```
In [67]: from sklearn.datasets import load_boston
         import numpy as np
         import matplotlib.pyplot as plt
         from sklearn.metrics import mean_squared_error
         boston = load_boston()
```

```
In [68]: print(boston.data.shape)
```

```
(506, 13)
```

```
In [69]: print(boston.feature_names)
```

```
['CRIM' 'ZN' 'INDUS' 'CHAS' 'NOX' 'RM' 'AGE' 'DIS' 'RAD' 'TAX' 'PTRATIO'
 'B' 'LSTAT']
```

```
In [70]: print(boston.target)
```

```
[24.  21.6 34.7 33.4 36.2 28.7 22.9 27.1 16.5 18.9 15.  18.9 21.7 20.4
 18.2 19.9 23.1 17.5 20.2 18.2 13.6 19.6 15.2 14.5 15.6 13.9 16.6 14.8
 18.4 21.  12.7 14.5 13.2 13.1 13.5 18.9 20.  21.  24.7 30.8 34.9 26.6
 25.3 24.7 21.2 19.3 20.  16.6 14.4 19.4 19.7 20.5 25.  23.4 18.9 35.4
 24.7 31.6 23.3 19.6 18.7 16.  22.2 25.  33.  23.5 19.4 22.  17.4 20.9
 24.2 21.7 22.8 23.4 24.1 21.4 20.  20.8 21.2 20.3 28.  23.9 24.8 22.9
 23.9 26.6 22.5 22.2 23.6 28.7 22.6 22.  22.9 25.  20.6 28.4 21.4 38.7
 43.8 33.2 27.5 26.5 18.6 19.3 20.1 19.5 19.5 20.4 19.8 19.4 21.7 22.8
 18.8 18.7 18.5 18.3 21.2 19.2 20.4 19.3 22.  20.3 20.5 17.3 18.8 21.4
 15.7 16.2 18.  14.3 19.2 19.6 23.  18.4 15.6 18.1 17.4 17.1 13.3 17.8
 14.  14.4 13.4 15.6 11.8 13.8 15.6 14.6 17.8 15.4 21.5 19.6 15.3 19.4
 17.  15.6 13.1 41.3 24.3 23.3 27.  50.  50.  50.  22.7 25.  50.  23.8
 23.8 22.3 17.4 19.1 23.1 23.6 22.6 29.4 23.2 24.6 29.9 37.2 39.8 36.2
 37.9 32.5 26.4 29.6 50.  32.  29.8 34.9 37.  30.5 36.4 31.1 29.1 50.
 33.3 30.3 34.6 34.9 32.9 24.1 42.3 48.5 50.  22.6 24.4 22.5 24.4 20.
 21.7 19.3 22.4 28.1 23.7 25.  23.3 28.7 21.5 23.  26.7 21.7 27.5 30.1
 44.8 50.  37.6 31.6 46.7 31.5 24.3 31.7 41.7 48.3 29.  24.  25.1 31.5
 23.7 23.3 22.  20.1 22.2 23.7 17.6 18.5 24.3 20.5 24.5 26.2 24.4 24.8
 29.6 42.8 21.9 20.9 44.  50.  36.  30.1 33.8 43.1 48.8 31.  36.5 22.8
 30.7 50.  43.5 20.7 21.1 25.2 24.4 35.2 32.4 32.  33.2 33.1 29.1 35.1
 45.4 35.4 46.  50.  32.2 22.  20.1 23.2 22.3 24.8 28.5 37.3 27.9 23.9
 21.7 28.6 27.1 20.3 22.5 29.  24.8 22.  26.4 33.1 36.1 28.4 33.4 28.2
 22.8 20.3 16.1 22.1 19.4 21.6 23.8 16.2 17.8 19.8 23.1 21.  23.8 23.1
 20.4 18.5 25.  24.6 23.  22.2 19.3 22.6 19.8 17.1 19.4 22.2 20.7 21.1
 19.5 18.5 20.6 19.  18.7 32.7 16.5 23.9 31.2 17.5 17.2 23.1 24.5 26.6
 22.9 24.1 18.6 30.1 18.2 20.6 17.8 21.7 22.7 22.6 25.  19.9 20.8 16.8
 21.9 27.5 21.9 23.1 50.  50.  50.  50.  50.  13.8 13.8 15.  13.9 13.3
 13.1 10.2 10.4 10.9 11.3 12.3  8.8  7.2 10.5  7.4 10.2 11.5 15.1 23.2
  9.7 13.8 12.7 13.1 12.5  8.5  5.   6.3  5.6  7.2 12.1  8.3  8.5  5.
 11.9 27.9 17.2 27.5 15.  17.2 17.9 16.3  7.   7.2  7.5 10.4  8.8  8.4
 16.7 14.2 20.8 13.4 11.7  8.3 10.2 10.9 11.   9.5 14.5 14.1 16.1 14.3
 11.7 13.4  9.6  8.7  8.4 12.8 10.5 17.1 18.4 15.4 10.8 11.8 14.9 12.6
 14.1 13.  13.4 15.2 16.1 17.8 14.9 14.1 12.7 13.5 14.9 20.  16.4 17.7
 19.5 20.2 21.4 19.9 19.  19.1 19.1 20.1 19.9 19.6 23.2 29.8 13.8 13.3
 16.7 12.  14.6 21.4 23.  23.7 25.  21.8 20.6 21.2 19.1 20.6 15.2  7.
  8.1 13.6 20.1 21.8 24.5 23.1 19.7 18.3 21.2 17.5 16.8 22.4 20.6 23.9
 22.  11.9]
```

```
In [71]: print(boston.DESCR)
```

```
Boston House Prices dataset
===========================

Notes
------
Data Set Characteristics:

    :Number of Instances: 506

    :Number of Attributes: 13 numeric/categorical predictive

    :Median Value (attribute 14) is usually the target

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

    :Missing Attribute Values: None

    :Creator: Harrison, D. and Rubinfeld, D.L.

This is a copy of UCI ML housing dataset.
http://archive.ics.uci.edu/ml/datasets/Housing


This dataset was taken from the StatLib library which is maintained at Carnegie Mellon University.

The Boston house-price data of Harrison, D. and Rubinfeld, D.L. 'Hedonic
prices and the demand for clean air', J. Environ. Economics & Management,
vol.5, 81-102, 1978.   Used in Belsley, Kuh & Welsch, 'Regression diagnostics
...', Wiley, 1980.   N.B. Various transformations are used in the table on
pages 244-261 of the latter.

The Boston house-price data has been used in many machine learning papers that address regression
problems.

**References**

   - Belsley, Kuh & Welsch, 'Regression diagnostics: Identifying Influential Data and Sources of Collinearity', Wiley, 198
0. 244-261.
   - Quinlan,R. (1993). Combining Instance-Based and Model-Based Learning. In Proceedings on the Tenth International Confe
rence of Machine Learning, 236-243, University of Massachusetts, Amherst. Morgan Kaufmann.
   - many more! (see http://archive.ics.uci.edu/ml/datasets/Housing)
```

```
In [72]: import pandas as pd

         bos = pd.DataFrame(boston.data)
         print(bos.head())
```

```
         0     1     2    3      4      5     6       7    8      9     10  \
0  0.00632  18.0  2.31  0.0  0.538  6.575  65.2  4.0900  1.0  296.0  15.3
1  0.02731   0.0  7.07  0.0  0.469  6.421  78.9  4.9671  2.0  242.0  17.8
2  0.02729   0.0  7.07  0.0  0.469  7.185  61.1  4.9671  2.0  242.0  17.8
3  0.03237   0.0  2.18  0.0  0.458  6.998  45.8  6.0622  3.0  222.0  18.7
4  0.06905   0.0  2.18  0.0  0.458  7.147  54.2  6.0622  3.0  222.0  18.7

       11    12
0  396.90  4.98
1  396.90  9.14
2  392.83  4.03
3  394.63  2.94
4  396.90  5.33
```

```
In [73]: bos['PRICE'] = boston.target
         X = bos.drop('PRICE', axis = 1)
         Y = bos['PRICE']
```

```
In [74]: print(bos.head())
```

```
         0     1     2    3      4      5     6       7    8      9     10  \
0  0.00632  18.0  2.31  0.0  0.538  6.575  65.2  4.0900  1.0  296.0  15.3
1  0.02731   0.0  7.07  0.0  0.469  6.421  78.9  4.9671  2.0  242.0  17.8
2  0.02729   0.0  7.07  0.0  0.469  7.185  61.1  4.9671  2.0  242.0  17.8
3  0.03237   0.0  2.18  0.0  0.458  6.998  45.8  6.0622  3.0  222.0  18.7
4  0.06905   0.0  2.18  0.0  0.458  7.147  54.2  6.0622  3.0  222.0  18.7

       11    12  PRICE
0  396.90  4.98   24.0
1  396.90  9.14   21.6
2  392.83  4.03   34.7
3  394.63  2.94   33.4
4  396.90  5.33   36.2
```

```
In [75]: # applying column standardization on train and test data
         from sklearn.preprocessing import StandardScaler
         s=StandardScaler()
         X_data=s.fit_transform(np.array(X))
         Y_data=s.fit_transform(np.array(Y).reshape(-1,1))
```

```
In [76]: results=pd.DataFrame(columns=['sno', 'algo', 'alpha', 'init_lr_rate', 'n_iter','weight','intercept', 'error'])
```

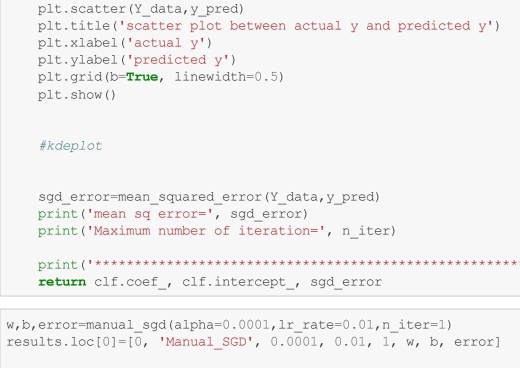
Applying manual SGD on Boston Dataset

```
In [77]: def manual_sgd(alpha, lr_rate, n_iter):
             wj_plus1=np.zeros(shape=(1,13))
             bj_plus1=0
             n=1
             r=lr_rate
             n_iter=n_iter
             while(n<=n_iter):
                 wj=wj_plus1
                 bj=bj_plus1
                 w_=np.zeros(shape=(1,13))
                 b_=0


                 for i in range(10):  # for getting the derivatives using sgd with k=10
                         y_curr=np.dot(wj,X_data[i])+bj
                         w_ = w_ + X_data[i] * (Y_data[i] - y_curr)
                         b_ = b_ + (Y_data[i]-y_curr)

                 wj_plus1=(wj-r*(w_ * (-2/X_data.shape[0])))
                 bj_plus1=(bj-r*(b_ * (-2/X_data.shape[0])))
                 n=n+1

             y_pred=[]
             for i in range(len(X_data)):
                 y=np.asscalar(np.dot(wj_plus1,X_data[i])+bj_plus1)
                 y_pred.append(y)


             plt.scatter(Y_data,y_pred)
             plt.grid(b=True, linewidth=0.3)
             plt.title('scatter plot between actual y and predicted y')
             plt.xlabel('actual y')
             plt.ylabel('predicted y')
             plt.show()



             manual_error=mean_squared_error(Y_data,y_pred)
             print('error=',manual_error)


             print('***************************************************************')
             return wj_plus1, bj_plus1, manual_error
```

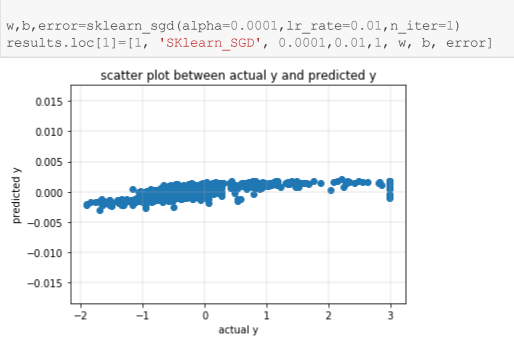
Applying sklearn SGD on boston dataset

```
In [78]: import seaborn as sns
         import numpy as np
         from sklearn.linear_model import SGDRegressor
         def sklearn_sgd(alpha,lr_rate,n_iter):
             clf=SGDRegressor(alpha=alpha,eta0 =lr_rate,max_iter=n_iter)
             clf.fit(X_data, Y_data.ravel())
             y_pred=clf.predict(X_data)

             #scatter plot
             plt.scatter(Y_data,y_pred)
             plt.title('scatter plot between actual y and predicted y')
             plt.xlabel('actual y')
             plt.ylabel('predicted y')
             plt.grid(b=True, linewidth=0.5)
             plt.show()


             #kdeplot


             sgd_error=mean_squared_error(Y_data,y_pred)
             print('mean sq error=', sgd_error)
             print('Maximum number of iteration=', n_iter)

             print('***************************************************************')
             return clf.coef_, clf.intercept_, sgd_error
```

```
In [79]: w,b,error=manual_sgd(alpha=0.0001,lr_rate=0.01,n_iter=1)
         results.loc[0]=[0, 'Manual_SGD', 0.0001, 0.01, 1, w, b, error]

         w,b,error=sklearn_sgd(alpha=0.0001,lr_rate=0.01,n_iter=1)
         results.loc[1]=[1, 'SKlearn_SGD', 0.0001,0.01,1, w, b, error]
```

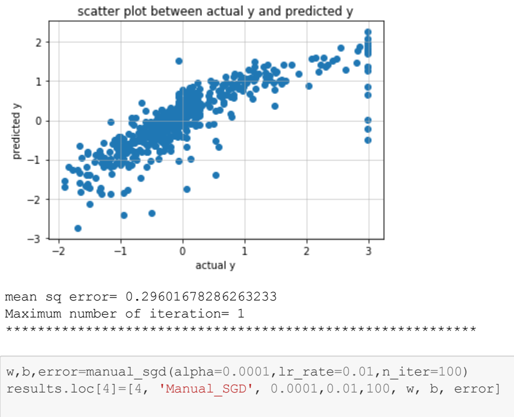



```
error= 0.9985375823741602
***************************************************************
```

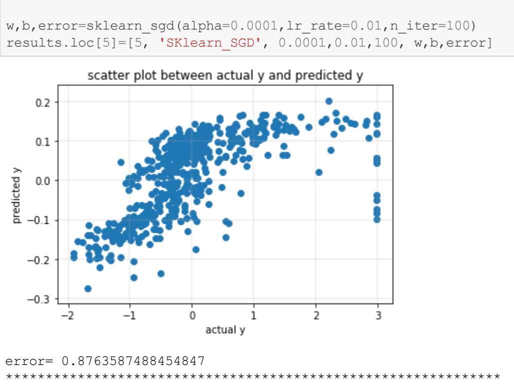



```
mean sq error= 0.29601678286263233
Maximum number of iteration= 1
***************************************************************
```

```
In [80]: w,b,error=manual_sgd(alpha=0.0001,lr_rate=0.01,n_iter=100)
         results.loc[4]=[4, 'Manual_SGD', 0.0001,0.01,100, w, b, error]

         w,b,error=sklearn_sgd(alpha=0.0001,lr_rate=0.01,n_iter=100)
         results.loc[5]=[5, 'SKlearn_SGD', 0.0001,0.01,100, w,b,error]
```

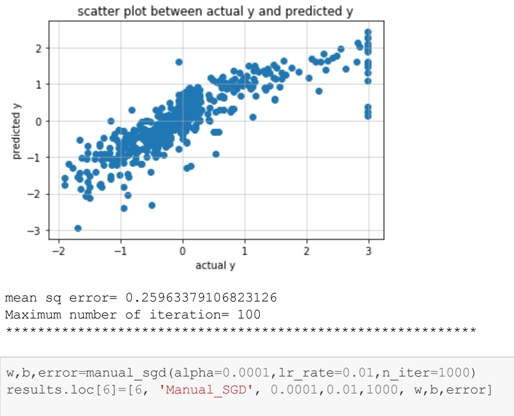



```
error= 0.8763587488454847
***************************************************************
```

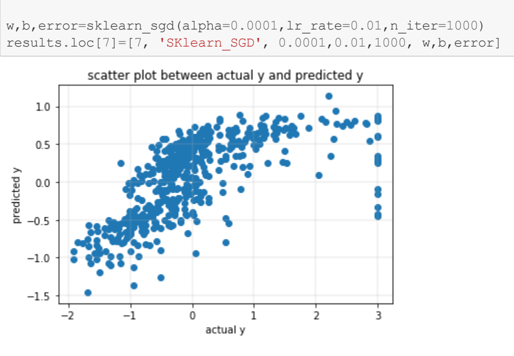



```
mean sq error= 0.25963379106823126
Maximum number of iteration= 100
***************************************************************
```

```
In [81]: w,b,error=manual_sgd(alpha=0.0001,lr_rate=0.01,n_iter=1000)
         results.loc[6]=[6, 'Manual_SGD', 0.0001,0.01,1000, w,b,error]

         w,b,error=sklearn_sgd(alpha=0.0001,lr_rate=0.01,n_iter=1000)
         results.loc[7]=[7, 'SKlearn_SGD', 0.0001,0.01,1000, w,b,error]
```

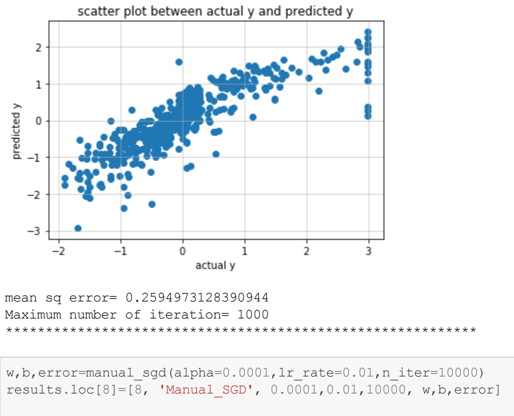



```
error= 0.5771405881414906
***************************************************************
```

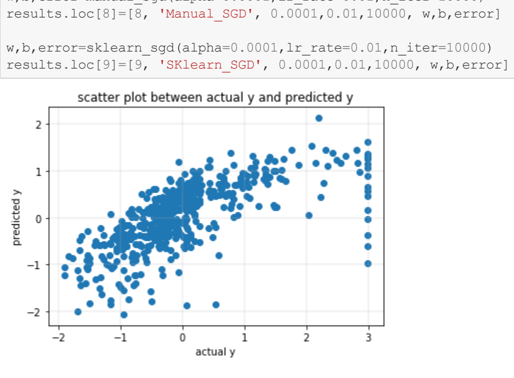



```
mean sq error= 0.2594973128390944
Maximum number of iteration= 1000
***************************************************************
```

```
In [82]: w,b,error=manual_sgd(alpha=0.0001,lr_rate=0.01,n_iter=10000)
         results.loc[8]=[8, 'Manual_SGD', 0.0001,0.01,10000, w,b,error]

         w,b,error=sklearn_sgd(alpha=0.0001,lr_rate=0.01,n_iter=10000)
         results.loc[9]=[9, 'SKlearn_SGD', 0.0001,0.01,10000, w,b,error]
```




```
error= 0.5310184235628574
***************************************************************
```




```
mean sq error= 0.25939250646535666
Maximum number of iteration= 10000
***************************************************************
```

```
In [83]: results
```

Out[83]:

	sno	algo	alpha	init_lr_rate	n_iter	weight	intercept	error
0	0	Manual_SGD	0.0001	0.01	1	[[-6.931550483673108e-05, -8.718166531702745e-...	[0.00016636189911452092]	0.998538
1	1	SKlearn_SGD	0.0001	0.01	1	[-0.07742519338874486, 0.04804328807342034, -0...	[-0.0071628270255034345]	0.296017
4	4	Manual_SGD	0.0001	0.01	100	[[-0.006206576105210674, -0.008101354188986604...	[0.014884942620773662]	0.876359
5	5	SKlearn_SGD	0.0001	0.01	100	[-0.10124733895573249, 0.11798991868751621, 0....	[0.0010130812402604113]	0.259634
6	6	Manual_SGD	0.0001	0.01	1000	[[-0.026410201684800766, -0.04695743578312188,...	[0.06299262009901374]	0.577141
7	7	SKlearn_SGD	0.0001	0.01	1000	[-0.10089931800742427, 0.11879727518006586, 0....	[-0.00011031510396503836]	0.259497
8	8	Manual_SGD	0.0001	0.01	10000	[[-0.020752725600802945, -0.07813056780485883,...	[0.05289423077898489]	0.531018
9	9	SKlearn_SGD	0.0001	0.01	10000	[-0.10014995937820508, 0.11751493827689273, 0....	[0.00017026462178552554]	0.259393

```
In [84]: from prettytable import PrettyTable

         x = PrettyTable()

         x.field_names = ["sno", "Algo", "Alpha","Init+lr_rate", "n_iter", "weight", "intercept", "error"]

         for i in range(len(results)):
             x.add_row(results.iloc[i])


         print(x)
```

```
+-----+-------------+--------+--------------+--------+-------------------------------------------------------------------
-------+---------------+---------------------+
| sno |     Algo    | Alpha  | Init+lr_rate | n_iter |                                   weight
|   intercept   |        error        |
+-----+-------------+--------+--------------+--------+-------------------------------------------------------------------
-------+---------------+---------------------+
|  0  |  Manual_SGD | 0.0001 |     0.01     |   1    |     [[-6.93155048e-05 -8.71816653e-05 -1.99710067e-04 -4.53500153e-
05     |  [0.00016636] |  0.9985375823741602 |
|     |             |        |              |        |       -1.41609251e-04  2.20859239e-04 -1.12886267e-04  1.42615907e-
04     |               |                     |
|     |             |        |              |        |       -1.36944269e-04 -1.86259196e-04  2.17079767e-05  7.37121466e-
05     |               |                     |
|     |             |        |              |        |                                   -2.74510817e-04]]
|             |                     |
|  1  | SKlearn_SGD | 0.0001 |     0.01     |   1    |  [-0.07742519  0.04804329 -0.06534176  0.09012836 -0.05484795  0.33
496082 | [-0.00716283] | 0.29601678286263233 |
|     |             |        |              |        |   -0.03285229 -0.11374552  0.01548553 -0.05875127 -0.17276461  0.08
103898 |               |                     |
|     |             |        |              |        |                                   -0.28935987]
|             |                     |
|  4  |  Manual_SGD | 0.0001 |     0.01     |  100   | [[-0.00620658 -0.00810135 -0.01813802 -0.00405761 -0.01296769  0.02
081819 |  [0.01488494] |  0.8763587488454847 |
|     |             |        |              |        |   -0.0107246   0.01282469 -0.01230666 -0.01691112  0.0027252   0.00
662907 |               |                     |
|     |             |        |              |        |                                   -0.02563311]]
|             |                     |
|  5  | SKlearn_SGD | 0.0001 |     0.01     |  100   |      [-1.01247339e-01  1.17989919e-01  8.53626423e-03  7.57492681e-
02     |  [0.00101308] | 0.25963379106823126 |
|     |             |        |              |        |       -2.25185946e-01  2.92822851e-01 -1.41916149e-04 -3.36980361e-
01     |               |                     |
|     |             |        |              |        |        2.75601861e-01 -2.13736951e-01 -2.26127978e-01  9.46991811e-
02     |               |                     |
|     |             |        |              |        |                                   -4.09340829e-01]
|             |                     |
|  6  |  Manual_SGD | 0.0001 |     0.01     |  1000  | [[-0.0264102  -0.04695744 -0.08680931 -0.0171717  -0.06728649  0.13
484726 |  [0.06299262] |  0.5771405881414906 |
|     |             |        |              |        |   -0.07008505  0.05911746 -0.0530611  -0.08145751  0.04360696  0.02
952771 |               |                     |
|     |             |        |              |        |                                   -0.14869698]]
|             |                     |
|  7  | SKlearn_SGD | 0.0001 |     0.01     |  1000  |  [-0.10089932  0.11879728  0.01398423  0.07344792 -0.22638566  0.29
054269 | [-0.00011032] |  0.2594973128390944 |
|     |             |        |              |        |    0.00099602 -0.33635659  0.28787323 -0.2268578  -0.2248696   0.09
397682 |               |                     |
|     |             |        |              |        |                                   -0.40933141]
|             |                     |
|  8  |  Manual_SGD | 0.0001 |     0.01     | 10000  | [[-0.02075273 -0.07813057 -0.06662508 -0.01441889 -0.09157262  0.40
690621 |  [0.05289423] |  0.5310184235628574 |
|     |             |        |              |        |   -0.10616348  0.14606074  0.005481   -0.08256396  0.10734655  0.03
588583 |               |                     |
|     |             |        |              |        |                                   -0.1137455 ]]
|             |                     |
|  9  | SKlearn_SGD | 0.0001 |     0.01     | 10000  |  [-0.10014996  0.11751494  0.01536462  0.07415924 -0.22420865  0.29
074026 |  [0.00017026] | 0.25939250646535666 |
|     |             |        |              |        |    0.00245992 -0.33800395  0.28898308 -0.2257533  -0.22465394  0.09
299506 |               |                     |
|     |             |        |              |        |                                   -0.40816289]
|             |                     |
+-----+-------------+--------+--------------+--------+-------------------------------------------------------------------
-------+---------------+---------------------+
```

From both above manual and sklearn SGD implementations, we can observe that as we increase the number of iterations upto 1000 the error value comes close to sklearn SGD error.But after 1000 iterations, the manual SGD error increases as the number of iterations increases.

```
In [ ]: # code source:https://medium.com/@haydar_ai/learning-data-science-day-9-linear-regression-on-boston-housing-dataset-cd62a8077
        5ef
        from sklearn.linear_model import LinearRegression
        import matplotlib.pyplot as plt

        lm = LinearRegression()
        lm.fit(X_train, Y_train)

        Y_pred = lm.predict(X_test)

        plt.scatter(Y_test, Y_pred)
        plt.xlabel("Prices: $Y_i$")
        plt.ylabel("Predicted prices: $\hat{Y}_i$")
        plt.title("Prices vs Predicted prices: $Y_i$ vs $\hat{Y}_i$")
        plt.show()
```

```
In [ ]: delta_y = Y_test - Y_pred;

        import seaborn as sns;
        import numpy as np;
        sns.set_style('whitegrid')
        sns.kdeplot(np.array(delta_y), bw=0.5)
        plt.show()
```

```
In [ ]: sns.set_style('whitegrid')
        sns.kdeplot(np.array(Y_pred), bw=0.5)
        plt.show()
```

```
In [ ]: # Make a prediction with coefficients
        def predict(row, coefficients):
            yhat = coefficients[0]
            for i in range(len(row)-1):
                yhat += coefficients[i + 1] * row[i]
            return yhat
```

```
In [ ]: # Estimate linear regression coefficients using stochastic gradient descent
        def coefficients_sgd(train, l_rate, n_epoch):
            coef = [0.0 for i in range(len(train[0]))]
            for epoch in range(n_epoch):
                for row in train:
                    yhat = predict(row, coef)
                    error = yhat - row[-1]
                    coef[0] = coef[0] - l_rate * error
                    for i in range(len(row)-1):
                        coef[i + 1] = coef[i + 1] - l_rate * error * row[i]
                    # print(l_rate, n_epoch, error)
            return coef
```

```
In [ ]: # Linear Regression Algorithm With Stochastic Gradient Descent
        def linear_regression_sgd(train, test, l_rate, n_epoch):
            predictions = list()
            coef = coefficients_sgd(train, l_rate, n_epoch)
            for row in test:
                yhat = predict(row, coef)
                predictions.append(yhat)
            return(predictions)
```