```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from sklearn.preprocessing import LabelEncoder
import seaborn as sns
from sklearn import metrics
```

```
hd = pd.read_csv("./heart.csv")
```

Head and Describe

```
hd.head()
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	c
0	52	1	0	125	212	0	1	168	0	1.0	2	
1	53	1	0	140	203	1	0	155	1	3.1	0	
2	70	1	0	145	174	0	1	125	1	2.6	0	
3	61	1	0	148	203	0	1	161	0	0.0	2	
4	62	0	0	138	294	1	1	106	0	1.9	1	

```
hd.describe()
```

	age	sex	cp	trestbps	chol	fbs	
count	1025.000000	1025.000000	1025.000000	1025.000000	1025.00000	1025.000000	102
mean	54.434146	0.695610	0.942439	131.611707	246.00000	0.149268	
std	9.072290	0.460373	1.029641	17.516718	51.59251	0.356527	
min	29.000000	0.000000	0.000000	94.000000	126.00000	0.000000	
25%	48.000000	0.000000	0.000000	120.000000	211.00000	0.000000	
50%	56.000000	1.000000	1.000000	130.000000	240.00000	0.000000	
75%	61.000000	1.000000	2.000000	140.000000	275.00000	0.000000	
max	77.000000	1.000000	3.000000	200.000000	564.00000	1.000000	

Checking for null values and found none

```
hd.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
```

```
hd.count()
```

```
age         1025
sex         1025
cp          1025
trestbps    1025
chol        1025
fbs         1025
restecg     1025
thalach     1025
exang       1025
oldpeak     1025
slope       1025
ca          1025
thal        1025
target      1025
dtype: int64
```

Checking for duplicates and removing the duplicates

```
hd.index[hd.duplicated()]
```

```
Int64Index([  15,   31,   43,   55,   61,   64,   79,   82,   83,   84,
            ...
            1015, 1016, 1017, 1018, 1019, 1020, 1021, 1022, 1023, 1024],
           dtype='int64', length=723)
```

```
hd.duplicated().sum()
```

```
723
```

```
hd.drop(axis="rows", labels=hd.index[hd.duplicated()], inplace=True)
hd.count()
```

```
age         302
sex         302
cp          302
trestbps    302
chol        302
fbs         302
restecg     302
thalach     302
```

```
exang       302
oldpeak     302
slope       302
ca          302
thal        302
target      302
dtype: int64
```

Remove skew

hd

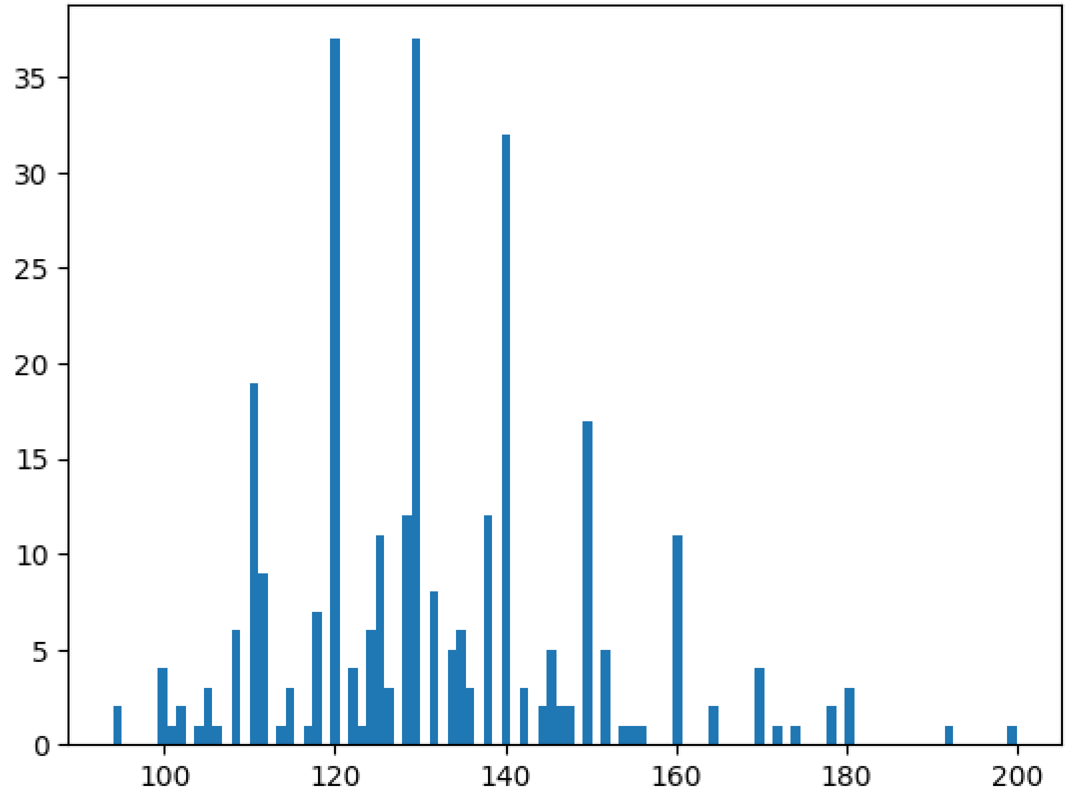
	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope
0	52	1	0	125	212	0	1	168	0	1.0	2
1	53	1	0	140	203	1	0	155	1	3.1	0
2	70	1	0	145	174	0	1	125	1	2.6	0
3	61	1	0	148	203	0	1	161	0	0.0	2
4	62	0	0	138	294	1	1	106	0	1.9	1
...	...	...	...	...	...	...	...	...	...	...	...
723	68	0	2	120	211	0	0	115	0	1.5	1
733	44	0	2	108	141	0	1	175	0	0.6	1
739	52	1	0	128	255	0	1	161	1	0.0	2
843	59	1	3	160	273	0	0	125	0	0.0	2
878	54	1	0	120	188	0	1	113	0	1.4	1

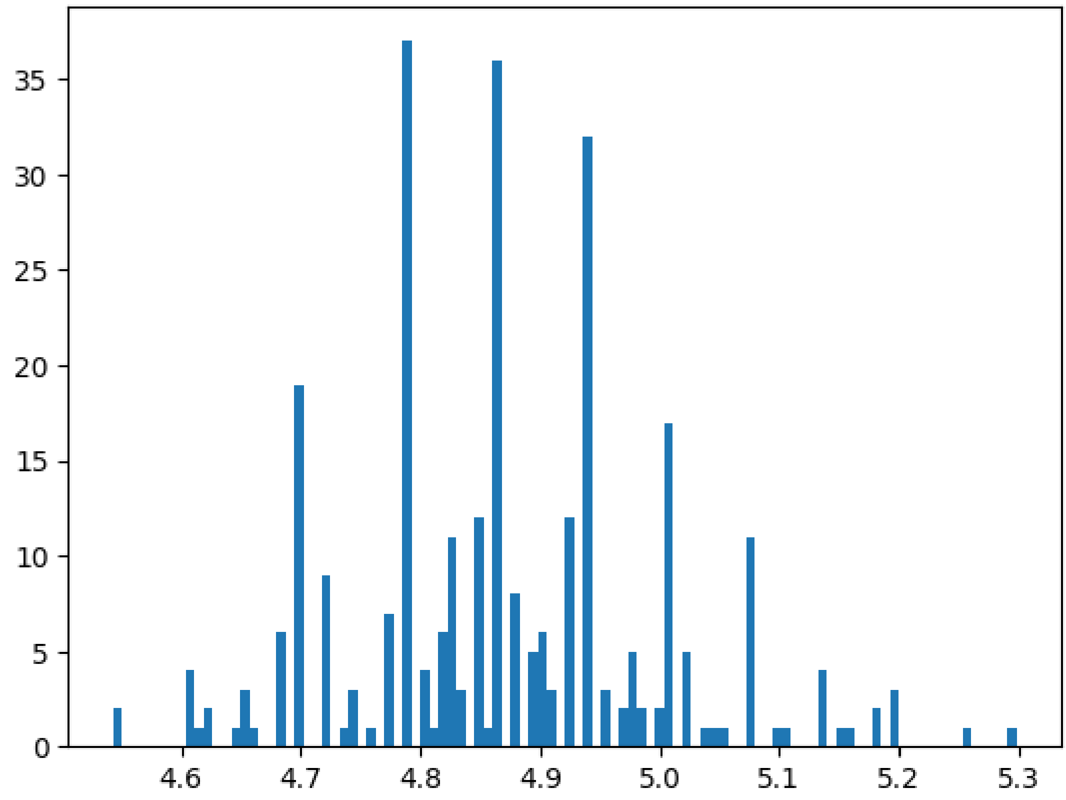
302 rows × 14 columns

