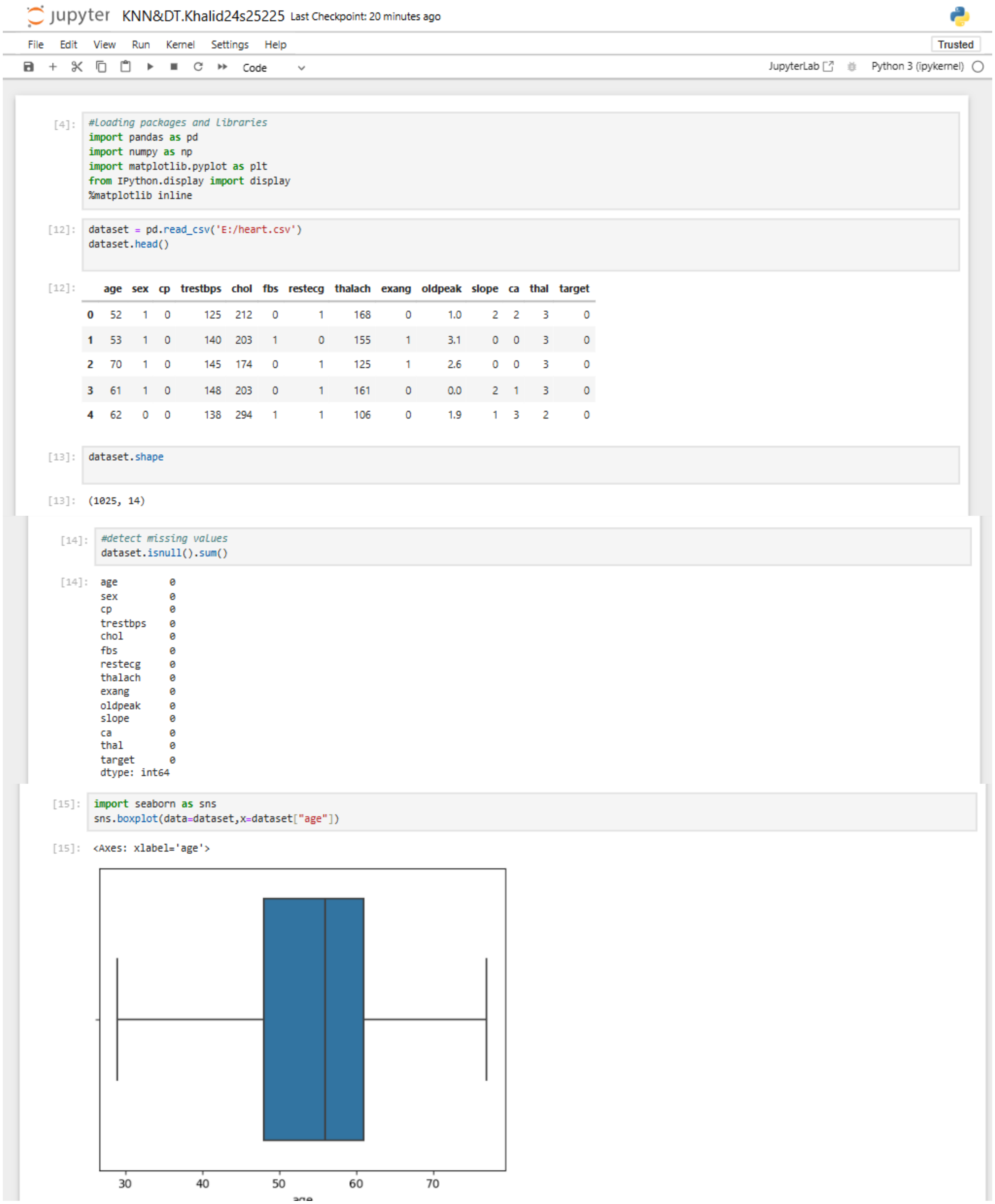


```
[4]:  #loading packages and libraries
      import pandas as pd
      import numpy as np
      import matplotlib.pyplot as plt
      from IPython.display import display
      %matplotlib inline
```

```
[12]: dataset = pd.read_csv('E:/heart.csv')
      dataset.head()
```

[12]:

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

```
[13]: dataset.shape
```

```
[13]: (1025, 14)
```

```
[14]: #detect missing values
      dataset.isnull().sum()
```

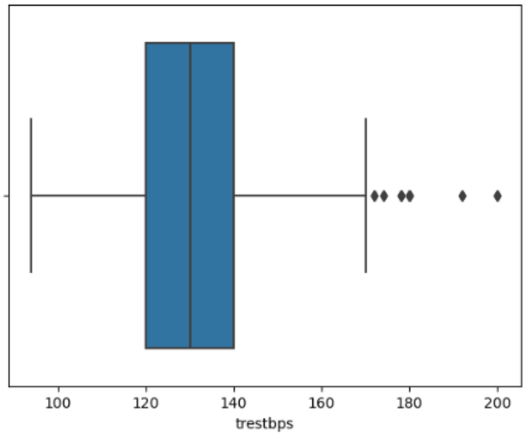
```
[14]: age         0
      sex         0
      cp          0
      trestbps    0
      chol        0
      fbs         0
      restecg     0
      thalach     0
      exang       0
      oldpeak     0
      slope       0
      ca          0
      thal        0
      target      0
      dtype: int64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

```
[15]: import seaborn as sns
      sns.boxplot(data=dataset,x=dataset["age"])
```

```
[15]: <Axes: xlabel='age'>
```

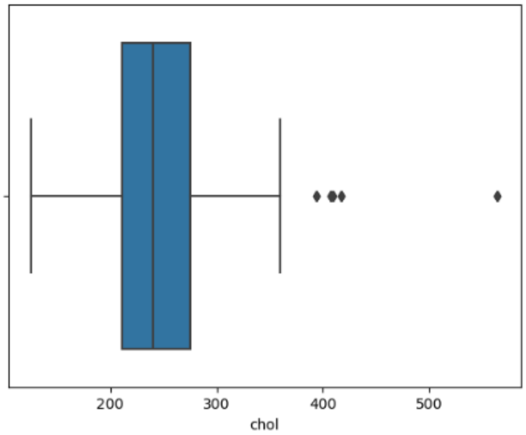
```
[16]: sns.boxplot(data=dataset,x=dataset["trestbps"])
```

```
[16]: <Axes: xlabel='trestbps'>
```



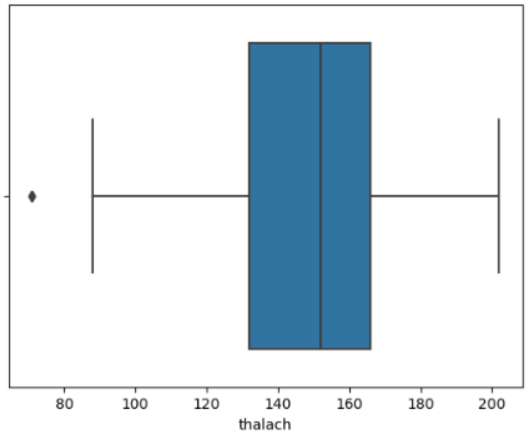
```
[17]: sns.boxplot(data=dataset,x=dataset["chol"])
```

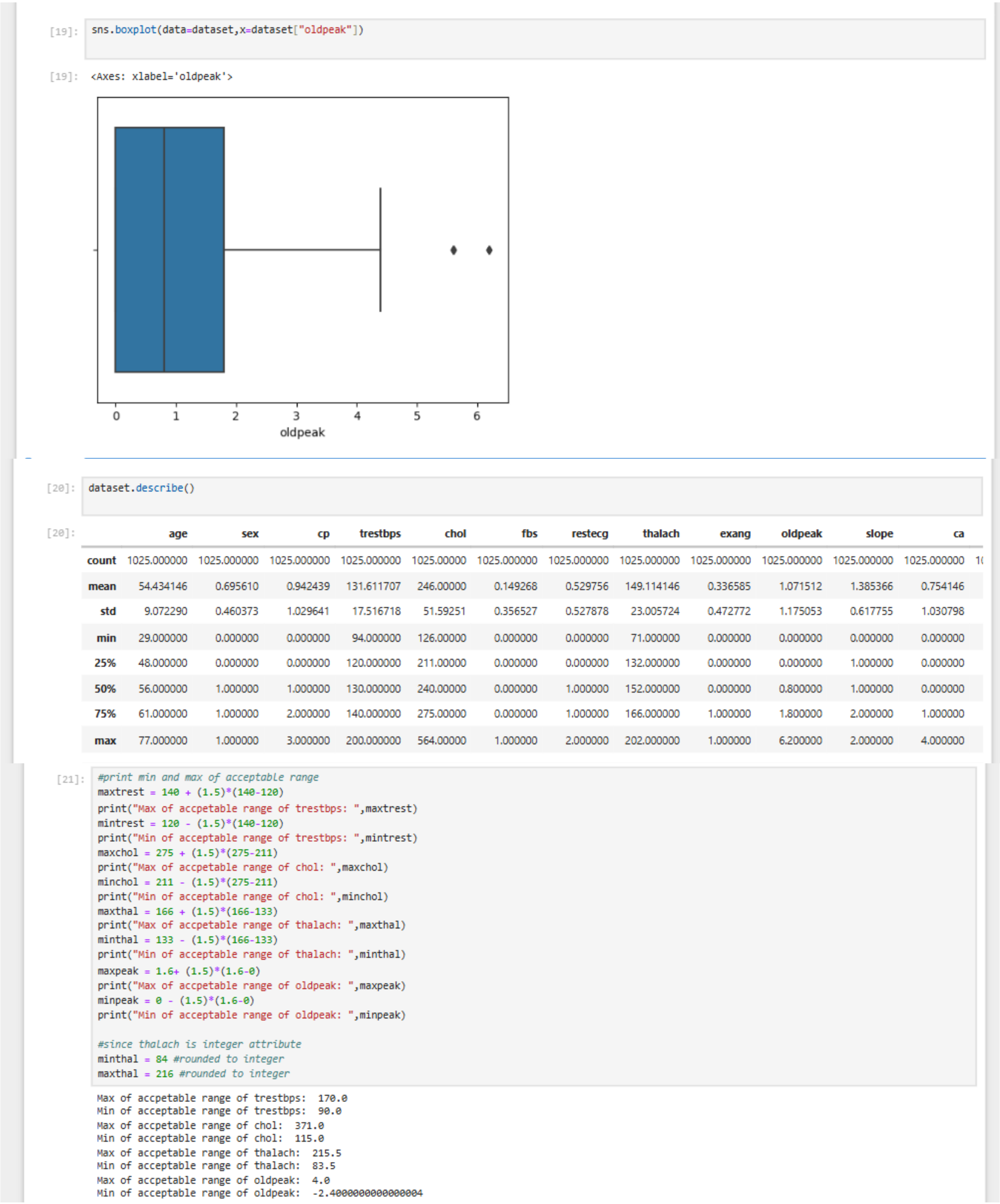
```
[17]: <Axes: xlabel='chol'>
```



```
[18]: sns.boxplot(data=dataset,x=dataset["thalach"])
```

```
[18]: <Axes: xlabel='thalach'>
```





```
[19]: sns.boxplot(data=dataset,x=dataset["oldpeak"])
```

```
[19]: <Axes: xlabel='oldpeak'>
```

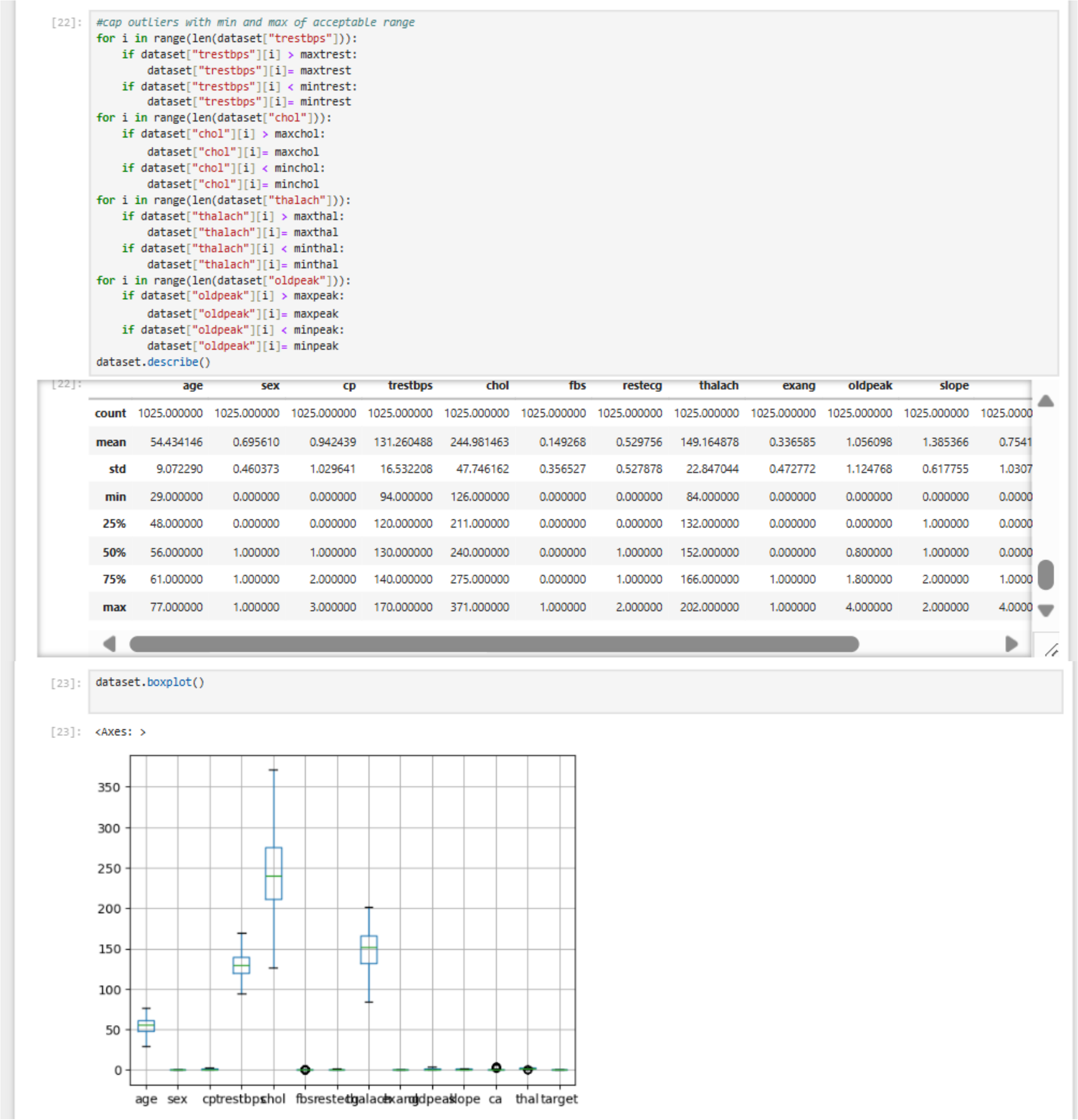
```
[20]: dataset.describe()
```

[20]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	
count	1025.000000	1025.000000	1025.000000	1025.000000	1025.00000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1(
mean	54.434146	0.695610	0.942439	131.611707	246.00000	0.149268	0.529756	149.114146	0.336585	1.071512	1.385366	0.754146	
std	9.072290	0.460373	1.029641	17.516718	51.59251	0.356527	0.527878	23.005724	0.472772	1.175053	0.617755	1.030798	
min	29.000000	0.000000	0.000000	94.000000	126.00000	0.000000	0.000000	71.000000	0.000000	0.000000	0.000000	0.000000	
25%	48.000000	0.000000	0.000000	120.000000	211.00000	0.000000	0.000000	132.000000	0.000000	0.000000	1.000000	0.000000	
50%	56.000000	1.000000	1.000000	130.000000	240.00000	0.000000	1.000000	152.000000	0.000000	0.800000	1.000000	0.000000	
75%	61.000000	1.000000	2.000000	140.000000	275.00000	0.000000	1.000000	166.000000	1.000000	1.800000	2.000000	1.000000	
max	77.000000	1.000000	3.000000	200.000000	564.00000	1.000000	2.000000	202.000000	1.000000	6.200000	2.000000	4.000000	

