06 Implement SGD

April 11, 2019

In [318]:
```
import warnings
warnings.filterwarnings("ignore")
from sklearn.datasets import load_boston
from random import seed
from random import randrange
from csv import reader
from math import sqrt
from sklearn import preprocessing
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from prettytable import PrettyTable
from sklearn.linear_model import SGDRegressor
import sklearn
from sklearn import preprocessing
from sklearn.metrics import mean_squared_error
```

In [319]:
```
#loading boston house price datasets

from sklearn.datasets import load_boston
boston = load_boston()
```

In [320]:
```
#Looking the shapr of the data
print(boston.data.shape)
```

```
(506, 13)
```

In [321]:
```
#Printing the features
print(boston.feature_names)
```

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

In [322]:
```
#looking the describtion and Attribute Information
print(boston.DESCR)
```

```
.. _boston_dataset:

Boston house prices dataset
---------------------------

**Data Set Characteristics:**

    :Number of Instances: 506

    :Number of Attributes: 13 numeric/categorical predictive. Median Value (attribute 14) is us

    :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.
https://archive.ics.uci.edu/ml/machine-learning-databases/housing/


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

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 regress
problems.

.. topic:: References
```

```
- Belsley, Kuh & Welsch, 'Regression diagnostics: Identifying Influential Data and Sources o
- Quinlan,R. (1993). Combining Instance-Based and Model-Based Learning. In Proceedings on th
```

In [323]:
```python
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 [324]:
```python
#converting into pandas and printing the head
import pandas as pd
```

```
bos = pd.DataFrame(data=boston.data)
bos.head(5)
```

Out[324]:

	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 [325]: `bos.describe()`

Out[325]:

	0	1	2	3	4	5	\
count	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	
mean	3.613524	11.363636	11.136779	0.069170	0.554695	6.284634	
std	8.601545	23.322453	6.860353	0.253994	0.115878	0.702617	
min	0.006320	0.000000	0.460000	0.000000	0.385000	3.561000	
25%	0.082045	0.000000	5.190000	0.000000	0.449000	5.885500	
50%	0.256510	0.000000	9.690000	0.000000	0.538000	6.208500	
75%	3.677083	12.500000	18.100000	0.000000	0.624000	6.623500	
max	88.976200	100.000000	27.740000	1.000000	0.871000	8.780000	

	6	7	8	9	10	11	\
count	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	
mean	68.574901	3.795043	9.549407	408.237154	18.455534	356.674032	
std	28.148861	2.105710	8.707259	168.537116	2.164946	91.294864	
min	2.900000	1.129600	1.000000	187.000000	12.600000	0.320000	
25%	45.025000	2.100175	4.000000	279.000000	17.400000	375.377500	
50%	77.500000	3.207450	5.000000	330.000000	19.050000	391.440000	
75%	94.075000	5.188425	24.000000	666.000000	20.200000	396.225000	
max	100.000000	12.126500	24.000000	711.000000	22.000000	396.900000	

	12
count	506.000000
mean	12.653063
std	7.141062
min	1.730000
25%	6.950000
50%	11.360000
75%	16.955000
max	37.970000

In [326]: bos.shape

Out[326]: (506, 13)

In [327]: bos.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 506 entries, 0 to 505
Data columns (total 13 columns):
0     506 non-null float64
1     506 non-null float64
2     506 non-null float64
3     506 non-null float64
4     506 non-null float64
5     506 non-null float64
6     506 non-null float64
7     506 non-null float64
8     506 non-null float64
9     506 non-null float64
10    506 non-null float64
11    506 non-null float64
12    506 non-null float64
dtypes: float64(13)
memory usage: 51.5 KB
```

In [328]:
```
#spliting the data into train and test
from sklearn.model_selection import train_test_split


price=boston.target
X_train, X_test, Y_train, Y_test = sklearn.model_selection.train_test_split(bos, pric


print('Train shape', X_train.shape)
print('Test shape', X_test.shape)
print('Train shape', Y_train.shape)
print('Test shape', Y_test.shape)
```

```
Train shape (339, 13)
Test shape (167, 13)
Train shape (339,)
Test shape (167,)
```

In [329]:
```
# applying column standardization on train and test data
from sklearn.preprocessing import StandardScaler

s=StandardScaler()
```

```
X_train=s.fit_transform(np.array(X_train))
X_test=s.transform(np.array(X_test))
```

