```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
```

```
df = pd.read_csv('processed.cleveland.data',names=  ['age','sex','chest_pain','blood press
               'electrocardiographic','max_heart_rate','induced_angina','ST_depression','s
```

```
df
```

	age	sex	chest_pain	blood pressure	serum_cholestoral	fasting_blood_sugar	electr
0	63.0	1.0	1.0	145.0	233.0	1.0	
1	67.0	1.0	4.0	160.0	286.0	0.0	
2	67.0	1.0	4.0	120.0	229.0	0.0	
3	37.0	1.0	3.0	130.0	250.0	0.0	
4	41.0	0.0	2.0	130.0	204.0	0.0	
...	...	...	...	...	...	...	
298	45.0	1.0	1.0	110.0	264.0	0.0	
299	68.0	1.0	4.0	144.0	193.0	1.0	
300	57.0	1.0	4.0	130.0	131.0	0.0	
301	57.0	0.0	2.0	130.0	236.0	0.0	
302	38.0	1.0	3.0	138.0	175.0	0.0	

303 rows × 14 columns

```
df.describe()
```

	age	sex	chest_pain	blood pressure	serum_cholestoral	fasting_blo
count	303.000000	303.000000	303.000000	303.000000	303.000000	30

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   age                   303 non-null    float64
 1   sex                   303 non-null    float64
 2   chest_pain            303 non-null    float64
 3   blood pressure        303 non-null    float64
 4   serum_cholestoral     303 non-null    float64
 5   fasting_blood_sugar   303 non-null    float64
 6   electrocardiographic  303 non-null    float64
 7   max_heart_rate        303 non-null    float64
 8   induced_angina        303 non-null    float64
 9   ST_depression         303 non-null    float64
 10  slope                 303 non-null    float64
 11  vessels               303 non-null    object 
 12  thal                  303 non-null    object 
 13  diagnosis             303 non-null    int64  
dtypes: float64(11), int64(1), object(2)
memory usage: 33.3+ KB
```

```
# checking for null
df.isna().sum()
```

```
age                     0
sex                     0
chest_pain              0
blood pressure          0
serum_cholestoral       0
fasting_blood_sugar     0
electrocardiographic    0
max_heart_rate          0
induced_angina          0
ST_depression           0
slope                   0
vessels                 0
thal                    0
diagnosis               0
dtype: int64
```

```
## vessel and thal variables have some missing values shown as '?'
(df == '?').sum()
```

```
age                     0
sex                     0
chest_pain              0
blood pressure          0
serum_cholestoral       0
fasting_blood_sugar     0
electrocardiographic    0
```

```
max_heart_rate          0
induced_angina          0
ST_depression           0
slope                   0
vessels                 4
thal                    2
diagnosis               0
dtype: int64
```

```
df['vessels'].value_counts()
```

```
0.0    176
1.0     65
2.0     38
3.0     20
?        4
Name: vessels, dtype: int64
```

```
df['thal'].value_counts()
```

```
3.0    166
7.0    117
6.0     18
?        2
Name: thal, dtype: int64
```

```
## removing the '?' misssing values
```

```
df[df['vessels'] == '?']['vessels']
```

```
166    ?
192    ?
287    ?
302    ?
Name: vessels, dtype: object
```

```
df[df['thal'] == '?']['thal']
```

```
87     ?
266    ?
Name: thal, dtype: object
```

```
missing_vessels = df[df['vessels'] == '?']['vessels'].index
missing_thals = df[df['thal'] == '?']['thal'].index
```

```
df.drop(missing_vessels,inplace=True)
df.drop(missing_thals,inplace=True)
```