```
[21]: #print min and max of acceptable range
maxtrest = 140 + (1.5)*(140-120)
print("Max of accpetable range of trestbps: ",maxtrest)
mintrest = 120 - (1.5)*(140-120)
print("Min of acceptable range of trestbps: ",mintrest)
maxchol = 275 + (1.5)*(275-211)
print("Max of accpetable range of chol: ",maxchol)
minchol = 211 - (1.5)*(275-211)
print("Min of acceptable range of chol: ",minchol)
maxthal = 166 + (1.5)*(166-133)
print("Max of accpetable range of thalach: ",maxthal)
minthal = 133 - (1.5)*(166-133)
print("Min of acceptable range of thalach: ",minthal)
maxpeak = 1.6+ (1.5)*(1.6-0)
print("Max of accpetable range of oldpeak: ",maxpeak)
minpeak = 0 - (1.5)*(1.6-0)
print("Min of acceptable range of oldpeak: ",minpeak)

#since thalach is integer attribute
minthal = 84 #rounded to integer
maxthal = 216 #rounded to integer
```

```
Max of accpetable range of trestbps:  170.0
Min of acceptable range of trestbps:  90.0
Max of accpetable range of chol:  371.0
Min of acceptable range of chol:  115.0
Max of accpetable range of thalach:  215.5
Min of acceptable range of thalach:  83.5
Max of accpetable range of oldpeak:  4.0
Min of acceptable range of oldpeak:  -2.4000000000000004
```



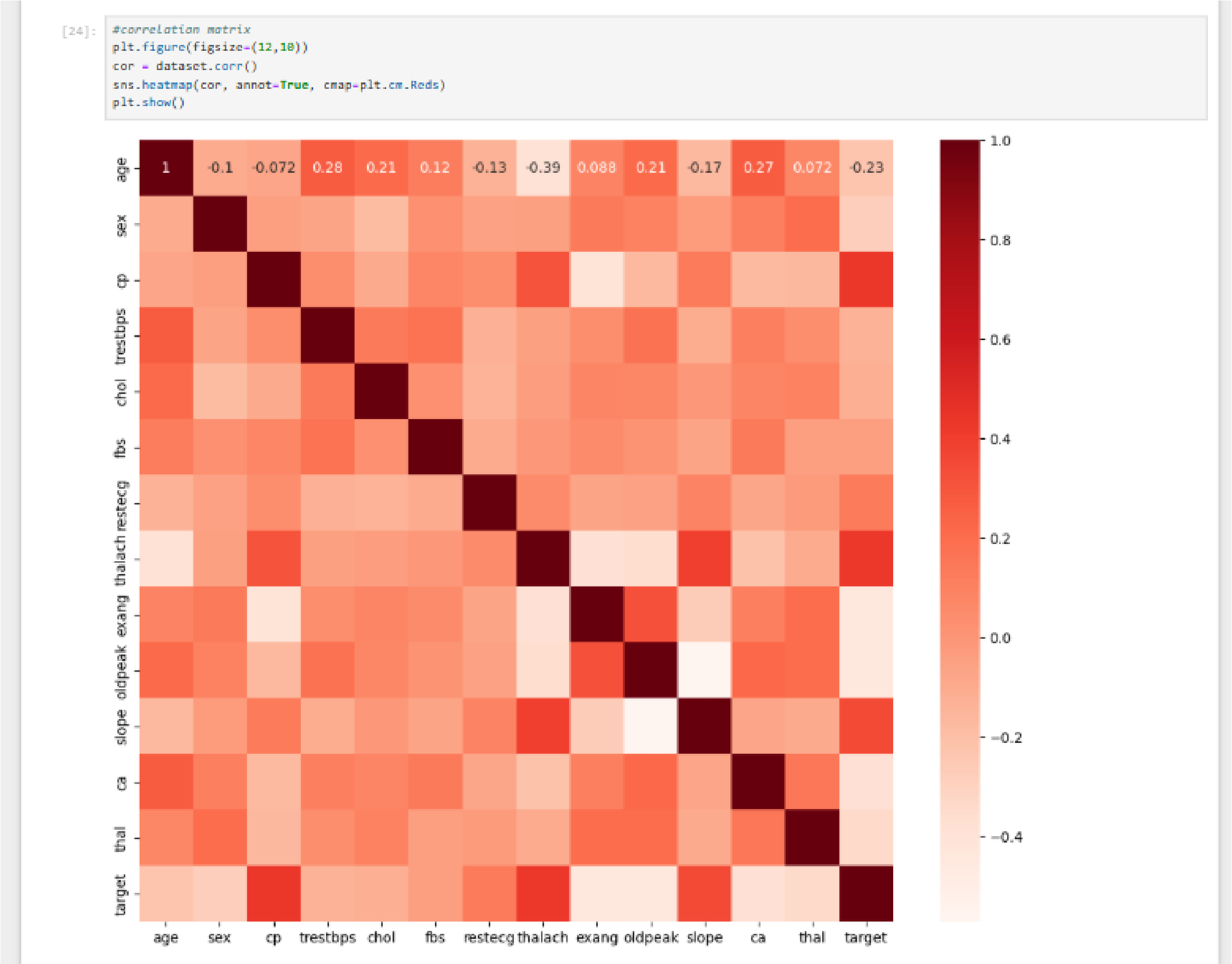
```
[22]: #cap outliers with min and max of acceptable range
      for i in range(len(dataset["trestbps"])):
          if dataset["trestbps"][i] > maxtrest:
              dataset["trestbps"][i]= maxtrest
          if dataset["trestbps"][i] < mintrest:
              dataset["trestbps"][i]= mintrest
      for i in range(len(dataset["chol"])):
          if dataset["chol"][i] > maxchol:
              dataset["chol"][i]= maxchol
          if dataset["chol"][i] < minchol:
              dataset["chol"][i]= minchol
      for i in range(len(dataset["thalach"])):
          if dataset["thalach"][i] > maxthal:
              dataset["thalach"][i]= maxthal
          if dataset["thalach"][i] < minthal:
              dataset["thalach"][i]= minthal
      for i in range(len(dataset["oldpeak"])):
          if dataset["oldpeak"][i] > maxpeak:
              dataset["oldpeak"][i]= maxpeak
          if dataset["oldpeak"][i] < minpeak:
              dataset["oldpeak"][i]= minpeak
      dataset.describe()
```

[22]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	
count	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.0000
mean	54.434146	0.695610	0.942439	131.260488	244.981463	0.149268	0.529756	149.164878	0.336585	1.056098	1.385366	0.7541
std	9.072290	0.460373	1.029641	16.532208	47.746162	0.356527	0.527878	22.847044	0.472772	1.124768	0.617755	1.0307
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	84.000000	0.000000	0.000000	0.000000	0.0000
25%	48.000000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000	132.000000	0.000000	0.000000	1.000000	0.0000
50%	56.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000	152.000000	0.000000	0.800000	1.000000	0.0000
75%	61.000000	1.000000	2.000000	140.000000	275.000000	0.000000	1.000000	166.000000	1.000000	1.800000	2.000000	1.0000
max	77.000000	1.000000	3.000000	170.000000	371.000000	1.000000	2.000000	202.000000	1.000000	4.000000	2.000000	4.0000

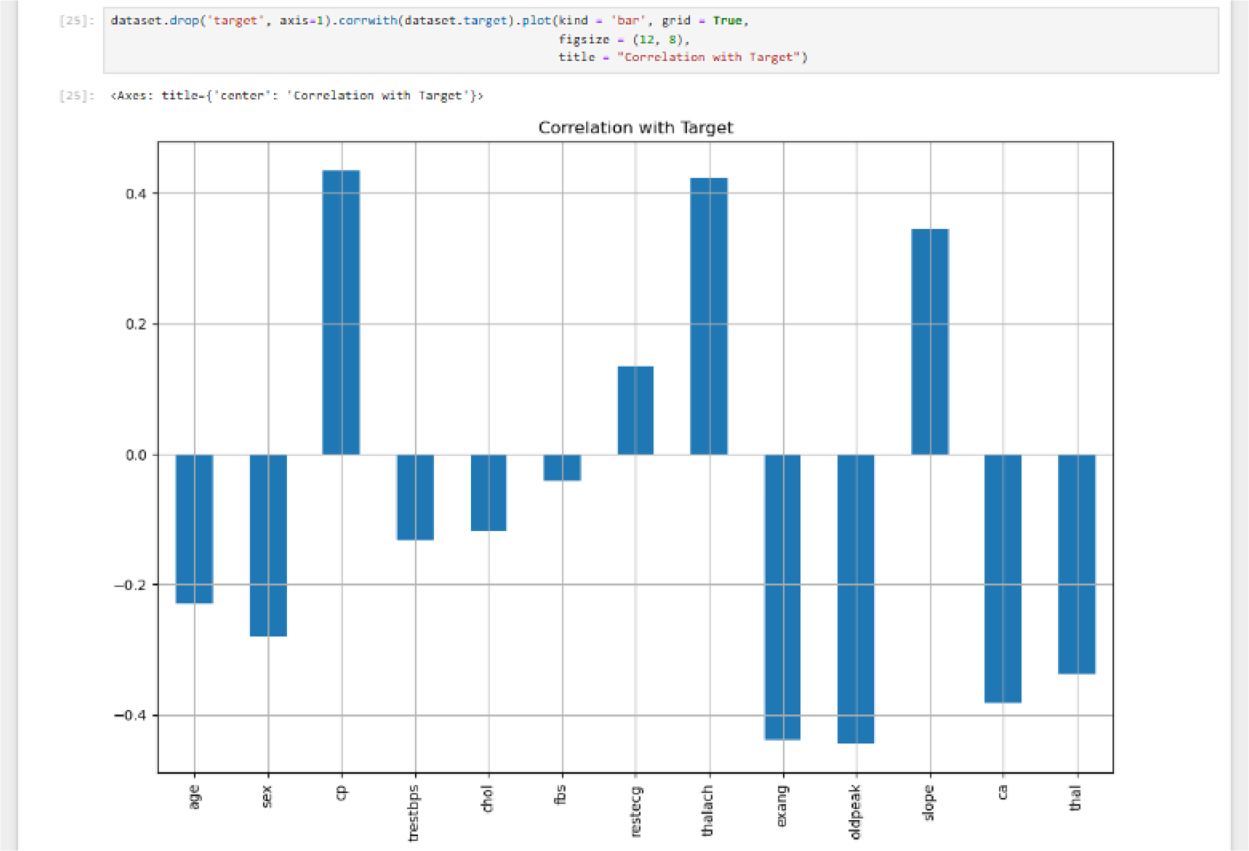
```
[23]: dataset.boxplot()
```

```
[23]: <Axes: >
```



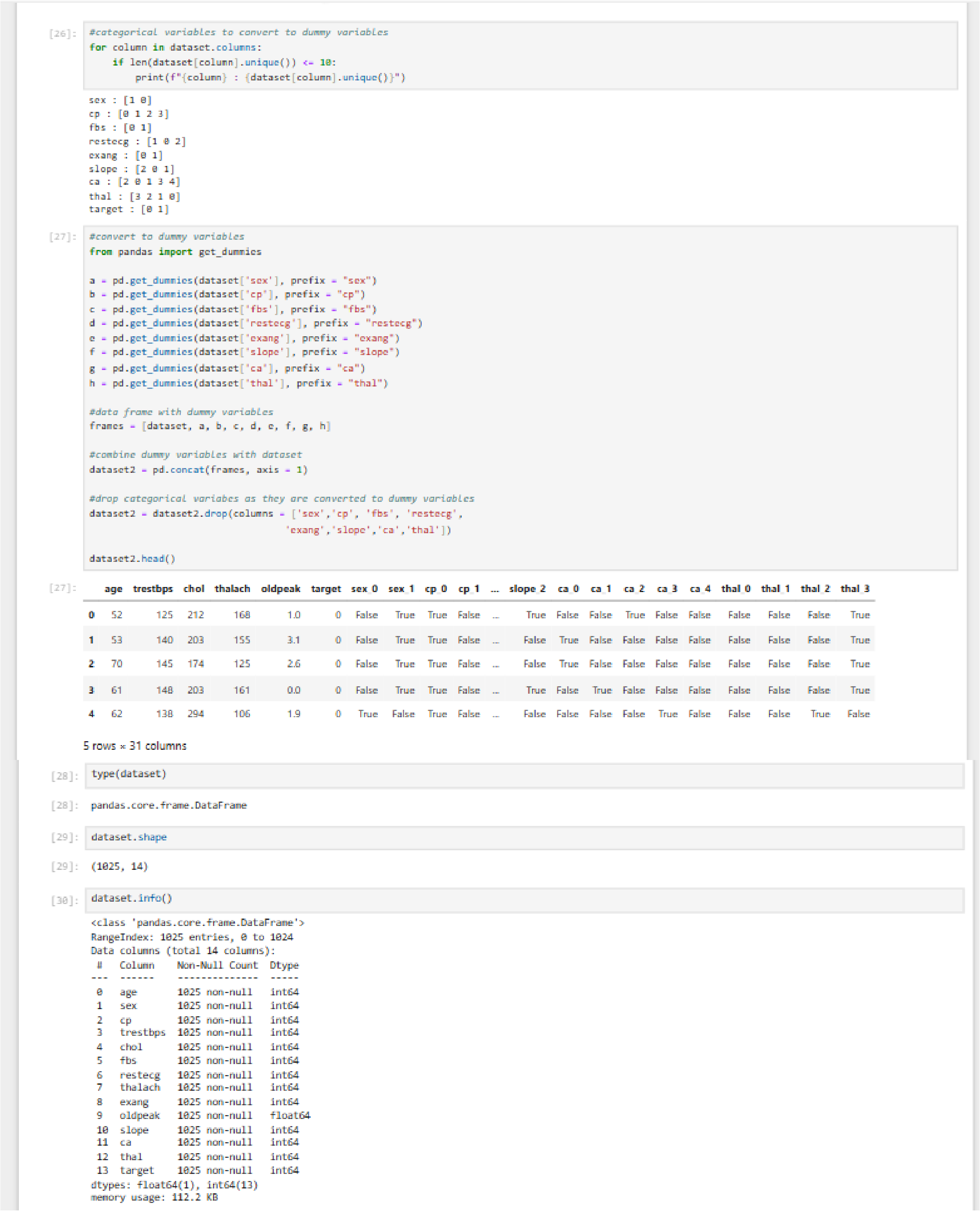
[24]:

```
#correlation matrix
plt.figure(figsize=(12,10))
cor = dataset.corr()
sns.heatmap(cor, annot=True, cmap=plt.cm.Reds)
plt.show()
```



```
[25]: dataset.drop('target', axis=1).corrwith(dataset.target).plot(kind = 'bar', grid = True,
                                                                   figsize = (12, 8),
                                                                   title = "Correlation with Target")
```

```
[25]: <Axes: title={'center': 'Correlation with Target'}>
```



[26]:

```
#categorical variables to convert to dummy variables
for column in dataset.columns:
    if len(dataset[column].unique()) <= 10:
        print(f"{column} : {dataset[column].unique()}")
```

```
sex : [1 0]
cp : [0 1 2 3]
fbs : [0 1]
restecg : [1 0 2]
exang : [0 1]
slope : [2 0 1]
ca : [2 0 1 3 4]
thal : [3 2 1 0]
target : [0 1]
```

[27]:

```
#convert to dummy variables
from pandas import get_dummies

a = pd.get_dummies(dataset['sex'], prefix = "sex")
b = pd.get_dummies(dataset['cp'], prefix = "cp")
c = pd.get_dummies(dataset['fbs'], prefix = "fbs")
d = pd.get_dummies(dataset['restecg'], prefix = "restecg")
e = pd.get_dummies(dataset['exang'], prefix = "exang")
f = pd.get_dummies(dataset['slope'], prefix = "slope")
g = pd.get_dummies(dataset['ca'], prefix = "ca")
h = pd.get_dummies(dataset['thal'], prefix = "thal")

#data frame with dummy variables
frames = [dataset, a, b, c, d, e, f, g, h]

#combine dummy variables with dataset
dataset2 = pd.concat(frames, axis = 1)

#drop categorical variabes as they are converted to dummy variables
dataset2 = dataset2.drop(columns = ['sex','cp', 'fbs', 'restecg',
                                  'exang','slope','ca','thal'])

dataset2.head()
```

[27]:

	age	trestbps	chol	thalach	oldpeak	target	sex_0	sex_1	cp_0	cp_1	...	slope_2	ca_0	ca_1	ca_2	ca_3	ca_4	thal_0	thal_1	thal_2	thal_3
0	52	125	212	168	1.0	0	False	True	True	False	...	True	False	False	True	False	False	False	False	False	True
1	53	140	203	155	3.1	0	False	True	True	False	...	False	True	False	False	False	False	False	False	False	True
2	70	145	174	125	2.6	0	False	True	True	False	...	False	True	False	False	False	False	False	False	False	True
3	61	148	203	161	0.0	0	False	True	True	False	...	True	False	True	False	False	False	False	False	False	True
4	62	138	294	106	1.9	0	True	False	True	False	...	False	False	False	False	True	False	False	False	True	False

5 rows × 31 columns

[28]:

```
type(dataset)
```

[28]:

```
pandas.core.frame.DataFrame
```

[29]:

```
dataset.shape
```

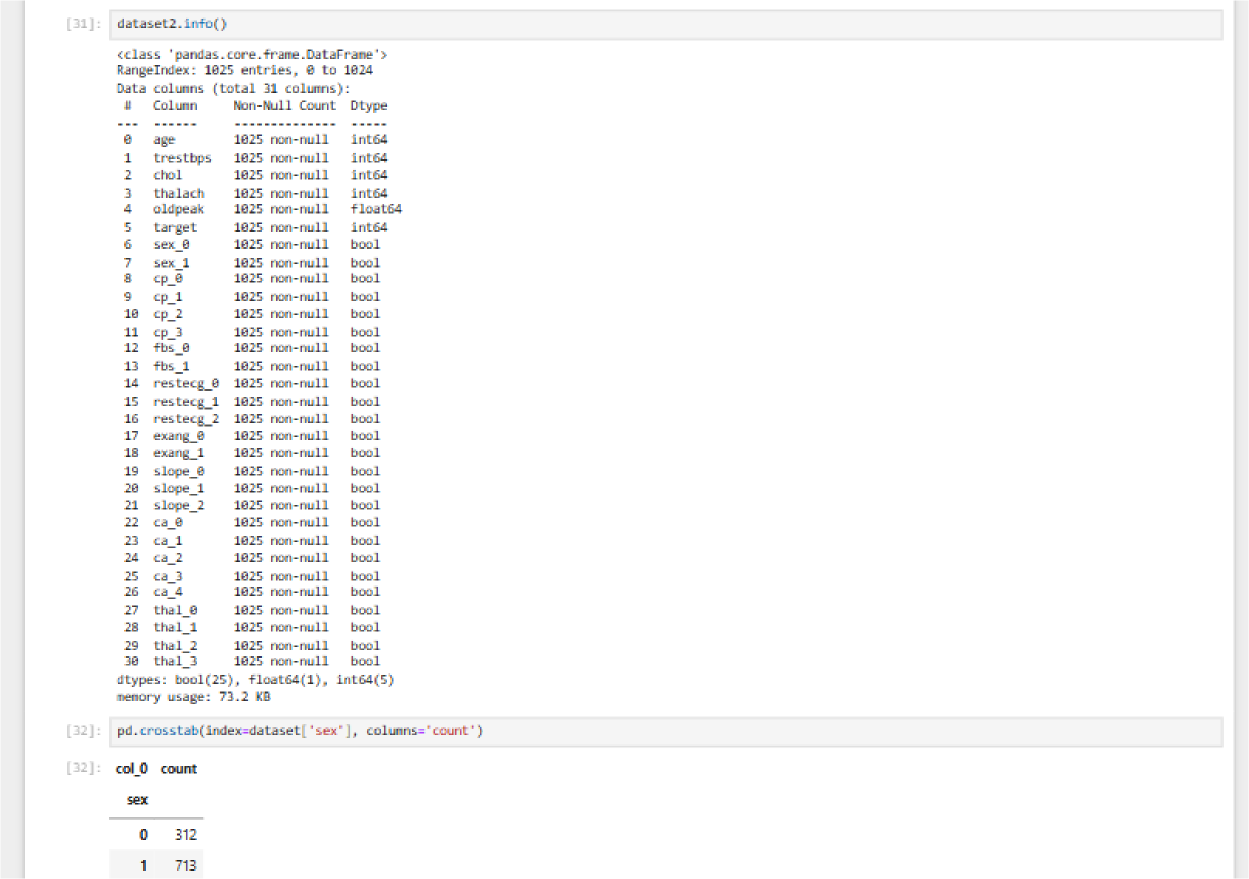
[29]:

```
(1025, 14)
```

[30]:

```
dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1025 entries, 0 to 1024
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       1025 non-null   int64  
 1   sex       1025 non-null   int64  
 2   cp        1025 non-null   int64  
 3   trestbps  1025 non-null   int64  
 4   chol      1025 non-null   int64  
 5   fbs       1025 non-null   int64  
 6   restecg   1025 non-null   int64  
 7   thalach   1025 non-null   int64  
 8   exang     1025 non-null   int64  
 9   oldpeak   1025 non-null   float64
 10  slope     1025 non-null   int64  
 11  ca        1025 non-null   int64  
 12  thal      1025 non-null   int64  
 13  target    1025 non-null   int64  
dtypes: float64(1), int64(13)
memory usage: 112.2 KB
```



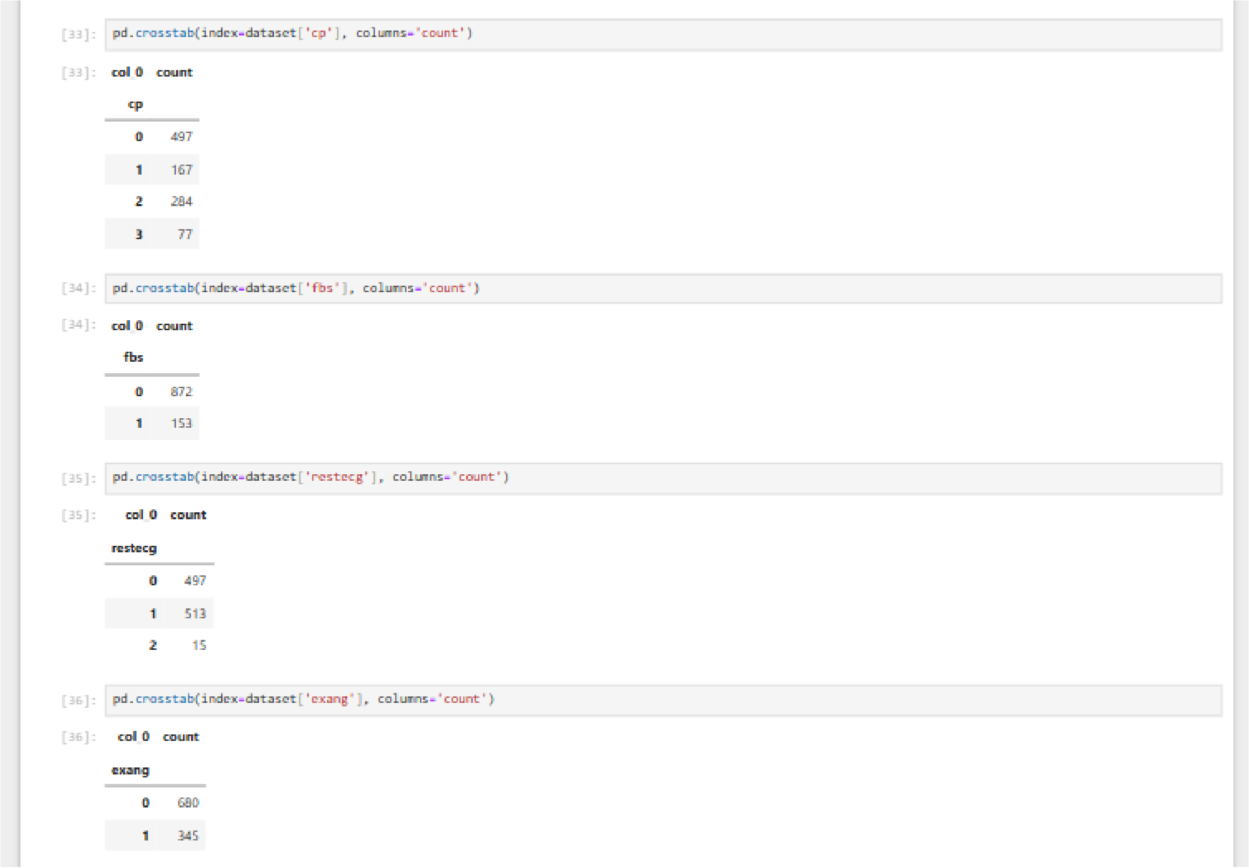
[31]:
```
dataset2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1025 entries, 0 to 1024
Data columns (total 31 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   age        1025 non-null   int64  
 1   trestbps   1025 non-null   int64  
 2   chol       1025 non-null   int64  
 3   thalach    1025 non-null   int64  
 4   oldpeak    1025 non-null   float64
 5   target     1025 non-null   int64  
 6   sex_0      1025 non-null   bool   
 7   sex_1      1025 non-null   bool   
 8   cp_0       1025 non-null   bool   
 9   cp_1       1025 non-null   bool   
 10  cp_2       1025 non-null   bool   
 11  cp_3       1025 non-null   bool   
 12  fbs_0      1025 non-null   bool   
 13  fbs_1      1025 non-null   bool   
 14  restecg_0  1025 non-null   bool   
 15  restecg_1  1025 non-null   bool   
 16  restecg_2  1025 non-null   bool   
 17  exang_0    1025 non-null   bool   
 18  exang_1    1025 non-null   bool   
 19  slope_0    1025 non-null   bool   
 20  slope_1    1025 non-null   bool   
 21  slope_2    1025 non-null   bool   
 22  ca_0       1025 non-null   bool   
 23  ca_1       1025 non-null   bool   
 24  ca_2       1025 non-null   bool   
 25  ca_3       1025 non-null   bool   
 26  ca_4       1025 non-null   bool   
 27  thal_0     1025 non-null   bool   
 28  thal_1     1025 non-null   bool   
 29  thal_2     1025 non-null   bool   
 30  thal_3     1025 non-null   bool   
dtypes: bool(25), float64(1), int64(5)
memory usage: 73.2 KB
```

[32]:
```
pd.crosstab(index=dataset['sex'], columns='count')
```

[32]:

col_0	count
sex	
0	312
1	713



```
[33]: pd.crosstab(index=dataset['cp'], columns='count')
```

```
[33]: col_0  count
        cp
         0    497
         1    167
         2    284
         3     77
```

```
[34]: pd.crosstab(index=dataset['fbs'], columns='count')
```

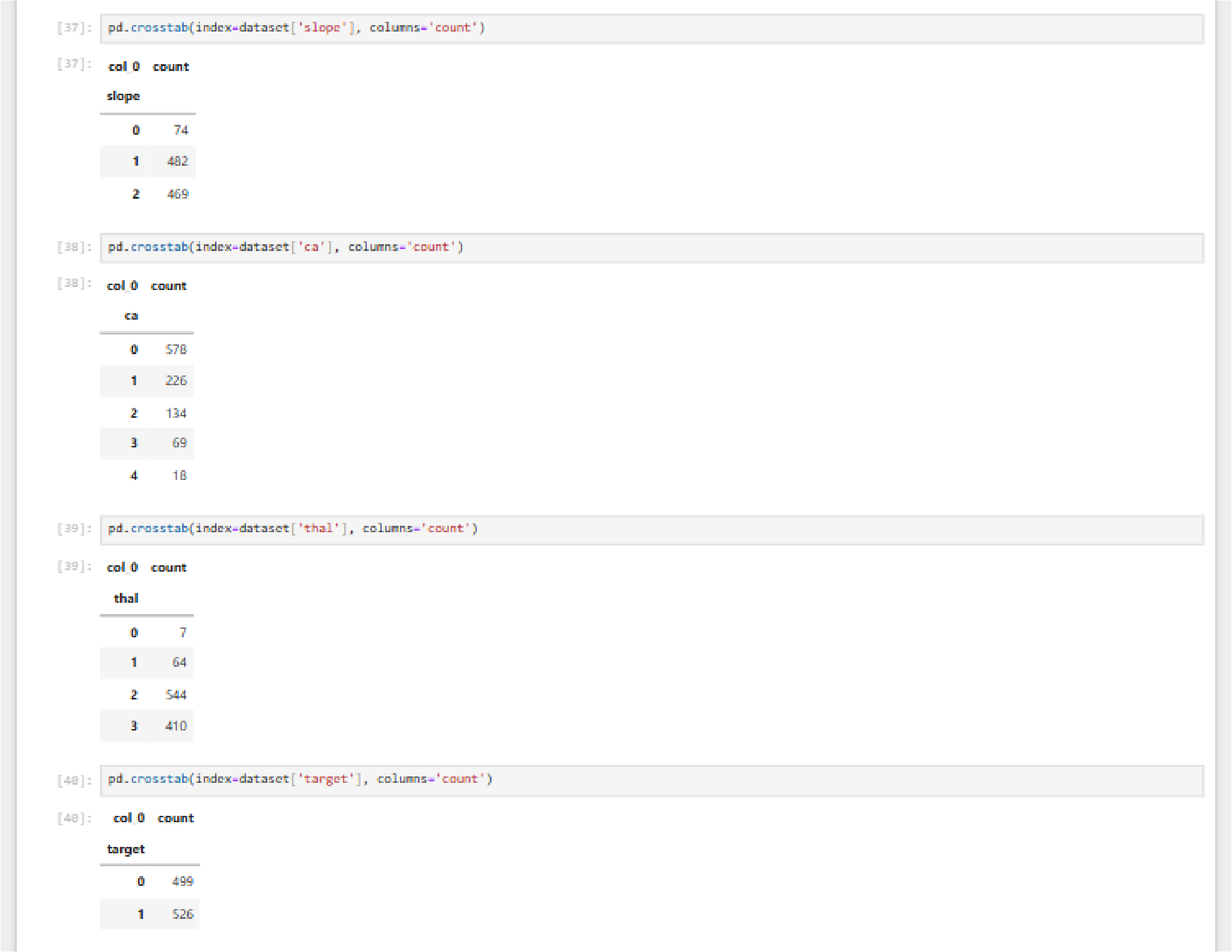
```
[34]: col_0  count
        fbs
         0    872
         1    153
```

