$$\hat{y} = \frac{1}{1 + e^{-z}}$$

Y_cap = predicted value x --> independent variable w = weight b = bias z = sigmoid function z = w*X + b

Gradient Descent

Gradient Descent is an optimization algorithm used for minimizing the loss function in various machine learning algorithm. It is used for updating the parameters of the learning model. Gradient Descent is the is use to find bias and weight value.

$w_2 = w - \alpha \cdot dw$

$b_2 = b - \alpha \cdot db$

w_2 = updated weight

w = previous weight

α = learning rate

For Bias

b_2 = updated bias

b = previous bias

Learning rate: How much change you want to impact to weight and bias Is the tuning parameter in an optimize algorithm that determines the step size at each iteration while moving toward a minimum of a loss function

$$dw = \frac{1}{m} + (\hat{Y} - Y) \cdot X$$

$$db = \frac{1}{m} + (\hat{Y} - Y) \cdot X$$

In [5]:
```
import numpy as np

class Logistic_Regression():
    def __init__(self, learning_rate, no_of_iterations):
        self.learning_rate = learning_rate
        self.no_of_iterations = no_of_iterations
    #Declaring learning rate and number of iteration (Hyperparameters)

#====================End of Step one ============================#


#====================Step two starts here ============================#
    #The purpose of the fit function is fitting our data to Logistic Regression model to
    def fit(self, x, y):
        self.m, self.n = x.shape      # m = numbers of rows and n = total number of colu

        self.w = np.zeros(self.n)
        self.b = 0
        self.x = x   #features of the data
        self.y = y   #target(Outcome) column in the dataset
```

```
        #implementing Gradient Descent for optimization

        for i in range(self.no_of_iterations):
            self.updated_weights()

#=====================End of Step two ============================#


#=====================Step three starts here ============================#

    def updated_weights(self):

       # y_cap = 1/(1+np.exp(-z))  # z = w.x + b   #
        y_cap = 1 / (1 + np.exp( - (self.x.dot(self.w) + self.b)))  #this equation is si

        #where w and x are arrays but b is a single integer values

        #exp = e which is the Euler's number = 2.718

        # to get the Eulers's number in jupyternotebook  print(np.exp(1))

        #replacing -z with its parameters.


    #Building the Derivatives

        dw = (1/self.m)*np.dot(self.x.T, (y_cap - self.y))

    # y_cap is the predicted value
    # y is the true value (outcome column)

        db = (1/self.m)*np.sum (y_cap - self.y)

    #updating the weights and bias using Gradient Descent

        self.w = self.w - self.learning_rate * dw

        self.b = self.b  - self.learning_rate * db


#=====================End of Step three ============================#


    def predict(self, x):  # to find the value of y

        y_pred = 1 / (1 + np.exp( - (x.dot(self.w) + self.b )))    #we can't use self.x

        y_pred = np.where (y_pred > 0.5, 1, 0)

        return(y_pred)
```

In [6]:
```
#Importing the libraries

import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
# import Log_Reg
```

In [7]:
```
#Importing the data
df = pd.read_csv('heart.csv')
```

In [8]:
```
#Top five rows
df.head()
```

Out[8]:

	age	sex	chest_pain_type	resting_bp	cholestoral	fasting_blood_sugar	restecg	max_hr	exang	oldpeak
0	63	1	3	145	233	1	0	150	0	2.3
1	37	1	2	130	250	0	1	187	0	3.5
2	41	0	1	130	204	0	0	172	0	1.4
3	56	1	1	120	236	0	1	178	0	0.8
4	57	0	0	120	354	0	1	163	1	0.6

