IMPORT NECESSARY LIBRARIES

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import missingno as msno
import warnings
warnings.filterwarnings('ignore')
```

IMPORT MODULES

```
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import
accuracy_score,classification_report,confusion_matrix,r2_score
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
```

LOAD THE DATASET

```
data=pd.read_csv(r"C:\Users\Admin\Downloads\processed_cleveland.csv")
data.head()
```

```
   age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  oldpeak
slope  \
0   63    1   1       145   233    1        2      150      0      2.3
3
1   67    1   4       160   286    0        2      108      1      1.5
2
2   67    1   4       120   229    0        2      129      1      2.6
2
3   37    1   3       130   250    0        0      187      0      3.5
3
4   41    0   2       130   204    0        2      172      0      1.4
1

  ca thal  num
0  0    6    0
1  3    3    2
2  2    7    1
```

```
3  0    3    0
4  0    3    0
```

```
data.shape
```

```
(303, 14)
```

```
data.duplicated().sum()
```

```
0
```

```
data.isnull().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
num         0
dtype: int64
```

```
data.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    object 
 12  thal      303 non-null    object 
 13  num       303 non-null    int64  
```

```
dtypes: float64(1), int64(11), object(2)
memory usage: 33.3+ KB
```

```
data['ca']=pd.to_numeric(data['ca'],errors='coerce')
data['thal']=pd.to_numeric(data['thal'],errors='coerce')

data.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        299 non-null    float64
 12  thal      301 non-null    float64
 13  num       303 non-null    int64
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

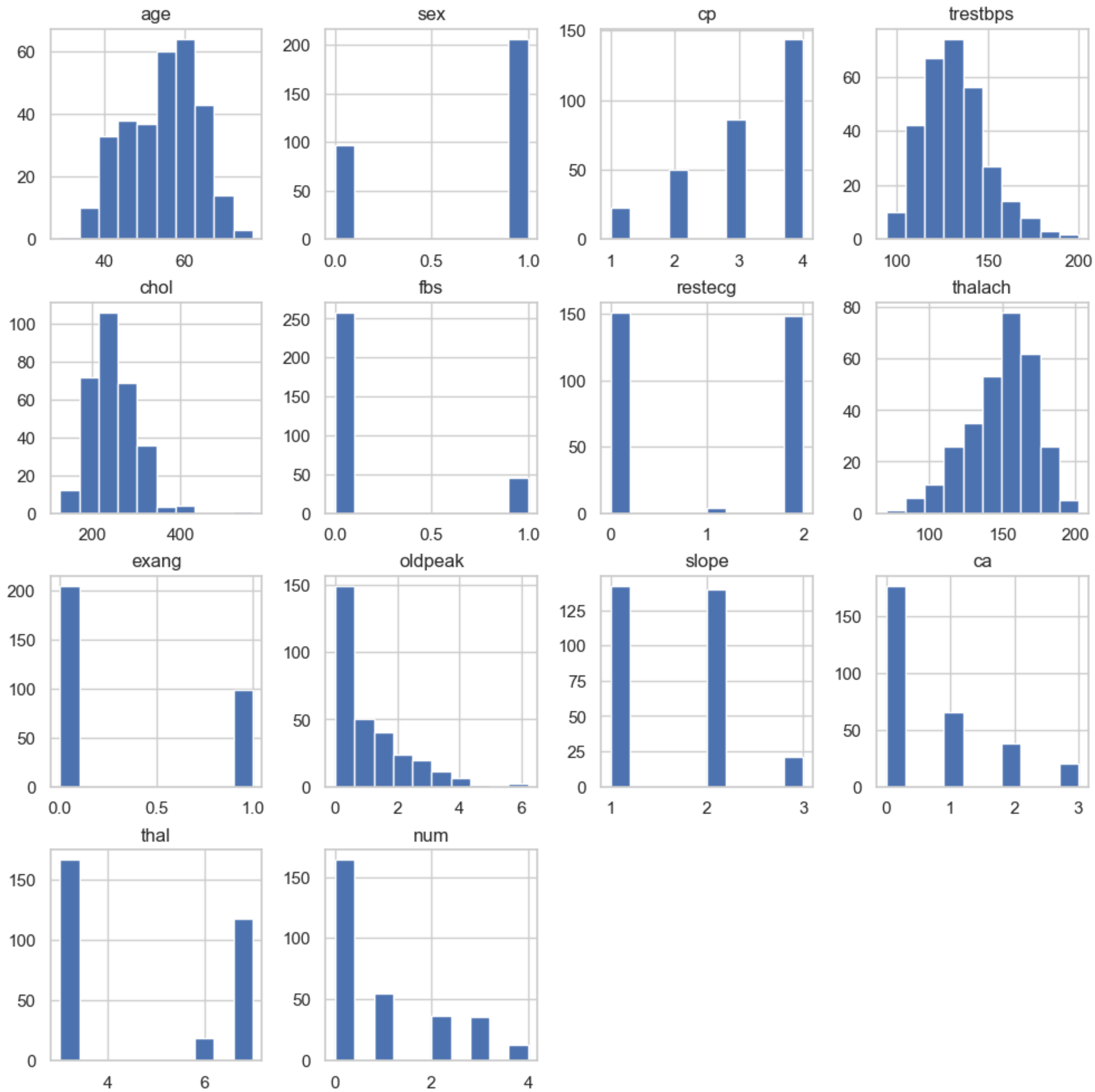
```
data.describe()
```

```
              age         sex          cp    trestbps        chol
fbs  \
count  303.000000  303.000000  303.000000  303.000000  303.000000
303.000000
mean    54.438944    0.679868    3.158416  131.689769  246.693069
0.148515
std      9.038662    0.467299    0.960126   17.599748   51.776918
0.356198
min     29.000000    0.000000    1.000000   94.000000  126.000000
0.000000
25%     48.000000    0.000000    3.000000  120.000000  211.000000
0.000000
50%     56.000000    1.000000    3.000000  130.000000  241.000000
0.000000
75%     61.000000    1.000000    4.000000  140.000000  275.000000
0.000000
max     77.000000    1.000000    4.000000  200.000000  564.000000
1.000000
```

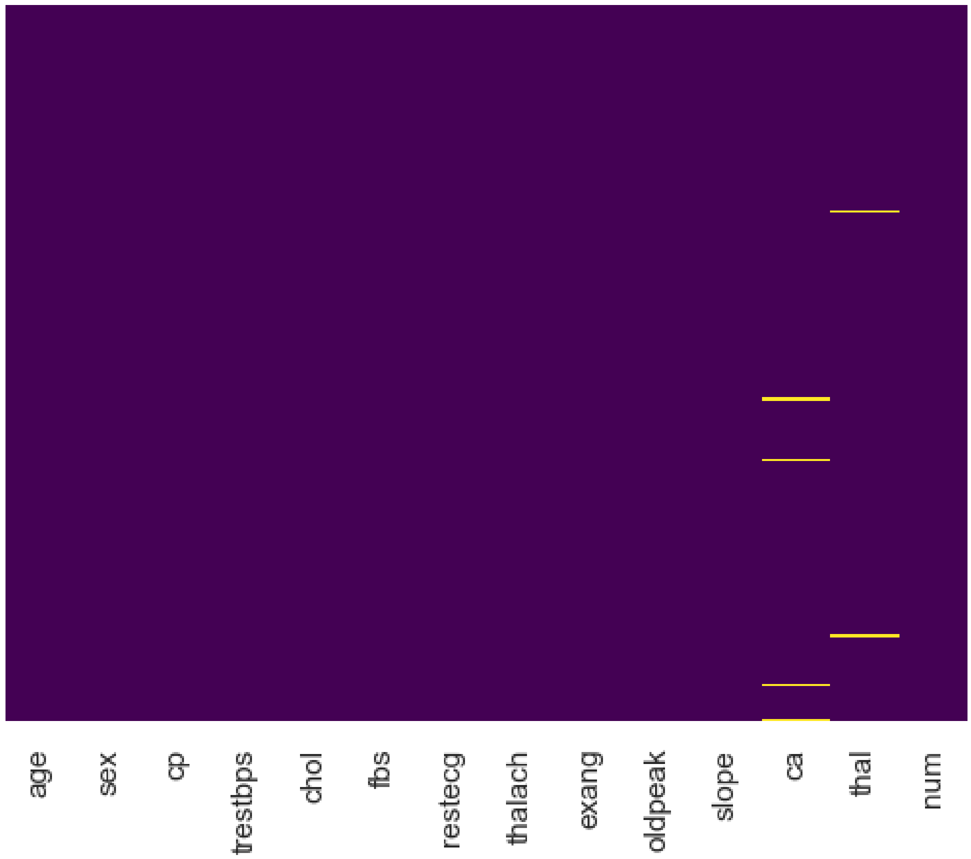
```
         restecg    thalach       exang     oldpeak       slope
ca  \
count  303.000000  303.000000  303.000000  303.000000  303.000000
299.000000
mean     0.990099  149.607261    0.326733    1.039604    1.600660
0.672241
std      0.994971   22.875003    0.469794    1.161075    0.616226
0.937438
min      0.000000   71.000000    0.000000    0.000000    1.000000
0.000000
25%      0.000000  133.500000    0.000000    0.000000    1.000000
0.000000
50%      1.000000  153.000000    0.000000    0.800000    2.000000
0.000000
75%      2.000000  166.000000    1.000000    1.600000    2.000000
1.000000
max      2.000000  202.000000    1.000000    6.200000    3.000000
3.000000

             thal         num
count  301.000000  303.000000
mean     4.734219    0.937294
std      1.939706    1.228536
min      3.000000    0.000000
25%      3.000000    0.000000
50%      3.000000    0.000000
75%      7.000000    2.000000
max      7.000000    4.000000
```

VISUALIZING THE DATA

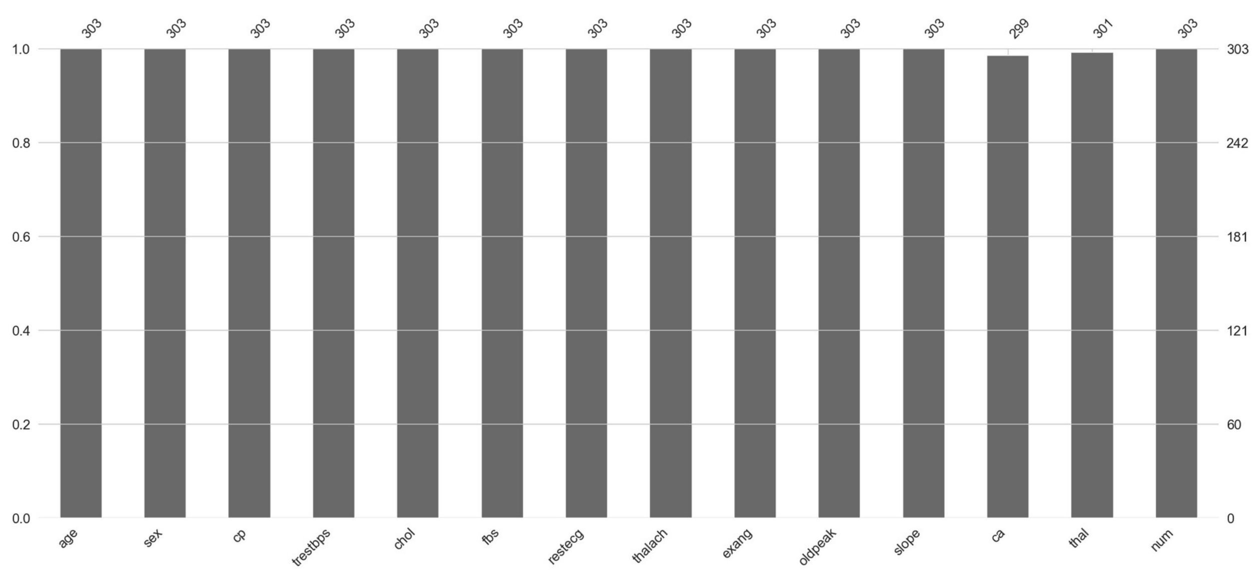
```
data.hist(figsize=(12,12))
plt.show()
```