```
[35]: pd.crosstab(index=dataset['restecg'], columns='count')
```

```
[35]:   col_0  count
      restecg
            0    497
            1    513
            2     15
```

```
[36]: pd.crosstab(index=dataset['exang'], columns='count')
```

```
[36]:  col_0  count
      exang
           0    680
           1    345
```



[37]:

```
pd.crosstab(index=dataset['slope'], columns='count')
```

[37]:

```
col_0  count
slope
    0     74
    1    482
    2    469
```

[38]:

```
pd.crosstab(index=dataset['ca'], columns='count')
```

[38]:

```
col_0  count
   ca
    0    578
    1    226
    2    134
    3     69
    4     18
```

[39]:

```
pd.crosstab(index=dataset['thal'], columns='count')
```

[39]:

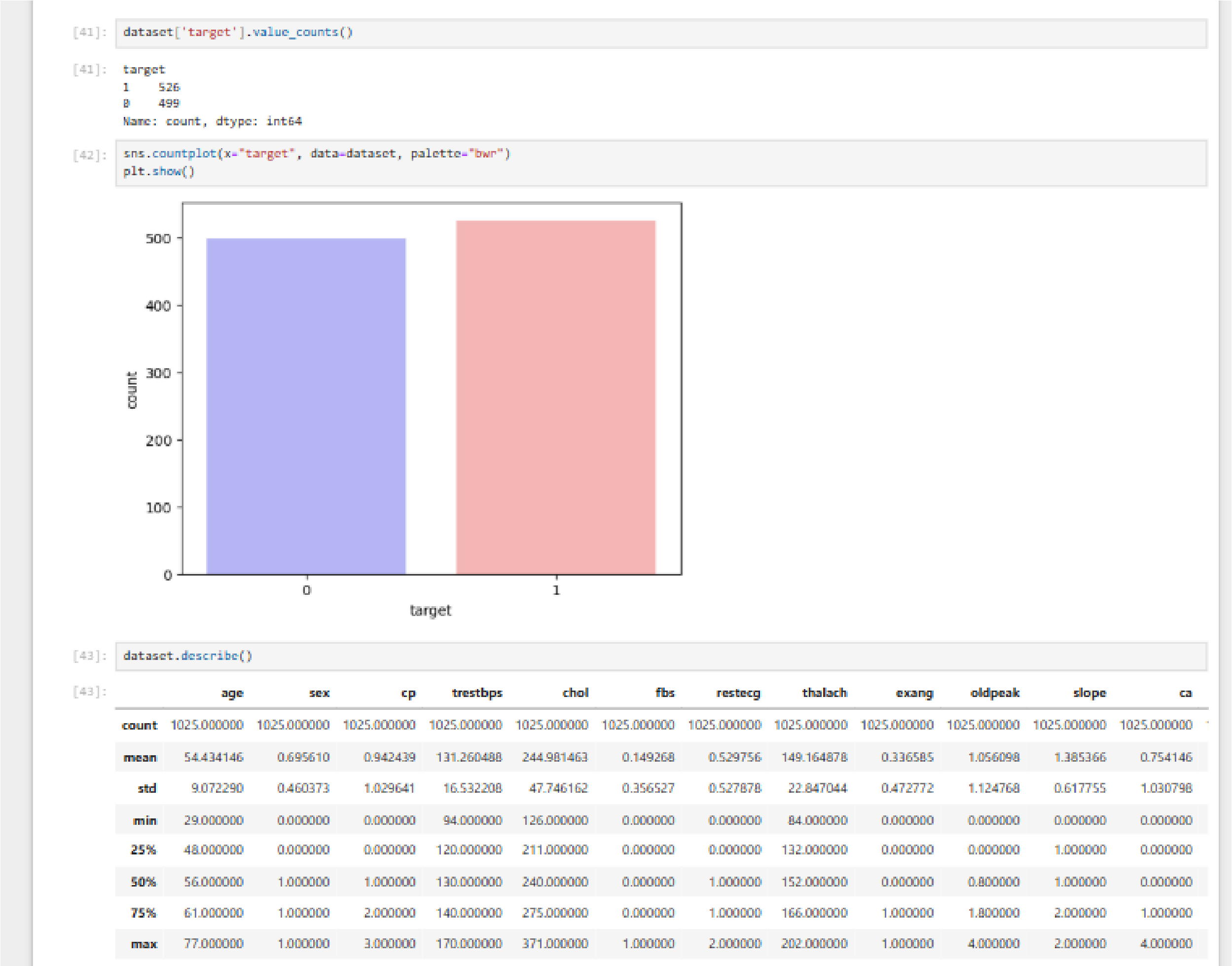
```
col_0  count
 thal
    0      7
    1     64
    2    544
    3    410
```

[40]:

```
pd.crosstab(index=dataset['target'], columns='count')
```

[40]:

```
 col_0  count
target
     0    499
     1    526
```



```
[41]: dataset['target'].value_counts()
```

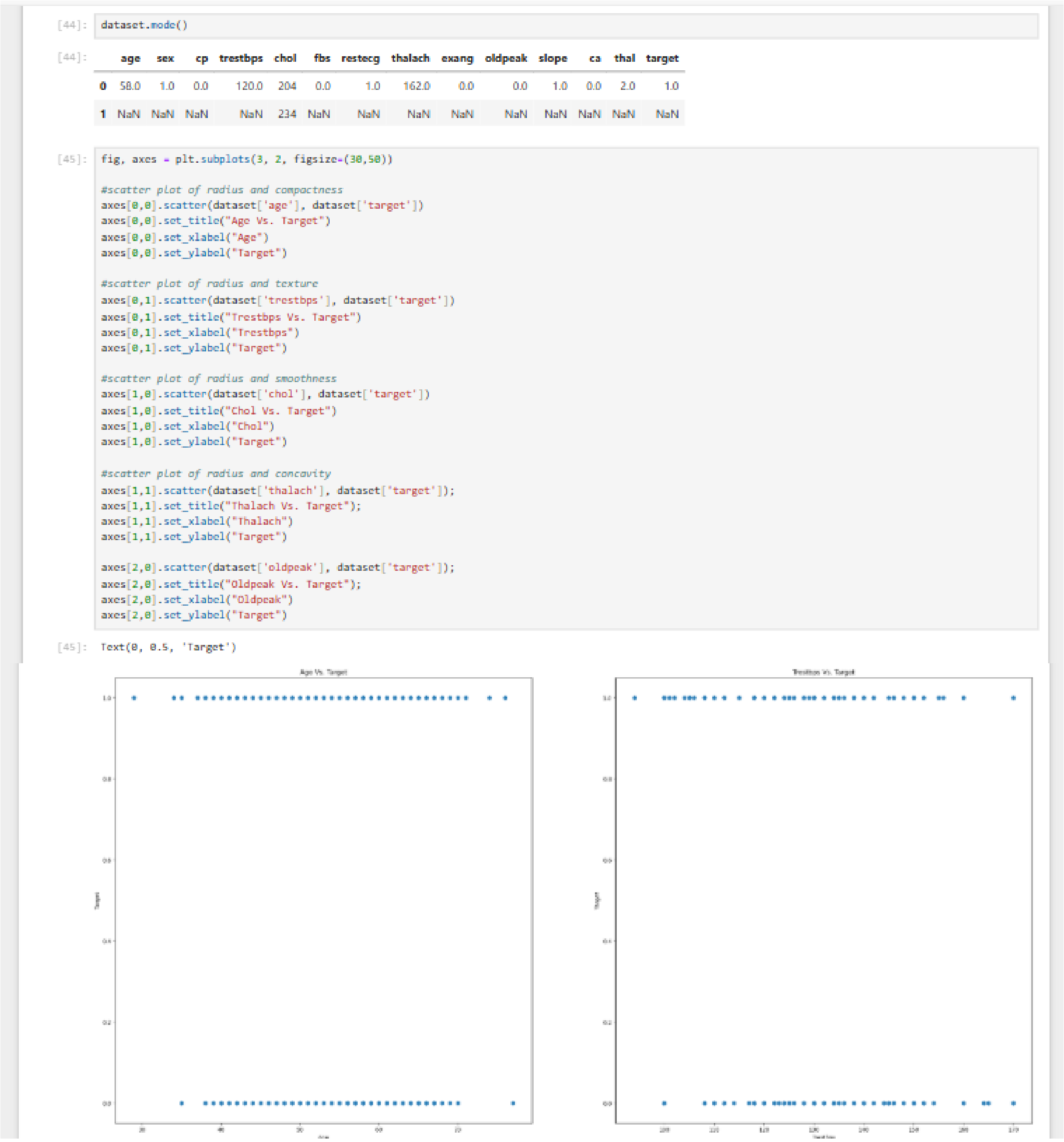
```
[41]: target
      1    526
      0    499
      Name: count, dtype: int64
```

```
[42]: sns.countplot(x="target", data=dataset, palette="bwr")
      plt.show()
```