```
hd["trestbps"].describe()
```

```
count    302.000000
mean     131.602649
std       17.563394
min       94.000000
25%      120.000000
50%      130.000000
75%      140.000000
max      200.000000
Name: trestbps, dtype: float64
```

```
plt.hist(hd["trestbps"], bins=100)
plt.show()
hd["trestbps"] = np.log(hd["trestbps"])
plt.hist(hd["trestbps"], bins=100)
plt.show()
```





standardization of the data

```
y = hd["target"]
hd = hd.drop(columns=["target"])
```

```
hd = (hd - hd.mean())/(hd.std())
hd.insert(len(hd.columns),"target",y )
```

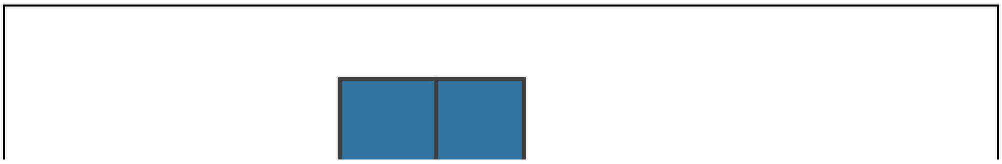
Remove outliers

```
hd
```

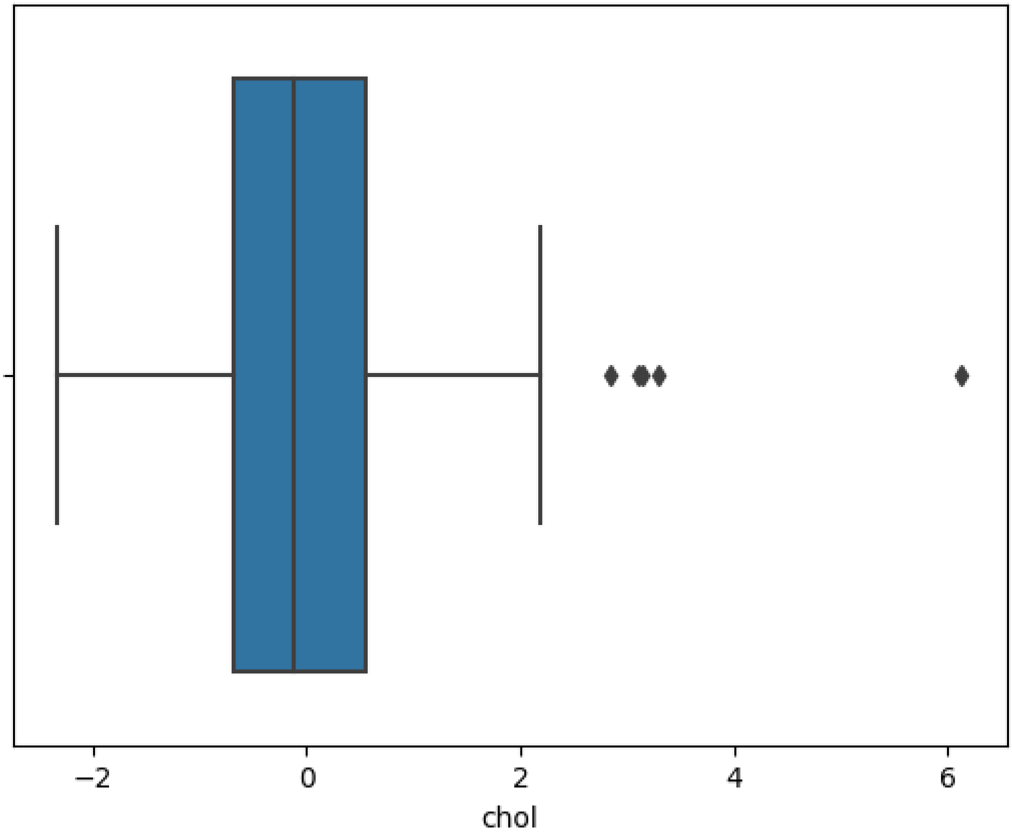
	age	sex	cp	trestbps	chol	fbs	restecg	thalac
0	-0.267522	0.681525	-0.933658	-0.329049	-0.666622	-0.417753	0.900163	0.80470
1	-0.157000	0.681525	-0.933658	0.540256	-0.840523	2.385833	-1.000880	0.23710
2	1.721875	0.681525	-0.933658	0.809430	-1.400872	-0.417753	0.900163	-1.07274
3	0.727176	0.681525	-0.933658	0.966514	-0.840523	-0.417753	0.900163	0.49907
4	0.837698	-1.462439	-0.933658	0.429885	0.917813	2.385833	0.900163	-1.90230
...	...	...	...	...	...	...	...	.
723	1.500831	-1.462439	1.004244	-0.642180	-0.685944	-0.417753	-1.000880	-1.50935
733	-1.151698	-1.462439	1.004244	-1.450365	-2.038510	-0.417753	0.900163	1.11033
739	-0.267522	0.681525	-0.933658	-0.147128	0.164240	-0.417753	0.900163	0.49907
843	0.506132	0.681525	1.973195	1.564530	0.512043	-0.417753	-1.000880	-1.07274
878	-0.046478	0.681525	-0.933658	-0.642180	-1.130359	-0.417753	0.900163	-1.59667

302 rows × 14 columns

```
sns.boxplot(x=hd["trestbps"])
plt.show()
```

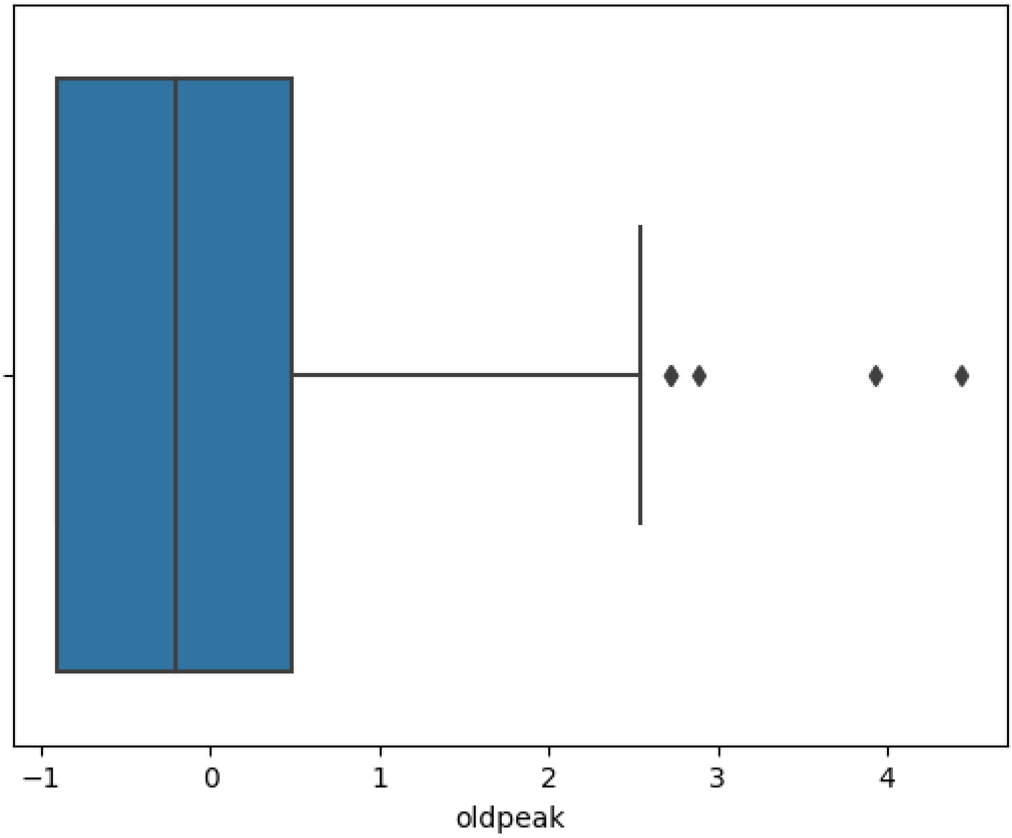