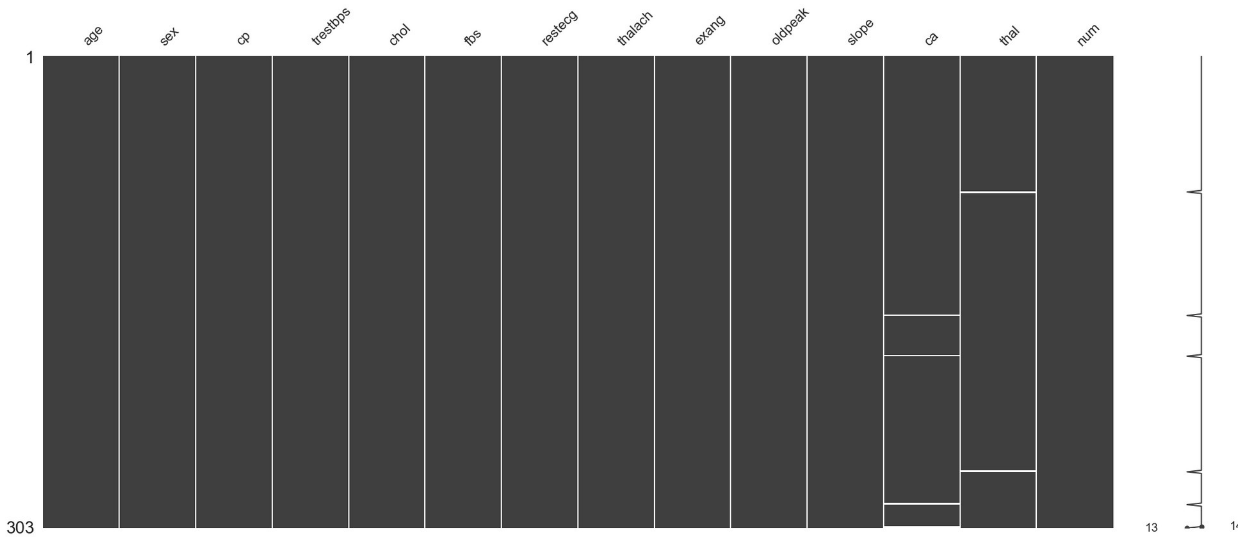

```
sns.heatmap(data.isnull(),yticklabels=False,cbar=False,cmap='viridis')
plt.show()
```




```
msno.bar(data)

<AxesSubplot:>
```



```
msno.matrix(data)
plt.show()
```




```
data.corr()
```

```
               age       sex        cp  trestbps      chol
fbs  \
age       1.000000 -0.097542  0.104139  0.284946  0.208950  0.118530

sex      -0.097542  1.000000  0.010084 -0.064456 -0.199915  0.047862

cp        0.104139  0.010084  1.000000 -0.036077  0.072319 -0.039975

trestbps  0.284946 -0.064456 -0.036077  1.000000  0.130120  0.175340

chol      0.208950 -0.199915  0.072319  0.130120  1.000000  0.009841

fbs       0.118530  0.047862 -0.039975  0.175340  0.009841  1.000000

restecg   0.148868  0.021647  0.067505  0.146560  0.171043  0.069564

thalach  -0.393806 -0.048663 -0.334422 -0.045351 -0.003432 -0.007854

exang     0.091661  0.146201  0.384060  0.064762  0.061310  0.025665

oldpeak   0.203805  0.102173  0.202277  0.189171  0.046564  0.005747

slope     0.161770  0.037533  0.152050  0.117382 -0.004062  0.059894

ca        0.362605  0.093185  0.233214  0.098773  0.119000  0.145478

thal      0.127389  0.380936  0.265246  0.133554  0.014214  0.071358
```

```
num        0.222853  0.224469  0.407075  0.157754  0.070909  0.059186


            restecg   thalach     exang   oldpeak     slope
ca  \
age        0.148868 -0.393806  0.091661  0.203805  0.161770  0.362605

sex        0.021647 -0.048663  0.146201  0.102173  0.037533  0.093185

cp         0.067505 -0.334422  0.384060  0.202277  0.152050  0.233214

trestbps   0.146560 -0.045351  0.064762  0.189171  0.117382  0.098773

chol       0.171043 -0.003432  0.061310  0.046564 -0.004062  0.119000

fbs        0.069564 -0.007854  0.025665  0.005747  0.059894  0.145478

restecg    1.000000 -0.083389  0.084867  0.114133  0.133946  0.128343

thalach   -0.083389  1.000000 -0.378103 -0.343085 -0.385601 -0.264246

exang      0.084867 -0.378103  1.000000  0.288223  0.257748  0.145570

oldpeak    0.114133 -0.343085  0.288223  1.000000  0.577537  0.295832

slope      0.133946 -0.385601  0.257748  0.577537  1.000000  0.110119

ca         0.128343 -0.264246  0.145570  0.295832  0.110119  1.000000

thal       0.024531 -0.279631  0.329680  0.341004  0.287232  0.256382

num        0.183696 -0.415040  0.397057  0.504092  0.377957  0.518909


               thal       num
age        0.127389  0.222853
sex        0.380936  0.224469
cp         0.265246  0.407075
trestbps   0.133554  0.157754
chol       0.014214  0.070909
fbs        0.071358  0.059186
restecg    0.024531  0.183696
thalach   -0.279631 -0.415040
exang      0.329680  0.397057
oldpeak    0.341004  0.504092
slope      0.287232  0.377957
ca         0.256382  0.518909
thal       1.000000  0.509923
num        0.509923  1.000000
```

```python
data.corr()['chol']
```

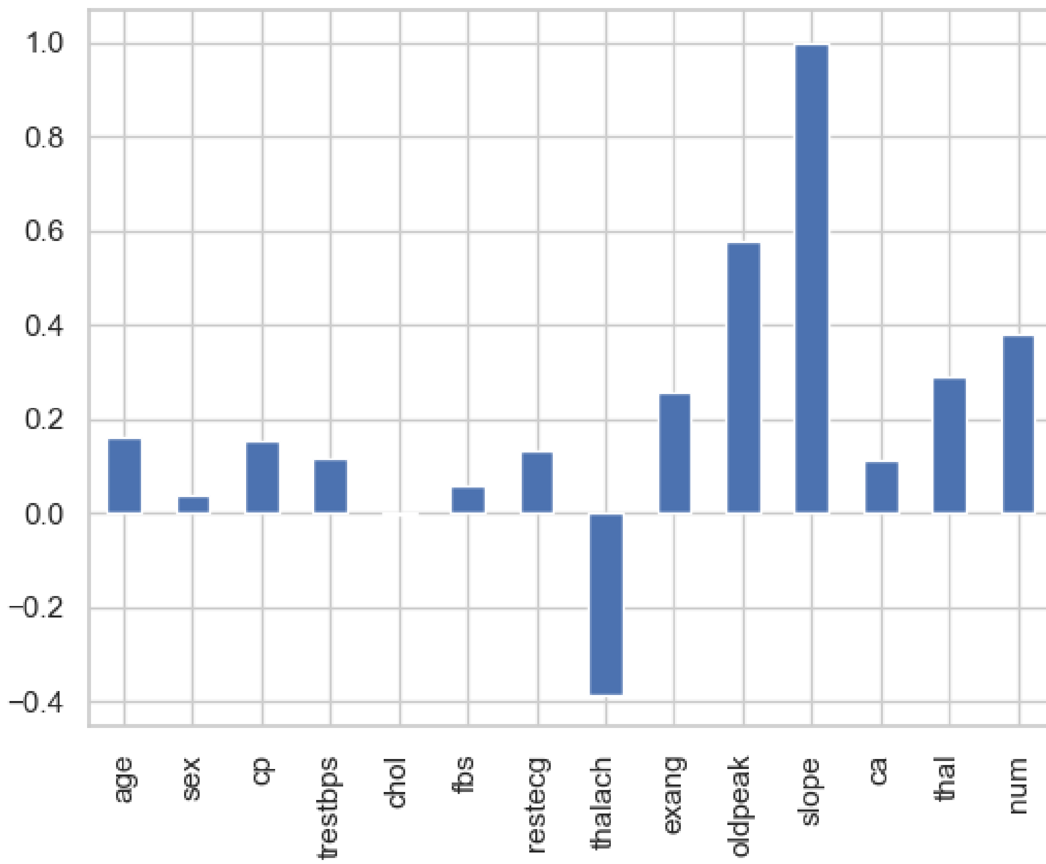
```
age         0.208950
sex        -0.199915
cp          0.072319
trestbps    0.130120
chol        1.000000
fbs         0.009841
restecg     0.171043
thalach    -0.003432
exang       0.061310
oldpeak     0.046564
slope      -0.004062
ca          0.119000
thal        0.014214
num         0.070909
Name: chol, dtype: float64
```

```
data.corr()['slope']
```

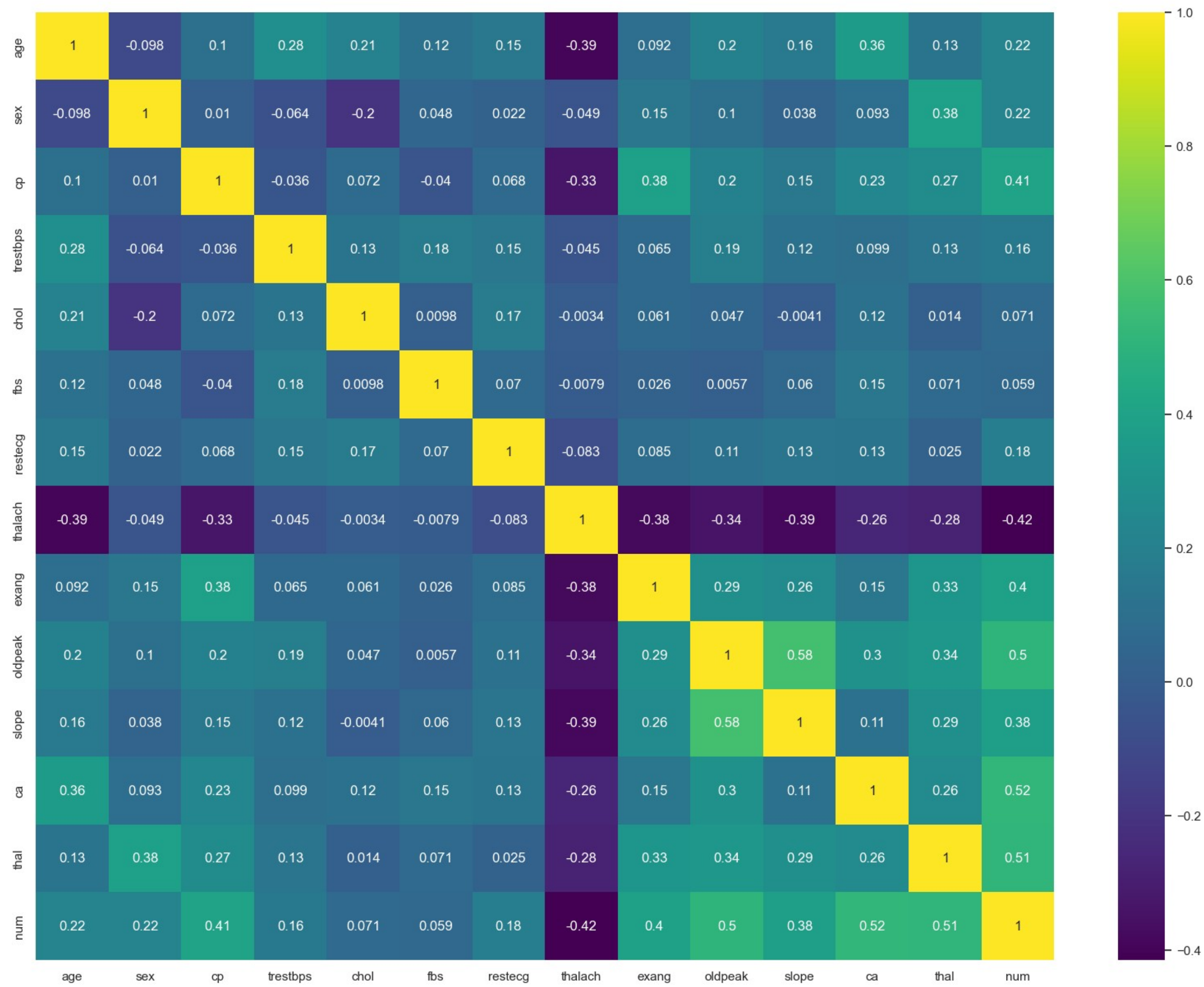
```
age         0.161770
sex         0.037533
cp          0.152050
trestbps    0.117382
chol       -0.004062
fbs         0.059894
restecg     0.133946
thalach    -0.385601
exang       0.257748
oldpeak     0.577537
slope       1.000000
ca          0.110119
thal        0.287232
num         0.377957
Name: slope, dtype: float64
```

```
data.corr()['slope'].plot(kind='bar')
```