```
## After removing 6 missing values
df
```

	age	sex	chest_pain	blood pressure	serum_cholestoral	fasting_blood_sugar	electr
0	63.0	1.0	1.0	145.0	233.0	1.0	
1	67.0	1.0	4.0	160.0	286.0	0.0	
2	67.0	1.0	4.0	120.0	229.0	0.0	
3	37.0	1.0	3.0	130.0	250.0	0.0	
4	41.0	0.0	2.0	130.0	204.0	0.0	
...	...	...	...	...	...	...	
297	57.0	0.0	4.0	140.0	241.0	0.0	
298	45.0	1.0	1.0	110.0	264.0	0.0	
299	68.0	1.0	4.0	144.0	193.0	1.0	
300	57.0	1.0	4.0	130.0	131.0	0.0	
301	57.0	0.0	2.0	130.0	236.0	0.0	

297 rows × 14 columns

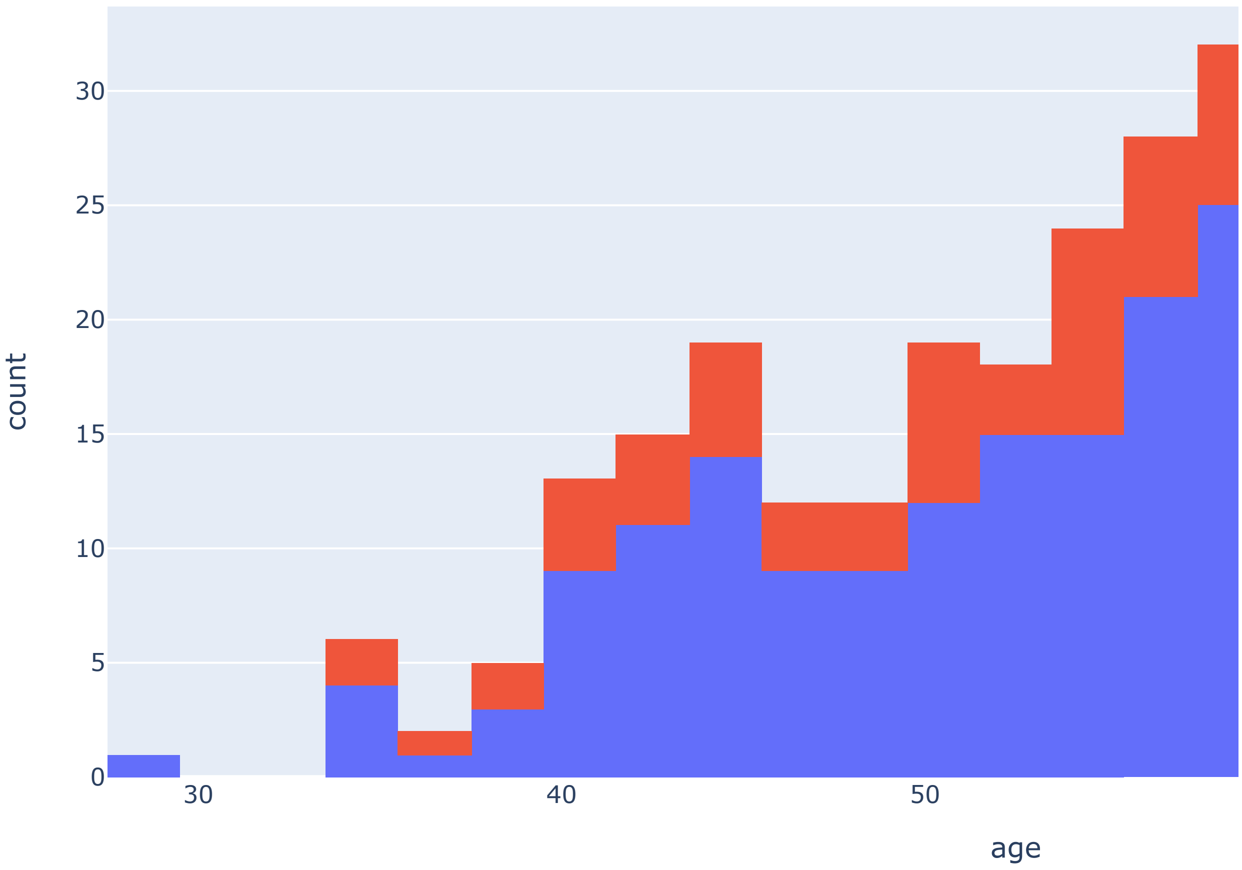
```
## Checking for age distribution
plt.figure(figsize=(12,8))
sns.distplot(df['age'])
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/distributions.py:2619: FutureWarning:

`distplot` is a deprecated function and will be removed in a future version. Please

