconda3\lib\site-packages\seaborn\_decorators.py:36: Futu
reWarning: Pass the following variables as keyword args: x, y. From versio
n 0.12, the only valid positional argument will be `data`, and passing oth
er arguments without an explicit keyword will result in an error or misint
erpretation.
  warnings.warn(
```



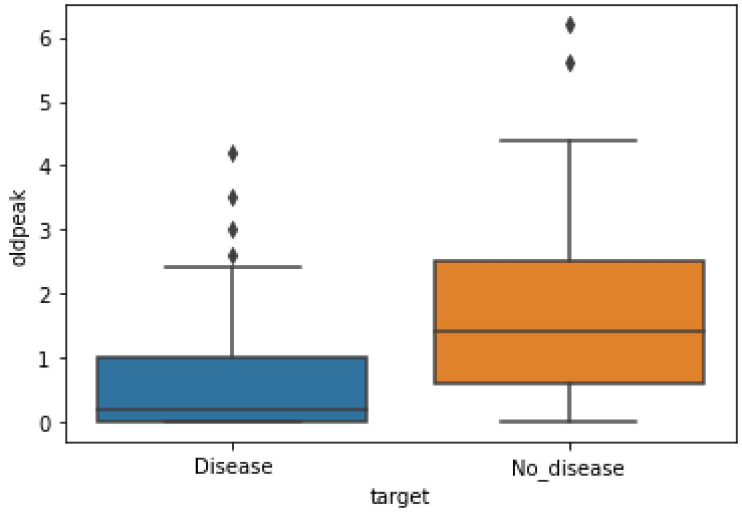
In [10]:
```
df.describe()
```

Out[10]:

	age	trestbps	chol	thalach	oldpeak
count	303.000000	303.000000	303.000000	303.000000	303.000000
mean	54.366337	131.623762	246.264026	149.646865	1.039604
std	9.082101	17.538143	51.830751	22.905161	1.161075
min	29.000000	94.000000	126.000000	71.000000	0.000000
25%	47.500000	120.000000	211.000000	133.500000	0.000000
50%	55.000000	130.000000	240.000000	153.000000	0.800000
75%	61.000000	140.000000	274.500000	166.000000	1.600000
max	77.000000	200.000000	564.000000	202.000000	6.200000

In [11]:
```
sns.boxplot(x='target', y='oldpeak', data=df)
```

Out[11]: <AxesSubplot:xlabel='target', ylabel='oldpeak'>



In [12]:
```
# define continuous variable & plot

continous_features = ['age','trestbps','chol','thalach','oldpeak']
def outliers(df_out, drop = False):
    for each_feature in df_out.columns:
        feature_data = df_out[each_feature]
        Q1 = np.percentile(feature_data, 25.) # 25th percentile of the data
        Q3 = np.percentile(feature_data, 75.) # 75th percentile of the data
        IQR = Q3-Q1 #Interquartile Range
        outlier_step = IQR * 1.5

        outliers=feature_data[~((feature_data >= Q1 - outlier_step)
                        &(feature_data<=Q3+outlier_step))].index.tolist()
        if not drop:
            print('For the feature {}, No of Outliers is{}'.format(each_fea
                                                                   len(outl
        if drop:
            df.drop(outliers, inplace = True, errors = 'ignore')
            print('Outliers from {} feature removed'.format(each_feature))

outliers(df[continous_features])
```

```
For the feature age, No of Outliers is0
For the feature trestbps, No of Outliers is9
For the feature chol, No of Outliers is5
For the feature thalach, No of Outliers is1
For the feature oldpeak, No of Outliers is5
```

In [13]:
```
# Drop Outliers
outliers(df[continous_features],drop=True)
```

```
Outliers from age feature removed
Outliers from trestbps feature removed
Outliers from chol feature removed
Outliers from thalach feature removed
Outliers from oldpeak feature removed
```

In [14]:
```
# Checking for the duplicate rows
duplicated=df.duplicated().sum()
if duplicated:
    print("Duplicated rows :{}".format(duplicated))
else:
    print("No duplicates")
```