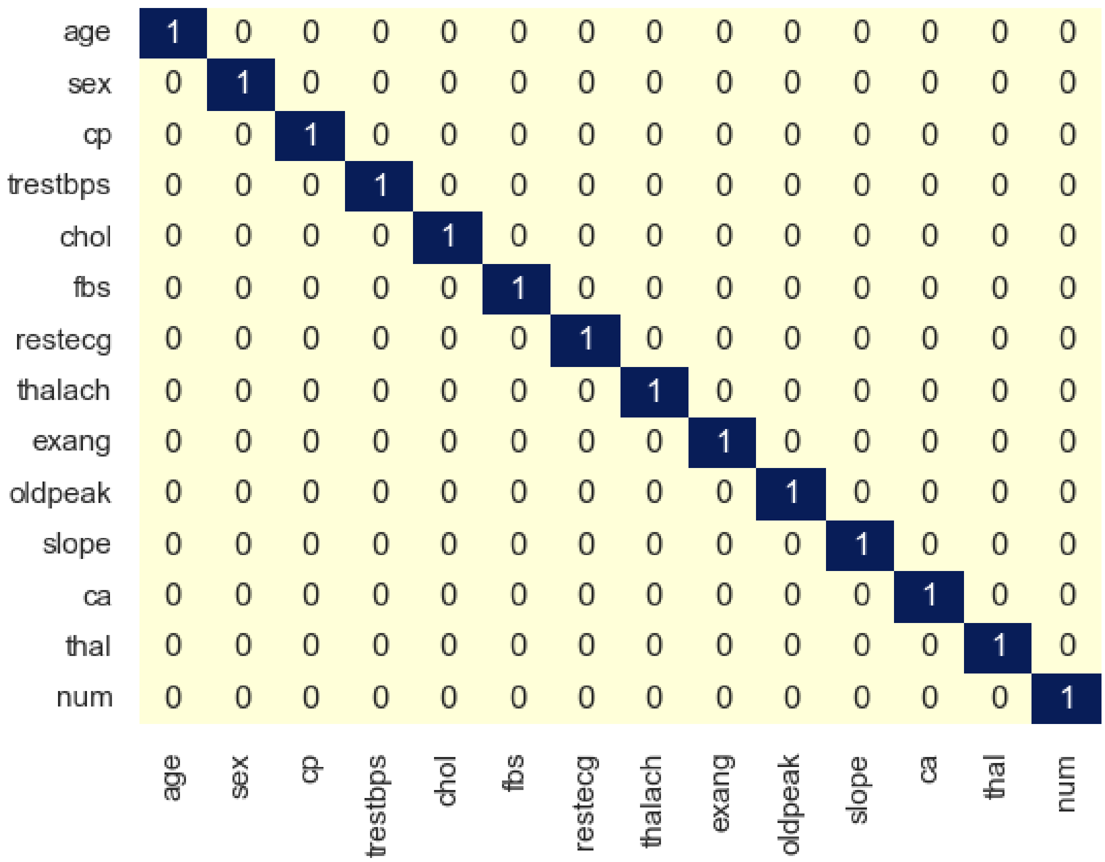
```
<AxesSubplot:>
```



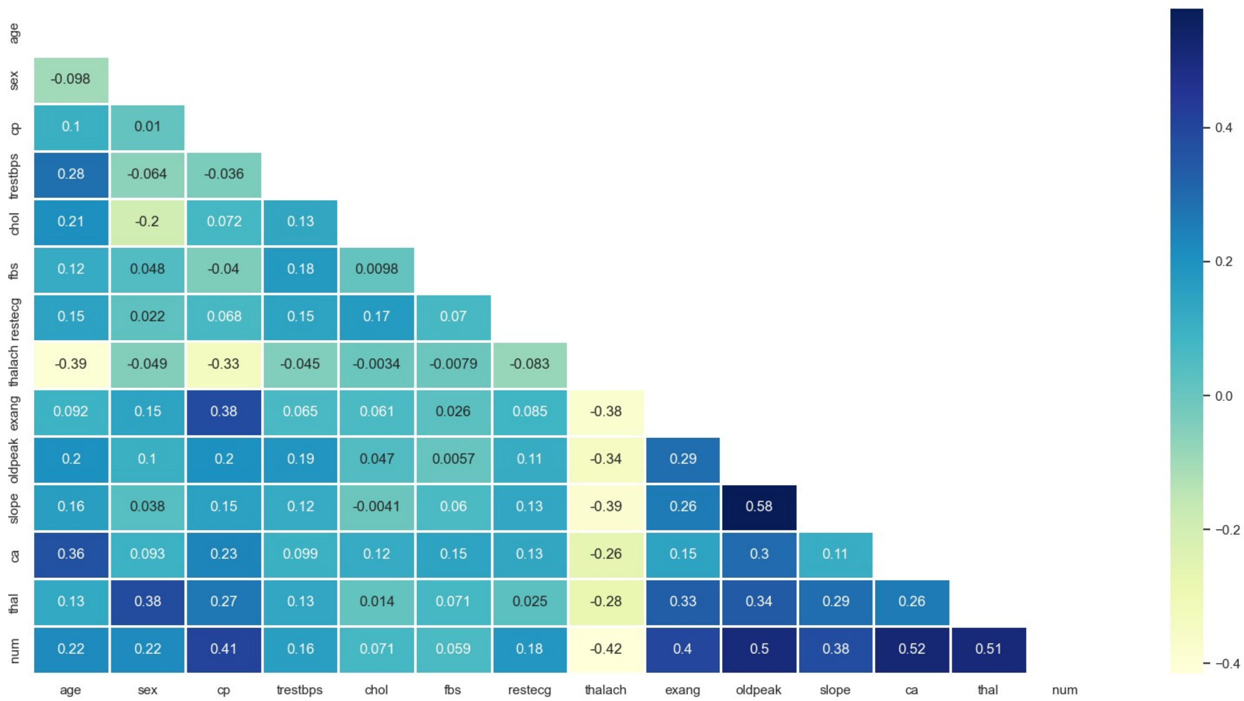

```
plt.figure(figsize=(20,15))
corr = data.corr()
sns.heatmap(data.corr(), cmap="viridis", annot=True)
plt.show()
```



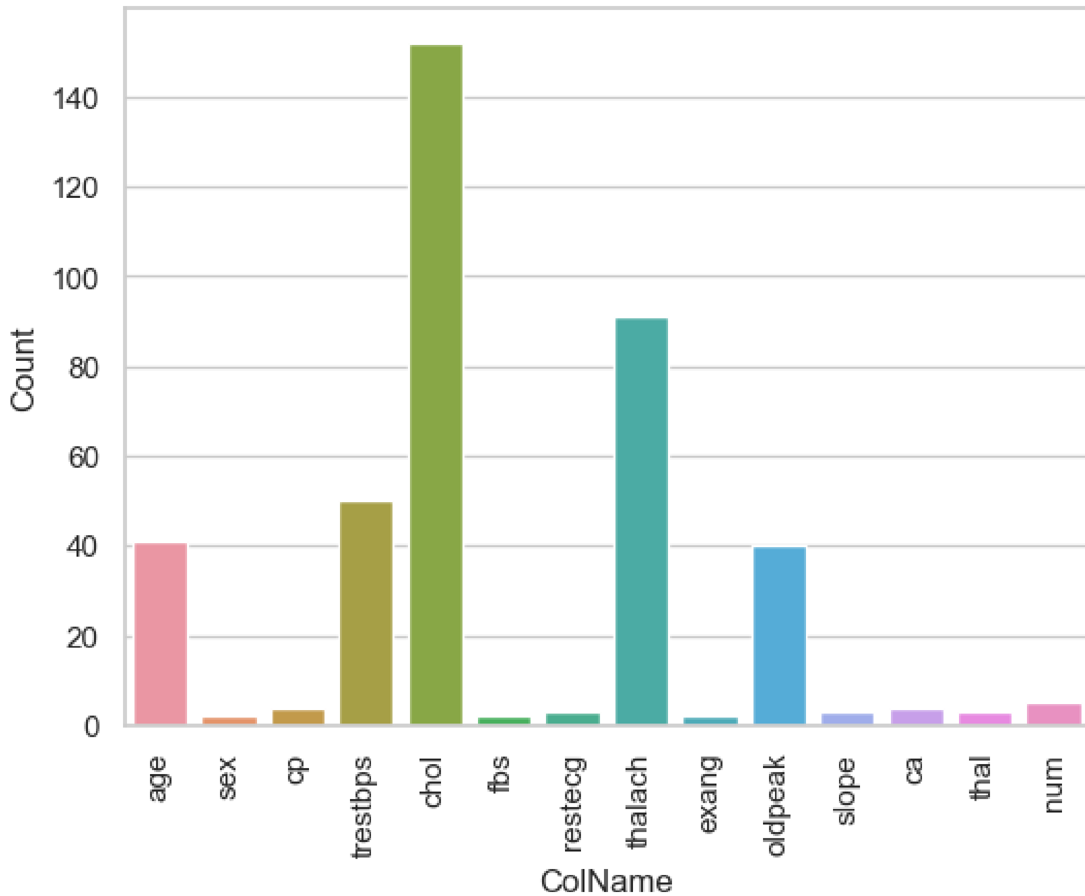

```python
sns.heatmap(data.corr() > 0.9, annot=True, cbar=False,cmap="YlGnBu")
plt.show()
```