```
sns.boxplot(x=hd["chol"])
plt.show()
```



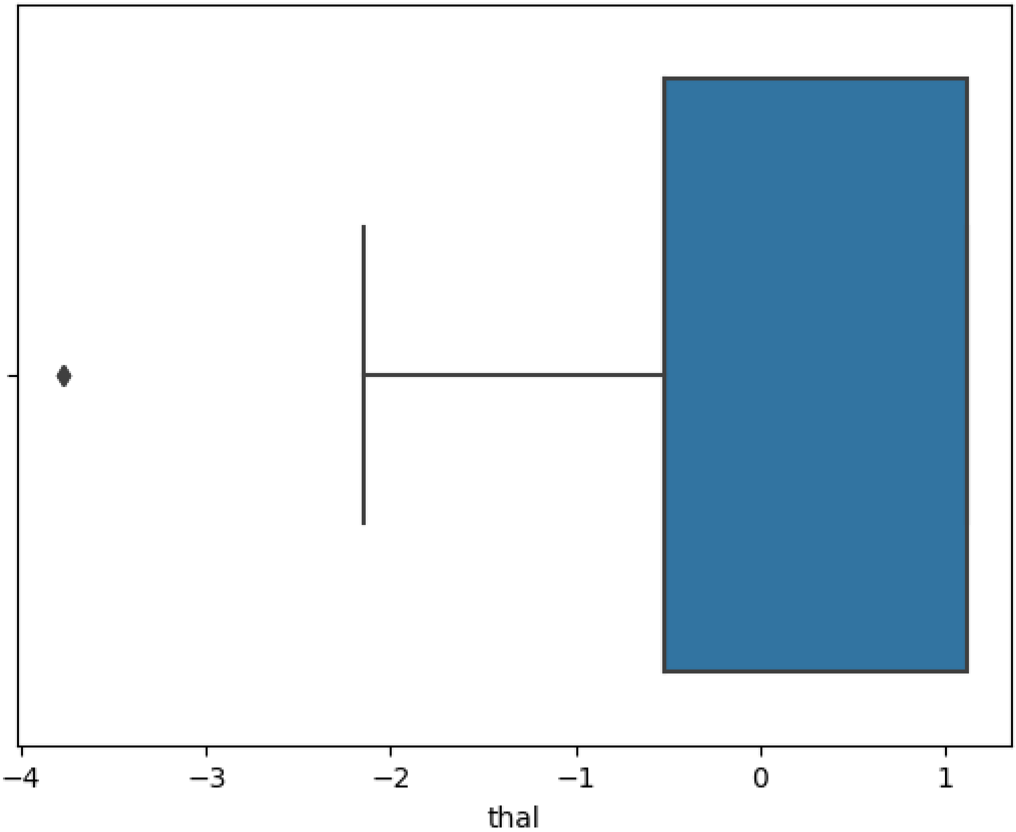

```
sns.boxplot(x=hd["thalach"])
plt.show()
```

```
sns.boxplot(x=hd["oldpeak"])
plt.show()
```

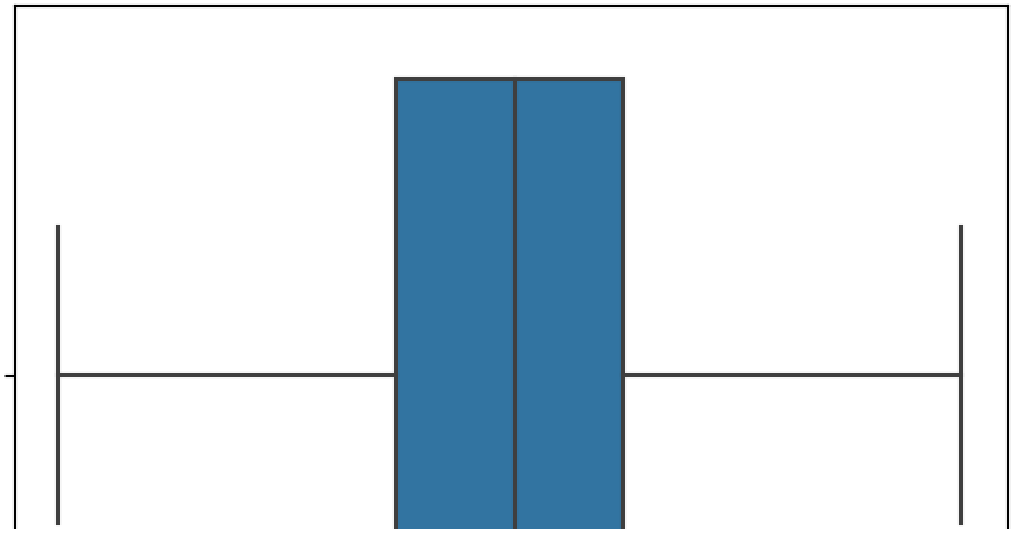



