```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
```

```
df = pd.read_csv("/content/heart.csv")
```

```
# First 5 rows of our data
df.head(10)
```

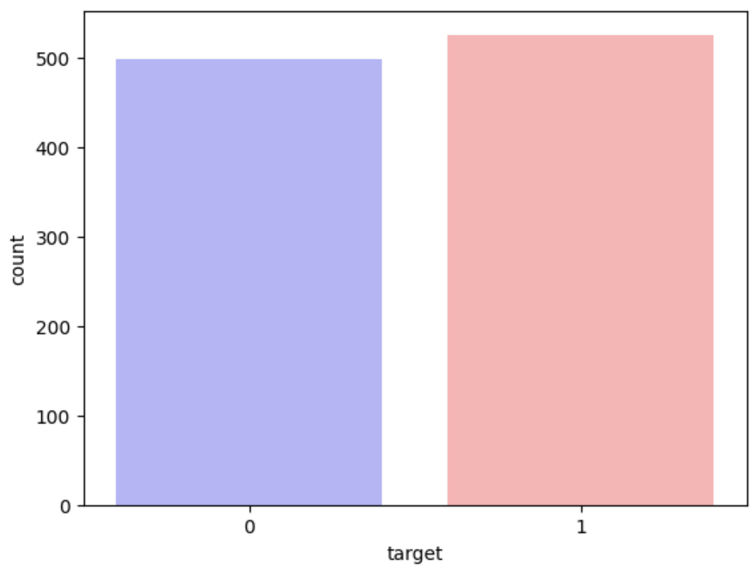
	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	52	1	0	125	212	0	1	168	0	1.0	2	2	3	0
1	53	1	0	140	203	1	0	155	1	3.1	0	0	3	0
2	70	1	0	145	174	0	1	125	1	2.6	0	0	3	0
3	61	1	0	148	203	0	1	161	0	0.0	2	1	3	0
4	62	0	0	138	294	1	1	106	0	1.9	1	3	2	0
5	58	0	0	100	248	0	0	122	0	1.0	1	0	2	1
6	58	1	0	114	318	0	2	140	0	4.4	0	3	1	0
7	55	1	0	160	289	0	0	145	1	0.8	1	1	3	0
8	46	1	0	120	249	0	0	144	0	0.8	2	0	3	0
9	54	1	0	122	286	0	0	116	1	3.2	1	2	2	0

Data Exploration

```
df.target.value_counts()
```

```
1    526
0    499
Name: target, dtype: int64
```

```
sns.countplot(x="target", data=df, palette="bwr")
plt.show()
```

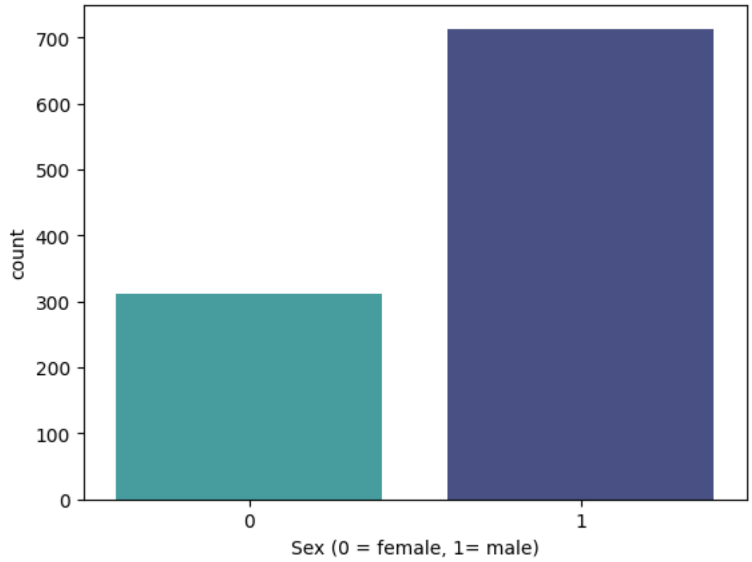



```
countNoDisease = len(df[df.target == 0])
countHaveDisease = len(df[df.target == 1])
print("Percentage of Patients Haven't Heart Disease: {:.2f}%".format((countNoDisease / (len(df.target))*100)))
print("Percentage of Patients Have Heart Disease: {:.2f}%".format((countHaveDisease / (len(df.target))*100)))
```

```
Percentage of Patients Haven't Heart Disease: 48.68%
Percentage of Patients Have Heart Disease: 51.32%
```

```
sns.countplot(x='sex', data=df, palette="mako_r")
plt.xlabel("Sex (0 = female, 1= male)")
```

```
plt.show()
```