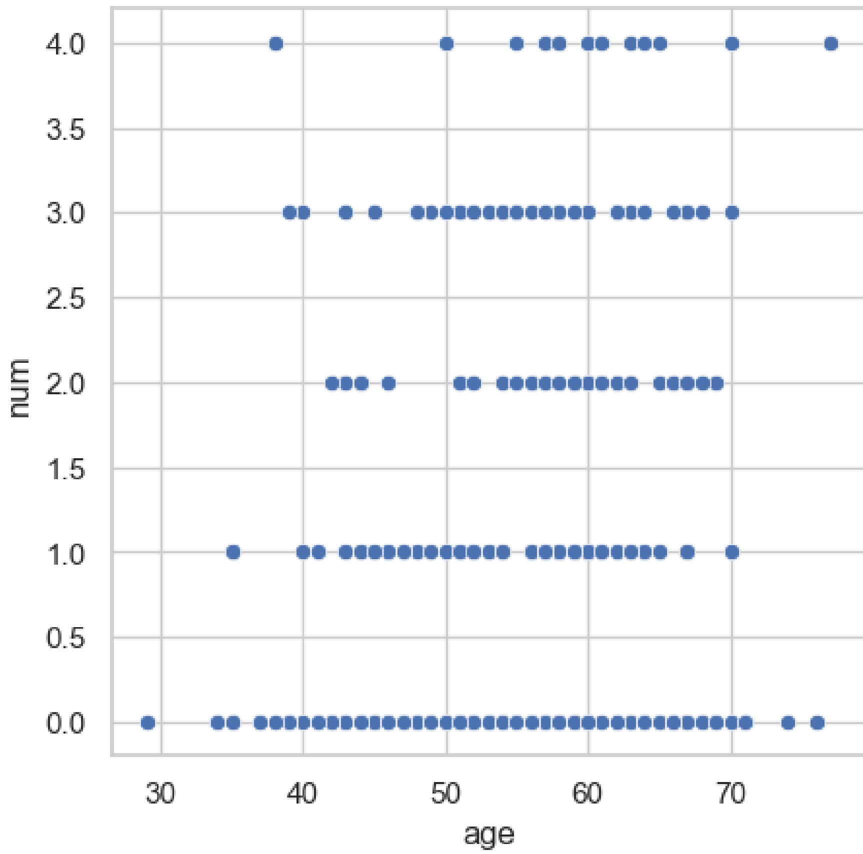

```
plt.figure(figsize=(20,10))
corr = data.corr()
mask=np.triu(np.ones_like(corr,dtype=bool))

sns.heatmap(data=corr, mask=mask,
cmap="YlGnBu",annot=True,linewidth=2)
plt.show()
```




```python
unique=data.nunique().to_frame()
unique.columns=['Count']
unique.index.names=['ColName']
unique=unique.reset_index()
sns.set(style='whitegrid',color_codes='True')
sns.barplot(x='ColName', y = 'Count', data = unique)
plt.xticks(rotation=90)
plt.show()
```

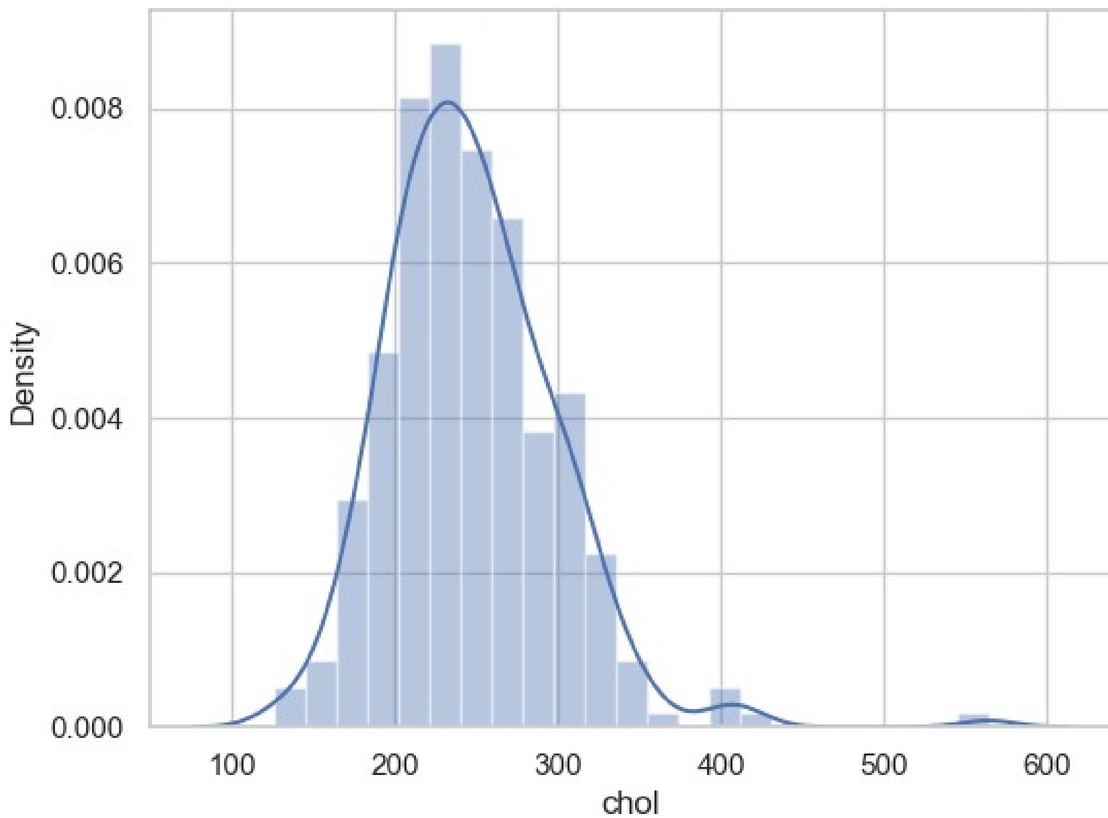



```
plt.figure(figsize=(5,5))
sns.scatterplot(x=data['age'],y=data['num'])
plt.show()
```

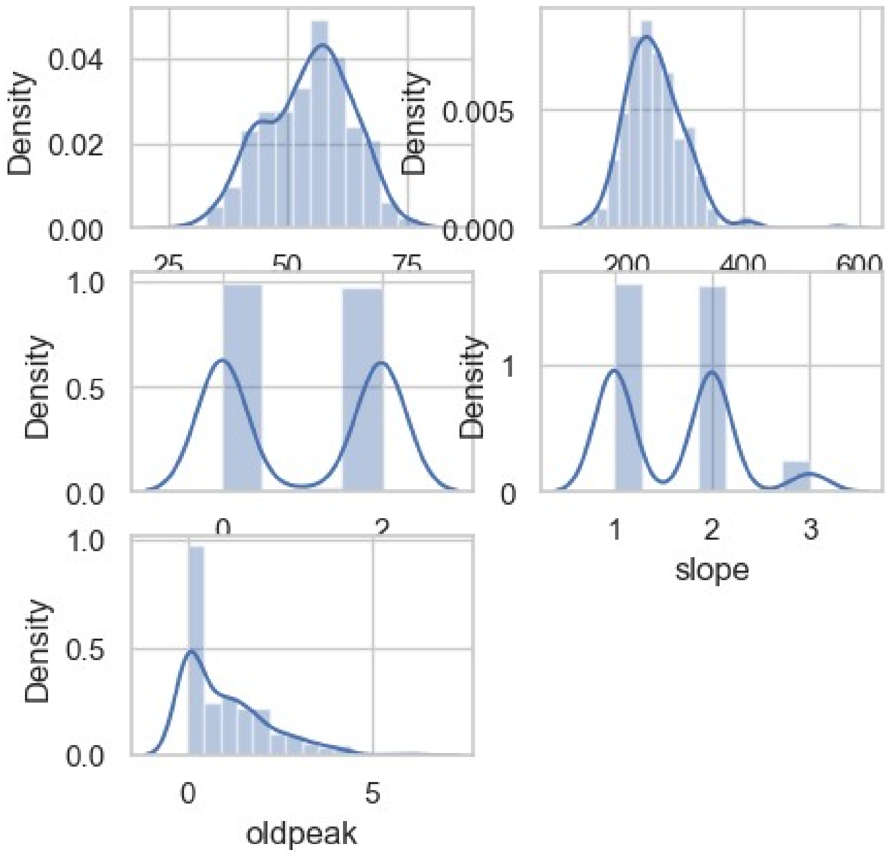



```
sns.distplot(data['chol'])
```

```
<AxesSubplot:xlabel='chol', ylabel='Density'>
```

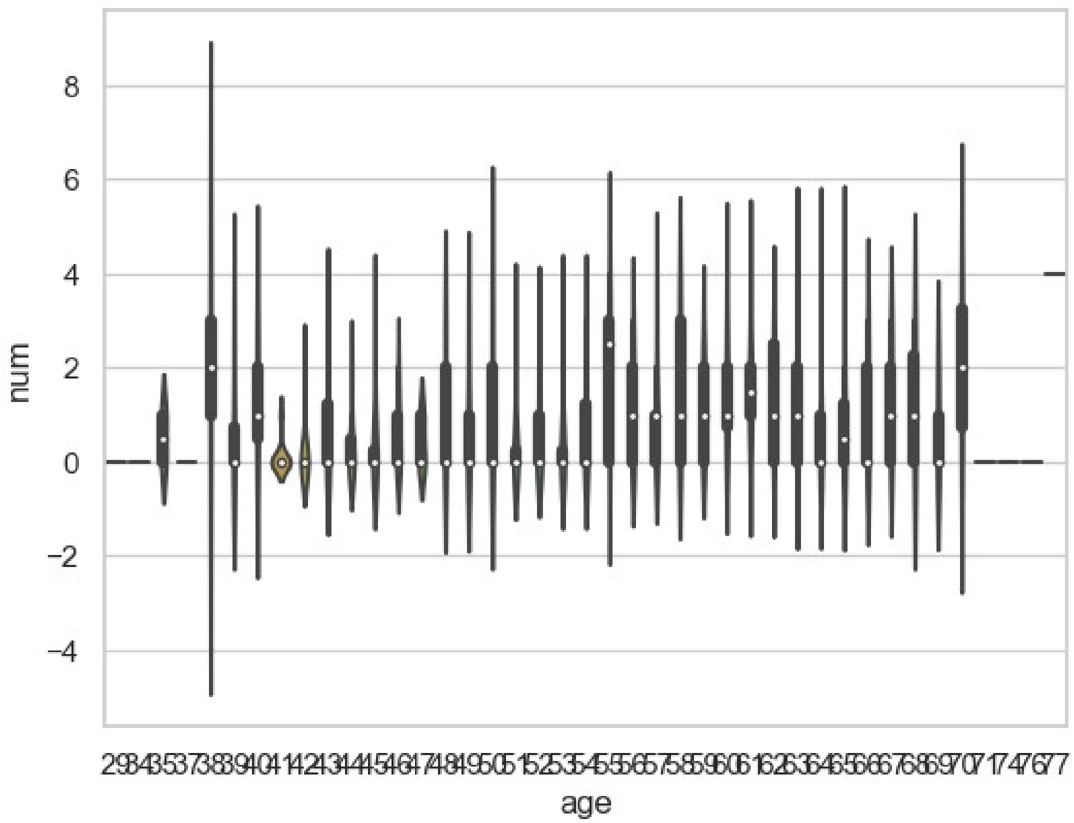



```
features = ['age','chol','restecg','slope', 'oldpeak']
plt.subplots(figsize=(5,5))

for i, col in enumerate(features):
  plt.subplot(3,2,i+1)
  sns.distplot(data[col])
plt.show()
```