```
sns.boxplot(x=hd["ca"])
plt.show()
```

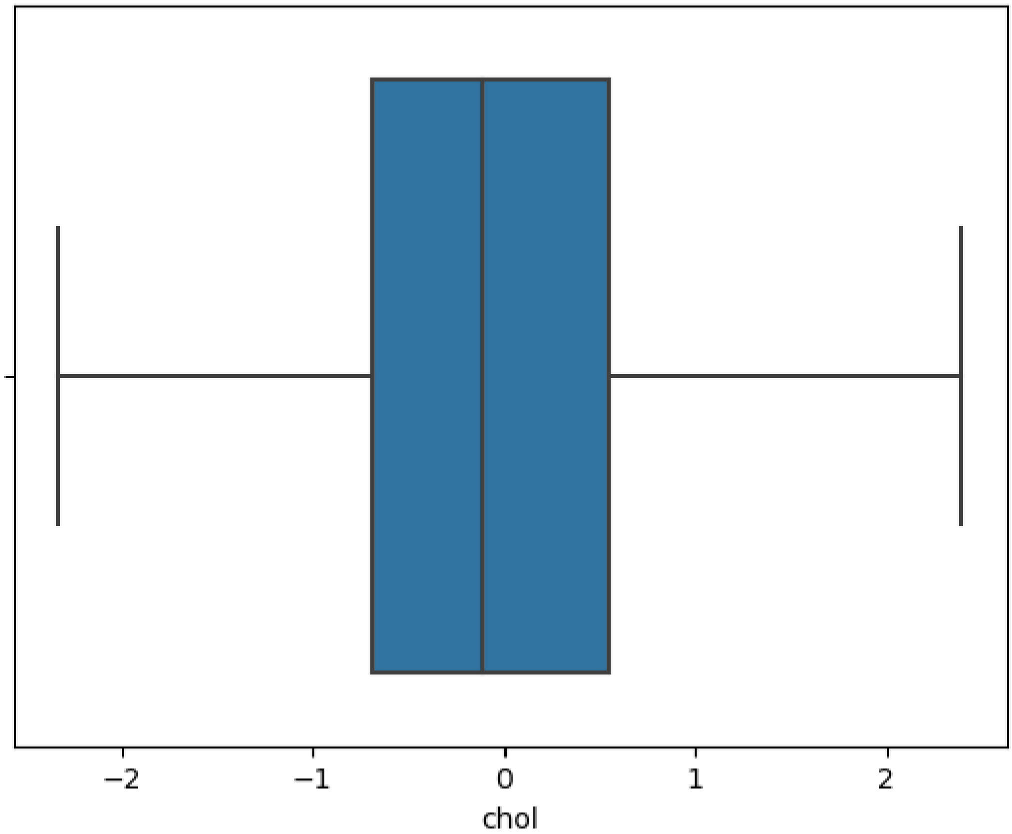
```
sns.boxplot(x=hd["thal"])
plt.show()
```



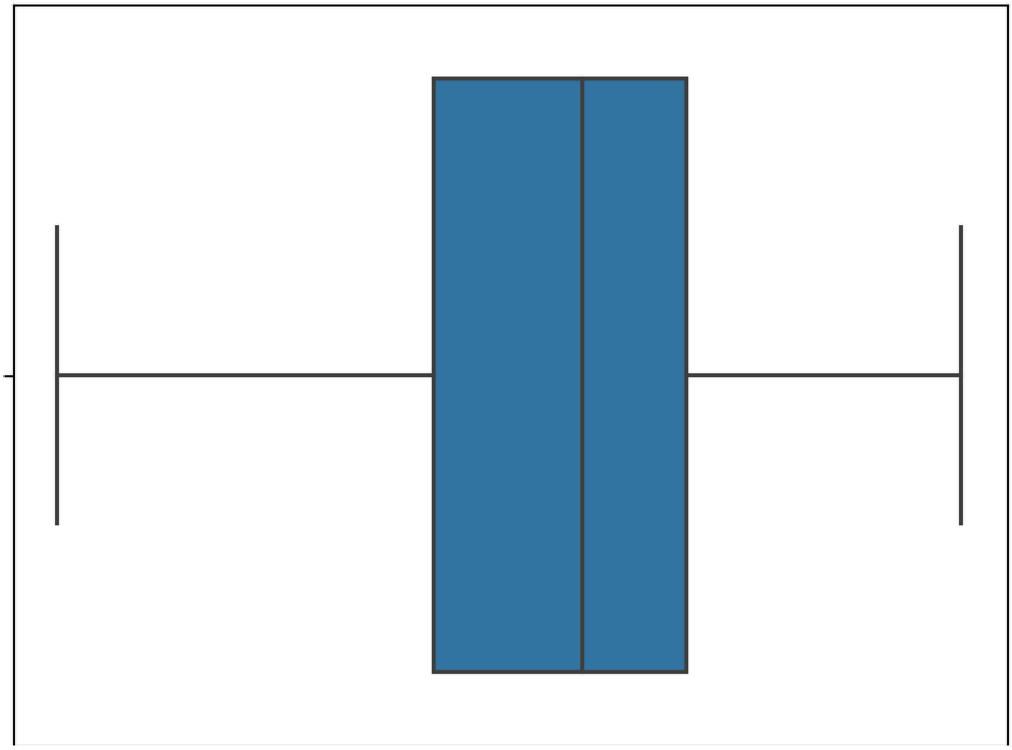

```
class OutlierRemoval:
    def __init__(self, lower_quartile, upper_quartile):
        self.lower_whisker = lower_quartile - 1.5*(upper_quartile - lower_quartile)
        self.upper_whisker = upper_quartile + 1.5*(upper_quartile - lower_quartile)
    def removeOutlier(self, x):
        return (x if x <= self.upper_whisker and x >= self.lower_whisker else (sel

outlier1 = OutlierRemoval(hd["trestbps"].quantile(0.25), hd["trestbps"].quantile(0.
t1 = hd["trestbps"].apply(outlier1.removeOutlier)
hd["trestbps"] = t1
sns.boxplot(x=hd["trestbps"])
plt.show()
```



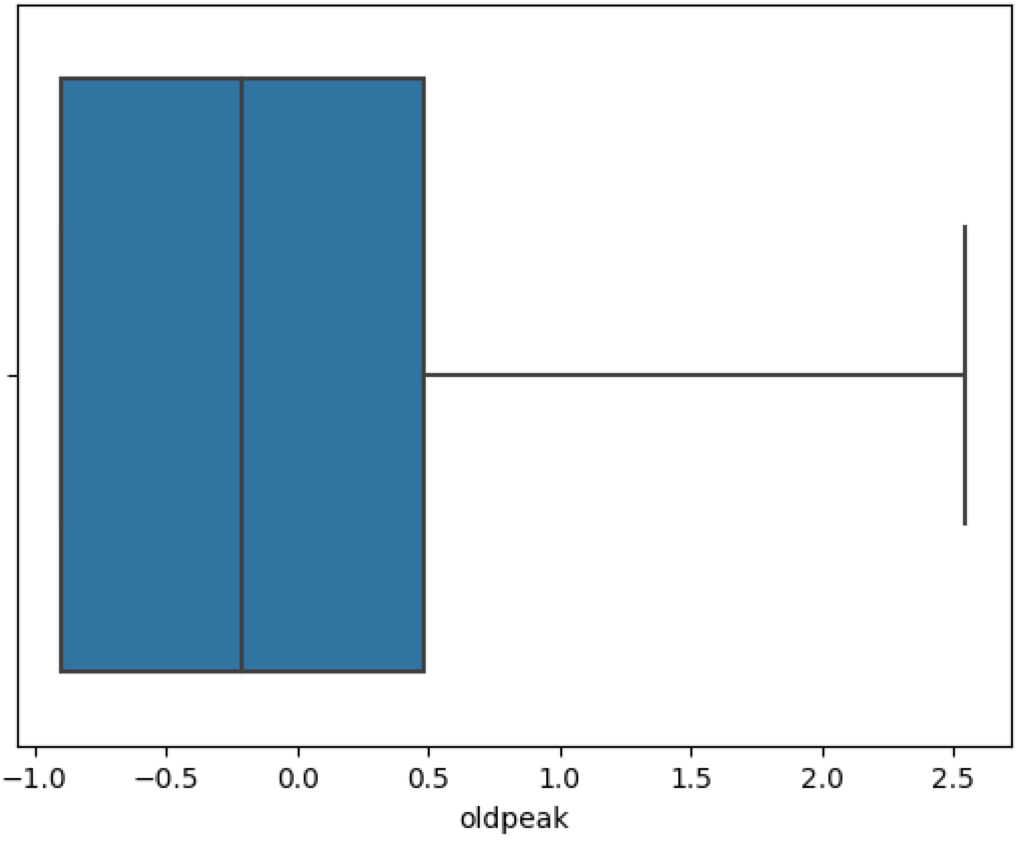
```
outlier2 = OutlierRemoval(hd["chol"].quantile(0.25), hd["chol"].quantile(0.75))
t2 = hd["chol"].apply(outlier2.removeOutlier)
hd["chol"] = t2
sns.boxplot(x=hd["chol"])
plt.show()
```