```
[43]: dataset.describe()
```

[43]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca
count	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000	1025.000000
mean	54.434146	0.695610	0.942439	131.260488	244.981463	0.149268	0.529756	149.164878	0.336585	1.056098	1.385366	0.754146
std	9.072290	0.460373	1.029641	16.532208	47.746162	0.356527	0.527878	22.847044	0.472772	1.124768	0.617755	1.030798
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	84.000000	0.000000	0.000000	0.000000	0.000000
25%	48.000000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000	132.000000	0.000000	0.000000	1.000000	0.000000
50%	56.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000	152.000000	0.000000	0.800000	1.000000	0.000000
75%	61.000000	1.000000	2.000000	140.000000	275.000000	0.000000	1.000000	166.000000	1.000000	1.800000	2.000000	1.000000
max	77.000000	1.000000	3.000000	170.000000	371.000000	1.000000	2.000000	202.000000	1.000000	4.000000	2.000000	4.000000



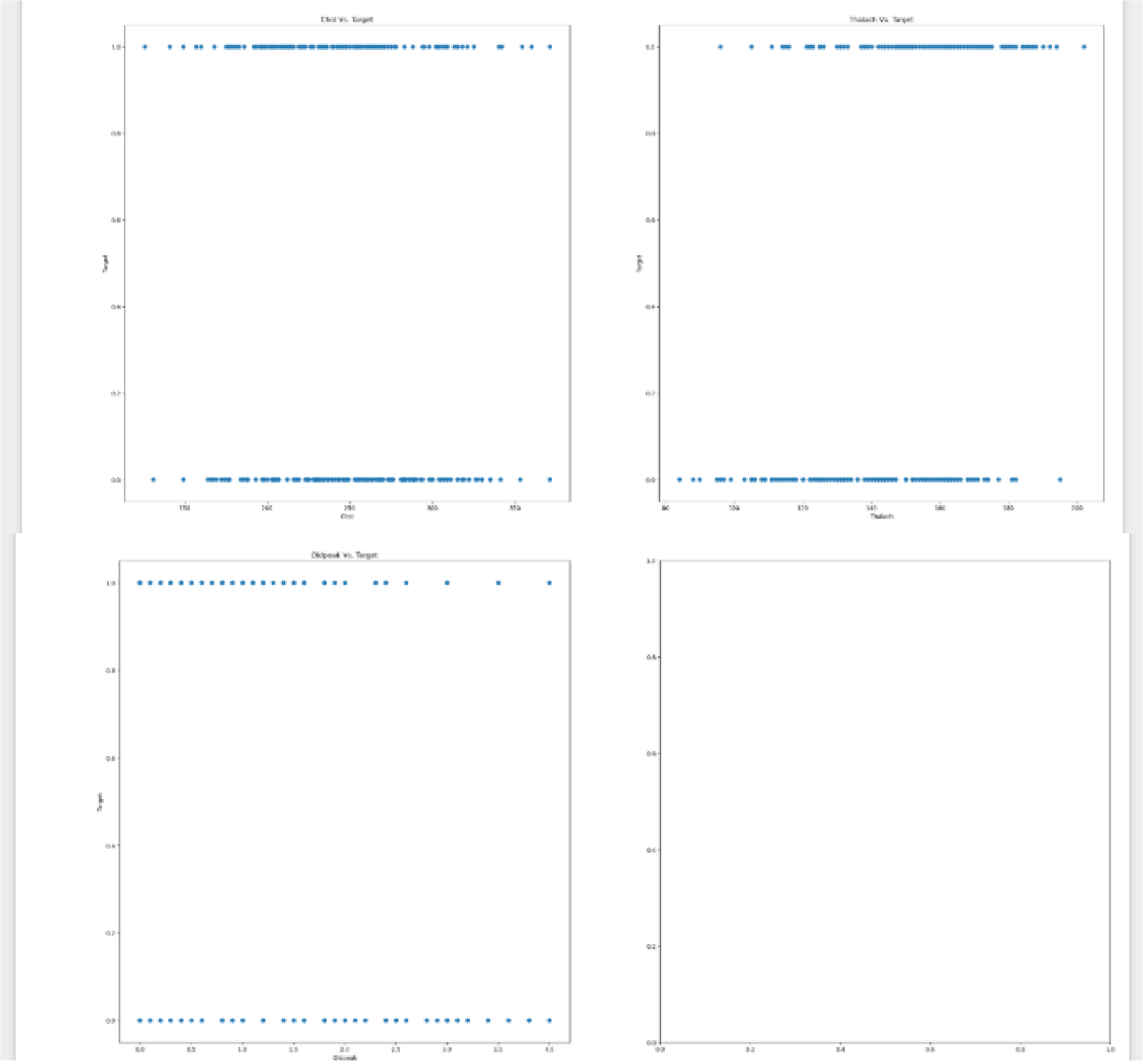
```
[44]: dataset.mode()
```

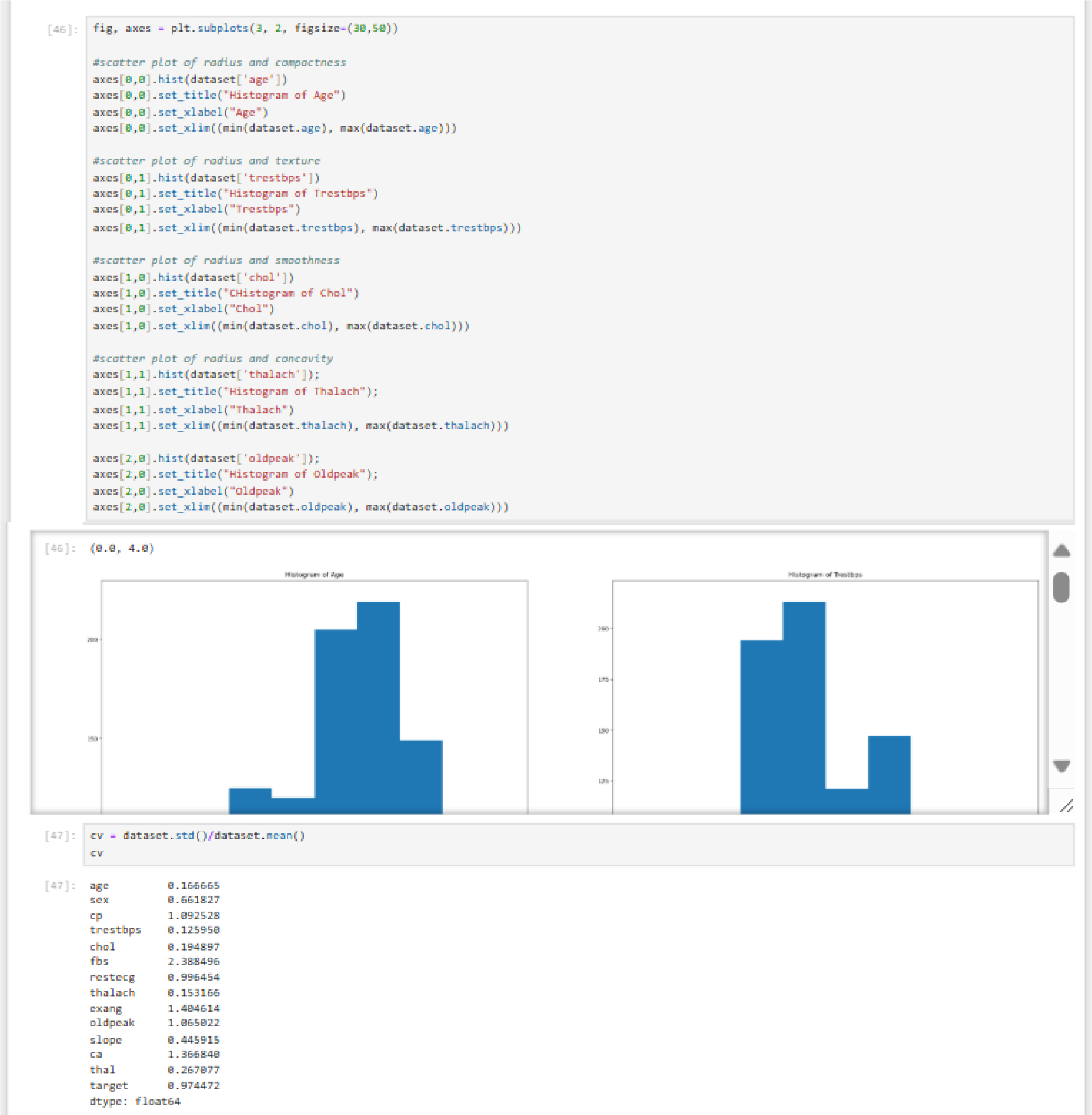
[44]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	58.0	1.0	0.0	120.0	204	0.0	1.0	162.0	0.0	0.0	1.0	0.0	2.0	1.0
1	NaN	NaN	NaN	NaN	234	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN

```
[45]: fig, axes = plt.subplots(3, 2, figsize=(30,50))

      #scatter plot of radius and compactness
      axes[0,0].scatter(dataset['age'], dataset['target'])
      axes[0,0].set_title("Age Vs. Target")
      axes[0,0].set_xlabel("Age")
      axes[0,0].set_ylabel("Target")

      #scatter plot of radius and texture
      axes[0,1].scatter(dataset['trestbps'], dataset['target'])
      axes[0,1].set_title("Trestbps Vs. Target")
      axes[0,1].set_xlabel("Trestbps")
      axes[0,1].set_ylabel("Target")

      #scatter plot of radius and smoothness
      axes[1,0].scatter(dataset['chol'], dataset['target'])
      axes[1,0].set_title("Chol Vs. Target")
      axes[1,0].set_xlabel("Chol")
      axes[1,0].set_ylabel("Target")

      #scatter plot of radius and concavity
      axes[1,1].scatter(dataset['thalach'], dataset['target']);
      axes[1,1].set_title("Thalach Vs. Target");
      axes[1,1].set_xlabel("Thalach")
      axes[1,1].set_ylabel("Target")

      axes[2,0].scatter(dataset['oldpeak'], dataset['target']);
      axes[2,0].set_title("Oldpeak Vs. Target");
      axes[2,0].set_xlabel("Oldpeak")
      axes[2,0].set_ylabel("Target")
```

```
[45]: Text(0, 0.5, 'Target')
```


Chol Vs. Target
Target
Chol
1.0
0.8
0.6
0.4
0.2
0.0
150
200
250
300
350
Thalach Vs. Target
Target
Thalach
80
100
120
140
160
180
200
Oldpeak Vs. Target
Target
Oldpeak
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.0
0.2
0.4
0.6
0.8
1.0

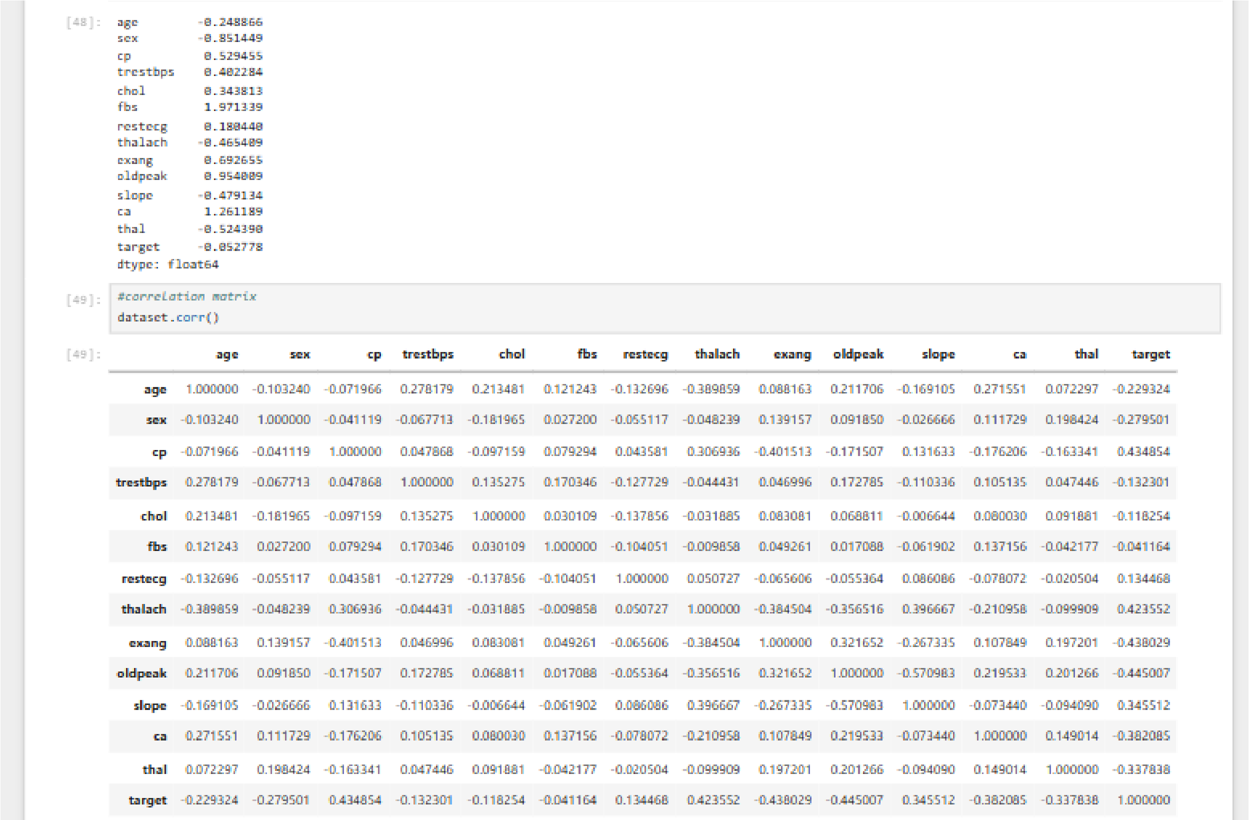


[46]:
```
fig, axes = plt.subplots(3, 2, figsize=(30,50))

#scatter plot of radius and compactness
axes[0,0].hist(dataset['age'])
axes[0,0].set_title("Histogram of Age")
axes[0,0].set_xlabel("Age")
axes[0,0].set_xlim((min(dataset.age), max(dataset.age)))

#scatter plot of radius and texture
axes[0,1].hist(dataset['trestbps'])
axes[0,1].set_title("Histogram of Trestbps")
axes[0,1].set_xlabel("Trestbps")
axes[0,1].set_xlim((min(dataset.trestbps), max(dataset.trestbps)))

#scatter plot of radius and smoothness
axes[1,0].hist(dataset['chol'])
axes[1,0].set_title("CHistogram of Chol")
axes[1,0].set_xlabel("Chol")
axes[1,0].set_xlim((min(dataset.chol), max(dataset.chol)))

#scatter plot of radius and concavity
axes[1,1].hist(dataset['thalach']);
axes[1,1].set_title("Histogram of Thalach");
axes[1,1].set_xlabel("Thalach")
axes[1,1].set_xlim((min(dataset.thalach), max(dataset.thalach)))

axes[2,0].hist(dataset['oldpeak']);
axes[2,0].set_title("Histogram of Oldpeak");
axes[2,0].set_xlabel("Oldpeak")
axes[2,0].set_xlim((min(dataset.oldpeak), max(dataset.oldpeak)))
```

[46]:
```
(0.0, 4.0)
```

[47]:
```
cv = dataset.std()/dataset.mean()
cv
```

[47]:
```
age         0.166665
sex         0.661827
cp          1.092528
trestbps    0.125950
chol        0.194897
fbs         2.388496
restecg     0.996454
thalach     0.153166
exang       1.404614
oldpeak     1.065022
slope       0.445915
ca          1.366840
thal        0.267077
target      0.974472
dtype: float64
```



[48]:

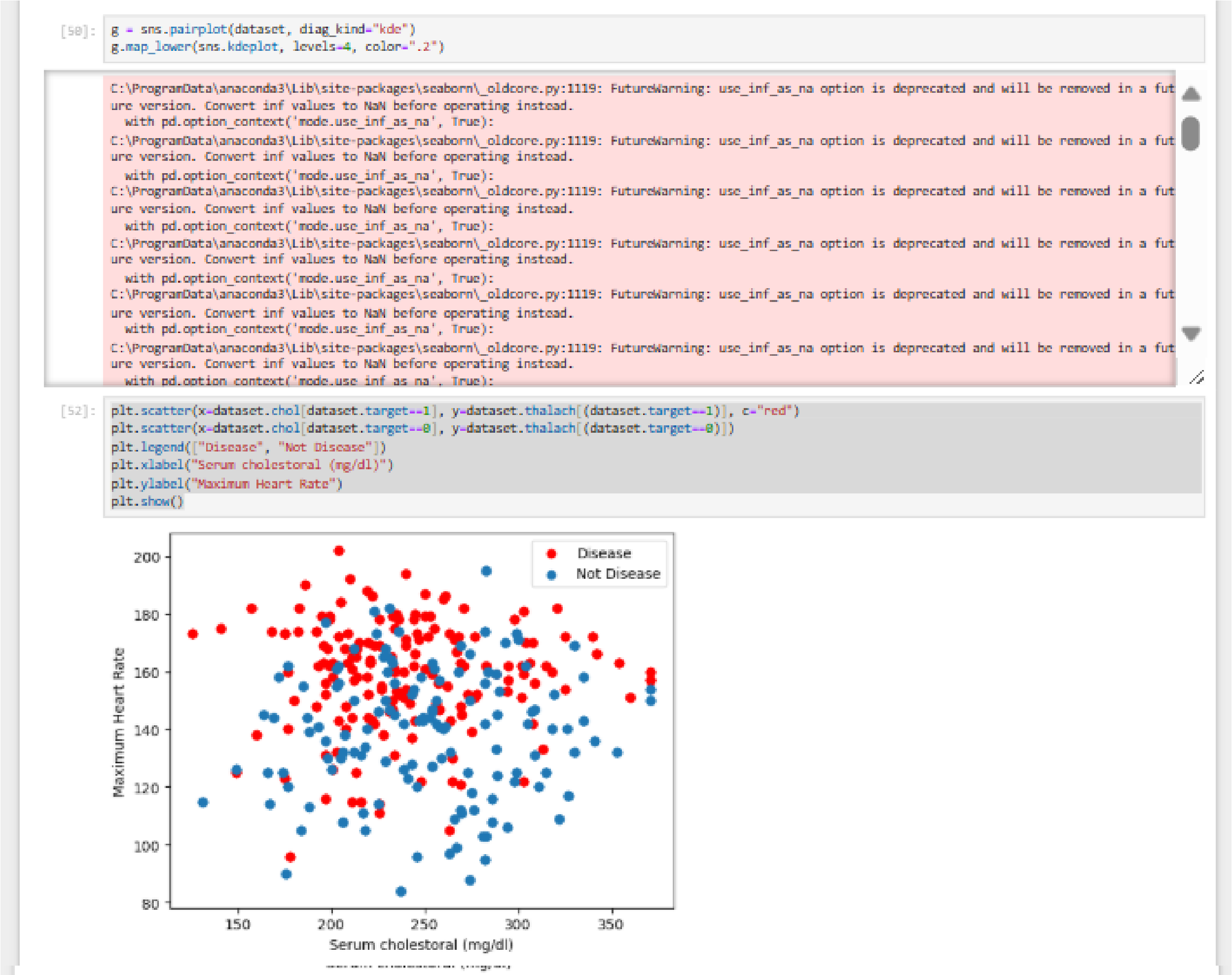
```
age        -0.248866
sex        -0.851449
cp          0.529455
trestbps    0.402284
chol        0.343813
fbs         1.971339
restecg     0.180440
thalach    -0.465409
exang       0.692655
oldpeak     0.954009
slope      -0.479134
ca          1.261189
thal       -0.524390
target     -0.052778
dtype: float64
```

[49]:

```
#correlation matrix
dataset.corr()
```

[49]:

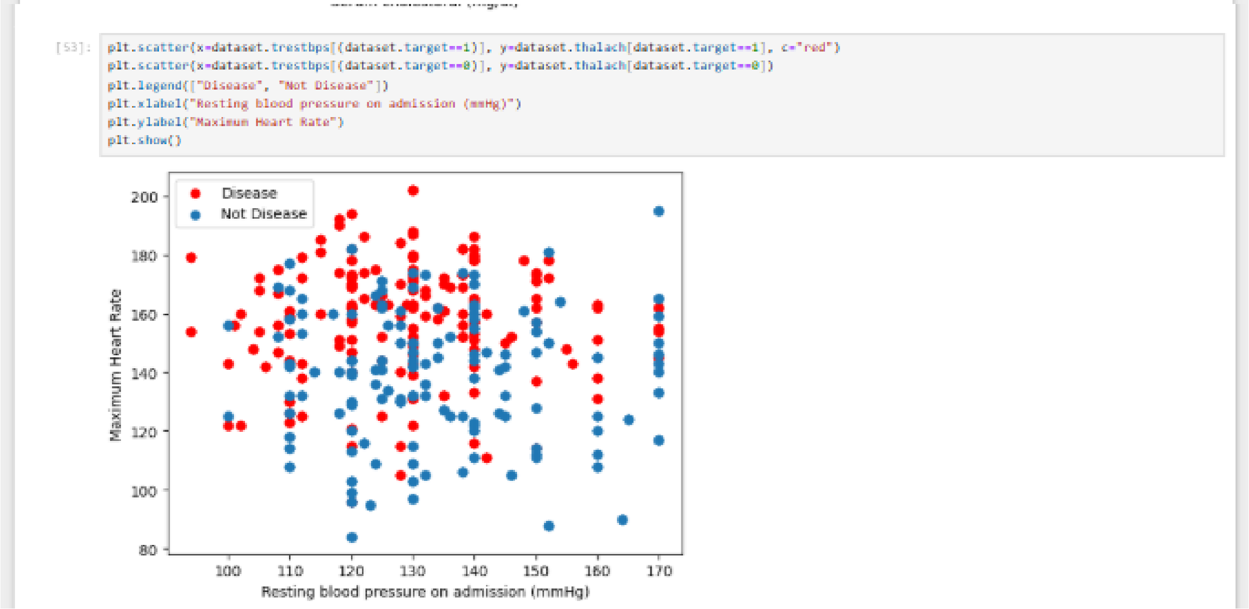
	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
age	1.000000	-0.103240	-0.071966	0.278179	0.213481	0.121243	-0.132696	-0.389859	0.088163	0.211706	-0.169105	0.271551	0.072297	-0.229324
sex	-0.103240	1.000000	-0.041119	-0.067713	-0.181965	0.027200	-0.055117	-0.048239	0.139157	0.091850	-0.026666	0.111729	0.198424	-0.279501
cp	-0.071966	-0.041119	1.000000	0.047868	-0.097159	0.079294	0.043581	0.306936	-0.401513	-0.171507	0.131633	-0.176206	-0.163341	0.434854
trestbps	0.278179	-0.067713	0.047868	1.000000	0.135275	0.170346	-0.127729	-0.044431	0.046996	0.172785	-0.110336	0.105135	0.047446	-0.132301
chol	0.213481	-0.181965	-0.097159	0.135275	1.000000	0.030109	-0.137856	-0.031885	0.083081	0.068811	-0.006644	0.080030	0.091881	-0.118254
fbs	0.121243	0.027200	0.079294	0.170346	0.030109	1.000000	-0.104051	-0.009858	0.049261	0.017088	-0.061902	0.137156	-0.042177	-0.041164
restecg	-0.132696	-0.055117	0.043581	-0.127729	-0.137856	-0.104051	1.000000	0.050727	-0.065606	-0.055364	0.086086	-0.078072	-0.020504	0.134468
thalach	-0.389859	-0.048239	0.306936	-0.044431	-0.031885	-0.009858	0.050727	1.000000	-0.384504	-0.356516	0.396667	-0.210958	-0.099909	0.423552
exang	0.088163	0.139157	-0.401513	0.046996	0.083081	0.049261	-0.065606	-0.384504	1.000000	0.321652	-0.267335	0.107849	0.197201	-0.438029
oldpeak	0.211706	0.091850	-0.171507	0.172785	0.068811	0.017088	-0.055364	-0.356516	0.321652	1.000000	-0.570983	0.219533	0.201266	-0.445007
slope	-0.169105	-0.026666	0.131633	-0.110336	-0.006644	-0.061902	0.086086	0.396667	-0.267335	-0.570983	1.000000	-0.073440	-0.094090	0.345512
ca	0.271551	0.111729	-0.176206	0.105135	0.080030	0.137156	-0.078072	-0.210958	0.107849	0.219533	-0.073440	1.000000	0.149014	-0.382085
thal	0.072297	0.198424	-0.163341	0.047446	0.091881	-0.042177	-0.020504	-0.099909	0.197201	0.201266	-0.094090	0.149014	1.000000	-0.337838
target	-0.229324	-0.279501	0.434854	-0.132301	-0.118254	-0.041164	0.134468	0.423552	-0.438029	-0.445007	0.345512	-0.382085	-0.337838	1.000000



[50]:
```
g = sns.pairplot(dataset, diag_kind="kde")
g.map_lower(sns.kdeplot, levels=4, color=".2")
```

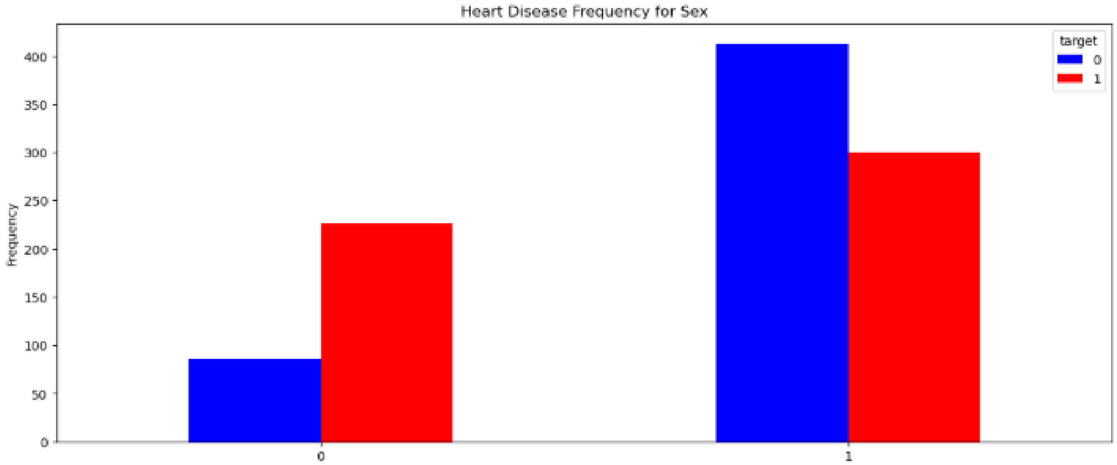
```
C:\ProgramData\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be removed in a fut
ure version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\ProgramData\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be removed in a fut
ure version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\ProgramData\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be removed in a fut
ure version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\ProgramData\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be removed in a fut
ure version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\ProgramData\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be removed in a fut
ure version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\ProgramData\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be removed in a fut
ure version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
```

[52]:
```
plt.scatter(x=dataset.chol[dataset.target==1], y=dataset.thalach[(dataset.target==1)], c="red")
plt.scatter(x=dataset.chol[dataset.target==0], y=dataset.thalach[(dataset.target==0)])
plt.legend(["Disease", "Not Disease"])
plt.xlabel("Serum cholestoral (mg/dl)")
plt.ylabel("Maximum Heart Rate")
plt.show()
```

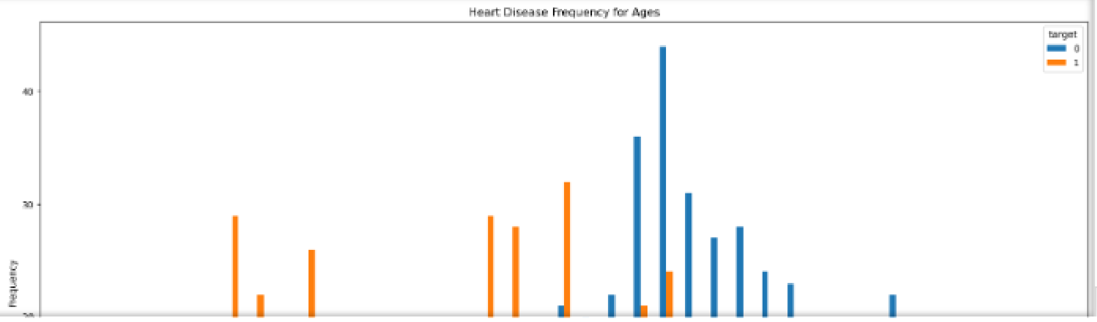


[53]:
```
plt.scatter(x=dataset.trestbps[(dataset.target==1)], y=dataset.thalach[dataset.target==1], c="red")
plt.scatter(x=dataset.trestbps[(dataset.target==0)], y=dataset.thalach[dataset.target==0])
plt.legend(["Disease", "Not Disease"])
plt.xlabel("Resting blood pressure on admission (mmHg)")
plt.ylabel("Maximum Heart Rate")
plt.show()
```

[54]:
```
pd.crosstab(dataset.sex,dataset.target).plot(kind="bar",figsize=(15,6),color=["blue","red"])
plt.title('Heart Disease Frequency for Sex')
plt.xlabel('Sex')
plt.xticks(rotation = 0)
plt.ylabel('Frequency')
plt.show()
```



[55]:
```
pd.crosstab(dataset.age,dataset.target).plot(kind="bar",figsize=(20,10))
plt.title('Heart Disease Frequency for Ages')
plt.xlabel('Age')
plt.ylabel('Frequency')
plt.show()
```

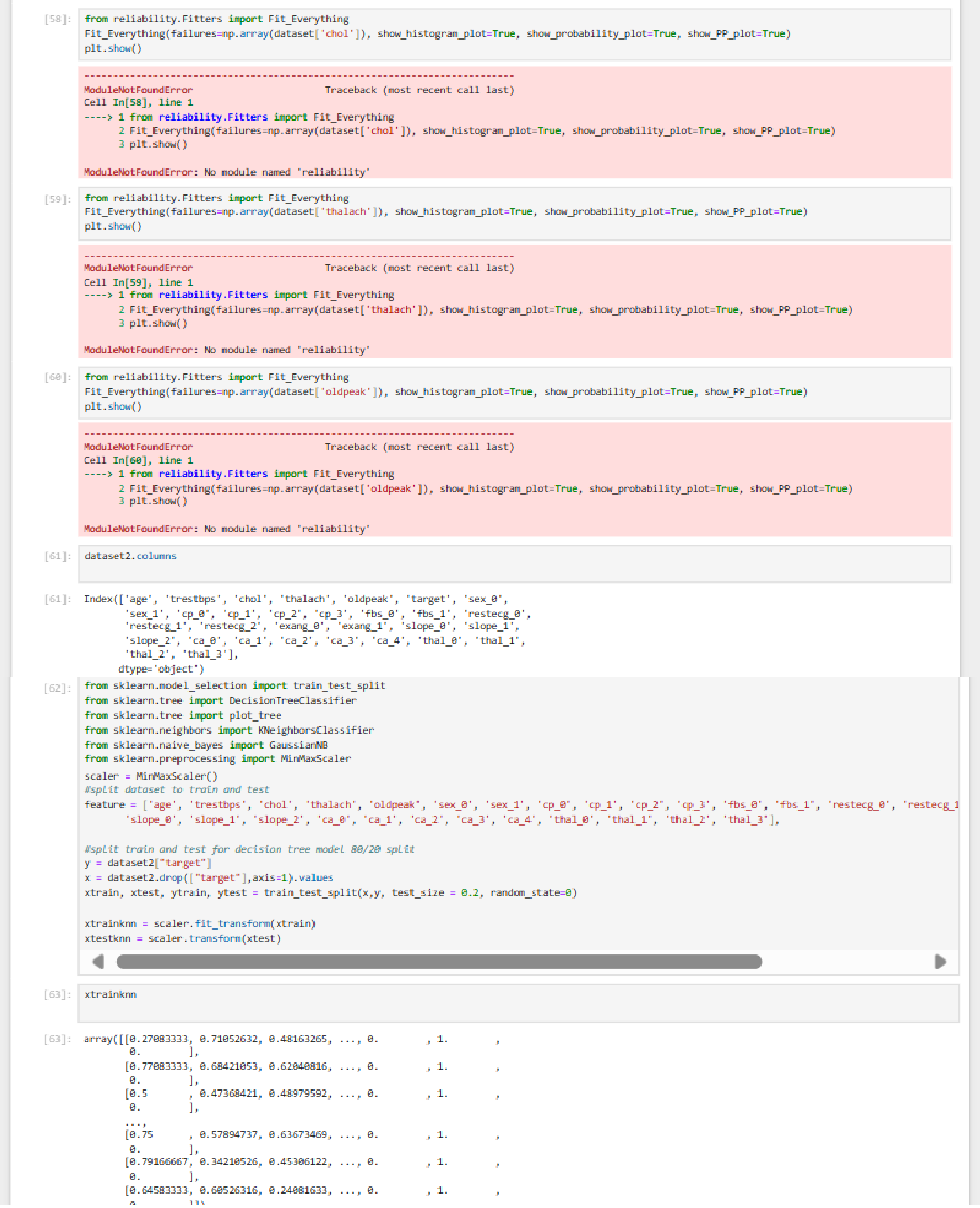


[56]:
```
from reliability.Fitters import Fit_Everything
Fit_Everything(failures=np.array(dataset['age']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
plt.show()
```

```
---------------------------------------------------------------------------
ModuleNotFoundError                       Traceback (most recent call last)
Cell In[56], line 1
----> 1 from reliability.Fitters import Fit_Everything
      2 Fit_Everything(failures=np.array(dataset['age']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
      3 plt.show()

ModuleNotFoundError: No module named 'reliability'
```

[57]:
```
from reliability.Fitters import Fit_Everything
Fit_Everything(failures=np.array(dataset['trestbps']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
plt.show()
```

```
---------------------------------------------------------------------------
ModuleNotFoundError                       Traceback (most recent call last)
Cell In[57], line 1
----> 1 from reliability.Fitters import Fit_Everything
      2 Fit_Everything(failures=np.array(dataset['trestbps']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
      3 plt.show()

