Assignment-6 : Implement SGD For Linear Regression

1.0 Introduction ¶

(i).Linear regression is used for finding linear relationship between dependent (target) and independent (one or more predictors) variables.

2.0 Objective

Implement SGD (Stochastic Gradient Descent) for Linear Regression on scikit learn boston dataset.

3.0 Importing All Required Library

In [1]:

```
%matplotlib inline
import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
import math

from sklearn.datasets import load_boston
from prettytable import PrettyTable
from sklearn.linear_model import SGDRegressor
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import mean_squared_error,mean_absolute_error


from tqdm import tqdm
import os
import warnings
warnings.filterwarnings("ignore")
```

4.0 Importing Boston Dataset

In [2]:

```
Data = load_boston()
```

In [3]:

```
# Printing some data of DataFrame
Data.data.shape
```

Out[3]:

```
(506, 13)
```

In [4]:

```
# Printing Features Name
Data.feature_names
```

Out[4]:

```
array(['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD',
       'TAX', 'PTRATIO', 'B', 'LSTAT'], dtype='<U7')
```

In [5]:

```
BosData = pd.DataFrame(Data.data)
```

In [6]:

```
BosData.head()
```

Out[6]:

	0	1	2	3	4	5	6	7	8	9	10	11	12
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.0	296.0	15.3	396.90	4.98
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.0	242.0	17.8	396.90	9.14
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.0	242.0	17.8	392.83	4.03
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.0	222.0	18.7	394.63	2.94
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.0	222.0	18.7	396.90	5.33

In [7]:

```
BosData = (BosData - BosData.mean())/BosData.std()
BosData.head()
```

Out[7]:

	0	1	2	3	4	5	6	7	
0	-0.419367	0.284548	-1.286636	-0.272329	-0.144075	0.413263	-0.119895	0.140075	-0.98
1	-0.416927	-0.487240	-0.592794	-0.272329	-0.739530	0.194082	0.366803	0.556609	-0.86
2	-0.416929	-0.487240	-0.592794	-0.272329	-0.739530	1.281446	-0.265549	0.556609	-0.86
3	-0.416338	-0.487240	-1.305586	-0.272329	-0.834458	1.015298	-0.809088	1.076671	-0.75
4	-0.412074	-0.487240	-1.305586	-0.272329	-0.834458	1.227362	-0.510674	1.076671	-0.75

In [8]:

```
BosData['Price']=Data.target
BosData.head()
```

Out[8]:

	0	1	2	3	4	5	6	7	
0	-0.419367	0.284548	-1.286636	-0.272329	-0.144075	0.413263	-0.119895	0.140075	-0.98
1	-0.416927	-0.487240	-0.592794	-0.272329	-0.739530	0.194082	0.366803	0.556609	-0.86
2	-0.416929	-0.487240	-0.592794	-0.272329	-0.739530	1.281446	-0.265549	0.556609	-0.86
3	-0.416338	-0.487240	-1.305586	-0.272329	-0.834458	1.015298	-0.809088	1.076671	-0.75
4	-0.412074	-0.487240	-1.305586	-0.272329	-0.834458	1.227362	-0.510674	1.076671	-0.75

In [9]:

```
# Extracting Dependent(Y) and Independent Variable(X) From Dataset
X = BosData.drop('Price',axis=1)
Y = BosData['Price']
```

5.0 Information About DataSet

In [10]:

```
print("\nShape of Data: ", BosData.shape)
print("\nNumber of Attributes: 13 numeric/categorical predictive")
print("\nMedian Value (attribute 14) is usually the target")
```

```
Shape of Data:  (506, 14)

Number of Attributes: 13 numeric/categorical predictive

Median Value (attribute 14) is usually the target
```

5.1 Attribute Information About DataSet

1. CRIM per capita crime rate by town
2. ZN proportion of residential land zoned for lots over 25,000 sq.ft.
3. INDUS proportion of non-retail business acres per town
4. CHAS Charles River dummy variable (= 1 if tract bounds river; 0 otherwise)
5. NOX nitric oxides concentration (parts per 10 million)
6. RM average number of rooms per dwelling
7. AGE proportion of owner-occupied units built prior to 1940
8. DIS weighted distances to five Boston employment centres
9. RAD index of accessibility to radial highways
10. TAX full-value property-tax rate per $10,000
11. PTRATIO pupil-teacher ratio by town

```
- B        1000(Bk - 0.63)^2 where Bk is the proportion of blacks by town
- LSTAT    % lower status of the population
- MEDV     Median value of owner-occupied homes in $1000's
```

12. Missing Attribute Values: None

6.0 Splitting DataSet into Train and Test Data

In [11]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.33, random_stat
e = 5)
```

In [12]:

```
X_train_new =X_train.copy()
X_train_new['Price']=Y_train
```

7.0 Defining Some Function

In [13]:

```
def Plot(y_test,y_pred):
    plt.scatter(y_test,y_pred)
    plt.grid()
    plt.title('Scatter plot between actual y and predicted y')
    plt.xlabel('Actual Y')
    plt.ylabel('Predicted Y')
    plt.show()
```

In [14]:

```
def weight_display(W_Manual,W_Model):
    from prettytable import PrettyTable
    X=PrettyTable()
    W_Manual1=[]

    for i in np.array(weight_M):
        for j in i:
            W_Manual1.append(j)

    X.field_names=["S.No","Manual Implementation Weight","Model Implementation Weight"]
    for i in range(W_Manual.shape[0]):
        X.add_row([i+1,W_Manual1[i],W_Model[i]])
    print(X)
```

In [15]:

```
def train_test_error_each_iteration(cost_train,cost_test):
    plt.figure()
    plt.plot(range(len(cost_train)), np.reshape(cost_train,[len(cost_train), 1]), label
= "Train Cost")
    plt.plot(range(len(cost_test)), np.reshape(cost_test, [len(cost_test), 1]), label =
"Test Cost")
    plt.title("Cost/Loss per iteration")
    plt.xlabel("Number of iterations")
    plt.ylabel("Cost/Loss")
    plt.legend()
    plt.show()
```

In [16]:

```
def Predict(x_test_data,w, b):
    y_pred=[]
    for i in range(len(x_test_data)):
        y=np.asscalar(np.dot(x_test_data[i],w)+b)
        y_pred.append(y)
    return np.array(y_pred)
```

In [17]:

```
def Manual_Implement_SGD(train_data,x_test,y_test,n_iter):

    w0_random = np.zeros(13)
    w0 = np.asmatrix(w0_random).T
    b0 = 0
    learning_rate=0.001
    n_iter = n_iter
    partial_deriv_m = 0
    partial_deriv_b = 0
    cost_train = []
    cost_test = []
    for j in range(1, n_iter):

        # Train sample
        train_sample = train_data.sample(180)
        y = np.asmatrix(train_sample["Price"])
        x = np.asmatrix(train_sample.drop("Price", axis = 1))
        for i in range(len(x)):
            partial_deriv_m += np.dot(-2*x[i].T , (y[:,i] - np.dot(x[i] , w0) + b0))
            partial_deriv_b += -2*(y[:,i] - (np.dot(x[i] , w0) + b0))

        w1 = w0 - learning_rate * partial_deriv_m
        b1 = b0 - learning_rate * partial_deriv_b

        if (w0==w1).all():
            break
        else:
            w0 = w1
            b0 = b1
            learning_rate = learning_rate/2

        error_train = cost_function(b0,w0,x, y)
        cost_train.append(error_train)
        error_test = cost_function(b0,w0,np.asmatrix(x_test), np.asmatrix(y_test))
        cost_test.append(error_test)

    return w0, b0, cost_train, cost_test
```

In [18]:

```
def Sklearn_SGD(X_train,Y_train,n_iter):

    model=SGDRegressor(penalty=None,n_iter=n_iter)
    model.fit(X_train,Y_train)

    return model
```

In [19]:

```
def cost_function(b, m, features, target):
    totalError = 0
    for i in range(0, len(features)):
        x = features
        y = target
        totalError += (y[:,i] - (np.dot(x[i] , m) + b)) ** 2
    return totalError / len(x)
```

7.0 Taking Iteration Value 100

7.1 Manual Implementation Of SGD

In [20]:

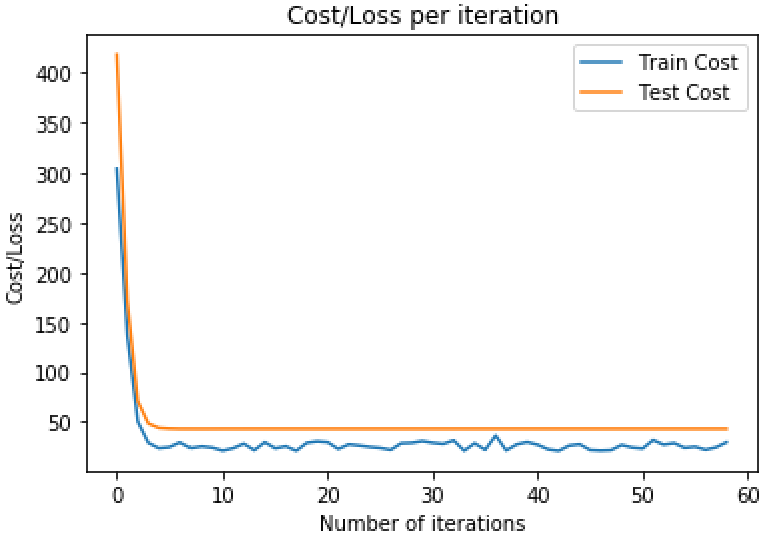
```
weight_M,b_M,cost_train,cost_test=Manual_Implement_SGD(X_train_new,X_test,Y_test,100)
```

In [21]:

```
Y_Pred_M =Predict(np.asmatrix(X_test),weight_M,b_M)
```

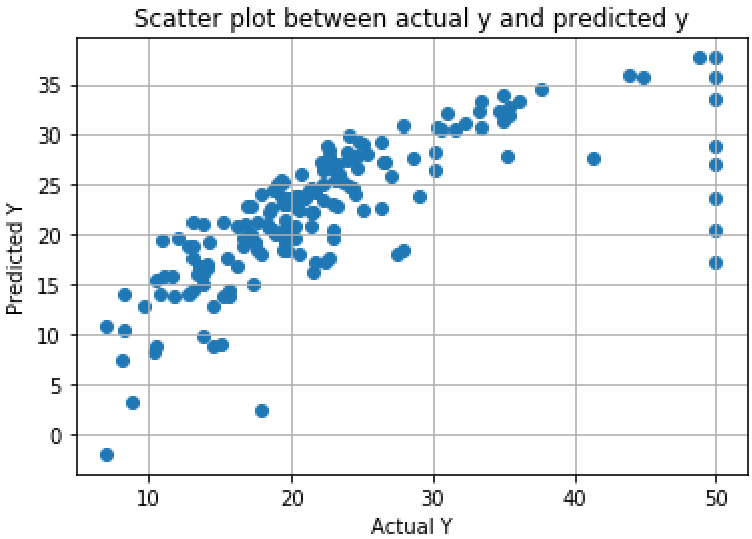
In [22]:

```
train_test_error_each_iteration(cost_train,cost_test)
```



In [23]:

```
Plot(Y_test,Y_Pred_M)
```



In [24]:

```
print("Mean Squared Error : ",cost_function(b_M,weight_M,np.asmatrix(X_test), np.asmatr
ix(Y_test)))
```

```
Mean Squared Error :  [[43.09968728]]
```

7.2 Sklearn Implementation of SGD

In [25]:

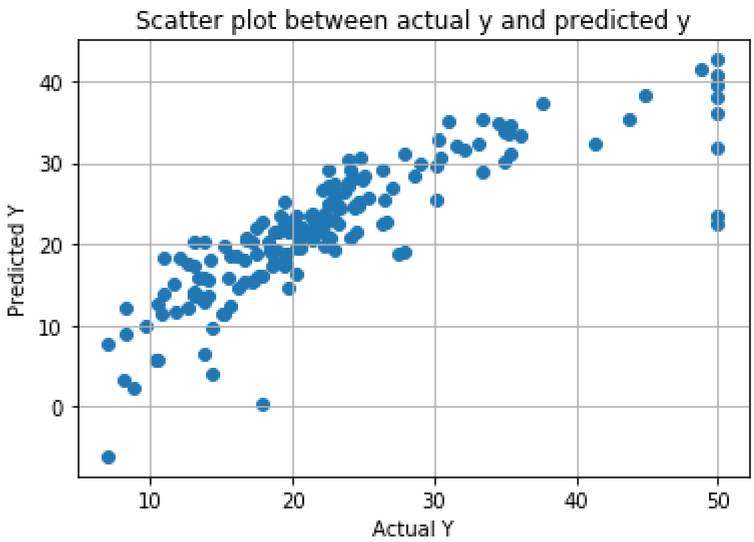
```
model=Sklearn_SGD(X_train,Y_train,100)
```

In [26]:

```
Y_Pred_F = model.predict(X_test)
```

In [27]:

```
Plot(Y_test,Y_Pred_F)
```



In [28]:

```
print("Mean Squared Error : ",mean_squared_error(Y_test,Y_Pred_F))
```

```
Mean Squared Error :  28.399369258523045
```

In [29]:

```
weight_F=model.coef_
b_F=model.intercept_
```

7.3 Comparison Between Sklearn & Manual Implementation

7.3.1 Intercept Information

In [30]:

```
print("Intercept of Manaual Implementation : ",b_M)
print("Intercept of Sklearn Implementation",b_F)
```

```
Intercept of Manaual Implementation :  [[22.89659758]]
Intercept of Sklearn Implementation [22.318952]
```

7.3.2 Weight Obtained By Manual & Sklearn Implementation

In [31]:

```
weight_display(weight_M,weight_F)
```

S.No	Manual Implementation Weight	Model Implementation Weight
1	-1.2670709987790072	-1.3160154638748793
2	0.24796297357026736	0.8710479589945289
3	-1.3778449938148662	-0.2761286381756941
4	-1.174926735255015	0.21051742479960323
5	0.14177883122073878	-1.487184369583639
6	2.6251943051315623	2.8254239527450684
7	-1.48503529720376	-0.33957484929683285
8	-1.7276450446917608	-2.902389812828027
9	1.1467227427461884	2.6454220157745776
10	-0.7447874319319048	-1.891187529155848
11	-0.7304981882287312	-2.1199105577453623
12	1.2654483449957503	1.0832944390331352
13	-2.220484737858589	-3.3595048286700493

8.0 Taking Iteration Value of 500

8.1 Manual Implementation Of SGD

In [32]:

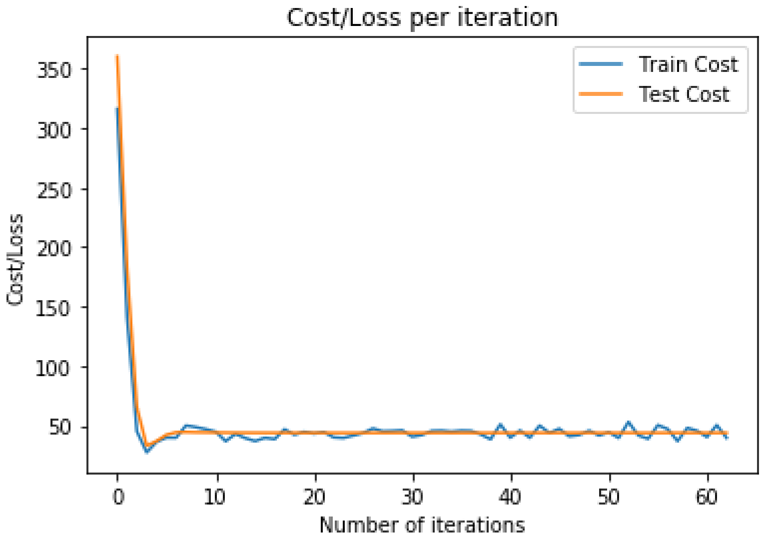
```
weight_M,b_M,cost_train,cost_test=Manual_Implement_SGD(X_train_new,X_test,Y_test,500)
```

In [33]:

```
Y_Pred_M =Predict(np.asmatrix(X_test),weight_M,b_M)
```

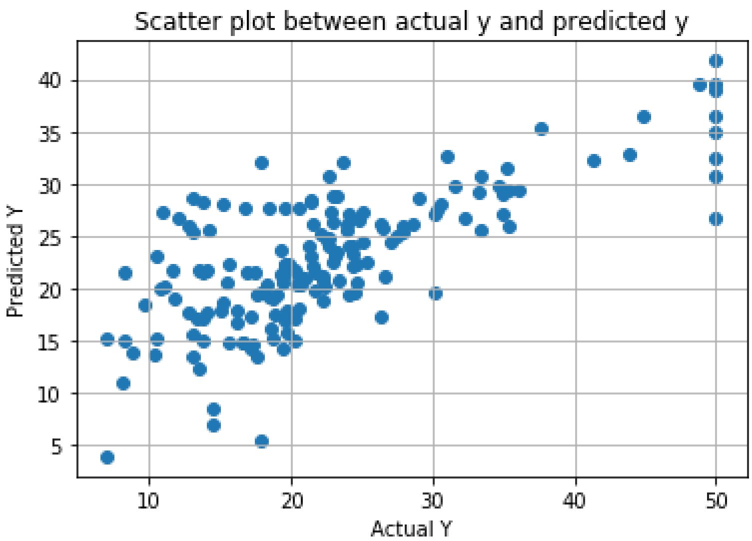
In [34]:

```
train_test_error_each_iteration(cost_train,cost_test)
```



In [35]:

```
Plot(Y_test,Y_Pred_M)
```



In [36]:

```
print("Mean Squared Error : ",cost_function(b_M,weight_M,np.asmatrix(X_test), np.asmatr
ix(Y_test)))
```

```
Mean Squared Error :  [[44.1459459]]
```

8.2 Sklearn Implementation of SGD

In [37]:

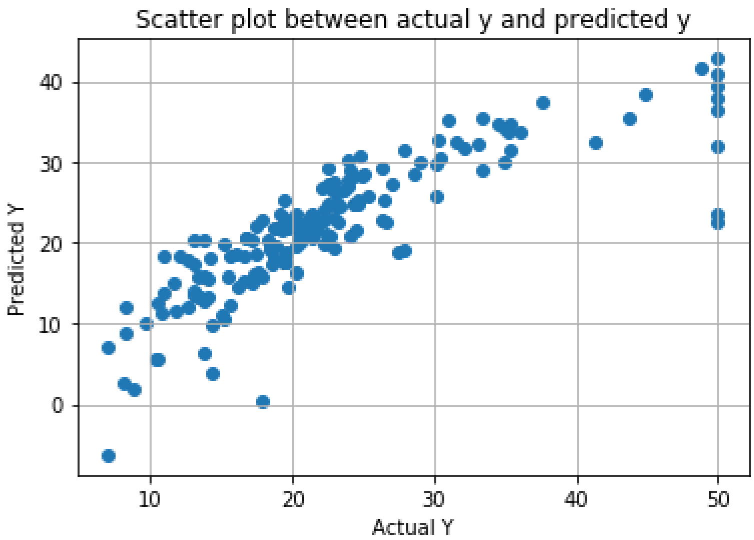
```
model=Sklearn_SGD(X_train,Y_train,500)
```

In [38]:

```
Y_Pred_F = model.predict(X_test)
```

In [39]:

```
Plot(Y_test,Y_Pred_F)
```



In [40]:

```
print("Mean Squared Error : ",mean_squared_error(Y_test,Y_Pred_F))
```

```
Mean Squared Error :  28.5272168184641
```

In [41]:

```
weight_F=model.coef_
b_F=model.intercept_
```

8.3 Comparison Between Sklearn & Manual Implementation

8.3.1 Intercept Information

In [42]:

```
print("Intercept of Manaual Implementation : ",b_M)
print("Intercept of Sklearn Implementation",b_F)
```

```
Intercept of Manaual Implementation :  [[23.15133995]]
Intercept of Sklearn Implementation [22.31300041]
```

8.3.2 Weight Obtained By Manual & Sklearn Implementation

In [43]:

```
weight_display(weight_M,weight_F)
```

S.No	Manual Implementation Weight	Model Implementation Weight
1	-0.45699301358919114	-1.3477172686121794
2	0.30690699548744876	0.8996382535154619
3	0.20186466954322435	-0.1745415300597715
4	0.4763343944510008	0.2030867835628962
5	0.3502708614805677	-1.5062877147540947
6	3.3619985529004266	2.814051651509481
7	-0.8366886910291909	-0.32613184726357003
8	-2.3336383337824227	-2.88658255546854
9	2.4416782421545875	2.9743497011704334
10	0.8126251112622226	-2.274478787451737
11	-1.5191217506661354	-2.14066542479728
12	1.796101988515469	1.10446154671888
13	-2.6804572595060048	-3.3810122324417384

9.0 Taking Iteration Value 1000

9.1 Manual Implementation Of SGD

In [44]:

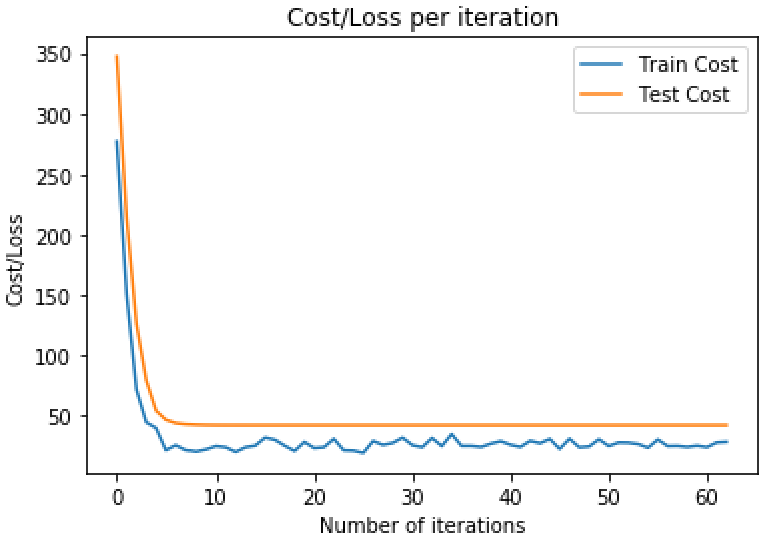
```
weight_M,b_M,cost_train,cost_test=Manual_Implement_SGD(X_train_new,X_test,Y_test,10000)
```

In [45]:

```
Y_Pred_M =Predict(np.asmatrix(X_test),weight_M,b_M)
```

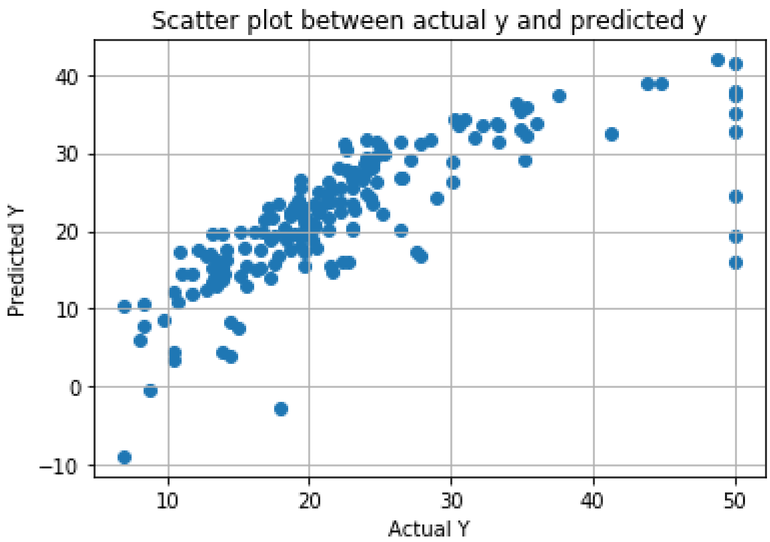
In [46]:

```
train_test_error_each_iteration(cost_train,cost_test)
```



In [47]:

```
Plot(Y_test,Y_Pred_M)
```



In [48]:

```
print("Mean Squared Error : ",cost_function(b_M,weight_M,np.asmatrix(X_test), np.asmatr
ix(Y_test)))
```

```
Mean Squared Error :  [[41.73049258]]
```

9.2 Sklearn Implementation Of SGD

In [49]:

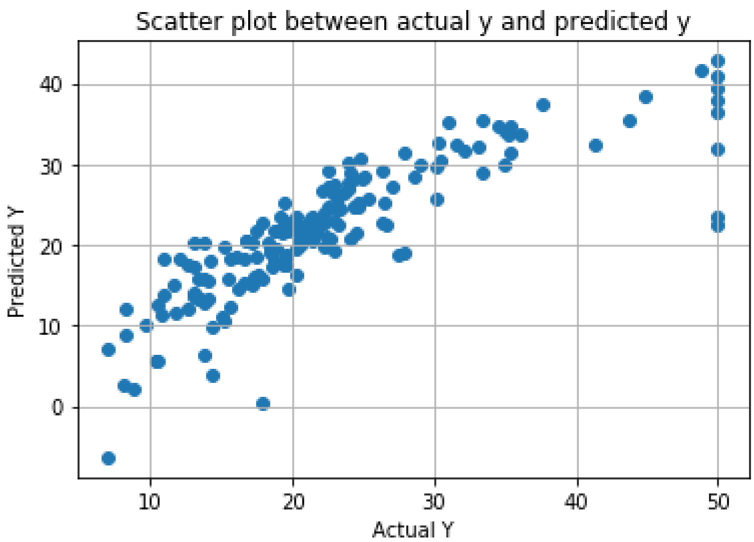
```
model=Sklearn_SGD(X_train,Y_train,1000)
```

In [50]:

```
Y_Pred_F = model.predict(X_test)
```

In [51]:

```
Plot(Y_test,Y_Pred_F)
```



In [52]:

```
print("Mean Squared Error : ",mean_squared_error(Y_test,Y_Pred_F))
```

```
Mean Squared Error :  28.564463703174166
```

In [53]:

```
weight_F=model.coef_
b_F=model.intercept_
```

9.3 Comparison Between Sklearn & Manual Implementation

9.3.1 Intercept Information

In [54]:

```
print("Intercept of Manaual Implementation : ",b_M)
print("Intercept of Sklearn Implementation",b_F)
```

```
Intercept of Manaual Implementation :  [[22.58776205]]
Intercept of Sklearn Implementation [22.30754811]
```

9.3.2 Weight Obtained By Manual & Sklearn Implementation

In [55]:

```
weight_display(weight_M,weight_F)
```

```
+------+-----------------------------+---------------------------+
| S.No | Manual Implementation Weight | Model Implementation Weight |
+------+-----------------------------+---------------------------+
|  1   |      -1.5032586158351413     |      -1.3430347820333557     |
|  2   |     -0.025389937015346132    |       0.9028344688806086     |
|  3   |      -0.3262986046327045     |       -0.177005332776656     |
|  4   |      -1.3194221563062645     |      0.19697065607736197     |
|  5   |       -0.361781564394641     |       -1.50622407890077      |
|  6   |       3.435069453285313      |       2.8167857631940514     |
|  7   |      -2.1264509712022317     |      -0.32839865940779006    |
|  8   |      -2.0100401644101233     |      -2.8779461148219654     |
|  9   |       0.8097034039124889     |       2.9766620497157272     |
|  10  |      -0.23711099431954244    |      -2.2827481883146703     |
|  11  |       -2.070273871064911     |       -2.138725396009798     |
|  12  |       1.1313349151142869     |       1.100279002116749      |
|  13  |       -3.150264905319655     |       -3.380898130355045     |
+------+-----------------------------+---------------------------+
```

10.0 Taking Iteration 10000

10.1 Manual Implementation Of SGD

In [60]:

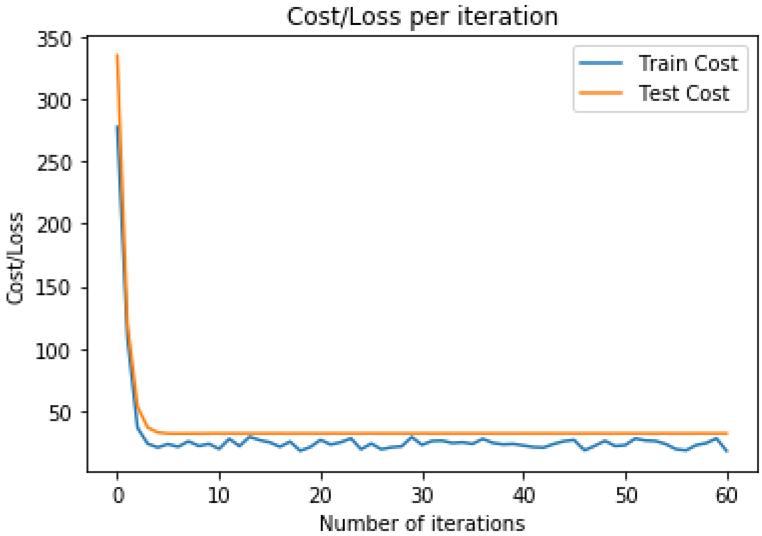
```
weight_M,b_M,cost_train,cost_test=Manual_Implement_SGD(X_train_new,X_test,Y_test,10000)
```

In [61]:

```
Y_Pred_M =Predict(np.asmatrix(X_test),weight_M,b_M)
```

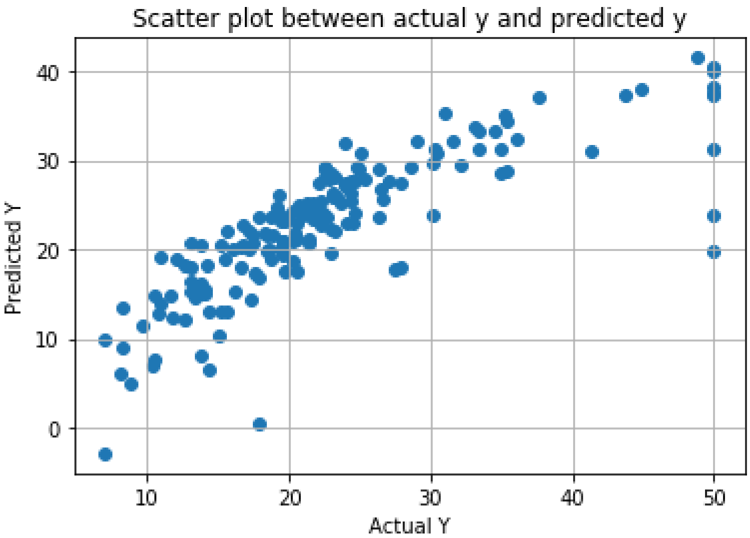
In [62]:

```
train_test_error_each_iteration(cost_train,cost_test)
```



In [63]:

```
Plot(Y_test,Y_Pred_M)
```



In [64]:

```
print("Mean Squared Error : ",cost_function(b_M,weight_M,np.asmatrix(X_test), np.asmatr
ix(Y_test)))
```

```
Mean Squared Error :  [[31.84742686]]
```

10.2 Sklearn Implementation Of SGD

In [65]:

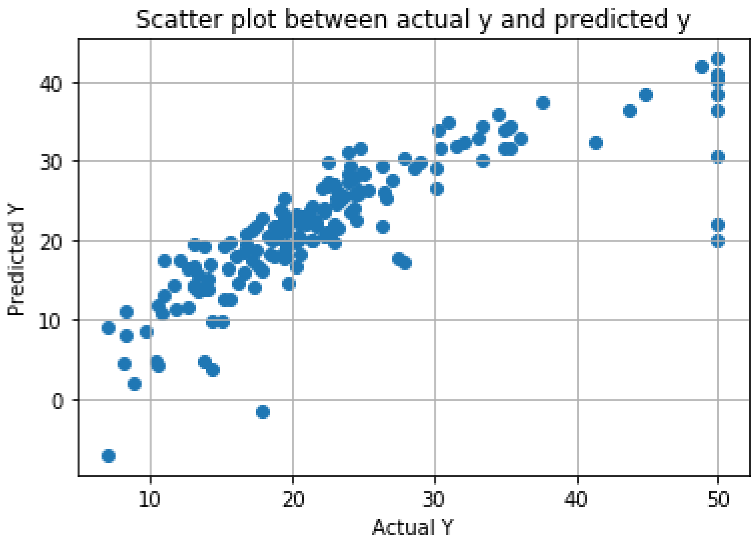
```
model=Sklearn_SGD(X_train,Y_train,10)
```

In [66]:

```
Y_Pred_F = model.predict(X_test)
```

In [67]:

```
Plot(Y_test,Y_Pred_F)
```



In [69]:

```
print("Mean Squared Error : ",mean_squared_error(Y_test,Y_Pred_F))
```

```
Mean Squared Error :  30.551503948527454
```

In [70]:

```
weight_F=model.coef_
b_F=model.intercept_
```

10.3 Comparison Between Sklearn & Manual Implementation

10.3.1 Intercept Information

In [71]:

```
print("Intercept of Manaual Implementation : ",b_M)
print("Intercept of Sklearn Implementation",b_F)
```

```
Intercept of Manaual Implementation :  [[23.15849266]]
Intercept of Sklearn Implementation [22.28967489]
```

Weight Obtained By Manual & Sklearn Implementation

In [72]:

```
weight_display(weight_M,weight_F)
```

```
+------+----------------------------+---------------------------+
| S.No | Manual Implementation Weight | Model Implementation Weight |
+------+----------------------------+---------------------------+
|  1   |    -0.8575878949668416     |    -1.1941218861345153    |
|  2   |     -0.718640292119655     |     0.5208726294053448    |
|  3   |    -1.4972534445048742     |    -0.5725776219759126    |
|  4   |     0.6247167112277762     |     0.2457938707302134    |
|  5   |    -0.21252270634222556    |    -0.9278945253668555    |
|  6   |     2.9194362815342383     |     3.177284180179496     |
|  7   |    -0.9217320997936677     |    -0.5541056564842918    |
|  8   |    -1.7972666402070991     |    -2.1178567502413355    |
|  9   |     0.876372735298303      |     1.241108327077085     |
|  10  |    -0.5456206398935565     |    -0.8477992087671062    |
|  11  |     -1.953157742110251     |    -2.0746385459929675    |
|  12  |     1.387151571253131      |     1.0726120871782119    |
|  13  |     -2.540620783610168     |    -3.2345948301055683    |
+------+----------------------------+---------------------------+
```

Conclusion

1.0 Manual Implementation Report

In [76]:

```python
from prettytable import PrettyTable
X=PrettyTable()
X.field_names =["Iteration","Intercept","Mean-Squared-Error"]
X.add_row([100,22.89,43.09])
X.add_row([500,23.15,44.14])
X.add_row([1000,22.58,41.73])
X.add_row([10000,23.15,31.84])
print(X)
```

```
+-----------+-----------+--------------------+
| Iteration | Intercept | Mean-Squared-Error |
+-----------+-----------+--------------------+
|    100    |   22.89   |       43.09        |
|    500    |   23.15   |       44.14        |
|    1000   |   22.58   |       41.73        |
|   10000   |   23.15   |       31.84        |
+-----------+-----------+--------------------+
```

2.0 Sklearn Implementation Report

In [77]:

```
from prettytable import PrettyTable
X=PrettyTable()
X.field_names =["Iteration","Intercept","Mean-Squared-Error"]
X.add_row([100,22.31,28.39])
X.add_row([500,22.31,28.52])
X.add_row([1000,22.30,28.56])
X.add_row([10000,22.28,30.55])
print(X)
```

```
+-----------+-----------+--------------------+
| Iteration | Intercept | Mean-Squared-Error |
+-----------+-----------+--------------------+
|    100    |   22.31   |       28.39        |
|    500    |   22.31   |       28.52        |
|    1000   |    22.3   |       28.56        |
|   10000   |   22.28   |       30.55        |
+-----------+-----------+--------------------+
```

3.0 I have used Boston House Price Dataset.

4.0 In Manaul Implementation ,As suggested i decreased the learning rate by half everytime then the value of mean squared error decreased first then again increased.