```
outlier3 = OutlierRemoval(hd["thalach"].quantile(0.25), hd["thalach"].quantile(0.75
t3 = hd["thalach"].apply(outlier3.removeOutlier)
hd["thalach"] = t3
sns.boxplot(x=hd["thalach"])
plt.show()
```

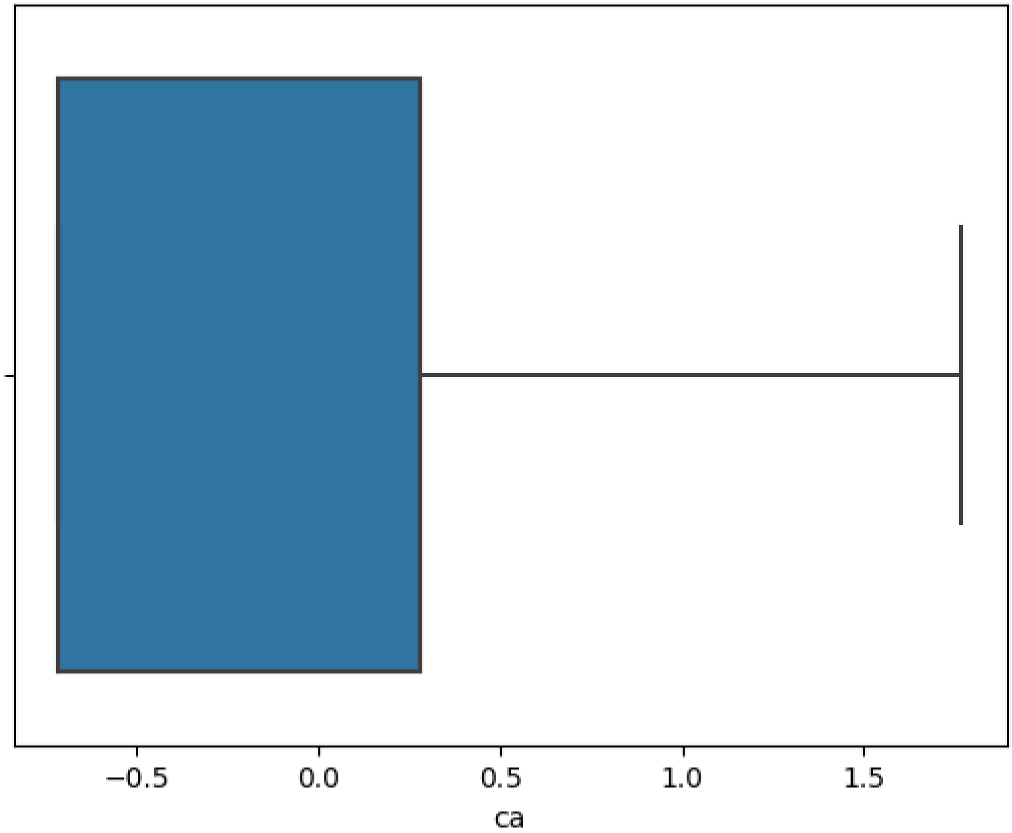


```
outlier4 = OutlierRemoval(hd["oldpeak"].quantile(0.25), hd["oldpeak"].quantile(0.75
t4 = hd["oldpeak"].apply(outlier4.removeOutlier)
hd["oldpeak"] = t4
sns.boxplot(x=hd["oldpeak"])
plt.show()
```




```
outlier5 = OutlierRemoval(hd["ca"].quantile(0.25), hd["ca"].quantile(0.75))
t5 = hd["ca"].apply(outlier5.removeOutlier)
hd["ca"] = t5
```

```
sns.boxplot(x=hd["ca"])
plt.show()
```




```
outlier6 = OutlierRemoval(hd["thal"].quantile(0.25), hd["thal"].quantile(0.75))
t6 = hd["thal"].apply(outlier6.removeOutlier)
hd["thal"] = t6
sns.boxplot(x=hd["thal"])
plt.show()
```

```
hd
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalac
0	-0.267522	0.681525	-0.933658	-0.329049	-0.666622	-0.417753	0.900163	0.80470
1	-0.157000	0.681525	-0.933658	0.540256	-0.840523	2.385833	-1.000880	0.23710
2	1.721875	0.681525	-0.933658	0.809430	-1.400872	-0.417753	0.900163	-1.07274
3	0.727176	0.681525	-0.933658	0.966514	-0.840523	-0.417753	0.900163	0.49907
4	0.837698	-1.462439	-0.933658	0.429885	0.917813	2.385833	0.900163	-1.90230
...	...	...	...	...	...	...	...	.
723	1.500831	-1.462439	1.004244	-0.642180	-0.685944	-0.417753	-1.000880	-1.50935
733	-1.151698	-1.462439	1.004244	-1.450365	-2.038510	-0.417753	0.900163	1.11033
739	-0.267522	0.681525	-0.933658	-0.147128	0.164240	-0.417753	0.900163	0.49907
843	0.506132	0.681525	1.973195	1.564530	0.512043	-0.417753	-1.000880	-1.07274
878	-0.046478	0.681525	-0.933658	-0.642180	-1.130359	-0.417753	0.900163	-1.59667

302 rows × 14 columns

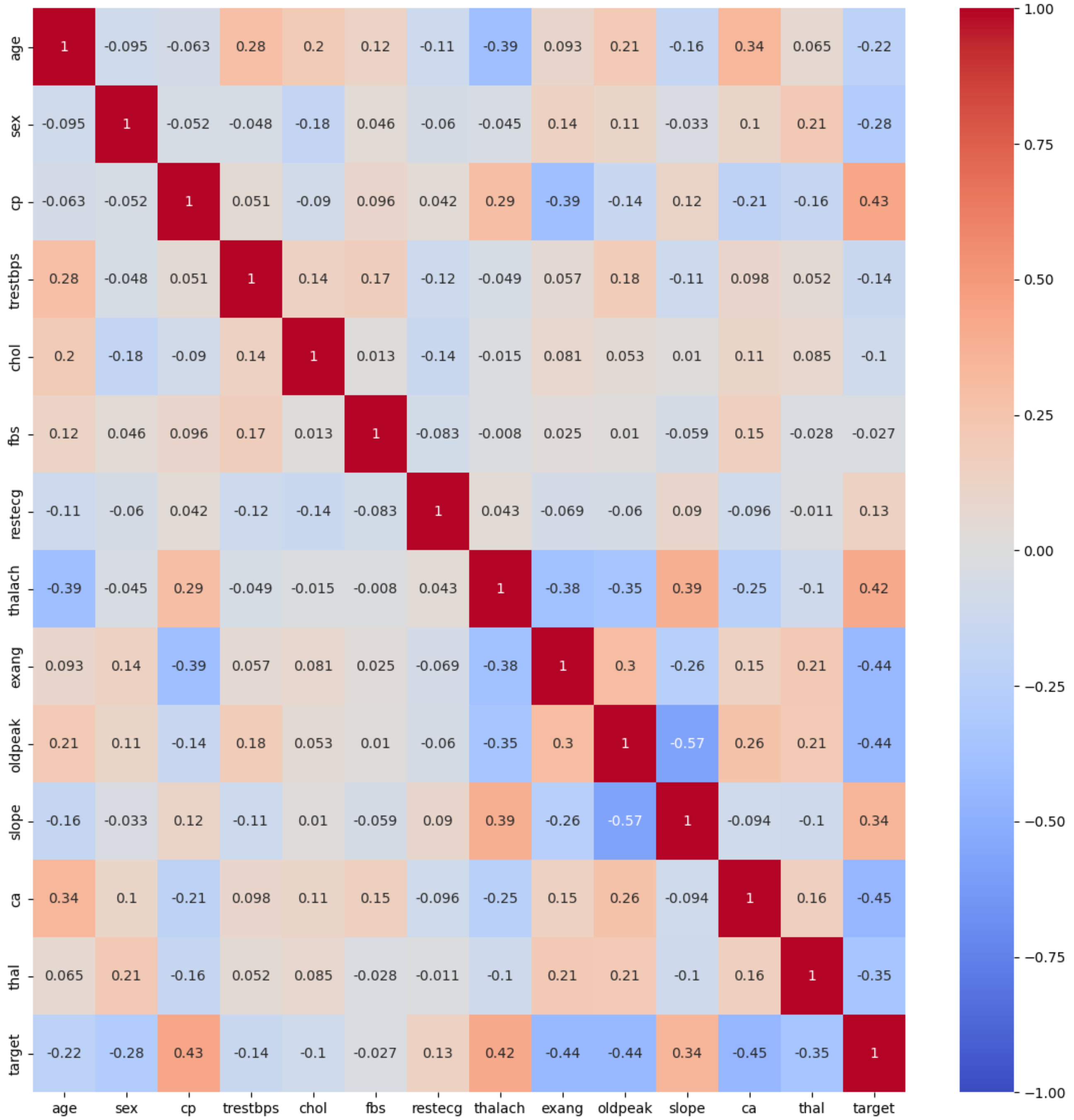
Correlation matrix

```
c=hd.corr()
ct = abs(c["target"])
rf = ct[ct>0.15]
rf
```

```
age        0.221476
sex        0.283609
cp         0.432080
thalach    0.420408
exang      0.435601
oldpeak    0.435099
slope      0.343940
ca         0.447434
thal       0.350021
target     1.000000
Name: target, dtype: float64
```

```
plt.figure(figsize=(14,14))
sns.heatmap(hd.corr(), vmin=-1, cmap="coolwarm", annot=True)
```