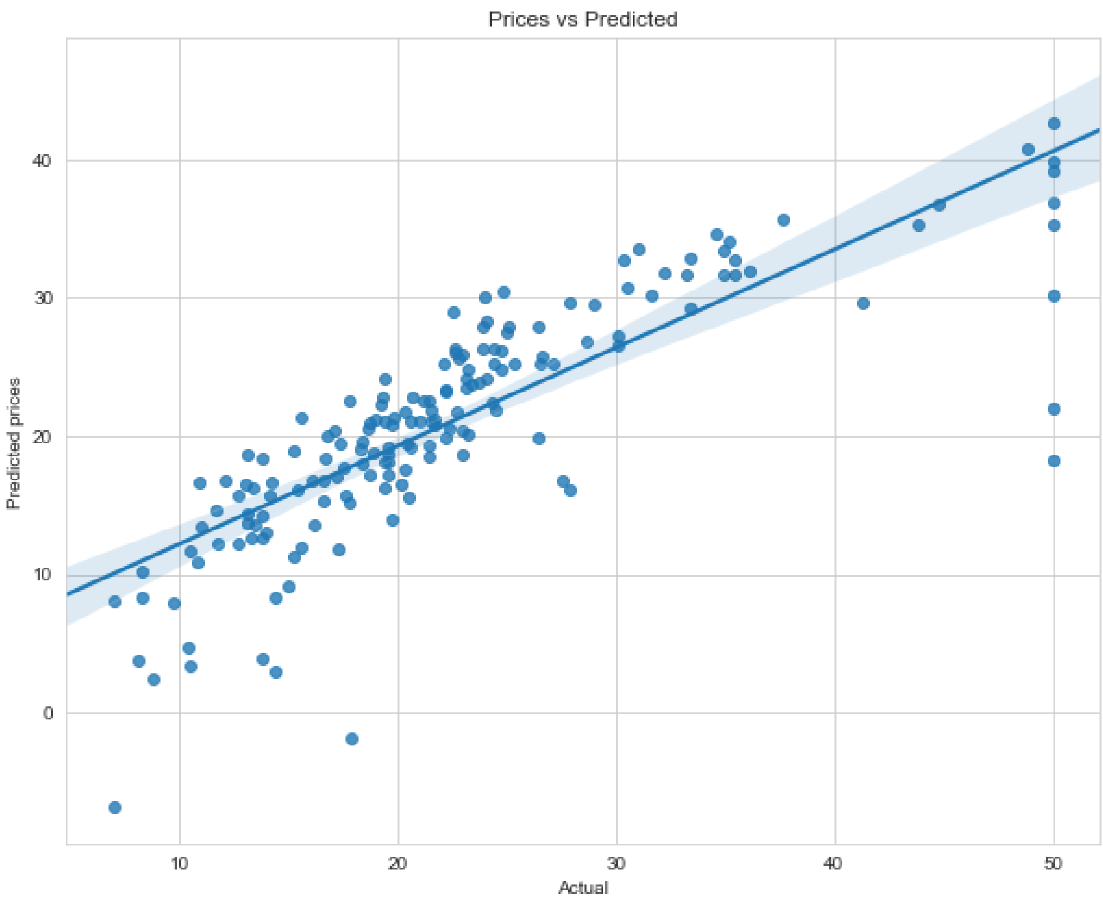
In [330]:
```
# SGD regressor manual training data
man_train=pd.DataFrame(data=X_train)
man_train['price']=Y_train
```

In [331]:
```
#converting to numpy array
X_test = np.array(X_test)
Y_test=np.array(Y_test)
```

In [332]:
```
res=pd.DataFrame(columns=['sno', 'algo', 'alpha', 'lr_rate_variation', 'init_lr_rate
```

In [333]:
```
def sklearn_sgd(alpha, lr_rate_variation, eta0=0.01, power_t=0.25, n_iter=100, X_trai
    clf=SGDRegressor(alpha=alpha, penalty=None, learning_rate=lr_rate_variation, eta0
    clf.fit(X_train, Y_train)
    y_pred=clf.predict(X_test)

    plt.figure(figsize=(10,8))
    sns.set_style('whitegrid')
    sns.regplot(Y_test,y_pred)
    plt.xlabel("Actual")
    plt.ylabel("Predicted prices")
    plt.title("Prices vs Predicted")
    plt.grid(True)
    plt.show()


    sgd_error=mean_squared_error(Y_test,y_pred)
    print('mean sqr error=', sgd_error)
    print('number of iterations =', n_iter)
    print("\n ---Slope--- \n",clf.coef_)
    print("\n---Intercept--- \n",clf.intercept_)
    return clf.coef_, clf.intercept_, sgd_error
```

In [334]:
```
# SGDRegressor, n_iter=1, lr_rate=0.01, lr_rate_variation='constant'
w_sgd, b_sgd, error_sgd=sklearn_sgd(alpha=0.0001, lr_rate_variation='constant', eta0=
```




```
mean sqr error= 32.68992458405756
number of iterations = 1

 ---Slope---
 [-1.15451538  0.62739545 -1.05270589  0.51272564 -0.00704808  3.28681963
 -0.83093975 -1.65508507  0.83708974 -0.42540257 -1.59714823  0.79687425
 -3.0168991 ]

---Intercept---
 [21.62476992]
```