In [9]:
```
#Columns and rows
df.shape
```

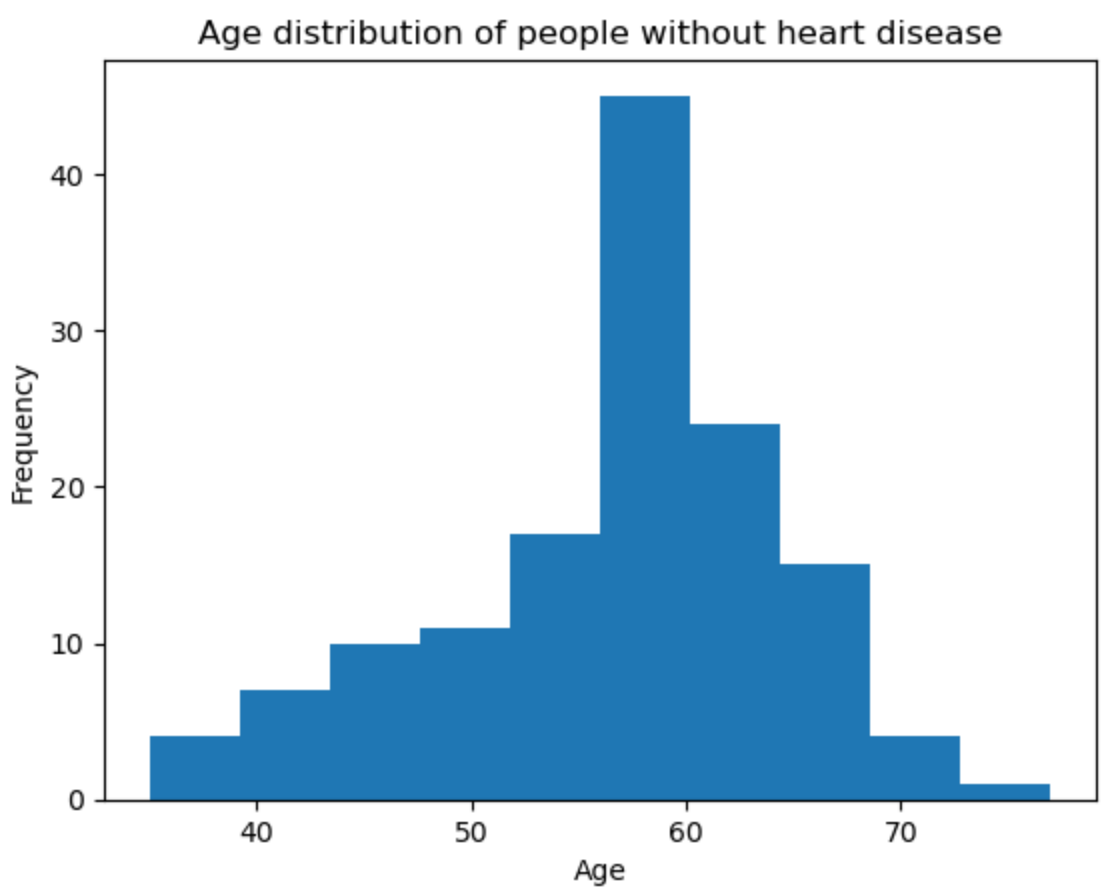
Out[9]:
```
(303, 14)
```

In [10]:
```
#Stats of the data
df.describe()
```

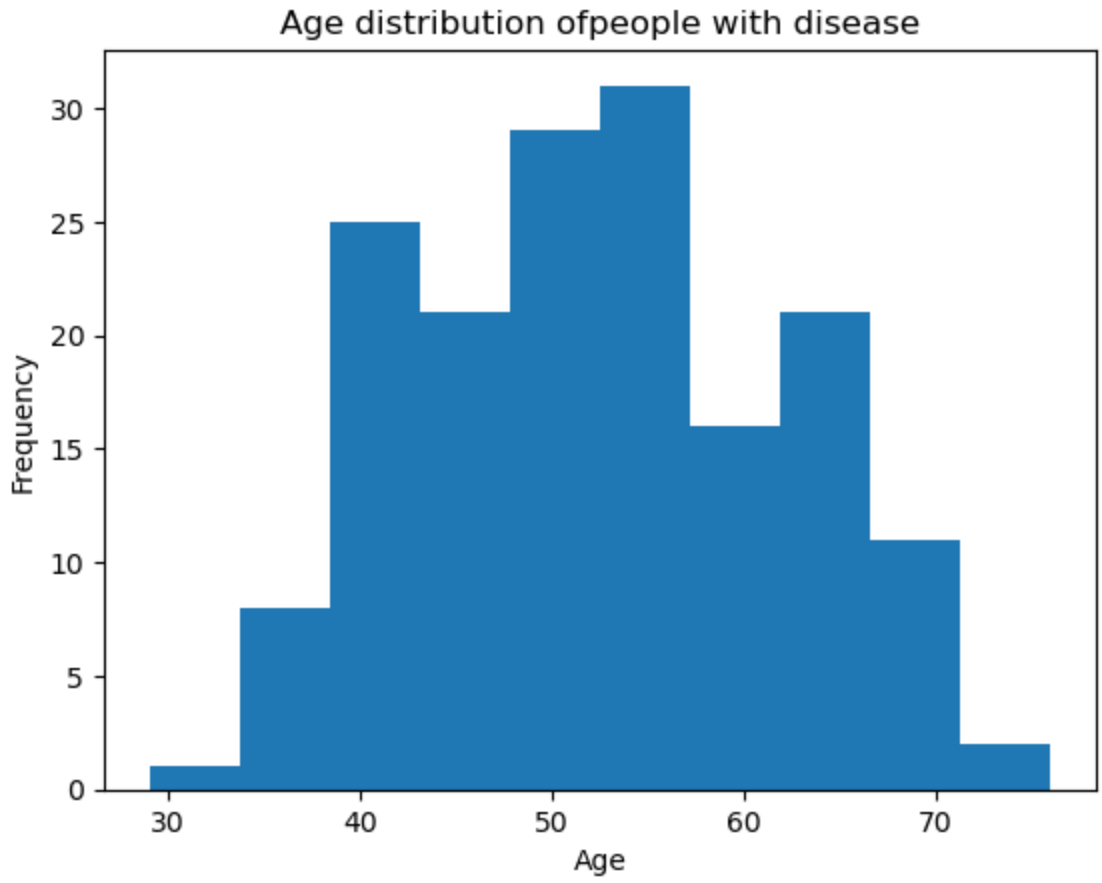
Out[10]:

	age	sex	chest_pain_type	resting_bp	cholestoral	fasting_blood_sugar	restecg	
count	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.
mean	54.366337	0.683168	0.966997	131.623762	246.264026	0.148515	0.528053	149.
std	9.082101	0.466011	1.032052	17.538143	51.830751	0.356198	0.525860	22.
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	71.
25%	47.500000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000	133.
50%	55.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000	153.
75%	61.000000	1.000000	2.000000	140.000000	274.500000	0.000000	1.000000	166.
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000	202.

In [11]:
```
plt.hist(df[df['target']==0]['age'], bins = 10)
plt.title('Age distribution of people without heart disease')
plt.xlabel('Age')
plt.ylabel('Frequency')
plt.show()
```



In [21]:
```
plt.hist(df[df['target']==1]['age'], bins = 10)
plt.title('Age distribution ofpeople with disease')
plt.xlabel('Age')
plt.ylabel('Frequency')
plt.show()
```