<AxesSubplot:>



Done with preprocessing and can start with the classification.

Checking number of classes

```
hd["target"].unique()
```

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

```
hd
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalac
0	-0.267522	0.681525	-0.933658	-0.329049	-0.666622	-0.417753	0.900163	0.80470
1	-0.157000	0.681525	-0.933658	0.540256	-0.840523	2.385833	-1.000880	0.23710
2	1.721875	0.681525	-0.933658	0.809430	-1.400872	-0.417753	0.900163	-1.07274
3	0.727176	0.681525	-0.933658	0.966514	-0.840523	-0.417753	0.900163	0.49907
4	0.837698	-1.462439	-0.933658	0.429885	0.917813	2.385833	0.900163	-1.90230
...	...	...	...	...	...	...	...	.
723	1.500831	-1.462439	1.004244	-0.642180	-0.685944	-0.417753	-1.000880	-1.50935
733	-1.151698	-1.462439	1.004244	-1.450365	-2.038510	-0.417753	0.900163	1.11033
739	-0.267522	0.681525	-0.933658	-0.147128	0.164240	-0.417753	0.900163	0.49907
843	0.506132	0.681525	1.973195	1.564530	0.512043	-0.417753	-1.000880	-1.07274
878	-0.046478	0.681525	-0.933658	-0.642180	-1.130359	-0.417753	0.900163	-1.59667

302 rows × 14 columns

```
def train_test_data(hd):

    shuffle_df = hd.sample(frac=1)
    train_set = shuffle_df[:int(0.9 * len(hd))]
    X_train = train_set.drop(columns=["target"])
    Y_train = train_set["target"]

    shuffle_df = hd.sample(frac=1)
    test_set = shuffle_df[int(0.9*len(hd)):]
    X_test = test_set.drop(columns=["target"])
    Y_test = test_set["target"]


    return X_train, Y_train, X_test, Y_test
```

Multivariate logistic regression

```
X_train, Y_train, X_test, Y_test = train_test_data(hd)
```

```
ones = np.ones([X_train.shape[0],1])
X_train.insert(0,'ones', ones )
ones = np.ones([X_test.shape[0],1])
X_test.insert(0,'ones', ones )
```

```
X_test
```

	ones	age	sex	cp	trestbps	chol	fbs	restecg
184	1.0	-1.041176	0.681525	0.035293	-0.147128	1.188326	-0.417753	-1.000880
94	1.0	0.837698	0.681525	0.035293	-0.147128	-0.743911	2.385833	-1.000880
262	1.0	-0.709610	0.681525	-0.933658	-0.515390	-0.473398	-0.417753	-1.000880
47	1.0	1.279787	-1.462439	-0.933658	2.313911	-0.357464	2.385833	0.900163
143	1.0	-2.256918	0.681525	1.973195	-0.771102	-1.246293	-0.417753	-1.000880
332	1.0	-1.925352	0.681525	1.004244	-0.028200	0.067628	-0.417753	0.900163

```
X_train
```

	ones	age	sex	cp	trestbps	chol	fbs	restecg	t
19	1.0	0.395610	0.681525	1.004244	0.540256	-0.685944	2.385833	-1.000880	C
332	1.0	-1.925352	0.681525	1.004244	-0.028200	0.067628	-0.417753	0.900163	1
267	1.0	1.390309	0.681525	-0.933658	-0.642180	-0.183563	-0.417753	0.900163	-2
368	1.0	0.395610	0.681525	1.004244	-1.666454	-0.125595	-0.417753	-1.000880	C
382	1.0	0.506132	0.681525	-0.933658	-1.309615	-0.144918	-0.417753	-1.000880	-C
...	...	...	...	...	...	...	...	...	
13	1.0	-0.378044	0.681525	-0.933658	0.540256	0.995102	-0.417753	0.900163	-1
148	1.0	-0.267522	0.681525	1.973195	1.171076	0.995102	2.385833	0.900163	1
34	1.0	-0.488566	0.681525	1.004244	-0.087434	-0.975780	-0.417753	0.900163	C
22	1.0	-1.041176	0.681525	-0.933658	-1.739858	-0.743911	-0.417753	-1.000880	-C
343	1.0	-0.267522	0.681525	1.004244	2.119277	-0.917813	2.385833	0.900163	C

271 rows × 14 columns

Done wit alloting X and Y's along with training and testing datas

Functions

```
def sigmoid(x):
  return 1/(1+np.exp(-x))
```

```
def compute_tp_tn_fn_fp(y_act, y_pred):
  '''
  True positive - actual = 1, predicted = 1
  False positive - actual = 1, predicted = 0
  False negative - actual = 0, predicted = 1
  True negative - actual = 0, predicted = 0
  '''
  tp = sum((y_act == 1) & (y_pred == 1))
```

```
    tn = sum((y_act == 0) & (y_pred == 0))
    fn = sum((y_act == 1) & (y_pred == 0))
    fp = sum((y_act == 0) & (y_pred == 1))
    return tp, tn, fp, fn

def compute_precision(tp, fp):
    '''
    Precision = TP  / FP + TP

    '''
    return (tp  * 100)/ float( tp + fp)

def compute_recall(tp, fn):
    '''
    Recall = TP /FN + TP

    '''
    return (tp  * 100)/ float( tp + fn)

def compute_f1_score(y_true, y_pred):
    # calculates the F1 score
    tp, tn, fp, fn = compute_tp_tn_fn_fp(y_true, y_pred)
    precision = compute_precision(tp, fp)/100
    recall = compute_recall(tp, fn)/100
    f1_score = (2*precision*recall)/ (precision + recall)
    return f1_score




def compute_accuracy(y_true, y_pred):
    tp, tn, fn, fp = compute_tp_tn_fn_fp(y_true, y_pred)
    return ((tp + tn) * 100)/ float( tp + tn + fn + fp)
```

setting learning rate, no of iterations and W vector