<matplotlib.axes._subplots.AxesSubplot at 0x7fdc6b89c590>
```

```
### age range of people with their gender 1: Male 0: Female
plt.figure(figsize=(10,6))
px.histogram(df,'age',color='sex')
```



```
<Figure size 720x432 with 0 Axes>
```

```
### Target distribution
df['diagnosis'].value_counts()
```

```
0    160
1     54
3     35
2     35
4     13
Name: diagnosis, dtype: int64
```

```
# ''' As given in the Dataset :The "goal" field refers to the presence of heart disease
#      in the patient.  It is integer valued from 0 (no presence) to 4.
#      Experiments with the Cleveland database have concentrated on simply
#      attempting to distinguish presence (values 1,2,3,4) from absence (value
#      0).  '''
```

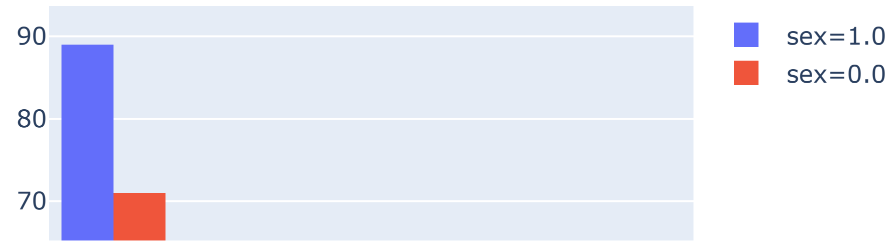
```
df['Target'] = df['diagnosis'].apply(lambda x : 1 if x >= 1 else 0)
```

```
df
```

	age	sex	chest_pain	blood pressure	serum_cholestoral	fasting_blood_sugar	electr
0	63.0	1.0	1.0	145.0	233.0	1.0	
1	67.0	1.0	4.0	160.0	286.0	0.0	
2	67.0	1.0	4.0	120.0	229.0	0.0	
3	37.0	1.0	3.0	130.0	250.0	0.0	
4	41.0	0.0	2.0	130.0	204.0	0.0	
...	...	...	...	...	...	...	
297	57.0	0.0	4.0	140.0	241.0	0.0	
298	45.0	1.0	1.0	110.0	264.0	0.0	
299	68.0	1.0	4.0	144.0	193.0	1.0	
300	57.0	1.0	4.0	130.0	131.0	0.0	
301	57.0	0.0	2.0	130.0	236.0	0.0	

297 rows × 15 columns

```
#### Distribution of Diagnosis to sex
plt.figure(figsize=(10,6))
px.histogram(df,x='diagnosis',color='sex',barmode="group")
```

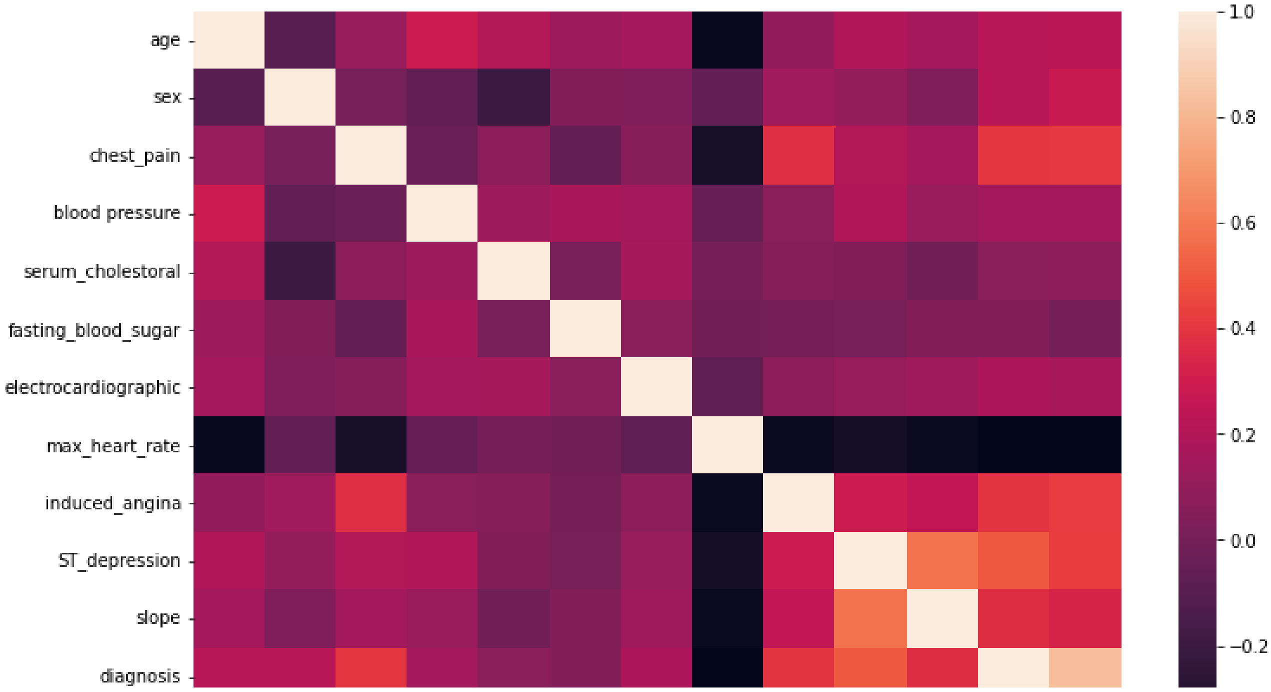