```
Duplicated rows :1
```

In [15]:
```
# Displaying duplicate rows
duplicates=df[df.duplicated(keep=False)]
duplicates.head()
```

Out[15]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope
163	38	Male	non-anginal pain	138	175	False	1	173	No	0.0	downsloping
164	38	Male	non-anginal pain	138	175	False	1	173	No	0.0	downsloping

In [16]:
```
# will remove duplicates
df.drop_duplicates()
```

Out[16]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	
0	63	Male	asymtomatic	145	233	True	0	150	No	2.3	
1	37	Male	non-anginal pain	130	250	False	1	187	No	3.5	
2	41	Female	atypical_angina	130	204	False	0	172	No	1.4	dc
3	56	Male	atypical_angina	120	236	False	1	178	No	0.8	dc
4	57	Female	typical_angina	120	354	False	1	163	Yes	0.6	dc
...	...	...	...	...	...	...	...	...	...	...	
298	57	Female	typical_angina	140	241	False	1	123	Yes	0.2	
299	45	Male	asymtomatic	110	264	False	1	132	No	1.2	
300	68	Male	typical_angina	144	193	True	1	141	No	3.4	
301	57	Male	typical_angina	130	131	False	1	115	Yes	1.2	
302	57	Female	atypical_angina	130	236	False	0	174	No	0.0	

283 rows × 14 columns

In [17]:
```
df['ca'].unique()
```

Out[17]:
```
array([0, 2, 1, 3, 4], dtype=object)
```

In [18]:
```
df['thal'].unique()
```

Out[18]:
```
array(['fixed_defect', 'reversable_defect', 'normal', 0], dtype=object)
```

In [19]:
```
df['thal'].replace({"fixed_defect":1, "reversable_defect":2, "normal":3},
                   inplace= True)
```

In [20]:
```
df[df['ca']==4]
```

Out[20]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	
92	52	Male	non-anginal pain	138	223	False	1	169	No	0.0	dowr
158	58	Male	atypical_angina	125	220	False	1	144	No	0.4	
163	38	Male	non-anginal pain	138	175	False	1	173	No	0.0	dowr
164	38	Male	non-anginal pain	138	175	False	1	173	No	0.0	dowr
251	43	Male	typical_angina	132	247	True	0	143	Yes	0.1	

In [21]:
```
df.loc[df['ca']==4,'ca']=np.NaN
df.loc[df['thal']==0,'thal']=np.NaN
```

In [22]:
```
df.isna().sum()
```

Out[22]:
```
age         0
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
slope       0
ca          5
thal        2
target      0
dtype: int64
```

In [23]:
```
df = df.fillna(df.median())
df.isnull().sum()
```

Out[23]:
```
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
```

In [24]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 284 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       284 non-null    int64  
 1   sex       284 non-null    object 
 2   cp        284 non-null    object 
 3   trestbps  284 non-null    int64  
 4   chol      284 non-null    int64  
 5   fbs       284 non-null    object 
 6   restecg   284 non-null    int64  
 7   thalach   284 non-null    int64  
 8   exang     284 non-null    object 
 9   oldpeak   284 non-null    float64
 10  slope     284 non-null    object 
 11  ca        284 non-null    float64
 12  thal      284 non-null    float64
 13  target    284 non-null    object 
dtypes: float64(3), int64(5), object(6)
memory usage: 33.3+ KB
```

In [25]:
```
df['target'] = df.target.replace({"Disease":1,"No_disease":0})
df['sex'] = df.sex.replace({"Male":1,"Female":0})
df['cp'] = df.cp.replace({"typical_angina":0,"atypical_angina":1,
                          "non-anginal pain":2, "asymtomatic":3})

df['exang'] = df.exang.replace({"Yes":1,"No":0})
df['fbs'] = df.fbs.replace({"True":1,"False":0})
df['slope'] = df.slope.replace({"upsloping":0,"flat":1,"downsloping":2})
df['thal'] = df.thal.replace({"fixed_defect":1, "reversable_defect":2,
                              "normal":3})
```

In [26]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 284 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       284 non-null    int64  
 1   sex       284 non-null    int64  
 2   cp        284 non-null    int64  
 3   trestbps  284 non-null    int64  
 4   chol      284 non-null    int64  
 5   fbs       284 non-null    int64  
 6   restecg   284 non-null    int64  
 7   thalach   284 non-null    int64  
 8   exang     284 non-null    int64  
 9   oldpeak   284 non-null    float64
 10  slope     284 non-null    int64  
 11  ca        284 non-null    float64
 12  thal      284 non-null    float64
 13  target    284 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