```
learning_rate = 0.01
n = 1000
W = np.random.uniform(low = -5, high =10, size = len(X_train.columns))
```

predicting Y from train and test datas

```
for i in range(n):
    temp = sigmoid(X_train@W)
    gradient = X_train.T@(Y_train-temp)
    W = W + learning_rate*gradient

class_prediction_train = np.array(sigmoid(X_train@W))

for i in range(len(class_prediction_train)):
    if(class_prediction_train[i] >= 0.5):
        class_prediction_train[i]=1
```

```
    else:
        class_prediction_train[i]=0

class_prediction_test = np.array(sigmoid(X_test@W))

for i in range(len(class_prediction_test)):
    if(class_prediction_test[i] >= 0.5):
        class_prediction_test[i]=1
    else:
        class_prediction_test[i]=0

from sklearn.metrics import mean_squared_error
# A = metrics.accuracy_score(Y_train, class_prediction_train)*100
# a11 = metrics.accuracy_score(Y_test, class_prediction_test)*100
A = compute_accuracy(np.array(Y_train),np.array(class_prediction_train))
a = compute_accuracy(np.array(Y_test),np.array(class_prediction_test))
```

Accuracy and f1 scores

```
# A
```

```
a
```

```
93.54838709677419
```

```
# a11
```

```
# F = metrics.f1_score(Y_train, class_prediction_train)
# f11 = metrics.f1_score(Y_test, class_prediction_test)
F = compute_f1_score(np.array(Y_train),np.array(class_prediction_train))
f = compute_f1_score(np.array(Y_test),np.array(class_prediction_test))
```

```
# F
```

```
f
```

```
0.9473684210526316
```

```
# f11
```

multivariate Bayes classification

Dividing X and Y to class 1 and 0

```
hd
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalac
0	-0.267522	0.681525	-0.933658	-0.329049	-0.666622	-0.417753	0.900163	0.80470
1	-0.157000	0.681525	-0.933658	0.540256	-0.840523	2.385833	-1.000880	0.23710
2	1.721875	0.681525	-0.933658	0.809430	-1.400872	-0.417753	0.900163	-1.07274
3	0.727176	0.681525	-0.933658	0.966514	-0.840523	-0.417753	0.900163	0.49907
4	0.837698	-1.462439	-0.933658	0.429885	0.917813	2.385833	0.900163	-1.90230
...	...	...	...	...	...	...	...	.
723	1.500831	-1.462439	1.004244	-0.642180	-0.685944	-0.417753	-1.000880	-1.50935
733	-1.151698	-1.462439	1.004244	-1.450365	-2.038510	-0.417753	0.900163	1.11033
739	-0.267522	0.681525	-0.933658	-0.147128	0.164240	-0.417753	0.900163	0.49907
843	0.506132	0.681525	1.973195	1.564530	0.512043	-0.417753	-1.000880	-1.07274
878	-0.046478	0.681525	-0.933658	-0.642180	-1.130359	-0.417753	0.900163	-1.59667

302 rows × 14 columns

```
X_train.insert(len(X_train.columns),"target",Y_train )
X_train
```

	ones	age	sex	cp	trestbps	chol	fbs	restecg	t
19	1.0	0.395610	0.681525	1.004244	0.540256	-0.685944	2.385833	-1.000880	0
332	1.0	-1.925352	0.681525	1.004244	-0.028200	0.067628	-0.417753	0.900163	1
267	1.0	1.390309	0.681525	-0.933658	-0.642180	-0.183563	-0.417753	0.900163	-2
368	1.0	0.395610	0.681525	1.004244	-1.666454	-0.125595	-0.417753	-1.000880	0
382	1.0	0.506132	0.681525	-0.933658	-1.309615	-0.144918	-0.417753	-1.000880	-0
...	...	...	...	...	...	...	...	...	
13	1.0	-0.378044	0.681525	-0.933658	0.540256	0.995102	-0.417753	0.900163	-1
148	1.0	-0.267522	0.681525	1.973195	1.171076	0.995102	2.385833	0.900163	1
34	1.0	-0.488566	0.681525	1.004244	-0.087434	-0.975780	-0.417753	0.900163	0
22	1.0	-1.041176	0.681525	-0.933658	-1.739858	-0.743911	-0.417753	-1.000880	-0
343	1.0	-0.267522	0.681525	1.004244	2.119277	-0.917813	2.385833	0.900163	0

271 rows × 15 columns

```
X_train  = X_train.drop(columns = ["ones"])
X_test  = X_test.drop(columns = ["ones"])
X_train
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach
19	0.395610	0.681525	1.004244	0.540256	-0.685944	2.385833	-1.000880	0.67371
332	-1.925352	0.681525	1.004244	-0.028200	0.067628	-0.417753	0.900163	1.63426
267	1.390309	0.681525	-0.933658	-0.642180	-0.183563	-0.417753	0.900163	-2.85740
368	0.395610	0.681525	1.004244	-1.666454	-0.125595	-0.417753	-1.000880	0.19344
382	0.506132	0.681525	-0.933658	-1.309615	-0.144918	-0.417753	-1.000880	-0.33049
...	...	...	...	...	...	...	...	..
13	-0.378044	0.681525	-0.933658	0.540256	0.995102	-0.417753	0.900163	-1.20372
148	-0.267522	0.681525	1.973195	1.171076	0.995102	2.385833	0.900163	1.24131
34	-0.488566	0.681525	1.004244	-0.087434	-0.975780	-0.417753	0.900163	0.58639
22	-1.041176	0.681525	-0.933658	-1.739858	-0.743911	-0.417753	-1.000880	-0.06852
343	-0.267522	0.681525	1.004244	2.119277	-0.917813	2.385833	0.900163	0.54273

splitting training data into 2 parts base don their outputs

```
X_train0 = X_train.loc[X_train.iloc[:,13] == 0]
X_train1 = X_train.loc[X_train.iloc[:,13] == 1]
```

```
X_train1 = X_train1.drop(columns=["target"])
X_train0 = X_train0.drop(columns=["target"])
X_train = X_train.drop(columns=["target"])
```

```
X0 = hd.loc[hd.iloc[:,13] == 0]
X1 = hd.loc[hd.iloc[:,13] == 1]
print(X1.count())
print(X0.count())
```

```
age         164
sex         164
cp          164
trestbps    164
chol        164
fbs         164
restecg     164
thalach     164
exang       164
oldpeak     164
slope       164
ca          164
thal        164
target      164
dtype: int64
age         138
sex         138
cp          138
trestbps    138
```

```
chol        138
fbs         138
restecg     138
thalach     138
exang       138
oldpeak     138
slope       138
ca          138
thal        138
target      138
dtype: int64
```

Finding the mean and variance for inputs corresponding to outputs 0 and 1

```
mean0=[]
mean1=[]
sigma0=[]
sigma1=[]

for i in X_train1:
    M1 = np.mean(X_train1[i].values)
    mean1.append(M1)

    S1 = np.std(X_train1[i].values)
    sigma1.append(S1)

for i in X_train0:
    M0 = np.mean(X_train0[i].values)
    mean0.append(M0)

    S0 = np.std(X_train0[i].values)
    sigma0.append(S0)
```

```
sigma0
```

```
[0.8955810393883068,
 0.7672124411762409,
 0.903282766192504,
 0.997788808000423,
 0.8664168376451138,
 1.0448348563402672,
 1.0035264828178687,
 0.9839959885255143,
 1.056801914594122,
 1.0073600493813222,
 0.9085303516893541,
 0.9147356797013377,
 1.095277030711347]
```

```
def probability(mu, sigma, x):
    return 1/(sigma * np.sqrt(2 * np.pi)) * np.exp( - (x - mu)**2 / (2 * sigma**2))
```

```
X_train0.shape[0]
```

```
126
```

train and test output predictions

```
P0 = X_train0.shape[0]/X_train0.shape[0] + X_train1.shape[0]
P1 = X_train1.shape[0]/X_train0.shape[0] + X_train1.shape[0]

Y_train_pred = []
for i in range(X_train.shape[0]):
    p0_train = P0
    p1_train = P1
    for j in range(X_train.shape[1]):
        xij = X_train.iat[i,j]
        p0_train *= probability(mean0[j], sigma0[j], xij)
        p1_train *= probability(mean1[j], sigma1[j], xij)
    if(p0_train > p1_train):
        Y_train_pred.append(0)
    else:
        Y_train_pred.append(1)

Y_test_pred = []
for i in range(X_test.shape[0]):
    p0_test = P0
    p1_test = P1
    for j in range(X_test.shape[1]):
        xij1 = X_test.iat[i,j]
        p0_test *= probability(mean0[j], sigma0[j], xij1)
        p1_test *= probability(mean1[j], sigma1[j], xij1)
    if(p0_test > p1_test):
        Y_test_pred.append(0)
    else:
        Y_test_pred.append(1)
```

Accuracy and F1 scores

```
# A11 =  metrics.accuracy_score(Y_train, Y_train_pred)*100
# F11 = metrics.f1_score(Y_train, Y_train_pred)
A = compute_accuracy(np.array(Y_train),np.array(Y_train_pred))
F = compute_f1_score(np.array(Y_train),np.array(Y_train_pred))


a11 =  metrics.accuracy_score(Y_test, Y_test_pred)*100
f11 = metrics.f1_score(Y_test, Y_test_pred)
a = compute_accuracy(np.array(Y_test),np.array(Y_test_pred))
f = compute_f1_score(np.array(Y_test),np.array(Y_test_pred))
```

```
f
```

0.8947368421052632

```
# f11
```

```
a
```

87.09677419354838

```
# a11
```

Univariate classification

logistic regression

```
X_train
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach
19	0.395610	0.681525	1.004244	0.540256	-0.685944	2.385833	-1.000880	0.67371
332	-1.925352	0.681525	1.004244	-0.028200	0.067628	-0.417753	0.900163	1.63426
267	1.390309	0.681525	-0.933658	-0.642180	-0.183563	-0.417753	0.900163	-2.85740
368	0.395610	0.681525	1.004244	-1.666454	-0.125595	-0.417753	-1.000880	0.19344
382	0.506132	0.681525	-0.933658	-1.309615	-0.144918	-0.417753	-1.000880	-0.33049
...	...	...	...	...	...	...	...	..
13	-0.378044	0.681525	-0.933658	0.540256	0.995102	-0.417753	0.900163	-1.20372
148	-0.267522	0.681525	1.973195	1.171076	0.995102	2.385833	0.900163	1.24131
34	-0.488566	0.681525	1.004244	-0.087434	-0.975780	-0.417753	0.900163	0.58639
22	-1.041176	0.681525	-0.933658	-1.739858	-0.743911	-0.417753	-1.000880	-0.06852
343	-0.267522	0.681525	1.004244	2.119277	-0.917813	2.385833	0.900163	0.54273

271 rows × 13 columns

selected a feature for classification

```
train_X = X_train.iloc[:,11:12]
ones = np.ones([train_X.shape[0],1])
train_X.insert(0,'ones', ones )

test_X = X_test.iloc[:,11:12]
ones = np.ones([test_X.shape[0],1])
```

```
test_X.insert(0,'ones', ones )
test_X
```

ones **ca**

Gradient descent

94 1.0 -0.713727

```
w = np.random.uniform(low = -5, high =10, size = len(train_X.columns))

for i in range(n):
    temp1 = sigmoid(train_X@w)
    gradient1 = train_X.T@(Y_train-temp1)
    w = w + learning_rate*gradient1
```

predicting y values for training and test datas

```
class_prediction_train1 = np.array(sigmoid(train_X@w))

for i in range(len(class_prediction_train1)):
    if(class_prediction_train1[i] >= 0.5):
        class_prediction_train1[i]=1
    else:
        class_prediction_train1[i]=0

class_prediction_test1 = np.array(sigmoid(test_X@w))

for i in range(len(class_prediction_test1)):
    if(class_prediction_test1[i] >= 0.5):
        class_prediction_test1[i]=1
    else:
        class_prediction_test1[i]=0
```

F1 and Accuracy values

```
# A11 = metrics.accuracy_score(Y_train, class_prediction_train1)*100
# a11 = metrics.accuracy_score(Y_test, class_prediction_test1)*100

A1 = compute_accuracy(np.array(Y_train),np.array(class_prediction_train1))
a1 = compute_accuracy(np.array(Y_test),np.array(class_prediction_test1))
```

```
# A1
```

```
a1
```

```
70.96774193548387
```

384 1.0 -0.713727

```
# F11 = metrics.f1_score(Y_train, class_prediction_train1)
# f11 = metrics.f1_score(Y_test, class_prediction_test1)

F1 = compute_f1_score(np.array(Y_train),np.array(class_prediction_train1))
f1 = compute_f1_score(np.array(Y_test),np.array(class_prediction_test1))
```

```
# F1
```

```
f1
```

```
0.7692307692307692
```

Naive Bayes

Finding mean and standard deviation for the feature chosen

```
train_X1 = X_train1.iloc[:,11:12]
train_X0 = X_train0.iloc[:,11:12]

nu1 = np.mean(np.array(train_X1))
nu0 = np.mean(np.array(train_X0))

sig1 = np.std(np.array(train_X1))
sig0 = np.std(np.array(train_X0))
```

```
train_X
```

	ones	ca
19	1.0	-0.713727
332	1.0	-0.713727
267	1.0	-0.713727
368	1.0	-0.713727
382	1.0	0.279570
...	...	...
13	1.0	1.769516
148	1.0	-0.713727
34	1.0	-0.713727
22	1.0	-0.713727
343	1.0	-0.713727

271 rows × 2 columns

Predicting Y values for training and test data sets

```
Y_train_pred1 = []
```

```
for i in range(X_train.shape[0]):
    p0_traint = P0
    p1_traint = P1
    # print(p0_traint)
    # print(p1_traint)
    p0_traint *= probability(nu0,sig0,train_X.iat[i,1])
    p1_traint *= probability(nu1,sig1,train_X.iat[i,1])
    if(p1_traint > p0_traint):
        Y_train_pred1.append(1)
    else:
        Y_train_pred1.append(0)


Y_test_pred1 = []

for i in range(X_test.shape[0]):
    p0_testt = P0
    p1_testt = P1
    p0_testt *= probability(nu0,sig0,test_X.iat[i,1])
    p1_testt *= probability(nu1,sig1,test_X.iat[i,1])
    if(p0_testt > p1_testt):
        Y_test_pred1.append(0)
    else:
        Y_test_pred1.append(1)
len(Y_train_pred1)
```

```
271
```

Accuracy and F1 values calculation

```
# A11 = metrics.accuracy_score(Y_train, Y_train_pred1)*100
# a11 = metrics.accuracy_score(Y_test, Y_test_pred1)*100

A1 = compute_accuracy(np.array(Y_train),np.array(Y_train_pred1))
a1 = compute_accuracy(np.array(Y_test),np.array(Y_test_pred1))
```

```
# A1
```

```
a1
```

```
70.96774193548387
```

```
# F11 = metrics.f1_score(Y_train, Y_train_pred1)
# f11 = metrics.f1_score(Y_test, Y_test_pred1)

F1 = compute_f1_score(np.array(Y_train),np.array(Y_train_pred1))
f1 = compute_f1_score(np.array(Y_test),np.array(Y_test_pred1))
```

```
# F1
```

```
f1
```

```
0.7692307692307692
```