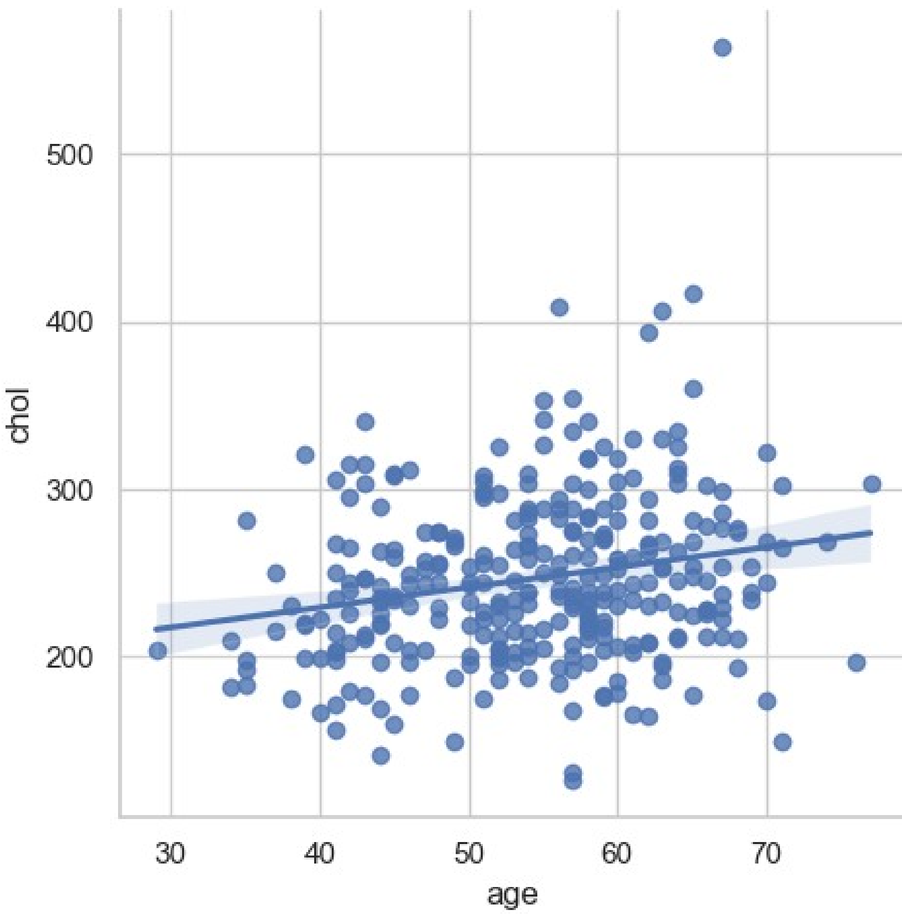

```
sns.violinplot(x='age', y='num', data=data)
```

```
<AxesSubplot:xlabel='age', ylabel='num'>
```



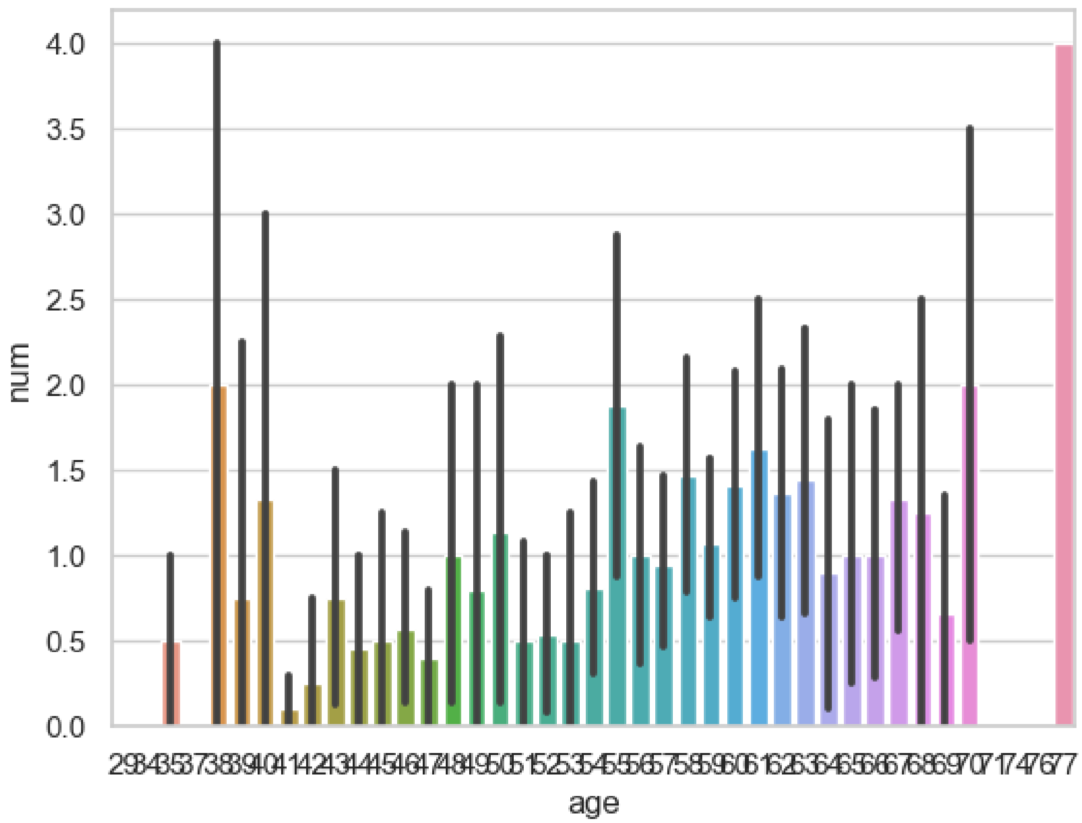

```
sns.lmplot(x='age',y='chol',data=data)
```

```
<seaborn.axisgrid.FacetGrid at 0x17845117a00>
```




```
sns.barplot(x='age',y='num',data=data)
```

```
<AxesSubplot:xlabel='age', ylabel='num'>
```




```
data.value_counts()

age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  oldpeak
slope  ca   thal  num
29   1    2   130       204   0    2        202      0      0.0        1
0.0  3.0   0       1
59   1    4   164       176   1    2        90       0      1.0        2
2.0  6.0   3       1
              138       271   0    2        182      0      0.0        1
0.0  3.0   0       1
              135       234   0    0        161      0      0.5        2
0.0  7.0   0       1
              110       239   0    2        142      1      1.2        2
1.0  7.0   2       1

..
51   1    3   110       175   0    0        123      0      0.6        1
0.0  3.0   0       1
              100       222   0    0        143      1      1.2        2
0.0  3.0   0       1
              94        227   0    0        154      1      0.0        1
1.0  7.0   0       1
          1   125       213   0    2        125      1      1.4        1
1.0  3.0   0       1
```

```
77   1    4   125        304   0    2          162       1       0.0       1
3.0  3.0   4       1
Length: 297, dtype: int64
```

```
data['chol'].value_counts()
```

```
204    6
197    6
234    6
269    5
212    5
      ..
340    1
160    1
394    1
184    1
131    1
Name: chol, Length: 152, dtype: int64
```

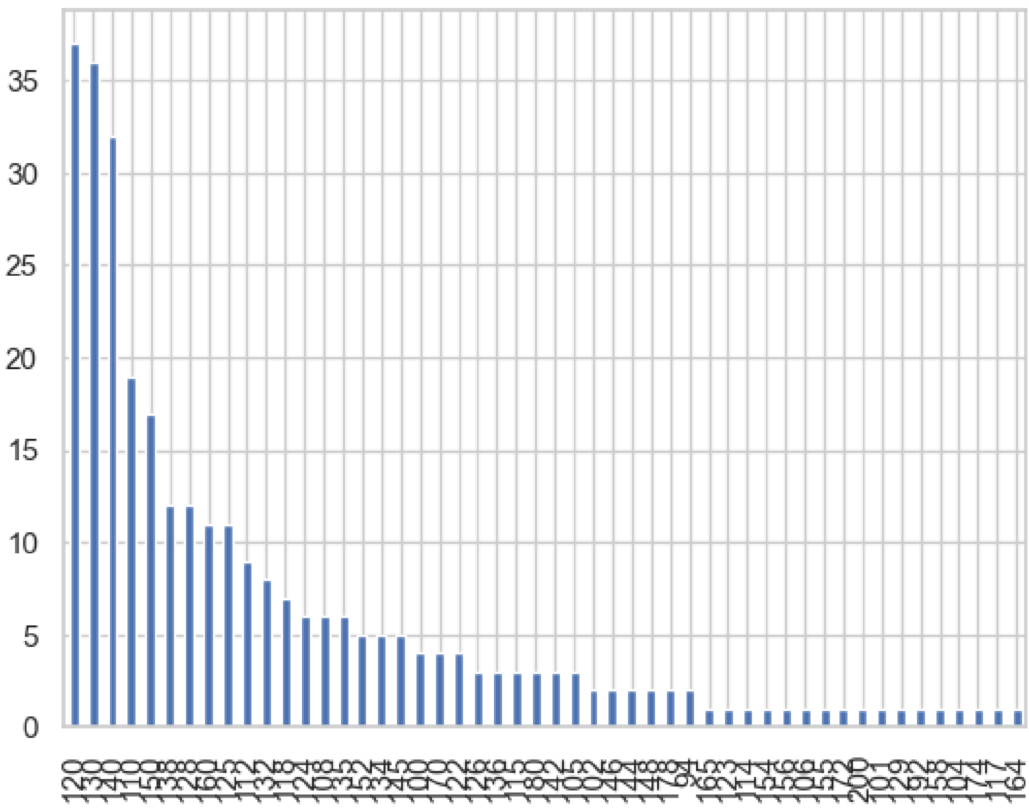
```
data['trestbps'].value_counts()
```

```
120    37
130    36
140    32
110    19
150    17
138    12
128    12
160    11
125    11
112     9
132     8
118     7
124     6
108     6
135     6
152     5
134     5
145     5
100     4
170     4
122     4
126     3
136     3
115     3
180     3
142     3
105     3
102     2
146     2
```