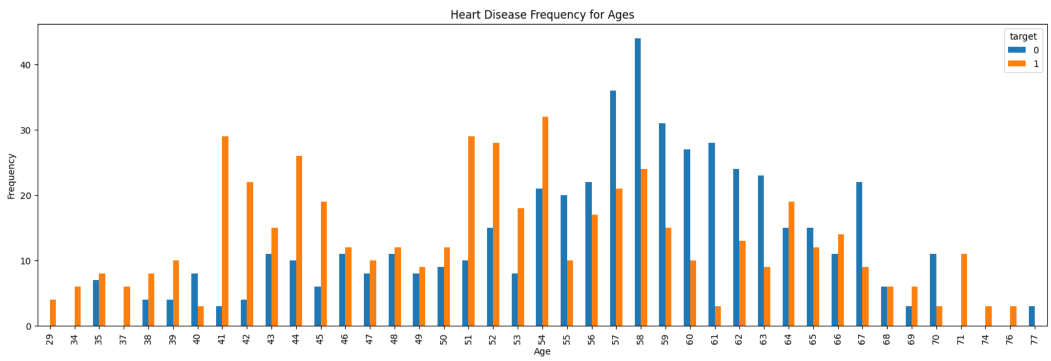

```
countFemale = len(df[df.sex == 0])
countMale = len(df[df.sex == 1])
print("Percentage of Female Patients: {:.2f}%".format((countFemale / (len(df.sex))*100)))
print("Percentage of Male Patients: {:.2f}%".format((countMale / (len(df.sex))*100)))
```

```
Percentage of Female Patients: 30.44%
Percentage of Male Patients: 69.56%
```

```
df.groupby('target').mean()
```

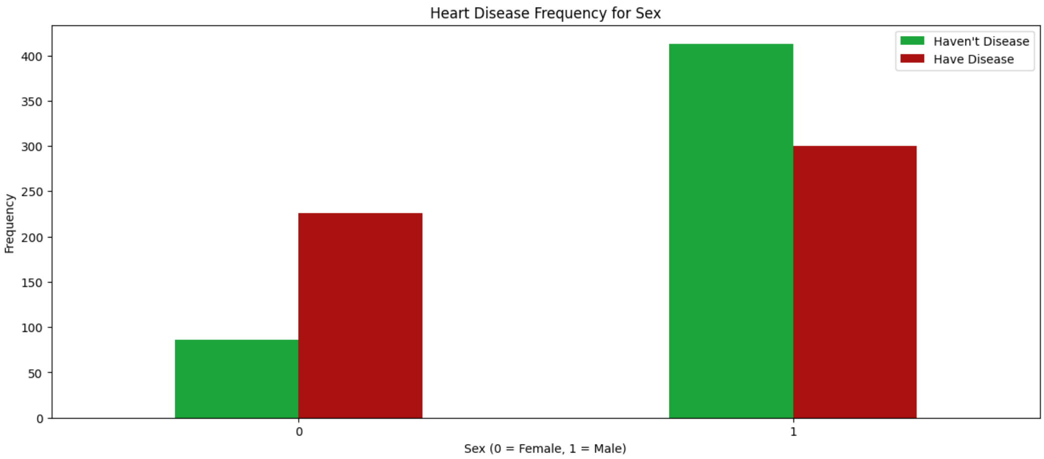
target	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	o:
0	56.569138	0.827655	0.482966	134.106212	251.292585	0.164329	0.456914	139.130261	0.549098	1.(
1	52.408745	0.570342	1.378327	129.245247	240.979087	0.134981	0.598859	158.585551	0.134981	0.!

```
pd.crosstab(df.age,df.target).plot(kind="bar",figsize=(20,6))
plt.title('Heart Disease Frequency for Ages')
plt.xlabel('Age')
plt.ylabel('Frequency')
plt.savefig('heartDiseaseAndAges.png')
plt.show()
```

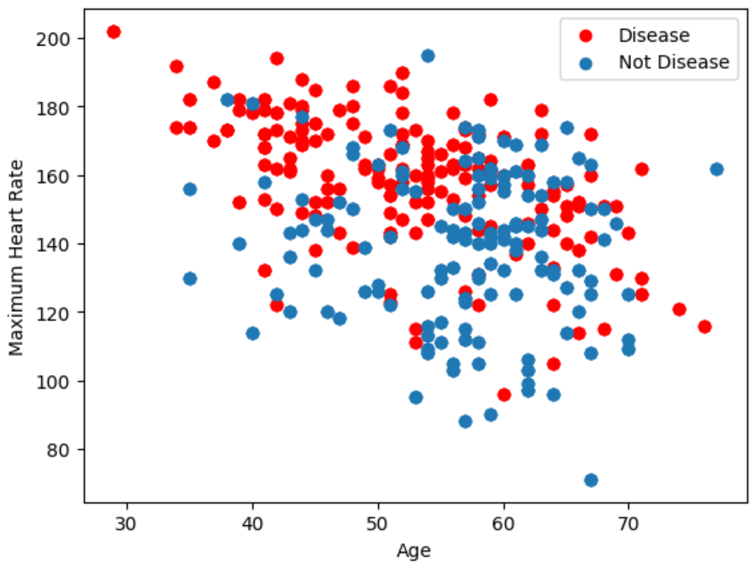



```
pd.crosstab(df.sex,df.target).plot(kind="bar",figsize=(15,6),color=['#1CA53B','#AA1111' ])
plt.title('Heart Disease Frequency for Sex')
plt.xlabel('Sex (0 = Female, 1 = Male)')
```

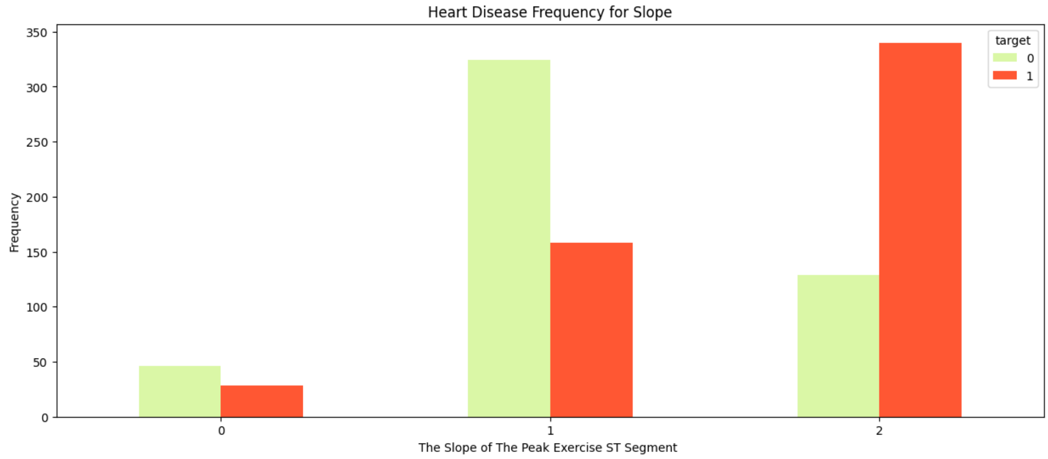
```
plt.xticks(rotation=0)
plt.legend(["Haven't Disease", "Have Disease"])
plt.ylabel('Frequency')
plt.show()
```



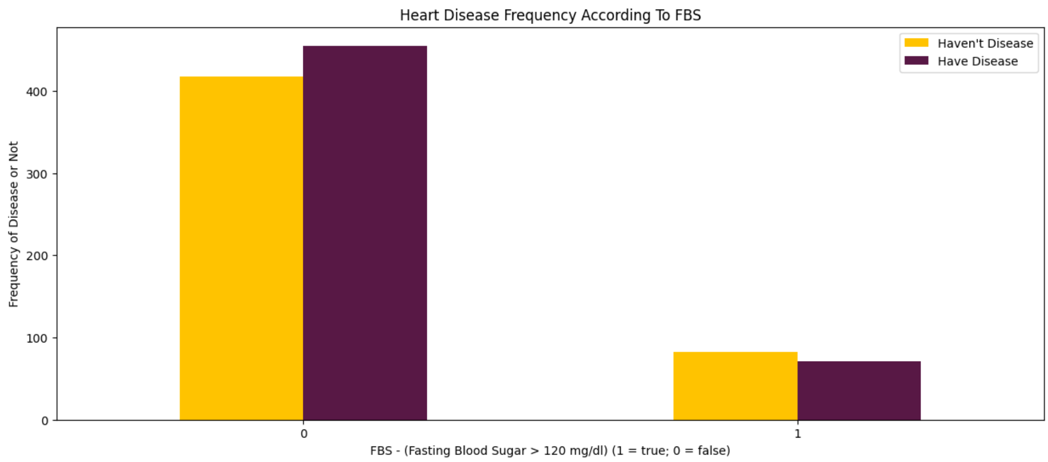

```
plt.scatter(x=df.age[df.target==1], y=df.thalach[(df.target==1)], c="red")
plt.scatter(x=df.age[df.target==0], y=df.thalach[(df.target==0)])
plt.legend(["Disease", "Not Disease"])
plt.xlabel("Age")
plt.ylabel("Maximum Heart Rate")
plt.show()
```



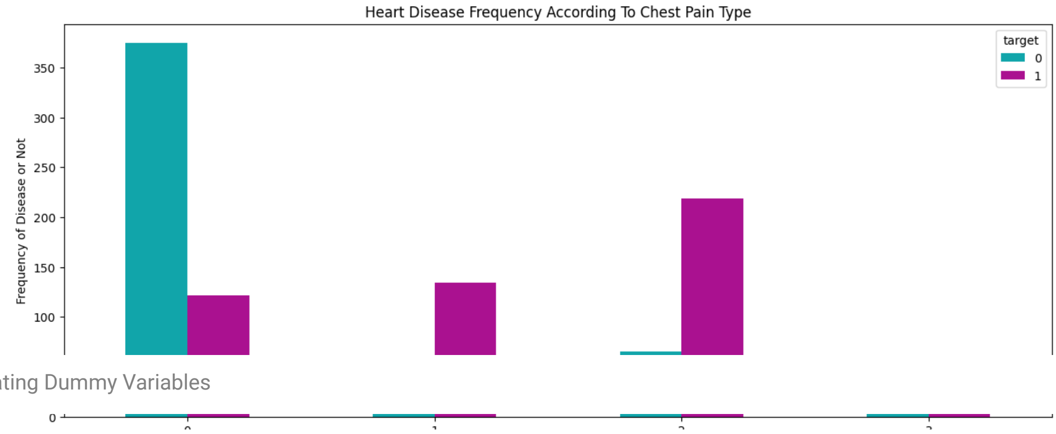

```
pd.crosstab(df.slope,df.target).plot(kind="bar",figsize=(15,6),color=['#DAF7A6','#FF5733' ])
plt.title('Heart Disease Frequency for Slope')
plt.xlabel('The Slope of The Peak Exercise ST Segment ')
plt.xticks(rotation = 0)
plt.ylabel('Frequency')
plt.show()
```




```
pd.crosstab(df.fbs,df.target).plot(kind="bar",figsize=(15,6),color=['#FFC300','#581845' ])
plt.title('Heart Disease Frequency According To FBS')
plt.xlabel('FBS - (Fasting Blood Sugar > 120 mg/dl) (1 = true; 0 = false)')
plt.xticks(rotation = 0)
plt.legend(["Haven't Disease", "Have Disease"])
plt.ylabel('Frequency of Disease or Not')
plt.show()
```




```
pd.crosstab(df.cp,df.target).plot(kind="bar",figsize=(15,6),color=['#11A5AA','#AA1190' ])
plt.title('Heart Disease Frequency According To Chest Pain Type')
plt.xlabel('Chest Pain Type')
plt.xticks(rotation = 0)
plt.ylabel('Frequency of Disease or Not')
plt.show()
```



Creating Dummy Variables

```
a = pd.get_dummies(df['cp'], prefix = "cp")
b = pd.get_dummies(df['thal'], prefix = "thal")
c = pd.get_dummies(df['slope'], prefix = "slope")
```

```
frames = [df, a, b, c]
df = pd.concat(frames, axis = 1)
df.head()
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	...	cp_1	cp_2	cp_3	thal_0	tl
0	52	1	0	125	212	0	1	168	0	1.0	...	0	0	0	0	
1	53	1	0	140	203	1	0	155	1	3.1	...	0	0	0	0	
2	70	1	0	145	174	0	1	125	1	2.6	...	0	0	0	0	
3	61	1	0	148	203	0	1	161	0	0.0	...	0	0	0	0	
4	62	0	0	138	294	1	1	106	0	1.9	...	0	0	0	0	

5 rows × 25 columns

```
df = df.drop(columns = ['cp', 'thal', 'slope'])
df.head()
```

	age	sex	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	ca	...	cp_1	cp_2	cp_3	thal_0	tl
0	52	1	125	212	0	1	168	0	1.0	2	...	0	0	0	0	
1	53	1	140	203	1	0	155	1	3.1	0	...	0	0	0	0	
2	70	1	145	174	0	1	125	1	2.6	0	...	0	0	0	0	
3	61	1	148	203	0	1	161	0	0.0	1	...	0	0	0	0	
4	62	0	138	294	1	1	106	0	1.9	3	...	0	0	0	0	

5 rows × 22 columns

Creating Model for Logistic Regression

```
y = df.target.values
x_data = df.drop(['target'], axis = 1)
```

Normalise

```
# Normalize
x = (x_data - np.min(x_data)) / (np.max(x_data) - np.min(x_data)).values
```

```
/usr/local/lib/python3.10/dist-packages/numpy/core/fromnumeric.py:84: FutureWarning: In a future version, DataFrame.min(axis=None)
  return reduction(axis=axis, out=out, **passkwargs)
/usr/local/lib/python3.10/dist-packages/numpy/core/fromnumeric.py:84: FutureWarning: In a future version, DataFrame.max(axis=None)
  return reduction(axis=axis, out=out, **passkwargs)
/usr/local/lib/python3.10/dist-packages/numpy/core/fromnumeric.py:84: FutureWarning: In a future version, DataFrame.min(axis=None)
  return reduction(axis=axis, out=out, **passkwargs)
```

```
x_train, x_test, y_train, y_test = train_test_split(x,y,test_size = 0.2,random_state=0)
```

```
#transpose matrices
x_train = x_train.T
y_train = y_train.T
```

```
x_test = x_test.T
y_test = y_test.T


#initialize
def initialize(dimension):

    weight = np.full((dimension,1),0.01)
    bias = 0.0
    return weight,bias
```

Sigmod

```
def sigmoid(z):

    y_head = 1/(1+ np.exp(-z))
    return y_head
```

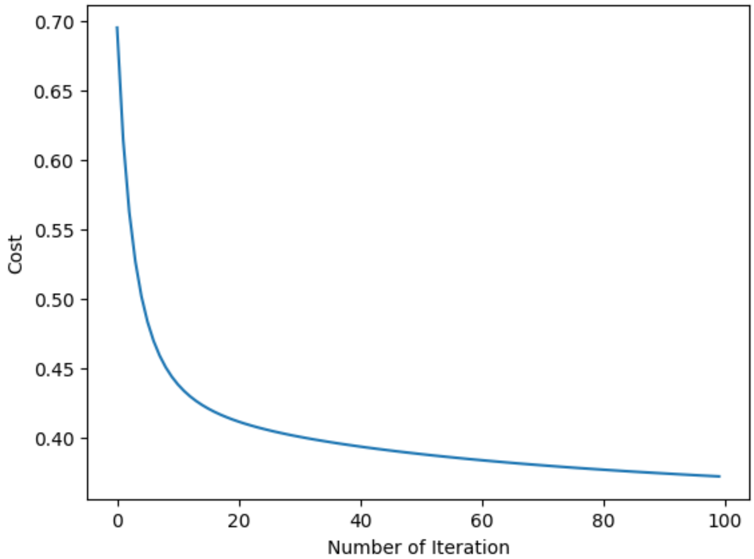
Forward & Backward Propogation

```
def forwardBackward(weight,bias,x_train,y_train):
    # Forward

    y_head = sigmoid(np.dot(weight.T,x_train) + bias)
    loss = -(y_train*np.log(y_head) + (1-y_train)*np.log(1-y_head))
    cost = np.sum(loss) / x_train.shape[1]

    # Backward
    derivative_weight = np.dot(x_train,((y_head-y_train).T))/x_train.shape[1]
    derivative_bias = np.sum(y_head-y_train)/x_train.shape[1]
    gradients = {"Derivative Weight" : derivative_weight, "Derivative Bias" : derivative_bias}

    return cost,gradients


def update(weight,bias,x_train,y_train,learningRate,iteration) :
    costList = []
    index = []

    #for each iteration, update weight and bias values
    for i in range(iteration):
        cost,gradients = forwardBackward(weight,bias,x_train,y_train)
        weight = weight - learningRate * gradients["Derivative Weight"]
        bias = bias - learningRate * gradients["Derivative Bias"]

        costList.append(cost)
        index.append(i)

    parameters = {"weight": weight,"bias": bias}

    print("iteration:",iteration)
    print("cost:",cost)

    plt.plot(index,costList)
    plt.xlabel("Number of Iteration")
    plt.ylabel("Cost")
    plt.show()

    return parameters, gradients


def predict(weight,bias,x_test):
    z = np.dot(weight.T,x_test) + bias
    y_head = sigmoid(z)

    y_prediction = np.zeros((1,x_test.shape[1]))

    for i in range(y_head.shape[1]):
        if y_head[0,i] <= 0.5:
            y_prediction[0,i] = 0
        else:
            y_prediction[0,i] = 1
    return y_prediction


def logistic_regression(x_train,y_train,x_test,y_test,learningRate,iteration):
    dimension = x_train.shape[0]
    weight,bias = initialize(dimension)

    parameters, gradients = update(weight,bias,x_train,y_train,learningRate,iteration)
```

```
    y_prediction = predict(parameters["weight"],parameters["bias"],x_test)

    print("Manuel Test Accuracy: {:.2f}%".format((100 - np.mean(np.abs(y_prediction - y_test))*100)))
```

```
logistic_regression(x_train,y_train,x_test,y_test,1,100)
```

```
iteration: 100
cost: 0.37214880873836975
```




```
Manuel Test Accuracy: 86.34%
```

```
accuracies = {}

lr = LogisticRegression()
lr.fit(x_train.T,y_train.T)
acc = lr.score(x_test.T,y_test.T)*100

accuracies['Logistic Regression'] = acc
print("Test Accuracy {:.2f}%".format(acc))
```

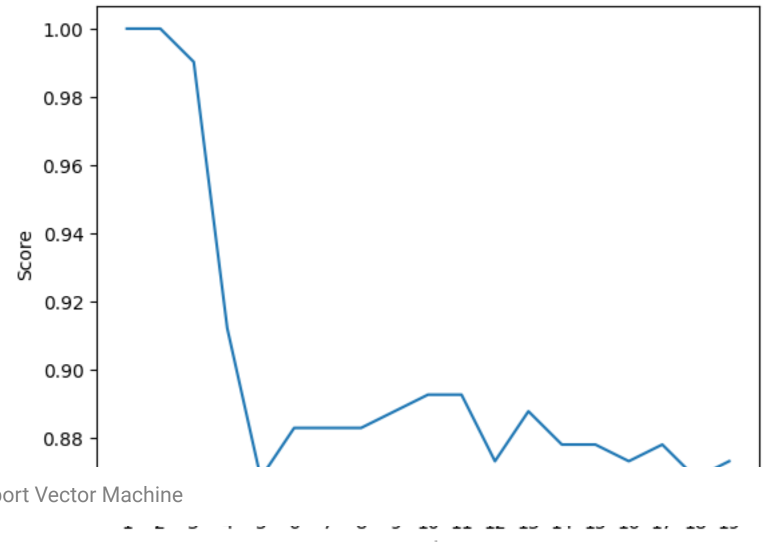
```
Test Accuracy 85.85%
```

KNN

```
# KNN Model
from sklearn.neighbors import KNeighborsClassifier
knn = KNeighborsClassifier(n_neighbors = 2)  # n_neighbors means k
knn.fit(x_train.T, y_train.T)
prediction = knn.predict(x_test.T)

print("{} NN Score: {:.2f}%".format(2, knn.score(x_test.T, y_test.T)*100))
```

```
2 NN Score: 100.00%
```

```
# try ro find best k value
scoreList = []
for i in range(1,20):
    knn2 = KNeighborsClassifier(n_neighbors = i)  # n_neighbors means k
    knn2.fit(x_train.T, y_train.T)
    scoreList.append(knn2.score(x_test.T, y_test.T))

plt.plot(range(1,20), scoreList)
plt.xticks(np.arange(1,20,1))
plt.xlabel("K value")
plt.ylabel("Score")
plt.show()

acc = max(scoreList)*100
accuracies['KNN'] = acc
print("Maximum KNN Score is {:.2f}%".format(acc))
```



Support Vector Machine

```
from sklearn.svm import SVC


svm = SVC(random_state = 1)
svm.fit(x_train.T, y_train.T)

acc = svm.score(x_test.T,y_test.T)*100
accuracies['SVM'] = acc
print("Test Accuracy of SVM Algorithm: {:.2f}%".format(acc))
```

```
Test Accuracy of SVM Algorithm: 91.71%
```

Naive Bayes

```
from sklearn.naive_bayes import GaussianNB
nb = GaussianNB()
nb.fit(x_train.T, y_train.T)

acc = nb.score(x_test.T,y_test.T)*100
accuracies['Naive Bayes'] = acc
print("Accuracy of Naive Bayes: {:.2f}%".format(acc))
```

```
Accuracy of Naive Bayes: 88.29%
```

Decision Tree

```
from sklearn.tree import DecisionTreeClassifier
dtc = DecisionTreeClassifier()
dtc.fit(x_train.T, y_train.T)

acc = dtc.score(x_test.T, y_test.T)*100
accuracies['Decision Tree'] = acc
print("Decision Tree Test Accuracy {:.2f}%".format(acc))
```

```
Decision Tree Test Accuracy 100.00%
```

Random Forest

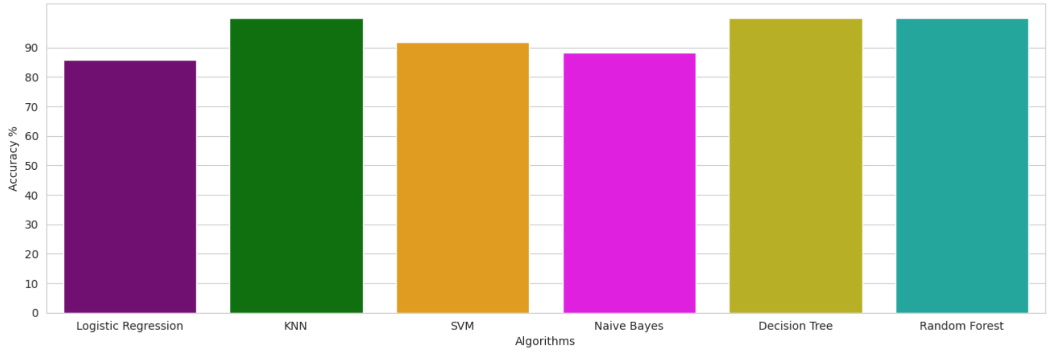
```
# Random Forest Classification
from sklearn.ensemble import RandomForestClassifier
rf = RandomForestClassifier(n_estimators = 1000, random_state = 1)
rf.fit(x_train.T, y_train.T)

acc = rf.score(x_test.T,y_test.T)*100
accuracies['Random Forest'] = acc
print("Random Forest Algorithm Accuracy Score : {:.2f}%".format(acc))
```

```
Random Forest Algorithm Accuracy Score : 100.00%
```

Comparing models

```
colors = ["purple", "green", "orange", "magenta","#CFC60E","#0FBBAE"]

sns.set_style("whitegrid")
```

```
plt.figure(figsize=(16,5))
plt.yticks(np.arange(0,100,10))
plt.ylabel("Accuracy %")
plt.xlabel("Algorithms")
sns.barplot(x=list(accuracies.keys()), y=list(accuracies.values()), palette=colors)
plt.show()
```



Confusion Matrix

```
# Predicted values
y_head_lr = lr.predict(x_test.T)
knn3 = KNeighborsClassifier(n_neighbors = 3)
knn3.fit(x_train.T, y_train.T)
y_head_knn = knn3.predict(x_test.T)
y_head_svm = svm.predict(x_test.T)
y_head_nb = nb.predict(x_test.T)
y_head_dtc = dtc.predict(x_test.T)
y_head_rf = rf.predict(x_test.T)
```

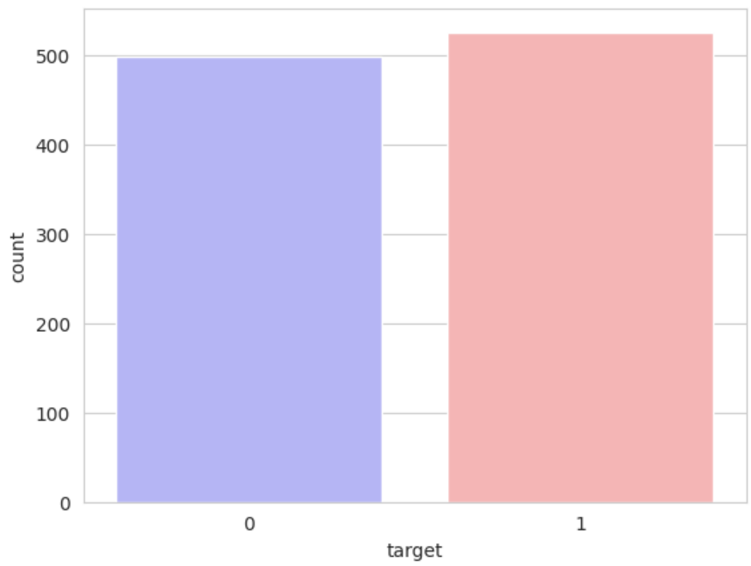
```
from sklearn.metrics import confusion_matrix

cm_lr = confusion_matrix(y_test,y_head_lr)
cm_knn = confusion_matrix(y_test,y_head_knn)
cm_svm = confusion_matrix(y_test,y_head_svm)
cm_nb = confusion_matrix(y_test,y_head_nb)
cm_dtc = confusion_matrix(y_test,y_head_dtc)
cm_rf = confusion_matrix(y_test,y_head_rf)
```

+ Code + Text

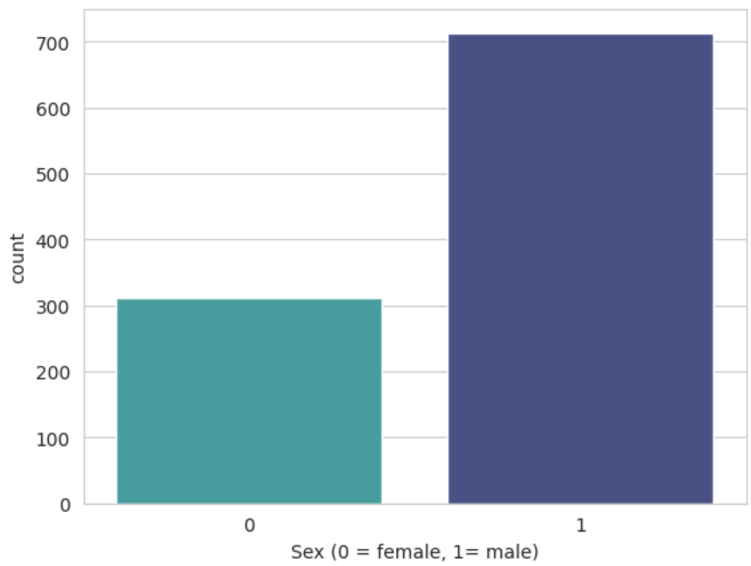
```
plt.figure(figsize=(24,12))

plt.suptitle("Confusion Matrixes",fontsize=24)
plt.subplots_adjust(wspace = 0.4, hspace= 0.4)

plt.subplot(2,3,1)
plt.title("Logistic Regression Confusion Matrix")
sns.heatmap(cm_lr,annot=True,cmap="Blues",fmt="d",cbar=False, annot_kws={"size": 24})

plt.subplot(2,3,2)
plt.title("K Nearest Neighbors Confusion Matrix")
sns.heatmap(cm_knn,annot=True,cmap="Blues",fmt="d",cbar=False, annot_kws={"size": 24})

plt.subplot(2,3,3)
plt.title("Support Vector Machine Confusion Matrix")
sns.heatmap(cm_svm,annot=True,cmap="Blues",fmt="d",cbar=False, annot_kws={"size": 24})

plt.subplot(2,3,4)
plt.title("Naive Bayes Confusion Matrix")
sns.heatmap(cm_nb,annot=True,cmap="Blues",fmt="d",cbar=False, annot_kws={"size": 24})

plt.subplot(2,3,5)
plt.title("Decision Tree Classifier Confusion Matrix")
sns.heatmap(cm_dtc,annot=True,cmap="Blues",fmt="d",cbar=False, annot_kws={"size": 24})

plt.subplot(2,3,6)
plt.title("Random Forest Confusion Matrix")
```

```
sns.heatmap(cm_rf,annot=True,cmap="Blues",fmt="d",cbar=False, annot_kws={"size": 24})

plt.show()
```

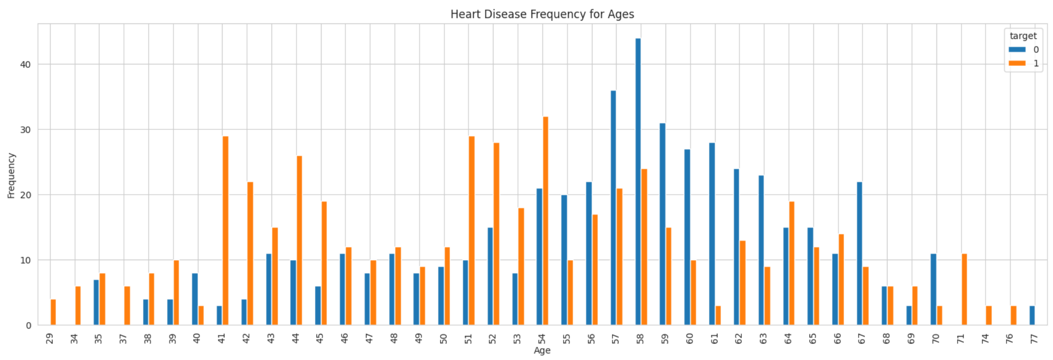

```
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split


sns.countplot(x="target", data=df, palette="bwr")
plt.show()
```



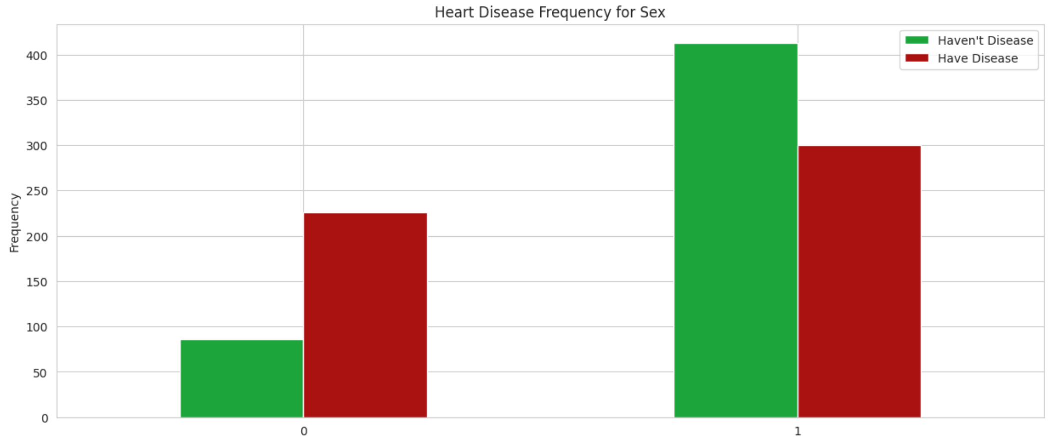
```
sns.countplot(x='sex', data=df, palette="mako_r")
plt.xlabel("Sex (0 = female, 1= male)")
plt.show()
```



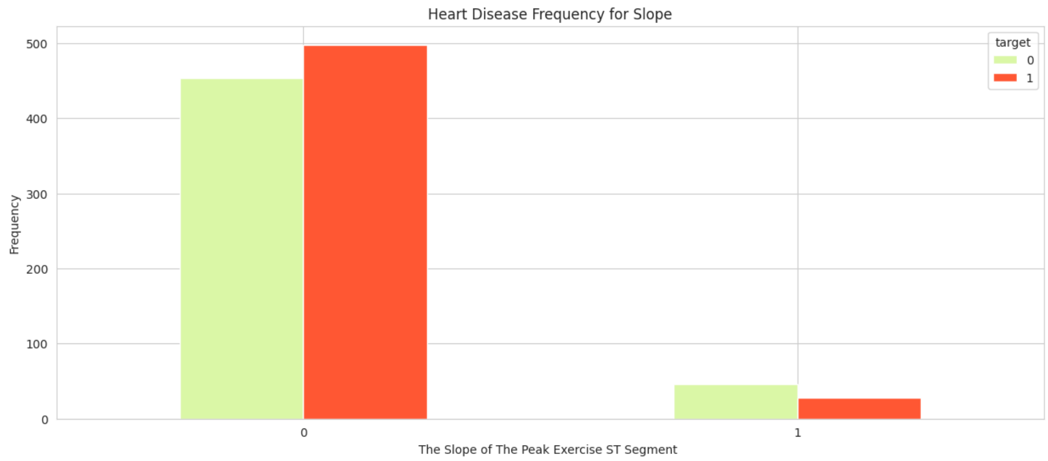

```
pd.crosstab(df.age,df.target).plot(kind="bar",figsize=(20,6))
plt.title('Heart Disease Frequency for Ages')
plt.xlabel('Age')
plt.ylabel('Frequency')
plt.savefig('heartDiseaseAndAges.png')
plt.show()
```



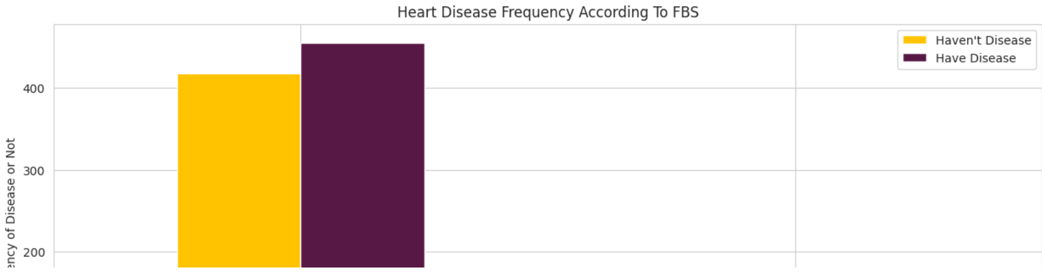

```
pd.crosstab(df.sex,df.target).plot(kind="bar",figsize=(15,6),color=['#1CA53B','#AA1111' ])
plt.title('Heart Disease Frequency for Sex')
plt.xlabel('Sex (0 = Female, 1 = Male)')
plt.xticks(rotation=0)
plt.legend(["Haven't Disease", "Have Disease"])
plt.ylabel('Frequency')
plt.show()
```




```
pd.crosstab(df.slope_0,df.target).plot(kind="bar",figsize=(15,6),color=['#DAF7A6','#FF5733'])
plt.title('Heart Disease Frequency for Slope')
plt.xlabel('The Slope of The Peak Exercise ST Segment ')
plt.xticks(rotation = 0)
plt.ylabel('Frequency')
plt.show()
```




```
pd.crosstab(df.fbs,df.target).plot(kind="bar",figsize=(15,6),color=['#FFC300','#581845' ])
plt.title('Heart Disease Frequency According To FBS')
plt.xlabel('FBS - (Fasting Blood Sugar > 120 mg/dl) (1 = true; 0 = false)')
plt.xticks(rotation = 0)
plt.legend(["Haven't Disease", "Have Disease"])
plt.ylabel('Frequency of Disease or Not')
plt.show()
```




```
pd.crosstab(df.cp_0,df.target).plot(kind="bar",figsize=(15,6),color=['#11A5AA','#AA1190' ])
plt.title('Heart Disease Frequency According To Chest Pain Type')
plt.xlabel('Chest Pain Type')
plt.xticks(rotation = 0)
plt.ylabel('Frequency of Disease or Not')
plt.show()
```