ModuleNotFoundError: No module named 'reliability'
```



[58]:

```
from reliability.Fitters import Fit_Everything
Fit_Everything(failures=np.array(dataset['chol']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
plt.show()
```

```
---------------------------------------------------------------------------
ModuleNotFoundError                       Traceback (most recent call last)
Cell In[58], line 1
----> 1 from reliability.Fitters import Fit_Everything
      2 Fit_Everything(failures=np.array(dataset['chol']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
      3 plt.show()

ModuleNotFoundError: No module named 'reliability'
```

[59]:

```
from reliability.Fitters import Fit_Everything
Fit_Everything(failures=np.array(dataset['thalach']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
plt.show()
```

```
---------------------------------------------------------------------------
ModuleNotFoundError                       Traceback (most recent call last)
Cell In[59], line 1
----> 1 from reliability.Fitters import Fit_Everything
      2 Fit_Everything(failures=np.array(dataset['thalach']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
      3 plt.show()

ModuleNotFoundError: No module named 'reliability'
```

[60]:

```
from reliability.Fitters import Fit_Everything
Fit_Everything(failures=np.array(dataset['oldpeak']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
plt.show()
```

```
---------------------------------------------------------------------------
ModuleNotFoundError                       Traceback (most recent call last)
Cell In[60], line 1
----> 1 from reliability.Fitters import Fit_Everything
      2 Fit_Everything(failures=np.array(dataset['oldpeak']), show_histogram_plot=True, show_probability_plot=True, show_PP_plot=True)
      3 plt.show()

ModuleNotFoundError: No module named 'reliability'
```

[61]:

```
dataset2.columns
```

[61]:

```
Index(['age', 'trestbps', 'chol', 'thalach', 'oldpeak', 'target', 'sex_0',
       'sex_1', 'cp_0', 'cp_1', 'cp_2', 'cp_3', 'fbs_0', 'fbs_1', 'restecg_0',
       'restecg_1', 'restecg_2', 'exang_0', 'exang_1', 'slope_0', 'slope_1',
       'slope_2', 'ca_0', 'ca_1', 'ca_2', 'ca_3', 'ca_4', 'thal_0', 'thal_1',
       'thal_2', 'thal_3'],
      dtype='object')
```

[62]:

```
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.tree import plot_tree
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.preprocessing import MinMaxScaler
scaler = MinMaxScaler()
#split dataset to train and test
feature = ['age', 'trestbps', 'chol', 'thalach', 'oldpeak', 'sex_0', 'sex_1', 'cp_0', 'cp_1', 'cp_2', 'cp_3', 'fbs_0', 'fbs_1', 'restecg_0', 'restecg_1
       'slope_0', 'slope_1', 'slope_2', 'ca_0', 'ca_1', 'ca_2', 'ca_3', 'ca_4', 'thal_0', 'thal_1', 'thal_2', 'thal_3'],

#split train and test for decision tree model 80/20 split
y = dataset2["target"]
x = dataset2.drop(["target"],axis=1).values
xtrain, xtest, ytrain, ytest = train_test_split(x,y, test_size = 0.2, random_state=0)

xtrainknn = scaler.fit_transform(xtrain)
xtestknn = scaler.transform(xtest)
```

[63]:

```
xtrainknn
```

[63]:

```
array([[0.27083333, 0.71052632, 0.48163265, ..., 0.        , 1.        ,
        0.        ],
       [0.77083333, 0.68421053, 0.62040816, ..., 0.        , 1.        ,
        0.        ],
       [0.5       , 0.47368421, 0.48979592, ..., 0.        , 1.        ,
        0.        ],
       ...,
       [0.75      , 0.57894737, 0.63673469, ..., 0.        , 1.        ,
        0.        ],
       [0.79166667, 0.34210526, 0.45306122, ..., 0.        , 1.        ,
        0.        ],
       [0.64583333, 0.60526316, 0.24081633, ..., 0.        , 1.        ,
        0.        ]])
```

```
[64]: xtestknn
```

```
[64]: array([[0.3125    , 0.47368421, 0.43673469, ..., 0.        , 1.        ,
         0.        ],
        [0.60416667, 0.55263158, 0.7877551 , ..., 0.        , 1.        ,
         0.        ],
        [0.70833333, 0.60526316, 0.24897959, ..., 0.        , 0.        ,
         1.        ],
        ...,
        [0.29166667, 0.36842105, 0.35510204, ..., 0.        , 1.        ,
         0.        ],
        [0.77083333, 1.        , 0.41632653, ..., 0.        , 0.        ,
         1.        ],
        [0.875     , 0.23684211, 0.09387755, ..., 0.        , 1.        ,
         0.        ]])
```

```
[65]: xtrain
```

```
[65]: array([[42, 148, 244, ..., False, True, False],
        [66, 146, 278, ..., False, True, False],
        [53, 130, 246, ..., False, True, False],
        ...,
        [65, 138, 282, ..., False, True, False],
        [67, 120, 237, ..., False, True, False],
        [60, 140, 185, ..., False, True, False]], dtype=object)
```

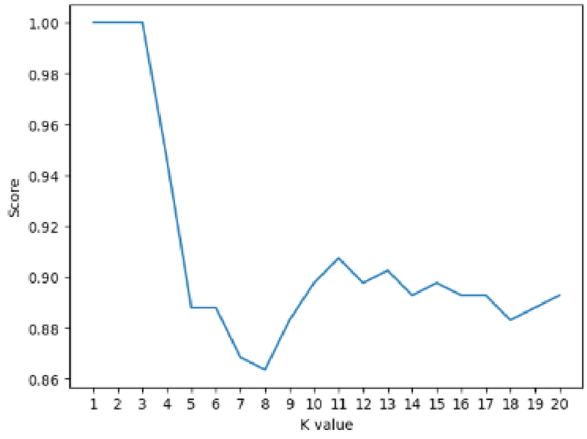
```
[66]: xtrain
```

```
[66]: array([[42, 148, 244, ..., False, True, False],
        [66, 146, 278, ..., False, True, False],
        [53, 130, 246, ..., False, True, False],
        ...,
        [65, 138, 282, ..., False, True, False],
        [67, 120, 237, ..., False, True, False],
        [60, 140, 185, ..., False, True, False]], dtype=object)
```

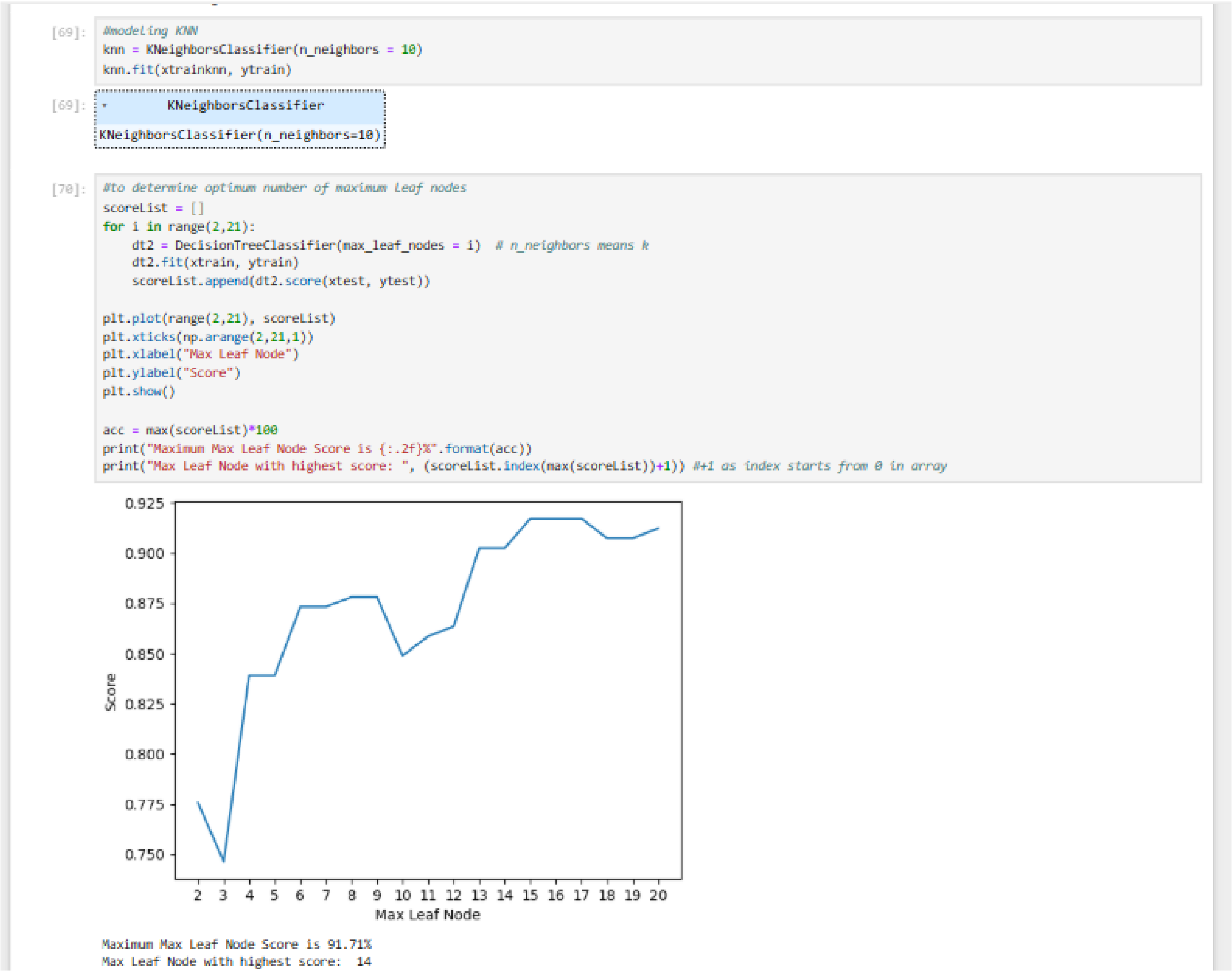
```
[67]: #suggested number of neighbours
import math
math.sqrt(301)
```

```
[67]: 17.349351572897472
```

```
[68]: #to determine optimum number of neighbours
scoreList = []
for i in range(1,21):
    knn2 = KNeighborsClassifier(n_neighbors = i)  # n_neighbors means k
    knn2.fit(xtrainknn, ytrain)
    scoreList.append(knn2.score(xtestknn, ytest))

plt.plot(range(1,21), scoreList)
plt.xticks(np.arange(1,21,1))
plt.xlabel("K value")
plt.ylabel("Score")
plt.show()

acc = max(scoreList)*100
print("Maximum KNN Score is {:.2f}%".format(acc))
print("K Value with highest score: ", (scoreList.index(max(scoreList))+1)) #+1 as index starts from 0 in array
```



```
Maximum KNN Score is 100.00%
K Value with highest score:  1
```

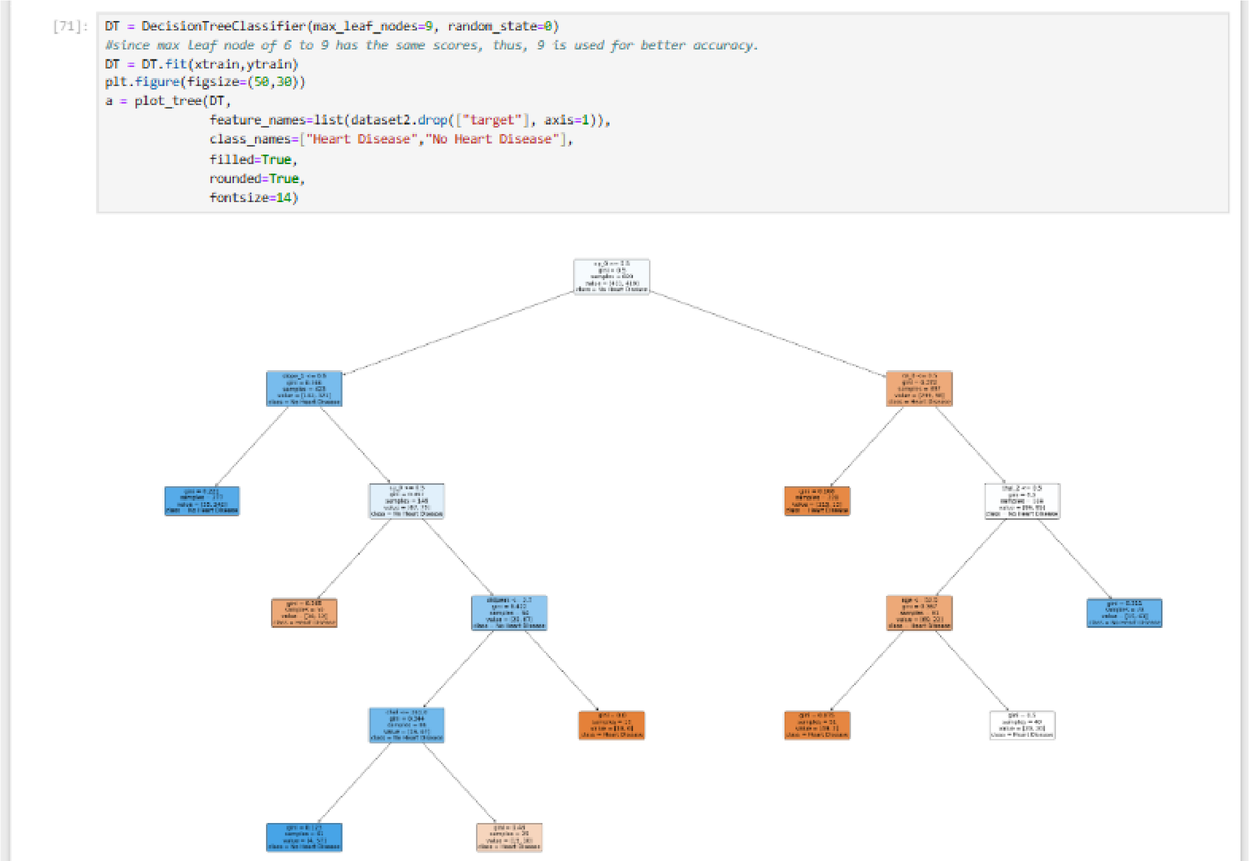