In [27]:
```
df['target'].value_counts()
```

Out[27]:
```
1    159
0    125
Name: target, dtype: int64
```

In [28]:
```
df.head()
```

Out[28]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	targ
0	63	1	3	145	233	1	0	150	0	2.3	0	0.0	1.0	
1	37	1	2	130	250	0	1	187	0	3.5	0	0.0	2.0	
2	41	0	1	130	204	0	0	172	0	1.4	2	0.0	2.0	
3	56	1	1	120	236	0	1	178	0	0.8	2	0.0	2.0	
4	57	0	0	120	354	0	1	163	1	0.6	2	0.0	2.0	

In [29]:
```
# splitting data
```

In [30]:
```
x = df.drop('target',axis = 1)
y = df['target']
```

In [31]:
```
# normalization
```

In [32]:
```
normal_scaler = MinMaxScaler(feature_range = (0,1))
x_scaled = normal_scaler.fit_transform(x)
x_scaled_df = pd.DataFrame(x_scaled, columns = x.columns)
x_scaled_df
```

Out[32]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	sl
0	0.708333	1.0	1.000000	0.671053	0.457265	1.0	0.0	0.543860	0.0	0.575	
1	0.166667	1.0	0.666667	0.473684	0.529915	0.0	0.5	0.868421	0.0	0.875	
2	0.250000	0.0	0.333333	0.473684	0.333333	0.0	0.0	0.736842	0.0	0.350	
3	0.562500	1.0	0.333333	0.342105	0.470085	0.0	0.5	0.789474	0.0	0.200	
4	0.583333	0.0	0.000000	0.342105	0.974359	0.0	0.5	0.657895	1.0	0.150	
...	...	...	...	...	...	...	...	...	...	...	
279	0.583333	0.0	0.000000	0.605263	0.491453	0.0	0.5	0.307018	1.0	0.050	
280	0.333333	1.0	1.000000	0.210526	0.589744	0.0	0.5	0.385965	0.0	0.300	
281	0.812500	1.0	0.000000	0.657895	0.286325	1.0	0.5	0.464912	0.0	0.850	
282	0.583333	1.0	0.000000	0.473684	0.021368	0.0	0.5	0.236842	1.0	0.300	
283	0.583333	0.0	0.333333	0.473684	0.470085	0.0	0.0	0.754386	0.0	0.000	

284 rows × 13 columns

In [33]:
```
# standardization
```

In [34]:
```
# standard_scaler = StandardScaler()
# x_scaled = standard_scaler.fit_transform(x)
# x_scaled_std_df = pd.DataFrame(x_scaled,columns = x.columns)
# x_scaled_std_df
```

In [35]:
```
x_train, x_test, y_train, y_test = train_test_split(x_scaled_df,y,
                    test_size = 0.2,random_state = 1,stratify = y)
```

In [36]:
```
log_reg = LogisticRegression()
```

In [37]:
```
log_reg.fit(x_train, y_train)
```

Out[37]:
```
LogisticRegression
LogisticRegression()
```

In [38]:
```
# prediction
y_pred = log_reg.predict(x_test)
```

In [39]:
```
y_pred[0:5]
```

Out[39]:
```
array([1, 0, 1, 0, 0], dtype=int64)
```

In [40]:
```
y_test[0:5]
```

Out[40]:
```
155    1
243    0
23     1
193    0
181    0
Name: target, dtype: int64
```

In [41]:
```
accuracy_score(y_test,y_pred)
```

Out[41]:
```
0.8421052631578947
```

In [42]:
```
confusion_matrix(y_test,y_pred)
```

Out[42]:
```
array([[18,  7],
       [ 2, 30]], dtype=int64)
```

In [43]:
```
clf_report = classification_report(y_test,y_pred)
print(clf_report)
```

```
              precision    recall  f1-score   support

           0       0.90      0.72      0.80        25
           1       0.81      0.94      0.87        32

    accuracy                           0.84        57
   macro avg       0.86      0.83      0.83        57
weighted avg       0.85      0.84      0.84        57
```

In [ ]:
```

```