```
### Finding correlation of variables
df.corr()
```

	age	sex	chest_pain	blood pressure	serum_cholestoral	fa
age	1.000000	-0.092399	0.110471	0.290476	0.202644	
sex	-0.092399	1.000000	0.008908	-0.066340	-0.198089	
chest_pain	0.110471	0.008908	1.000000	-0.036980	0.072088	
blood pressure	0.290476	-0.066340	-0.036980	1.000000	0.131536	
serum_cholestoral	0.202644	-0.198089	0.072088	0.131536	1.000000	
fasting_blood_sugar	0.132062	0.038850	-0.057663	0.180860	0.012708	
electrocardiographic	0.149917	0.033897	0.063905	0.149242	0.165046	
max_heart_rate	-0.394563	-0.060496	-0.339308	-0.049108	-0.000075	
induced_angina	0.096489	0.143581	0.377525	0.066691	0.059339	
ST_depression	0.197123	0.106567	0.203244	0.191243	0.038596	
slope	0.159405	0.033345	0.151079	0.121172	-0.009215	
diagnosis	0.222156	0.226797	0.404248	0.159620	0.066448	
Target	0.227075	0.278467	0.408945	0.153490	0.080285	

```
plt.figure(figsize=(12,8))
sns.heatmap(df.corr())
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fdc66cb9950>
```



```
df['diagnosis']
```

```
0      0
1      2
2      1
3      0
4      0
      ..
297    1
298    1
299    2
300    3
301    1
Name: diagnosis, Length: 297, dtype: int64
```

```
### Train test split
```

```
X= df.drop(['diagnosis','Target'],axis=1)
y = df['Target']
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)
```

```
## Model Classification
```

```
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
```

```
### Taking average of 10 training examples
```

```
dt_avg = []
for i in range(10):
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)
    clf1 = DecisionTreeClassifier()
    dt_model = clf1.fit(X_train,y_train)
    dt_pred = dt_model.predict(X_test)
    dt_avg.append(accuracy_score(y_test,dt_pred))

print('Average Decision Tree Test accuracy:',sum(dt_avg)/10)
```

```
     Average Decision Tree Test accuracy: 0.7333333333333334
```

```
from sklearn.metrics import classification_report, confusion_matrix,accuracy_score,log_los
print(classification_report(y_test,dt_pred))

print(confusion_matrix(y_test,dt_pred))
```

```
                   precision    recall  f1-score   support

                0       0.77      0.75      0.76        36
                1       0.64      0.67      0.65        24

         accuracy                           0.72        60
        macro avg       0.71      0.71      0.71        60
     weighted avg       0.72      0.72      0.72        60

     [[27  9]
      [ 8 16]]
```

```
print('Log loss for Decision Tree model:',log_loss(y_test,dt_pred))
```

```
     Log loss for Decision Tree model: 8.059114458598343
```