```
[69]: #modeling KNN
      knn = KNeighborsClassifier(n_neighbors = 10)
      knn.fit(xtrainknn, ytrain)
```

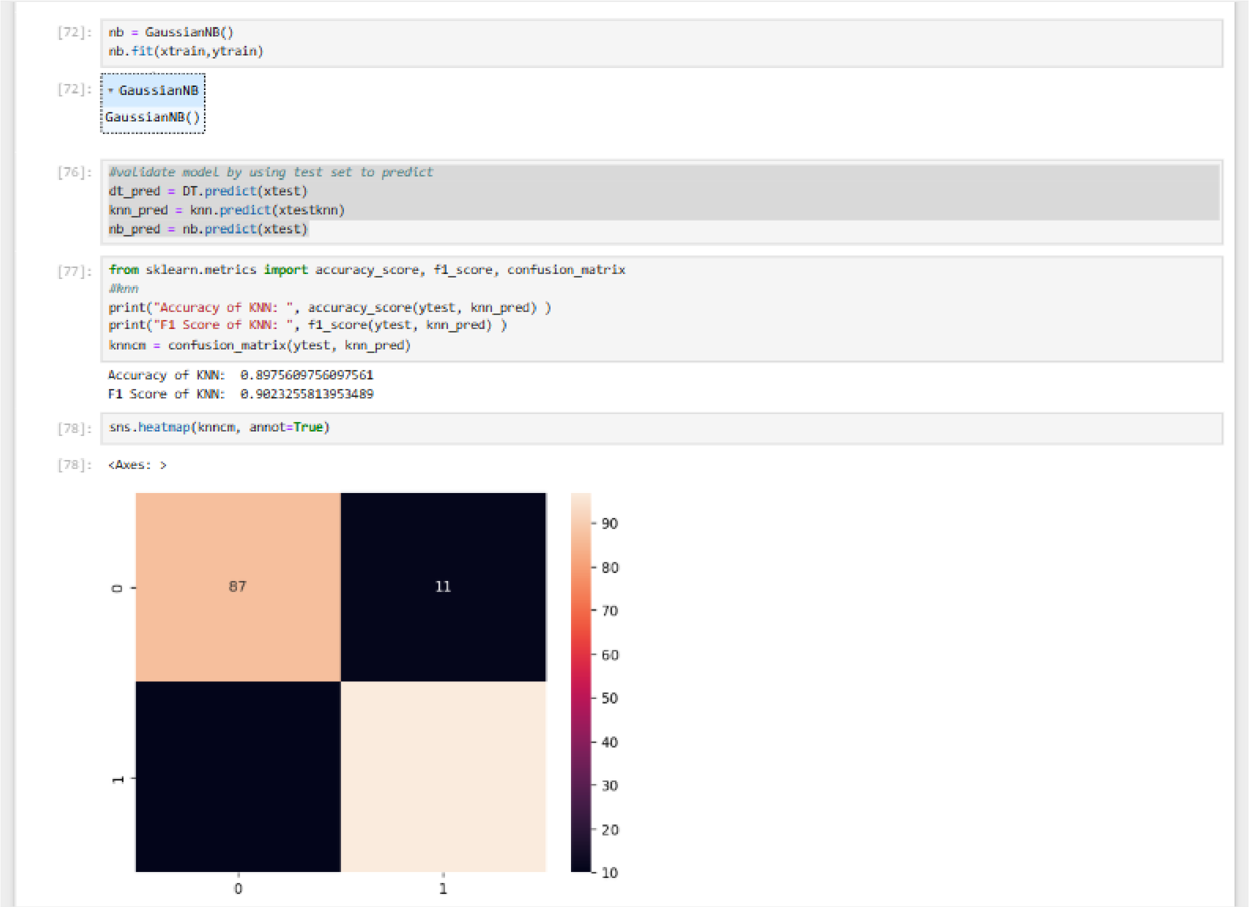
```
[69]: ▾         KNeighborsClassifier
      KNeighborsClassifier(n_neighbors=10)
```

```
[70]: #to determine optimum number of maximum leaf nodes
      scoreList = []
      for i in range(2,21):
          dt2 = DecisionTreeClassifier(max_leaf_nodes = i)  # n_neighbors means k
          dt2.fit(xtrain, ytrain)
          scoreList.append(dt2.score(xtest, ytest))

      plt.plot(range(2,21), scoreList)
      plt.xticks(np.arange(2,21,1))
      plt.xlabel("Max Leaf Node")
      plt.ylabel("Score")
      plt.show()

      acc = max(scoreList)*100
      print("Maximum Max Leaf Node Score is {:.2f}%".format(acc))
      print("Max Leaf Node with highest score: ", (scoreList.index(max(scoreList))+1)) #+1 as index starts from 0 in array
```

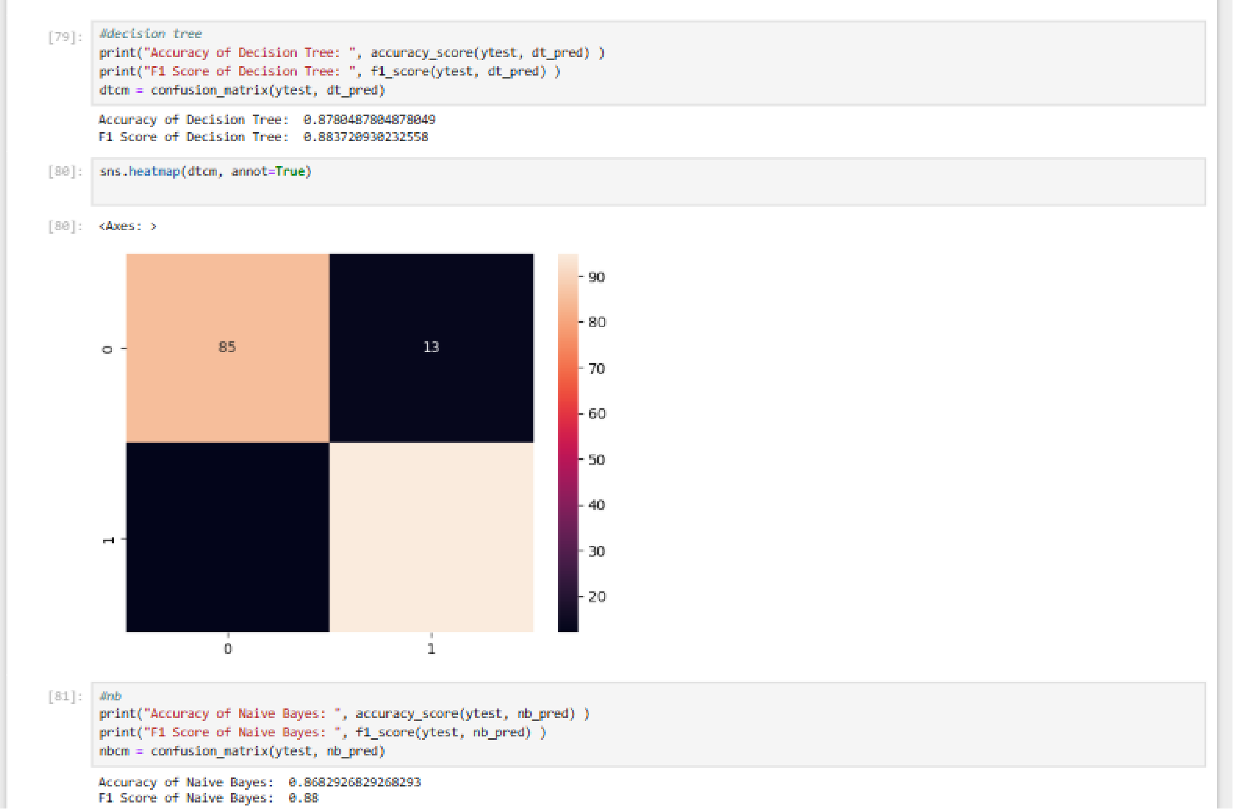
```
Maximum Max Leaf Node Score is 91.71%
Max Leaf Node with highest score:  14
```



```
[71]: DT = DecisionTreeClassifier(max_leaf_nodes=9, random_state=0)
      #since max leaf node of 6 to 9 has the same scores, thus, 9 is used for better accuracy.
      DT = DT.fit(xtrain,ytrain)
      plt.figure(figsize=(50,30))
      a = plot_tree(DT,
                    feature_names=list(dataset2.drop(["target"], axis=1)),
                    class_names=["Heart Disease","No Heart Disease"],
                    filled=True,
                    rounded=True,
                    fontsize=14)
```

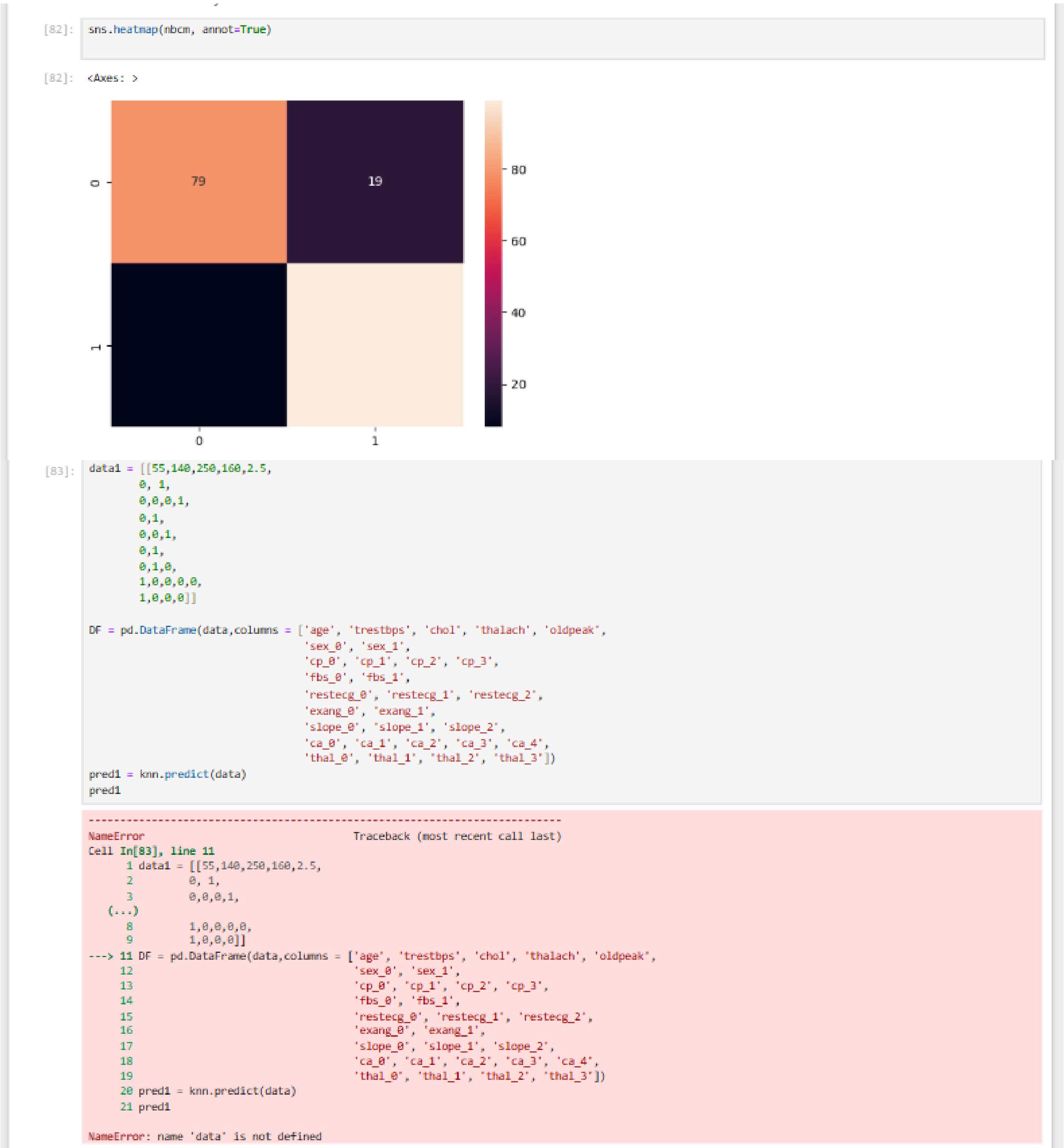


```
[72]: nb = GaussianNB()
      nb.fit(xtrain,ytrain)

[72]: ▾ GaussianNB
      GaussianNB()

[76]: #validate model by using test set to predict
      dt_pred = DT.predict(xtest)
      knn_pred = knn.predict(xtestknn)
      nb_pred = nb.predict(xtest)

[77]: from sklearn.metrics import accuracy_score, f1_score, confusion_matrix
      #knn
      print("Accuracy of KNN: ", accuracy_score(ytest, knn_pred) )
      print("F1 Score of KNN: ", f1_score(ytest, knn_pred) )
      knncm = confusion_matrix(ytest, knn_pred)

      Accuracy of KNN:  0.8975609756097561
      F1 Score of KNN:  0.9023255813953489

[78]: sns.heatmap(knncm, annot=True)

[78]: <Axes: >
```



```
[79]: #decision tree
      print("Accuracy of Decision Tree: ", accuracy_score(ytest, dt_pred) )
      print("F1 Score of Decision Tree: ", f1_score(ytest, dt_pred) )
      dtcm = confusion_matrix(ytest, dt_pred)

      Accuracy of Decision Tree:  0.8780487804878049
      F1 Score of Decision Tree:  0.883720930232558

[80]: sns.heatmap(dtcm, annot=True)

[80]: <Axes: >
```

```
[81]: #nb
      print("Accuracy of Naive Bayes: ", accuracy_score(ytest, nb_pred) )
      print("F1 Score of Naive Bayes: ", f1_score(ytest, nb_pred) )
      nbcm = confusion_matrix(ytest, nb_pred)

      Accuracy of Naive Bayes:  0.8682926829268293
      F1 Score of Naive Bayes:  0.88
```



```
[82]: sns.heatmap(nbcm, annot=True)

[82]: <Axes: >
```

```
[83]: data1 = [[55,140,250,160,2.5,
              0, 1,
              0,0,0,1,
              0,1,
              0,0,1,
              0,1,
              0,1,0,
              1,0,0,0,0,
              1,0,0,0]]

      DF = pd.DataFrame(data,columns = ['age', 'trestbps', 'chol', 'thalach', 'oldpeak',
                                        'sex_0', 'sex_1',
                                        'cp_0', 'cp_1', 'cp_2', 'cp_3',
                                        'fbs_0', 'fbs_1',
                                        'restecg_0', 'restecg_1', 'restecg_2',
                                        'exang_0', 'exang_1',
                                        'slope_0', 'slope_1', 'slope_2',
                                        'ca_0', 'ca_1', 'ca_2', 'ca_3', 'ca_4',
                                        'thal_0', 'thal_1', 'thal_2', 'thal_3'])
      pred1 = knn.predict(data)
      pred1
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
Cell In[83], line 11
      1 data1 = [[55,140,250,160,2.5,
      2         0, 1,
      3         0,0,0,1,
   (...)
      8         1,0,0,0,0,
      9         1,0,0,0]]
---> 11 DF = pd.DataFrame(data,columns = ['age', 'trestbps', 'chol', 'thalach', 'oldpeak',
     12                                   'sex_0', 'sex_1',
     13                                   'cp_0', 'cp_1', 'cp_2', 'cp_3',
     14                                   'fbs_0', 'fbs_1',
     15                                   'restecg_0', 'restecg_1', 'restecg_2',
     16                                   'exang_0', 'exang_1',
     17                                   'slope_0', 'slope_1', 'slope_2',
     18                                   'ca_0', 'ca_1', 'ca_2', 'ca_3', 'ca_4',
     19                                   'thal_0', 'thal_1', 'thal_2', 'thal_3'])
     20 pred1 = knn.predict(data)
     21 pred1

NameError: name 'data' is not defined
```