In [23]:
```
#Correlation
```

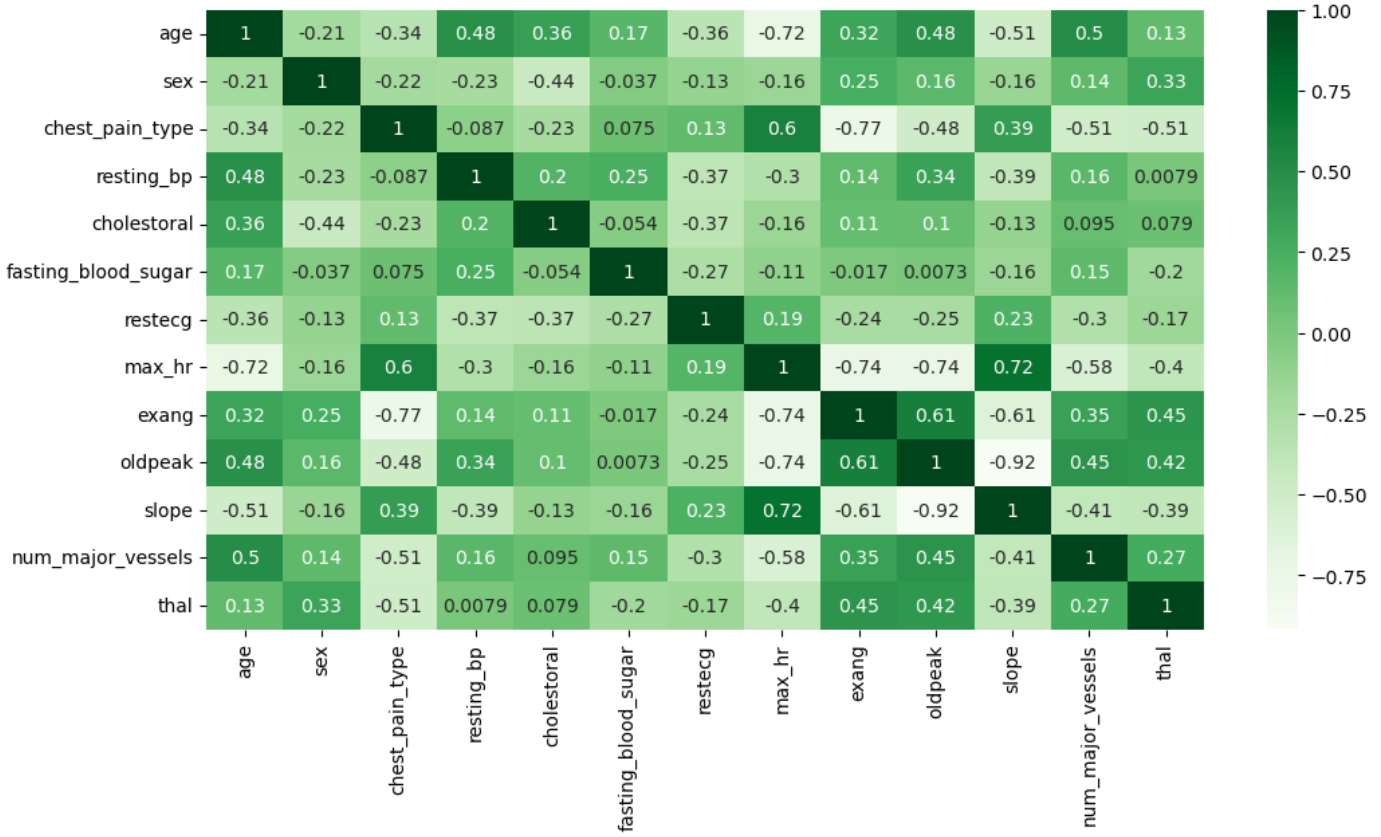
```
correlation = df.iloc[:,0:13].corr()

correlation
```

Out[23]:

	age	sex	chest_pain_type	resting_bp	cholestoral	fasting_blood_sugar	rest
age	1.000000	-0.098447	-0.068653	0.279351	0.213678	0.121308	-0.116
sex	-0.098447	1.000000	-0.049353	-0.056769	-0.197912	0.045032	-0.058
chest_pain_type	-0.068653	-0.049353	1.000000	0.047608	-0.076904	0.094444	0.044
resting_bp	0.279351	-0.056769	0.047608	1.000000	0.123174	0.177531	-0.114
cholestoral	0.213678	-0.197912	-0.076904	0.123174	1.000000	0.013294	-0.151
fasting_blood_sugar	0.121308	0.045032	0.094444	0.177531	0.013294	1.000000	-0.084
restecg	-0.116211	-0.058196	0.044421	-0.114103	-0.151040	-0.084189	1.000
max_hr	-0.398522	-0.044020	0.295762	-0.046698	-0.009940	-0.008567	0.044
exang	0.096801	0.141664	-0.394280	0.067616	0.067023	0.025665	-0.070
oldpeak	0.210013	0.096093	-0.149230	0.193216	0.053952	0.005747	-0.058
slope	-0.168814	-0.030711	0.119717	-0.121475	-0.004038	-0.059894	0.093
num_major_vessels	0.276326	0.118261	-0.181053	0.101389	0.070511	0.137979	-0.072
thal	0.068001	0.210041	-0.161736	0.062210	0.098803	-0.032019	-0.011