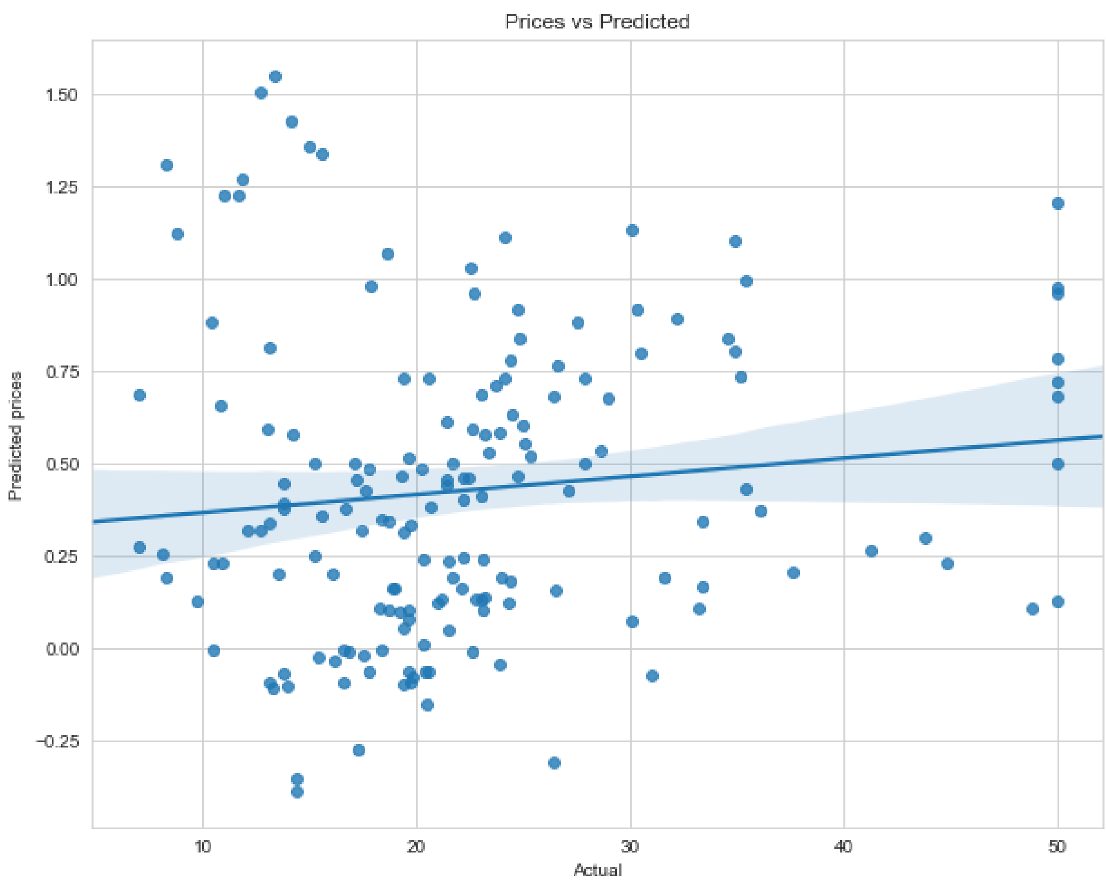
In [335]:
```
new=[1, 'SGDRegressor', 0.0001, 'constant', 0.01, 0.25, 1, error_sgd]
res.loc[0]=new
```

In [336]:
```
# Manual sgd, n_iter=1, lr_rate=0.01, lr_rate_variation='constant'

def manual_fixed(X, lr_rate_variation, alpha=0.0001, lr_rate=0.01, power_t=0.25, n_i
    w_new=np.zeros(shape=(1,13))
```

```
    b_new=0
    t=1
    r=lr_rate

    while(t<=n_iter):
        w_old=w_new
        b_old=b_new
        w_=np.zeros(shape=(1,13))
        b_=0
        x_data=X.sample(10)
        x=np.array(x_data.drop('price',axis=1))
        y=np.array(x_data['price'])


        for i in range(10):  # for getting the derivatives using sgd with k=10
            y_curr=np.dot(w_old,x[i])+b_old
            w_+=x[i] * (y[i] - y_curr)
            b_+=(y[i]-y_curr)


        w_*=(-2/x.shape[0])
        b_*=(-2/x.shape[0])

        #updating the parameters
        w_new=(w_old-r*w_)
        b_new=(b_old-r*b_)


        if(lr_rate_variation=='invscaling'):
            r = lr_rate / pow(t, power_t)
        t+=1

    return w_new, b_new


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


def plot_(X_test,y_pred):
    plt.figure(figsize=(10,8))
    sns.set_style('whitegrid')
    sns.regplot(Y_test,y_pred)
    plt.xlabel("Actual")
```

```
    plt.ylabel("Predicted prices")
    plt.title("Prices vs Predicted")
    plt.grid(True)
    plt.show()


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

    return manual_error
```

In [337]:
```
w, b=manual_fixed(X=man_train, lr_rate_variation='constant' , n_iter=1)
y_pred=pred(X_test, w=w, b=b)
manual_error=plot_(X_test,y_pred)
```




```
error= 581.1547866807905
```

In [338]:
```
new=[2, 'manual sgd', 0.0001, 'constant', 0.01, 0.25, 1, manual_error]
res.loc[1]=new
```

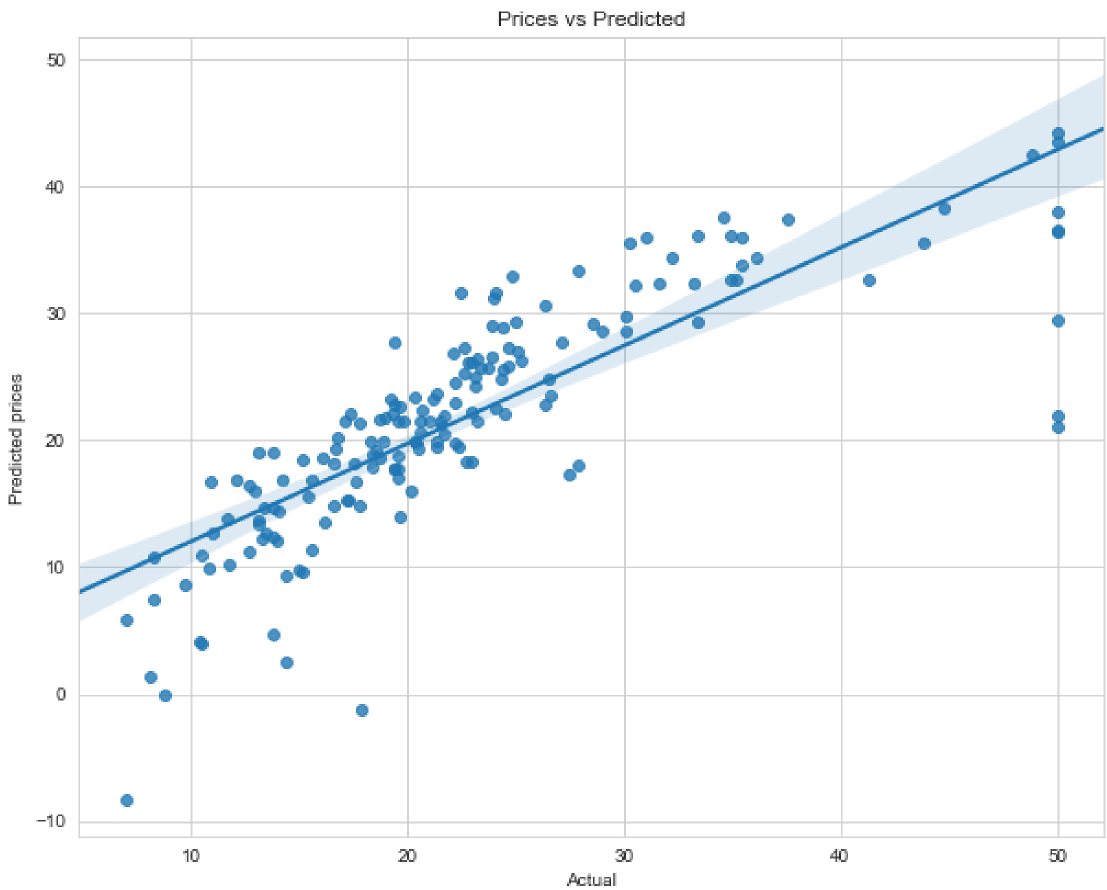
In [339]:
```
print('sgd weight---\n',w_sgd)
print('*******************************************************************************
print('sgd weight---\n',w)
```

```
sgd weight---
 [-1.15451538  0.62739545 -1.05270589  0.51272564 -0.00704808  3.28681963
 -0.83093975 -1.65508507  0.83708974 -0.42540257 -1.59714823  0.79687425
 -3.0168991 ]
*********************************************************************************
sgd weight---
 [[-0.02786544  0.09247879  0.07209797  0.09815829  0.00602633  0.03424121
  -0.13781974  0.12929866  0.09491071  0.145088   -0.00473804 -0.25241295
  -0.10620876]]
```

In [340]:
```
b_diff=[]
w_num=[]

percent=abs((w_sgd-w)/w)*100
cnt=0
for i in range(13):
    if (percent[0][i]>30):
        cnt+=1
w_num.append(cnt)
print('Number of points more than 30% =',cnt)
print('Sgd Intercept=',b_sgd)
print('Manual Intercept=',b)
b_diff.append(abs(b_sgd-b))
```

```
Number of points more than 30% = 13
Sgd Intercept= [21.62476992]
Manual Intercept= [0.4058]
```

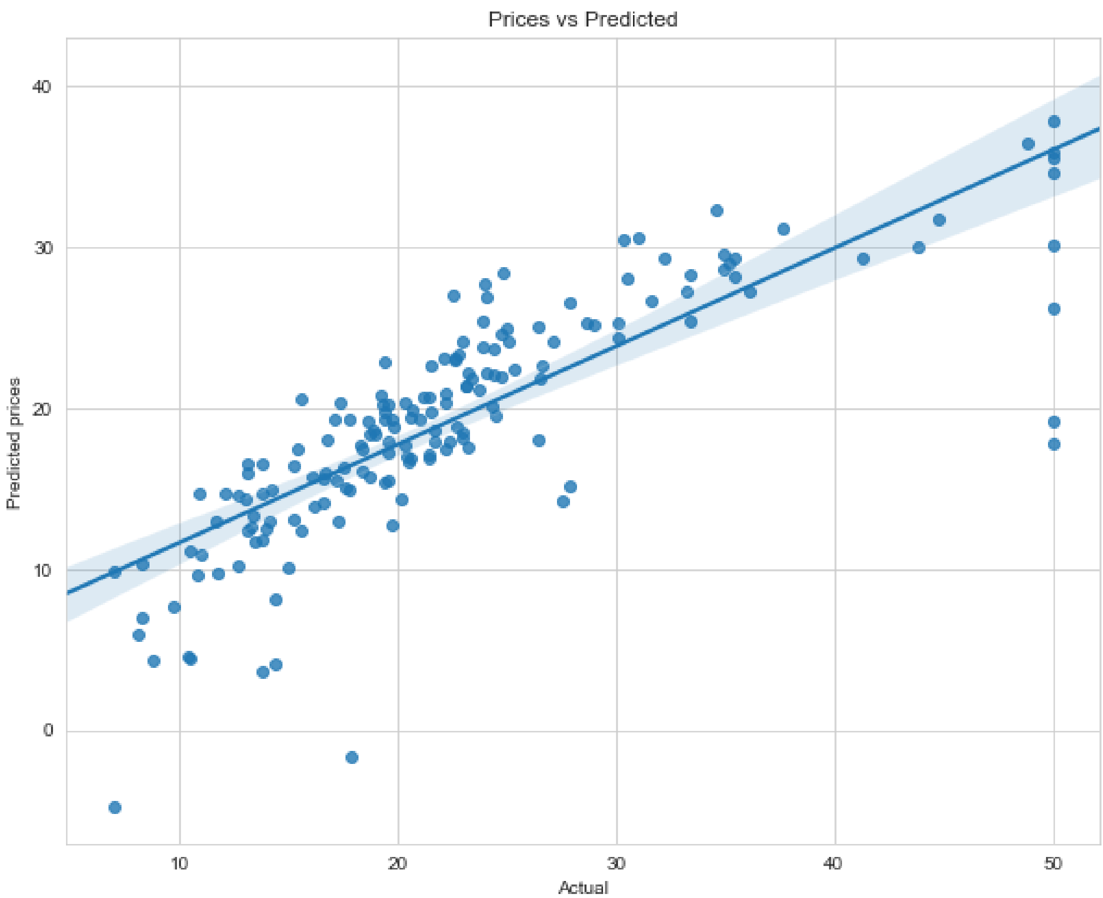
In [341]:
```
w_sgd, b_sgd, error_sgd=sklearn_sgd(alpha=0.0001, lr_rate_variation='constant', eta0=
```




```
mean sqr error= 32.555806480087476
number of iterations = 100

 ---Slope---
 [-1.42773685  1.33529848 -0.2202258  -0.16685147 -1.52507545  2.68300024
 -0.44231497 -2.69670534  2.90741932 -2.35707221 -2.45485885  1.01610677
 -3.56659361]

---Intercept---
 [22.42432868]
```

In [342]:
```
new=[3, 'SGDRegressor', 0.0001, 'constant', 0.01, 0.25, 100, error_sgd]
res.loc[2]=new
```

In [343]:
```
w, b = manual_fixed(X=man_train, lr_rate_variation='constant' , n_iter=100)
y_pred=pred(X_test, w=w, b=b)
manual_error=plot_(X_test,y_pred)
```




```
error= 42.38091998722532
```

```
In [344]: print('sgd weight---\n',w_sgd)
          print('******************************************************************************
          print('sgd weight---\n',w)
```

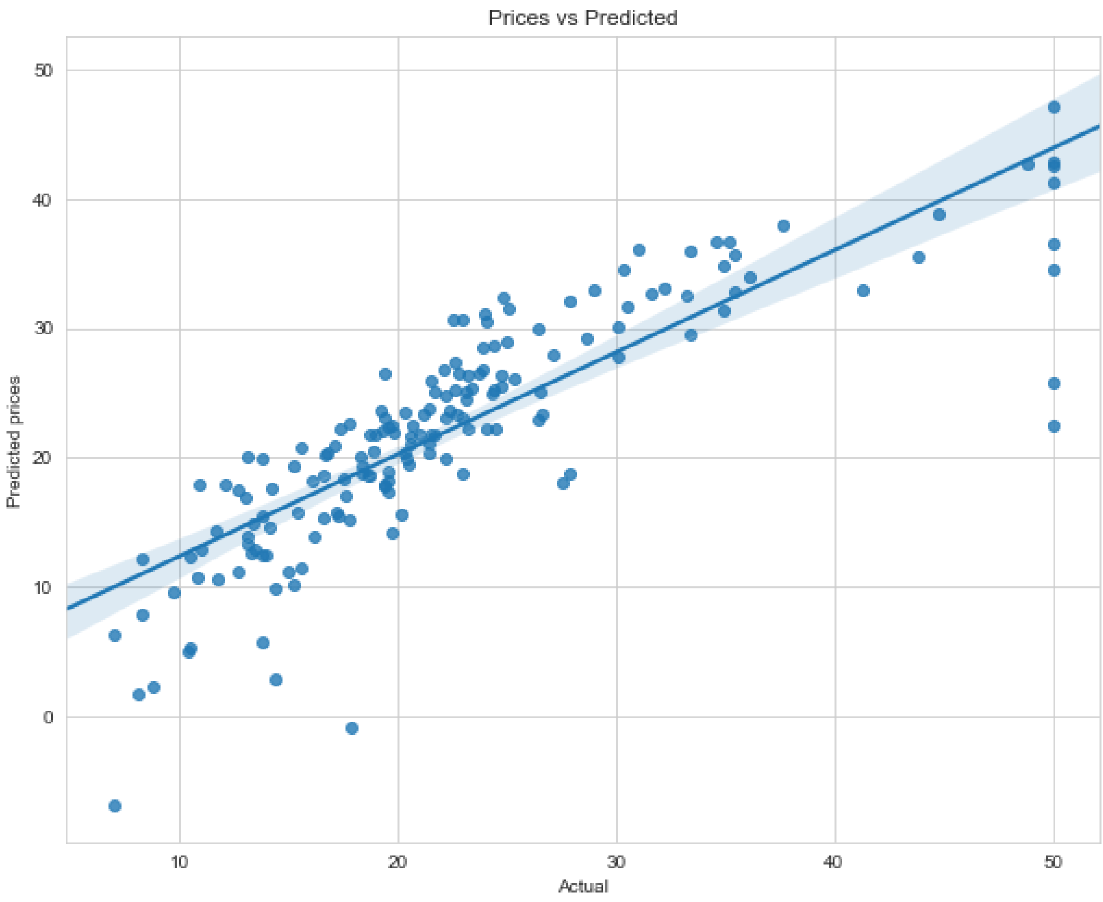
```
sgd weight---
 [-1.42773685  1.33529848 -0.2202258  -0.16685147 -1.52507545  2.68300024
 -0.44231497 -2.69670534  2.90741932 -2.35707221 -2.45485885  1.01610677
 -3.56659361]
*********************************************************************************
sgd weight---
 [[-0.6645535   0.80959274 -0.04504701  0.26514546  0.06043692  2.39162425
  -0.25013284 -1.15544769  0.0888184  -0.38187036 -1.97505101  0.87652696
  -3.09308562]]
```

```
In [345]: percent=abs((w_sgd-w)/w)*100
          cnt=0
```

```
    for i in range(13):
        if (percent[0][i]>30):
            cnt+=1
    w_num.append(cnt)
    print('number of points more than 30% in percent=',cnt)

    print('Sgd intercept=',b_sgd)
    print('Manual Intercept=',b)
    b_diff.append(abs(b_sgd-b))
```

```
number of points more than 30% in percent= 9
Sgd intercept= [22.42432868]
Manual Intercept= [19.638906]
```

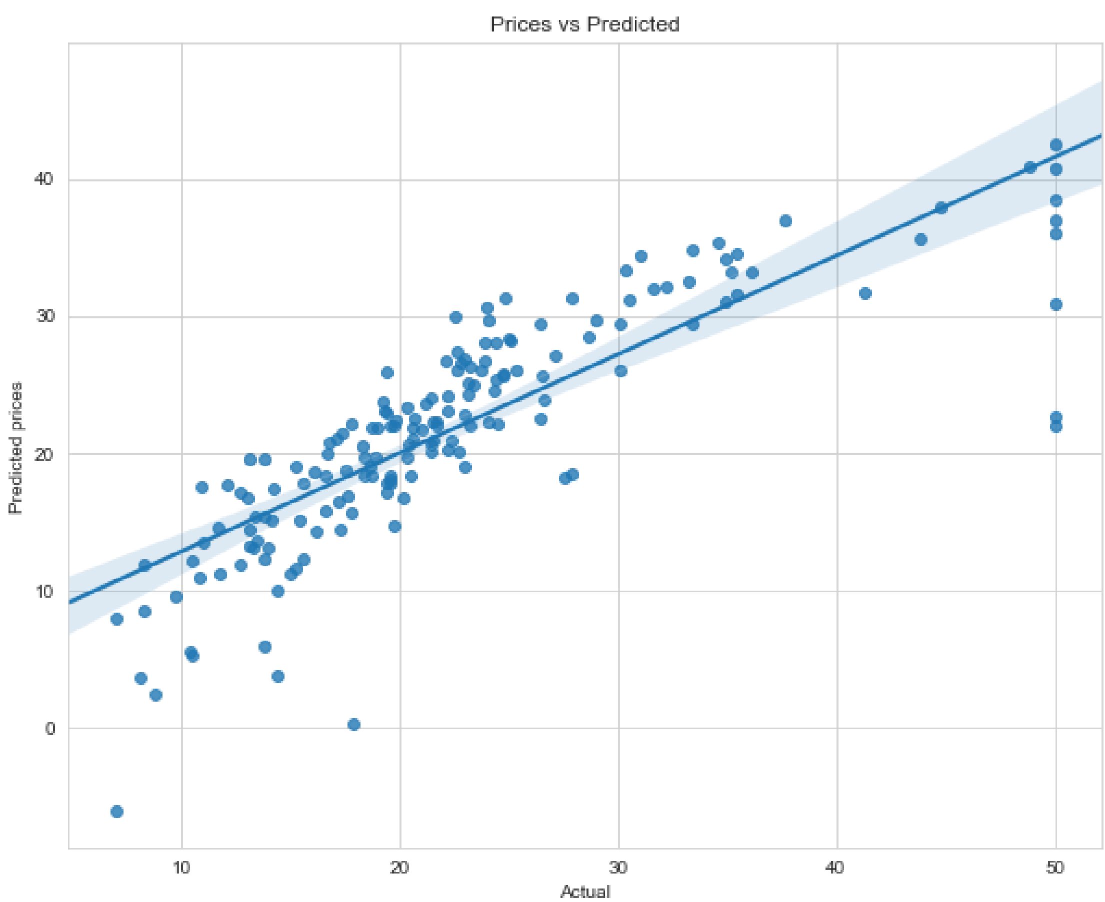
```
In [346]: new=[4, 'manual sgd', 0.0001, 'constant', 0.01, 0.25, 100, manual_error]
          res.loc[3]=new

In [347]: w_sgd, b_sgd, error_sgd=sklearn_sgd(alpha=0.0001, lr_rate_variation='constant', eta0=
```



```
mean sqr error= 27.950880163842545
number of iterations = 1000

 ---Slope---
 [-1.15487752  0.99163057 -0.21313446  0.84068331 -1.52606576  2.78784029
 -0.18089243 -2.48709914  2.97349628 -2.23978358 -2.45049694  1.20003159
 -3.512988  ]

---Intercept---
 [22.87429928]
```

In [348]:
```
new=[5, 'SGDRegressor', 0.0001, 'constant', 0.01, 0.25, 1000, error_sgd]
res.loc[4]=new
```

In [349]:
```
w, b=manual_fixed(X=man_train, lr_rate_variation='constant' , n_iter=1000)
y_pred=pred(X_test, w=w, b=b)
manual_error=plot_(X_test,y_pred)
```



```
error= 29.46133205930645
```

```
In [350]: print('sgd weight---\n',w_sgd)
          print('*************************************************************************************
          print('sgd weight---\n',w)
```

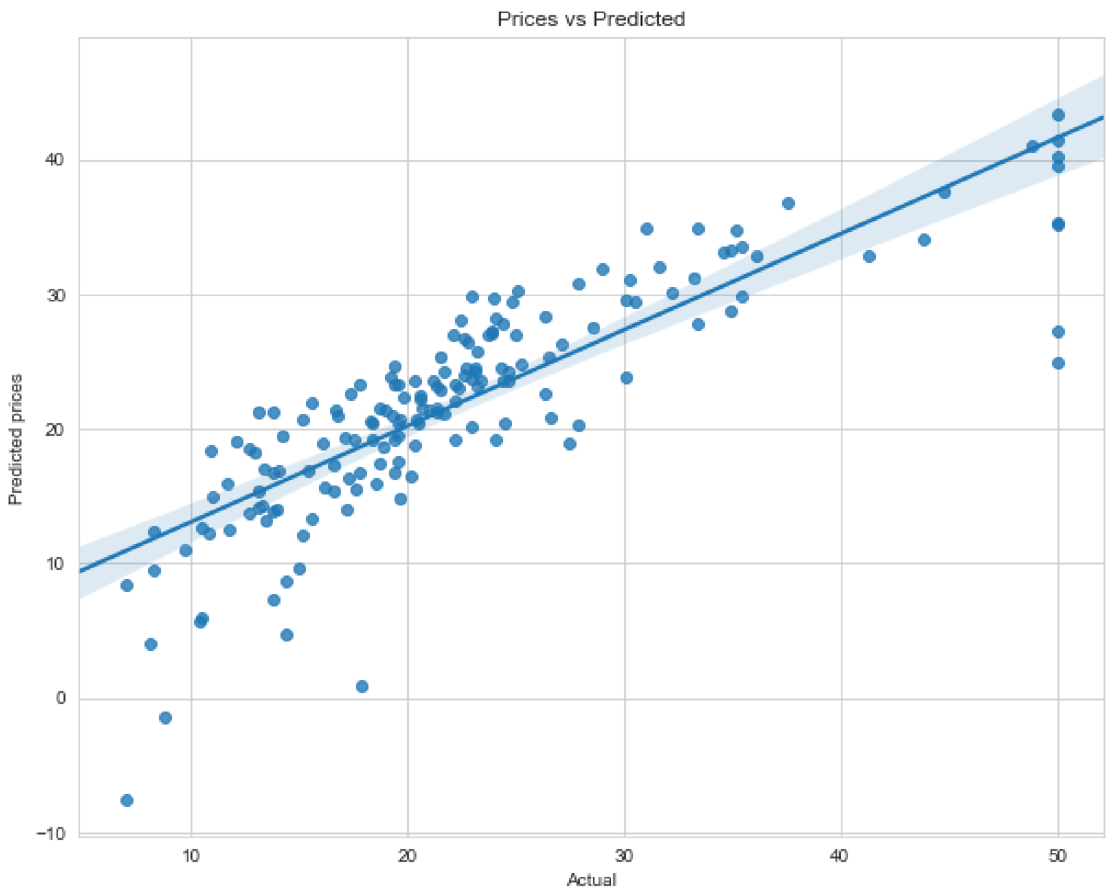
```
sgd weight---
 [-1.15487752  0.99163057 -0.21313446  0.84068331 -1.52606576  2.78784029
 -0.18089243 -2.48709914  2.97349628 -2.23978358 -2.45049694  1.20003159
 -3.512988  ]
*********************************************************************************
sgd weight---
 [[-1.21621368  0.73412432 -0.55344236  0.17098119 -1.54020225  2.6945703
  -0.40897904 -2.52355861  2.1788653  -1.40340508 -2.06784118  1.00089669
  -3.33184554]]
```

```
In [351]: percent=abs((w_sgd-w)/w)*100
          cnt=0
          for i in range(13):
              if (percent[0][i]>30):
                  cnt+=1
          w_num.append(cnt)
          print('number of points more than 30% in percent=',cnt)
          print('Sgd intercept=',b_sgd)
          print('Manual Intercept=',b)
          b_diff.append(abs(b_sgd-b))
```

```
number of points more than 30% in percent= 6
Sgd intercept= [22.87429928]
Manual Intercept= [22.48522577]
```

```
In [352]: new=[6, 'manual sgd', 0.0001, 'constant', 0.01, 0.25, 1000, manual_error]
          res.loc[5]=new
```

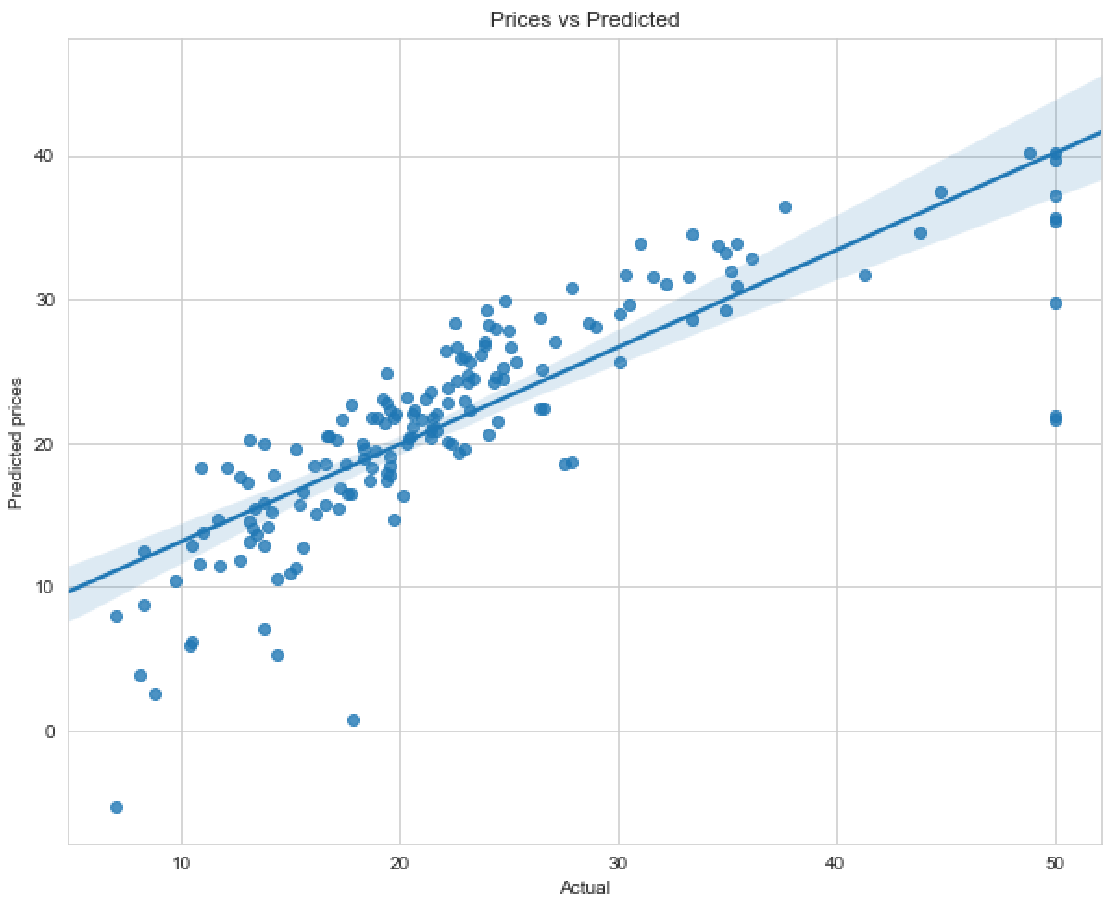
```
In [353]: w_sgd, b_sgd, error_sgd=sklearn_sgd(alpha=0.0001, lr_rate_variation='constant', eta0=
```




```
mean sqr error= 27.774536940739637
number of iterations = 10000

 ---Slope---
 [-1.93182433  0.97979841 -0.02380664  0.74163114 -1.18420346  2.44846007
 -0.19126889 -3.12289334  3.19893846 -2.13116739 -2.04915382  0.9676209
 -3.59916334]

---Intercept---
 [22.61401268]
```

In [354]:
```
new=[7, 'SGDRegressor', 0.0001, 'constant', 0.01, 0.25, 10000, error_sgd]
res.loc[6]=new
```

In [355]:
```
w, b=manual_fixed(X=man_train, lr_rate_variation='constant' , n_iter=10000)
y_pred=pred(X_test, w=w, b=b)
manual_error=plot_(X_test,y_pred)
```




```
error= 30.108587396756242
```

```
In [356]: print('sgd weight---\n',w_sgd)
          print('*******************************************************************************
          print('Manual sgd weight---\n',w)
```

```
sgd weight---
 [-1.93182433  0.97979841 -0.02380664  0.74163114 -1.18420346  2.44846007
 -0.19126889 -3.12289334  3.19893846 -2.13116739 -2.04915382  0.9676209
 -3.59916334]
*********************************************************************************
Manual sgd weight---
 [[-1.20983179  0.77161114  0.04899571 -0.11532283 -1.48136329  2.72921695
  -0.36759896 -2.53894548  2.74128198 -2.26884669 -1.93344156  1.13244462
  -3.06953316]]
```

```
In [357]: percent=abs((w_sgd-w)/w)*100
          cnt=0
```

```
    for i in range(13):
        if (percent[0][i]>30):
            cnt+=1
    w_num.append(cnt)
    print('Number of points more than 30%',cnt)
    print('Sgd intercept=',b_sgd)
    print('Manual Intercept=',b)
    b_diff.append(abs(b_sgd-b))
```

```
Number of points more than 30% 4
Sgd intercept= [22.61401268]
Manual Intercept= [22.29312088]
```

In [358]:
```
res
```

Out[358]:

	sno	algo	alpha	lr_rate_variation	init_lr_rate	power_t	n_iter	\
0	1	SGDRegressor	0.0001	constant	0.01	0.25	1	
1	2	manual sgd	0.0001	constant	0.01	0.25	1	
2	3	SGDRegressor	0.0001	constant	0.01	0.25	100	
3	4	manual sgd	0.0001	constant	0.01	0.25	100	
4	5	SGDRegressor	0.0001	constant	0.01	0.25	1000	
5	6	manual sgd	0.0001	constant	0.01	0.25	1000	
6	7	SGDRegressor	0.0001	constant	0.01	0.25	10000	

	error
0	32.689925
1	581.154787
2	32.555806
3	42.380920
4	27.950880
5	29.461332
6	27.774537

Observe: Elegent and fast and Increasing iterations reduces errors for manual sgd.