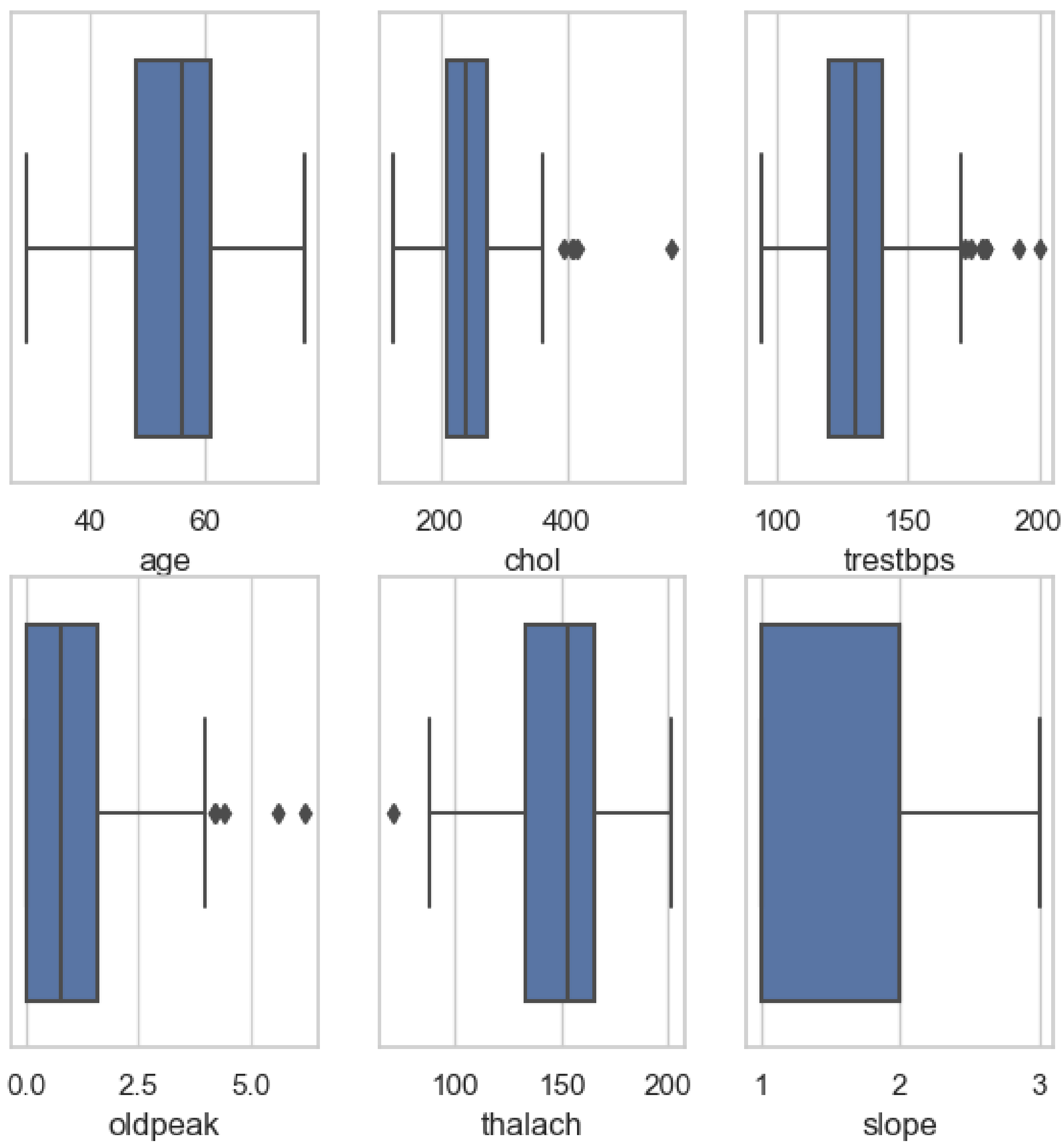
```
144    2
148    2
178    2
94     2
165    1
123    1
114    1
154    1
156    1
106    1
155    1
172    1
200    1
101    1
129    1
192    1
158    1
104    1
174    1
117    1
164    1
Name: trestbps, dtype: int64
```

```
data['trestbps'].value_counts().plot(kind='bar')
```

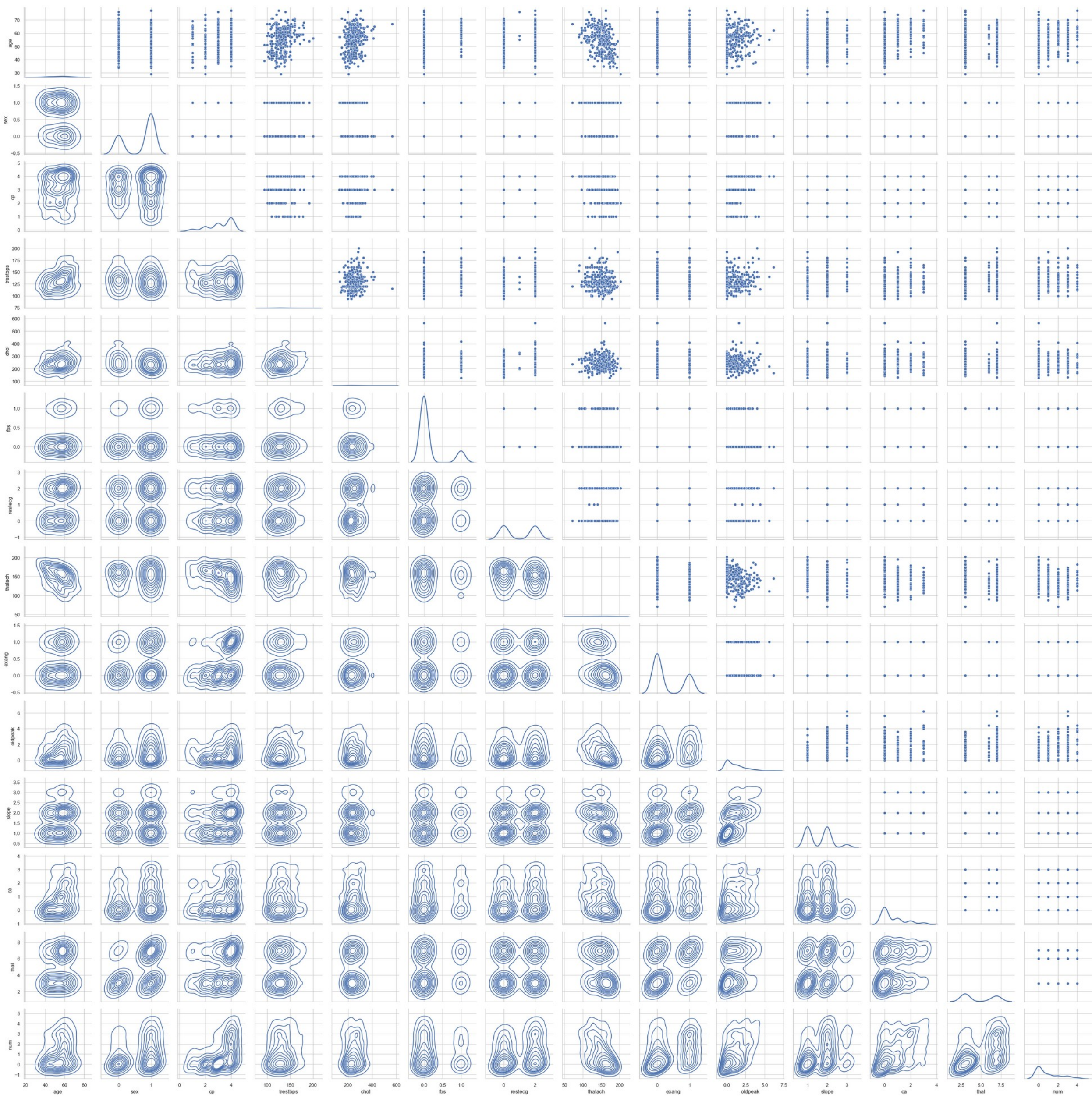
```
<AxesSubplot:>
```




```python
features = ['age','chol','trestbps','oldpeak','thalach','slope']

plt.subplots(figsize=(7,7))

for i, col in enumerate(features):
  plt.subplot(2,3,i+1)
  sns.boxplot(data[col])
plt.show()
```




```
graph=sns.PairGrid(data)

graph=graph.map_upper(sns.scatterplot)

graph=graph.map_lower(sns.kdeplot)

graph=graph.map_diag(sns.kdeplot,lw=2)

plt.show()
```



```python
import plotly.express as px
fig=px.scatter_3d(data,x='age',y='chol',z='num',
                  size='slope',
                  color='fbs')
fig.show()
```


```
{"config":{"plotlyServerURL":"https://plot.ly"},"data":
[{"hovertemplate":"age=%{x}<br>chol=%{y}<br>num=%{z}<br>slope=%
{marker.size}<br>fbs=%{marker.color}<extra></
extra>","legendgroup":"","marker":{"color":
[1,0,0,0,0,0,0,0,0,1,0,0,1,0,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,1,0,0,0
,0,0,0,0,1,0,0,0,1,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0
```

,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0
,0,0,0,0,0,0,1,0,1,0,0,1,0,1,0,1,0,0,0,1,0,1,0,0,0,0,0,0,0,0,0,0,0,1
,0,0,1,0,0,0,1,0,0,0,1,0,0,0,0,0,0,0,0,0,1,0,0,0,1,0,0,1,0,0,0,0,0,0
,0,1,0,0,1,0,0,0,0,0,0,1,0,0,0,0,0,1,1,0,0,1,0,0,0,0,0,1,0,0,0,0,0,0
,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,1
,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,1,0,0,1,0,0,0],"coloraxis":"coloraxis
","size":
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,1,2,2,2,2,2,1,1,1,1,2,1,2,1,3,1,1,1,1,1,2,2,1,3,1,2,3,2,1,2,2,2,1,3,2
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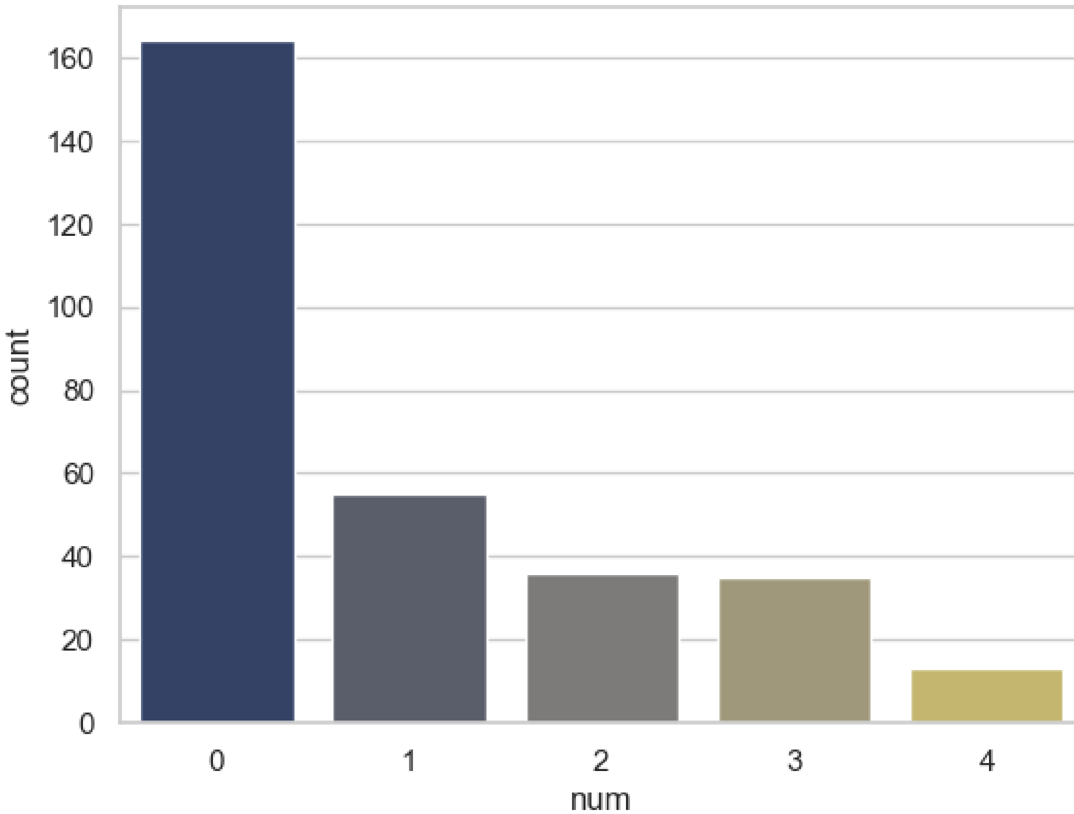


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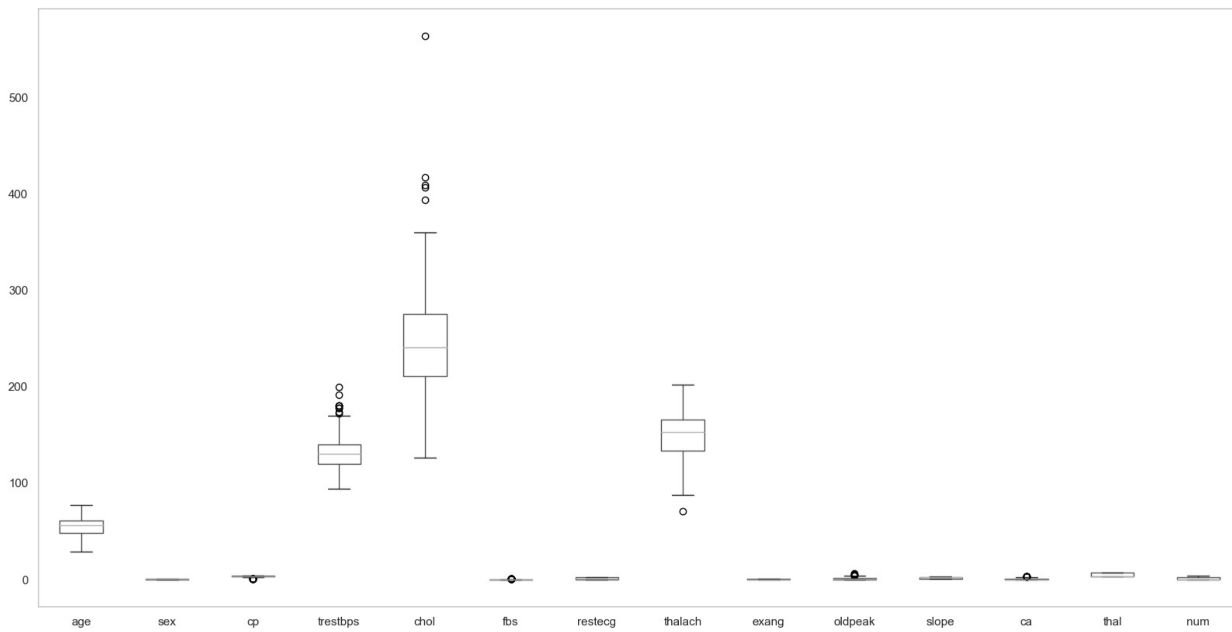
```
data.nunique().sort_values()
```

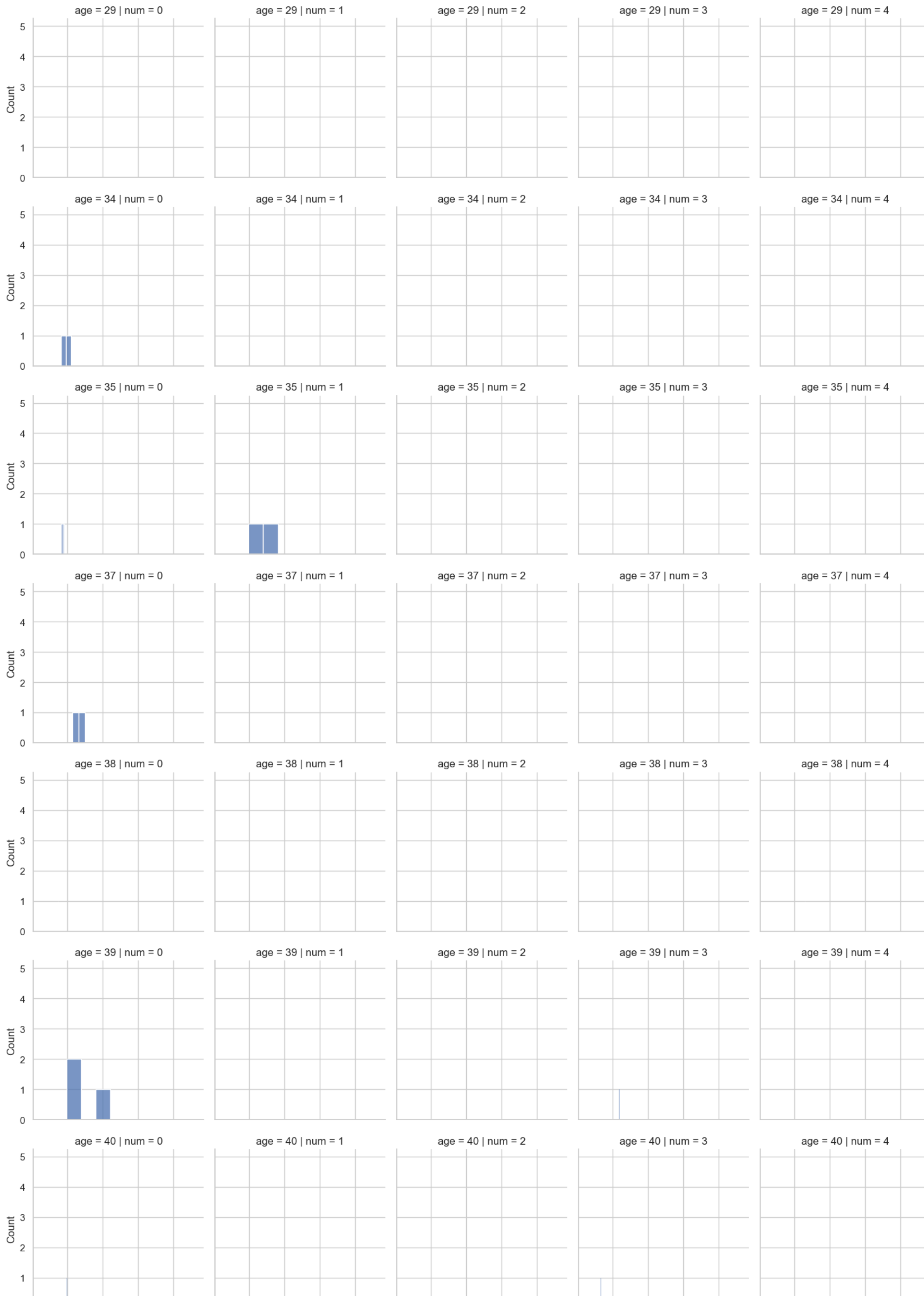
ColName	
sex	2
fbs	2
exang	2

```
restecg       3
slope         3
thal          3
cp            4
ca            4
num           5
oldpeak      40
age          41
trestbps     50
thalach      91
chol        152
dtype: int64
```

```
plt.figure(figsize=(20,10))
data.boxplot(grid=False)
plt.show()
```




```
a=sns.FacetGrid(data,row='age',col='num')
a.map(sns.histplot,'chol')
plt.show()
```


age = 29 | num = 0
age = 29 | num = 1
age = 29 | num = 2
age = 29 | num = 3
age = 29 | num = 4
age = 34 | num = 0
age = 34 | num = 1
age = 34 | num = 2
age = 34 | num = 3
age = 34 | num = 4
age = 35 | num = 0
age = 35 | num = 1
age = 35 | num = 2
age = 35 | num = 3
age = 35 | num = 4
age = 37 | num = 0
age = 37 | num = 1
age = 37 | num = 2
age = 37 | num = 3
age = 37 | num = 4
age = 38 | num = 0
age = 38 | num = 1
age = 38 | num = 2
age = 38 | num = 3
age = 38 | num = 4
age = 39 | num = 0
age = 39 | num = 1
age = 39 | num = 2
age = 39 | num = 3
age = 39 | num = 4
age = 40 | num = 0
age = 40 | num = 1
age = 40 | num = 2
age = 40 | num = 3
age = 40 | num = 4
Count
0
1
2
3
4
5

```
data.replace('?',' ',inplace=True)
data
```

```
ColName  age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  
oldpeak  \
0         63    1   1       145   233    1        2      150      0   
2.3   
1         67    1   4       160   286    0        2      108      1   
1.5   
2         67    1   4       120   229    0        2      129      1   
2.6   
3         37    1   3       130   250    0        0      187      0   
3.5   
4         41    0   2       130   204    0        2      172      0   
1.4   
..       ...  ...  ..       ...   ...  ...      ...      ...    ...   
...   
298       45    1   1       110   264    0        0      132      0   
1.2   
299       68    1   4       144   193    1        0      141      0   
3.4   
300       57    1   4       130   131    0        0      115      1   
1.2   
301       57    0   2       130   236    0        2      174      0   
0.0   
302       38    1   3       138   175    0        0      173      0   
0.0   

ColName  slope   ca  thal  num  
0            3  0.0   6.0    0  
1            2  3.0   3.0    2  
2            2  2.0   7.0    1  
3            3  0.0   3.0    0  
4            1  0.0   3.0    0  
..         ...  ...   ...  ...  
298          2  0.0   7.0    1  
299          2  2.0   7.0    2  
300          2  1.0   7.0    3  
301          2  1.0   3.0    1  
302          1  NaN   3.0    0  

[303 rows x 14 columns]
```

```
data['ca'].replace('',np.nan, inplace=True)
data['thal'].replace('',np.nan, inplace=True)
data.dropna(subset=['ca'],inplace=True)
data.dropna(subset=['thal'],inplace=True)
```

TRAINING AND TESTING DATA

```
cat_val=[]
count_val=[]

for col in data.columns:
    if data[col].nunique()<=10:
        cat_val.append(col)
    else:
        count_val.append(col)

cat_val

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

count_val

['age', 'trestbps', 'chol', 'thalach', 'oldpeak']

data=pd.get_dummies(data,columns=['cp','fbs','restecg','exang','slope'
,'ca','thal'])
data.head()

   age  sex  trestbps  chol  thalach  oldpeak  num  cp_1  cp_2
cp_3  ...  \
0   63    1       145   233      150      2.3    0     1     0
0  ...
1   67    1       160   286      108      1.5    2     0     0
0  ...
2   67    1       120   229      129      2.6    1     0     0
0  ...
3   37    1       130   250      187      3.5    0     0     0
1  ...
4   41    0       130   204      172      1.4    0     0     1
0  ...

   slope_1  slope_2  slope_3  ca_0.0  ca_1.0  ca_2.0  ca_3.0  thal_3.0
\
0        0        0        1       1       0       0       0        0

1        0        1        0       0       0       0       1        1

2        0        1        0       0       0       1       0        0

3        0        0        1       1       0       0       0        1

4        1        0        0       1       0       0       0        1


   thal_6.0  thal_7.0
0         1         0
```

```
1         0         0
2         0         1
3         0         0
4         0         0

[5 rows x 28 columns]
```

```
x=data.drop(['num'],axis=1)
y=data['num']

x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.2,rando
m_state=1)

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

Random Forest

```
clfr=RandomForestClassifier(n_estimators=10,criterion='entropy',random
_state=0)

clfr.fit(x_train,y_train)

RandomForestClassifier(criterion='entropy', n_estimators=10,
random_state=0)

clfr1=RandomForestClassifier(n_estimators=10,criterion='gini',random_s
tate=0)

clfr1.fit(x_train,y_train)

RandomForestClassifier(n_estimators=10, random_state=0)

ypre1=clfr.predict(x_test)# entropy ypre calculation

ypre2=clfr1.predict(x_test)# gini ypre calculation

print('entropy Accuracy Score:')
accuracy_score(y_test,ypre1)*100

entropy Accuracy Score:

55.00000000000001

print('gini Accuracy Score:')
accuracy_score(y_test,ypre2)*100

gini Accuracy Score:
```

```
53.333333333333336
```

```python
print('entropy - confusion matrix\n--------------------\n')
print(confusion_matrix(y_test,ypre1))
print('gini - confusion matrix\n--------------------\n')
print(confusion_matrix(y_test,ypre2))
```

```
entropy - confusion matrix
--------------------

[[27  3  0  0  0]
 [ 3  5  1  1  0]
 [ 5  3  0  3  0]
 [ 2  3  1  1  1]
 [ 0  0  0  1  0]]
gini - confusion matrix
--------------------

[[26  3  0  1  0]
 [ 5  3  1  0  1]
 [ 6  2  0  3  0]
 [ 2  1  1  3  1]
 [ 1  0  0  0  0]]
```

```python
print('entropy result\n--------------')
print(classification_report(y_test,ypre1))
print('gini index result\n----------------------')
print(classification_report(y_test,ypre2))
```

```
entropy result
--------------
              precision    recall  f1-score   support

           0       0.73      0.90      0.81        30
           1       0.36      0.50      0.42        10
           2       0.00      0.00      0.00        11
           3       0.17      0.12      0.14         8
           4       0.00      0.00      0.00         1

    accuracy                           0.55        60
   macro avg       0.25      0.30      0.27        60
weighted avg       0.45      0.55      0.49        60

gini index result
----------------------
              precision    recall  f1-score   support

           0       0.65      0.87      0.74        30
           1       0.33      0.30      0.32        10
           2       0.00      0.00      0.00        11
           3       0.43      0.38      0.40         8
```

```
              4       0.00      0.00      0.00         1

    accuracy                            0.53        60
   macro avg       0.28      0.31      0.29        60
weighted avg       0.44      0.53      0.48        60
```

Decision Tree

```
dtree = DecisionTreeClassifier(max_depth=6, random_state=1)

dtree.fit(x_train,y_train)

DecisionTreeClassifier(max_depth=6, random_state=1)

y_pre3=dtree.predict(x_test)
from sklearn.metrics import
classification_report,confusion_matrix,accuracy_score,mean_squared_err
or
print(classification_report(y_test,y_pre3))

              precision    recall  f1-score   support

           0       0.76      0.83      0.79        30
           1       0.18      0.20      0.19        10
           2       0.33      0.27      0.30        11
           3       0.00      0.00      0.00         8
           4       0.00      0.00      0.00         1

    accuracy                           0.50        60
   macro avg       0.25      0.26      0.26        60
weighted avg       0.47      0.50      0.48        60


print(confusion_matrix(y_test,y_pre3))
print("Training Score: ",dtree.score(x_train,y_train)*100)

[[25  3  0  2  0]
 [ 3  2  3  1  1]
 [ 4  3  3  1  0]
 [ 1  2  3  0  2]
 [ 0  1  0  0  0]]
Training Score:  82.70042194092827

print(accuracy_score(y_test,y_pre3)*100)

50.0

data = pd.DataFrame({'Actual': y_test, 'Predicted': y_pre3})
data.head()
```

```
     Actual  Predicted
139       0          0
236       2          1
51        0          1
295       0          0
245       2          0
```

Logistic Regression

```
reg = LogisticRegression()
reg.fit(x_train,y_train)

LogisticRegression()

y_pre4=reg.predict(x_test)
y_pre4

array([0, 3, 0, 0, 1, 1, 0, 4, 0, 2, 3, 2, 0, 1, 1, 1, 3, 0, 0, 0, 1,
0,
       0, 0, 0, 0, 0, 3, 1, 0, 0, 1, 0, 4, 2, 0, 0, 0, 0, 4, 0, 0, 0,
1,
       0, 0, 0, 1, 3, 4, 0, 1, 3, 1, 4, 3, 4, 4, 0, 1], dtype=int64)

print(classification_report(y_test,y_pre4))
print(confusion_matrix(y_test,y_pre4))
print("Training Score: ",reg.score(x_train,y_train)*100)

              precision    recall  f1-score   support

           0       0.80      0.80      0.80        30
           1       0.23      0.30      0.26        10
           2       0.00      0.00      0.00        11
           3       0.14      0.12      0.13         8
           4       0.00      0.00      0.00         1

    accuracy                           0.47        60
   macro avg       0.23      0.25      0.24        60
weighted avg       0.46      0.47      0.46        60

[[24  3  0  1  2]
 [ 4  3  0  1  2]
 [ 2  4  0  4  1]
 [ 0  3  2  1  2]
 [ 0  0  1  0  0]]
Training Score:  73.83966244725738

data = pd.DataFrame({'Actual': y_test, 'Predicted': y_pre4})
data.head()
```

```
     Actual  Predicted
139       0          0
236       2          3
51        0          0
295       0          0
245       2          1
```

```
print(accuracy_score(y_test,y_pre4)*100)
```

```
46.666666666666664
```

```
from sklearn.model_selection import GridSearchCV
param = {
         'penalty':['l1','l2'],
         'C':[0.001, 0.01, 0.1, 1, 10, 20,100, 1000]
}
lr= LogisticRegression(penalty='l1')
cv=GridSearchCV(reg,param,cv=5,n_jobs=-1)
cv.fit(x_train,y_train)
cv.predict(x_test)
```

```
array([0, 3, 0, 0, 0, 1, 0, 4, 0, 2, 3, 2, 0, 1, 1, 0, 3, 0, 0, 0, 1,
0,
       0, 0, 0, 0, 0, 3, 1, 0, 0, 0, 0, 4, 2, 0, 0, 0, 0, 4, 0, 0, 0,
1,
       0, 0, 0, 1, 0, 4, 0, 1, 3, 1, 4, 3, 4, 4, 0, 1], dtype=int64)
```

```
print("Best CV score", cv.best_score_*100)
```

```
Best CV score 59.9290780141844
```

KNN

```
knn=KNeighborsClassifier(n_neighbors=7)
```

```
knn.fit(x_train,y_train)
```

```
KNeighborsClassifier(n_neighbors=7)
```

```
y_pre5=knn.predict(x_test)
```

```
data = pd.DataFrame({'Actual': y_test, 'Predicted': y_pre5})
data.head()
```

```
     Actual  Predicted
139       0          0
236       2          2
51        0          0
```

```
295       0          0
245       2          0
```

```
from sklearn.metrics import
classification_report,confusion_matrix,accuracy_score,mean_squared_err
or,r2_score
print(classification_report(y_test,y_pre5))
```

```
              precision    recall  f1-score   support

           0       0.64      0.93      0.76        30
           1       0.25      0.20      0.22        10
           2       0.25      0.09      0.13        11
           3       0.00      0.00      0.00         8
           4       0.00      0.00      0.00         1

    accuracy                           0.52        60
   macro avg       0.23      0.24      0.22        60
weighted avg       0.41      0.52      0.44        60
```

```
print(confusion_matrix(y_test,y_pre5))
```

```
[[28  2  0  0  0]
 [ 6  2  0  1  1]
 [ 6  3  1  1  0]
 [ 3  1  3  0  1]
 [ 1  0  0  0  0]]
```

```
print("Training Score: ",knn.score(x_train,y_train)*100)
print(knn.score(x_test,y_test))
```

```
Training Score:  66.66666666666666
0.5166666666666667
```

```
accuracy_score(y_test,y_pre5)
```

```
0.5166666666666667
```

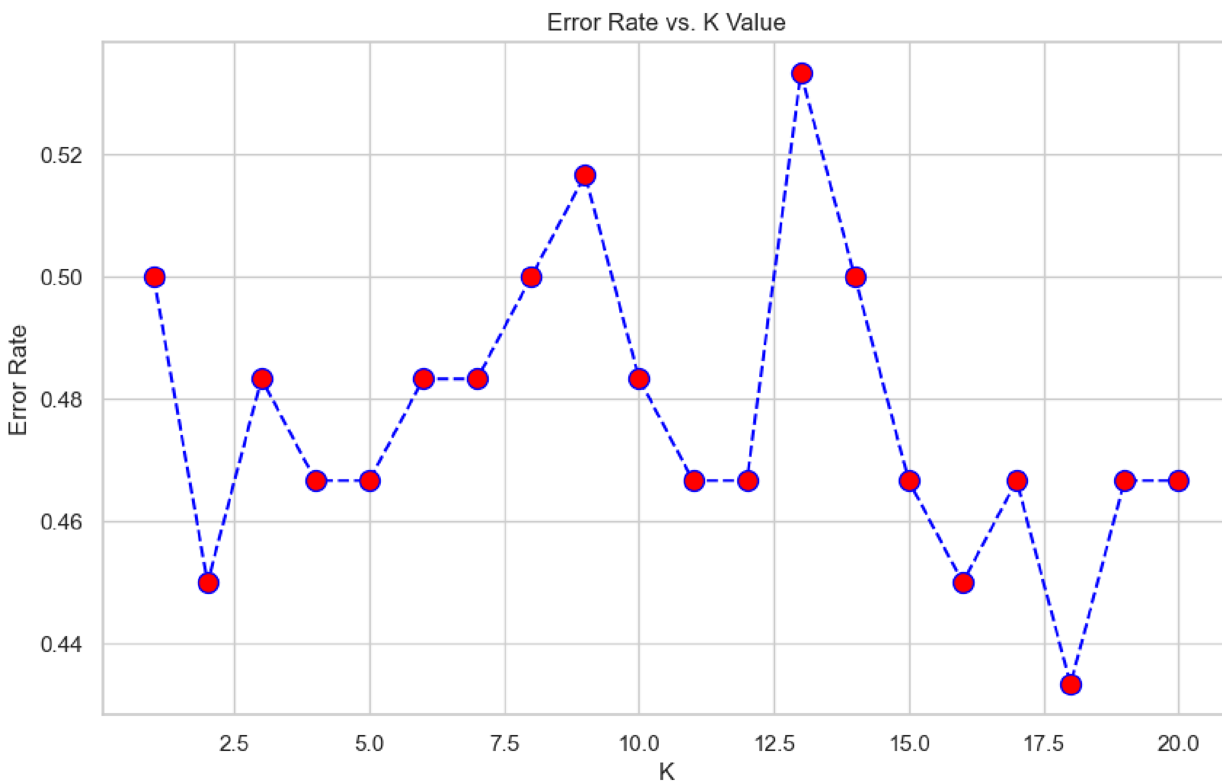
```
t=1-accuracy_score(y_test,y_pre5)
t
```

```
0.48333333333333333
```

```
error_rate = []

for i in range(1,21):

    knn = KNeighborsClassifier(n_neighbors=i)
    knn.fit(x_train,y_train)
    pred_i = knn.predict(x_test)
```

```
    t=1-accuracy_score(y_test,pred_i)
    error_rate.append(t)

plt.figure(figsize=(10,6))
plt.plot(range(1,21),error_rate,color='blue', linestyle='dashed',
marker='o',markerfacecolor='red', markersize=10)
plt.title('Error Rate vs. K Value')
plt.xlabel('K')
plt.ylabel('Error Rate')
```

```
Text(0, 0.5, 'Error Rate')
```




```
data=pd.DataFrame({'Models':
['Rf(Entropy)','Rf(Gini)','DT','Logreg','Knn'],
                'Accuracy':
[accuracy_score(y_test,ypre1)*100,accuracy_score(y_test,ypre2)*100,

accuracy_score(y_test,y_pre3)*100,accuracy_score(y_test,y_pre4)*100,
                            accuracy_score(y_test,y_pre5)*100]})
data
```

	Models	Accuracy
0	Rf(Entropy)	55.000000
1	Rf(Gini)	53.333333
2	DT	50.000000

```
3        Logreg  46.666667
4           Knn  51.666667
```

```
sns.barplot(data['Models'],data['Accuracy'])
plt.xticks(rotation=90)
plt.show()
```