In [24]:
```
 #heatmap showing the correlation between two variables
plt.figure(figsize=(12, 6))
sns.heatmap(correlation.corr(numeric_only=True).iloc[:,0:13], annot=True, cmap='Greens')
```



In [26]:
```
#number of disease and no-disease patients
#  0 = No heart disease
#  1 = Yes heart disease
```

In [27]:
```
#Mean value of the dataset by heart disease and non no heart disease groupby 'target'
```

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

Out[27]:

target	age	sex	chest_pain_type	resting_bp	cholestoral	fasting_blood_sugar	restecg	max_h
0	56.601449	0.826087	0.478261	134.398551	251.086957	0.159420	0.449275	139.10144
1	52.496970	0.563636	1.375758	129.303030	242.230303	0.139394	0.593939	158.46666

In [28]:
```
#Seperating features from label. x= features, y = target
x = df.drop(columns = 'target', axis = 1)
y = df['target']
```

In [29]:
```
print(x)
```

```
     age  sex  chest_pain_type  resting_bp  cholestoral  fasting_blood_sugar  \
0     63    1                3         145          233                    1
1     37    1                2         130          250                    0
2     41    0                1         130          204                    0
3     56    1                1         120          236                    0
4     57    0                0         120          354                    0
..   ...  ...              ...         ...          ...                  ...
298   57    0                0         140          241                    0
299   45    1                3         110          264                    0
300   68    1                0         144          193                    1
301   57    1                0         130          131                    0
302   57    0                1         130          236                    0

     restecg  max_hr  exang  oldpeak  slope  num_major_vessels  thal
0          0     150      0      2.3      0                  0     1
1          1     187      0      3.5      0                  0     2
2          0     172      0      1.4      2                  0     2
3          1     178      0      0.8      2                  0     2
4          1     163      1      0.6      2                  0     2
..       ...     ...    ...      ...    ...                ...   ...
298        1     123      1      0.2      1                  0     3
299        1     132      0      1.2      1                  0     3
300        1     141      0      3.4      1                  2     3
301        1     115      1      1.2      1                  1     3
302        0     174      0      0.0      1                  1     2

[303 rows x 13 columns]
```

In [30]:
```
print(y)
```

```
0      1
1      1
2      1
3      1
4      1
      ..
298    0
299    0
300    0
301    0
302    0
Name: target, Length: 303, dtype: int64
```

Data Standardaization

In [38]:
```
#Data standardization; to convert the values to a common range between 0 & 1 for our ML
scaler = StandardScaler()
```

In [40]:
```
#Fitting the 'x' data
```

```
scaler.fit(x)
```

Out[40]:

StandardScaler

```
StandardScaler()
```

In [42]:

```
#Transforming the 'x' data
standardized_data = scaler.transform(x)
```

In [44]:

```
x = standardized_data
y = df['target']
```

In [46]:

```
print(x)
print(y)
```

```
[[ 0.9521966   0.68100522  1.97312292 ... -2.27457861 -0.71442887
  -2.14887271]
 [-1.91531289  0.68100522  1.00257707 ... -2.27457861 -0.71442887
  -0.51292188]
 [-1.47415758 -1.46841752  0.03203122 ...  0.97635214 -0.71442887
  -0.51292188]
 ...
 [ 1.50364073  0.68100522 -0.93851463 ... -0.64911323  1.24459328
   1.12302895]
 [ 0.29046364  0.68100522 -0.93851463 ... -0.64911323  0.26508221
   1.12302895]
 [ 0.29046364 -1.46841752  0.03203122 ... -0.64911323  0.26508221
  -0.51292188]]
0      1
1      1
2      1
3      1
4      1
      ..
298    0
299    0
300    0
301    0
302    0
Name: target, Length: 303, dtype: int64
```

Train Test Split

In [49]:

```
# test_size 0.2 = 20% data
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size= 0.2, stratify=y, ra
```

In [51]:

```
print(x.shape, x_train.shape, x_test.shape)
```

```
(303, 13) (242, 13) (61, 13)
```

Training the Model

In [54]:

```
#Training the model, by calling the Logistic_Regression I built and assigning parameters
classifier = Logistic_Regression(learning_rate=0.01, no_of_iterations=1000)
```

In [56]:

```
#Fitting the training data into the classifier
# x_training is the features and y_train is the label
classifier.fit(x_train, y_train)
```

Model Evaluation

X_Train Accuracy Score

In [60]:
```
#Evaluating the model to know the training data
x_train_prediction = classifier.predict(x_train)
training_data_accuracy = accuracy_score(y_train, x_train_prediction)
```

In [62]:
```
#Accuracy score of the train data

print('Accuracy score of the training data is:', training_data_accuracy)
print('Accuracy Score of training data:', training_data_accuracy)
```

```
Accuracy score of the training data is: 0.8471074380165289
Accuracy Score of training data: 0.8471074380165289
```

X_Test Accuracy Score

In [65]:
```
#Evaluating the model to know the test data
x_test_prediction = classifier.predict(x_test)
test_data_accuracy = accuracy_score(y_test, x_test_prediction)
```

In [67]:
```
print('Accuracy Score of the test data:', test_data_accuracy)
```

```
Accuracy Score of the test data: 0.8032786885245902
```

The Predictive System

In [70]:
```
import warnings
warnings.filterwarnings('ignore', category=UserWarning)

#Input data from the dataset
input_data = (63,1,3,145,233,1,0,150,0,2.3,0,0,1)

#Changing the input data to numpy arrray for efficient
input_data_as_numpy = np.asarray(input_data)

reshape_input_data = input_data_as_numpy.reshape(1, -1)

#Standardizing the data before predicting the outcome
standardized_data = scaler.transform(reshape_input_data)
print(standardized_data)

prediction = classifier.predict(standardized_data)
print(prediction)

if prediction [0] == 0:
    print('The person do not have any heart disease')

else:
    print('The person has heart disease')
```

```
[[ 0.9521966   0.68100522  1.97312292  0.76395577 -0.25633371  2.394438
  -1.00583187  0.01544279 -0.69663055  1.08733806 -2.27457861 -0.71442887
  -2.14887271]]
[1]
The person has heart disease
```

In [72]:
```
import warnings
warnings.filterwarnings('ignore', category=UserWarning)


input_data = (67,1,0,160,286,0,0,108,1,1.5,1,3,2)

input_data_as_numpy = np.asarray(input_data)
```

```
reshape_input_data = input_data_as_numpy.reshape(1, -1)

#Standardizing the data before predicting the outcome
standardized_data = scaler.transform(reshape_input_data)
print(standardized_data)

prediction = classifier.predict(standardized_data)
print(prediction)

if prediction [0] == 0:
    print('The person do not have any heart disease')

else:
    print('The person has heart disease')
```

```
[[ 1.39335191  0.68100522 -0.93851463  1.62064933  0.76791685 -0.41763453
  -1.00583187 -1.82123842  1.43548113  0.39718162 -0.64911323  2.22410436
  -0.51292188]]
[0]
The person do not have any heart disease
```

In [ ]:

In [75]:
```
df.columns
```

Out[75]:
```
Index(['age', 'sex', 'chest_pain_type', 'resting_bp', 'cholestoral',
       'fasting_blood_sugar', 'restecg', 'max_hr', 'exang', 'oldpeak', 'slope',
       'num_major_vessels', 'thal', 'target'],
      dtype='object')
```

In [79]:
```
df
```

Out[79]:

	age	sex	chest_pain_type	resting_bp	cholestoral	fasting_blood_sugar	restecg	max_hr	exang	oldpeak
0	63	1	3	145	233	1	0	150	0	2.3
1	37	1	2	130	250	0	1	187	0	3.5
2	41	0	1	130	204	0	0	172	0	1.4
3	56	1	1	120	236	0	1	178	0	0.8
4	57	0	0	120	354	0	1	163	1	0.6
...	...	...	...	...	...	...	...	...	...	..
298	57	0	0	140	241	0	1	123	1	0.2
299	45	1	3	110	264	0	1	132	0	1.2
300	68	1	0	144	193	1	1	141	0	3.4
301	57	1	0	130	131	0	1	115	1	1.2
302	57	0	1	130	236	0	0	174	0	0.0

303 rows × 14 columns

In [ ]: