Part a:

```
# Dr Jianhua Chen
# Programming assignment part a
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# CSC 7333


#Importing packages which are needed for programming
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

# Part a (Reading the dataset KCSmall2.csv)
mydataset= pd.read_csv('KCSmall2.csv',header=None)
x = mydataset.iloc[:,0]
y = mydataset.iloc[:,1]


# General code: Part a (Performing  gradient descent to learn parameter vector (theta0 = 
b ,theta1 = a)
# First we initialize values for a and be to be 0. We specify values for number of 
iterations and learning rate and m which is the number of
# training examples equals to length of x. After that, by using for loop we calculate our 
predicted value for y, loss (error) function and our
# derivatives. Then, by using update rule, we update the values for our parameters. This 
for loop continues until we complete our number of iterations
def gradient_descent(x,y):
    b_curr = a_curr = 0
    iterations = 1000
    m = len(x)
    learning_rate = 0.1

    for i in range(iterations):
        y_predicted = a_curr * x + b_curr
        loss = (1/(2*m)) * sum([val**2 for val in (y-y_predicted)])
        ad = -(1/m)*sum(x*(y-y_predicted))
        bd = -(1/m)*sum(y-y_predicted)
        a_curr = a_curr - learning_rate * ad
        b_curr = b_curr - learning_rate * bd
        print ("a {},b {}, loss {}, iteration {}".format(a_curr,b_curr,loss,i))

gradient_descent(x,y)
```
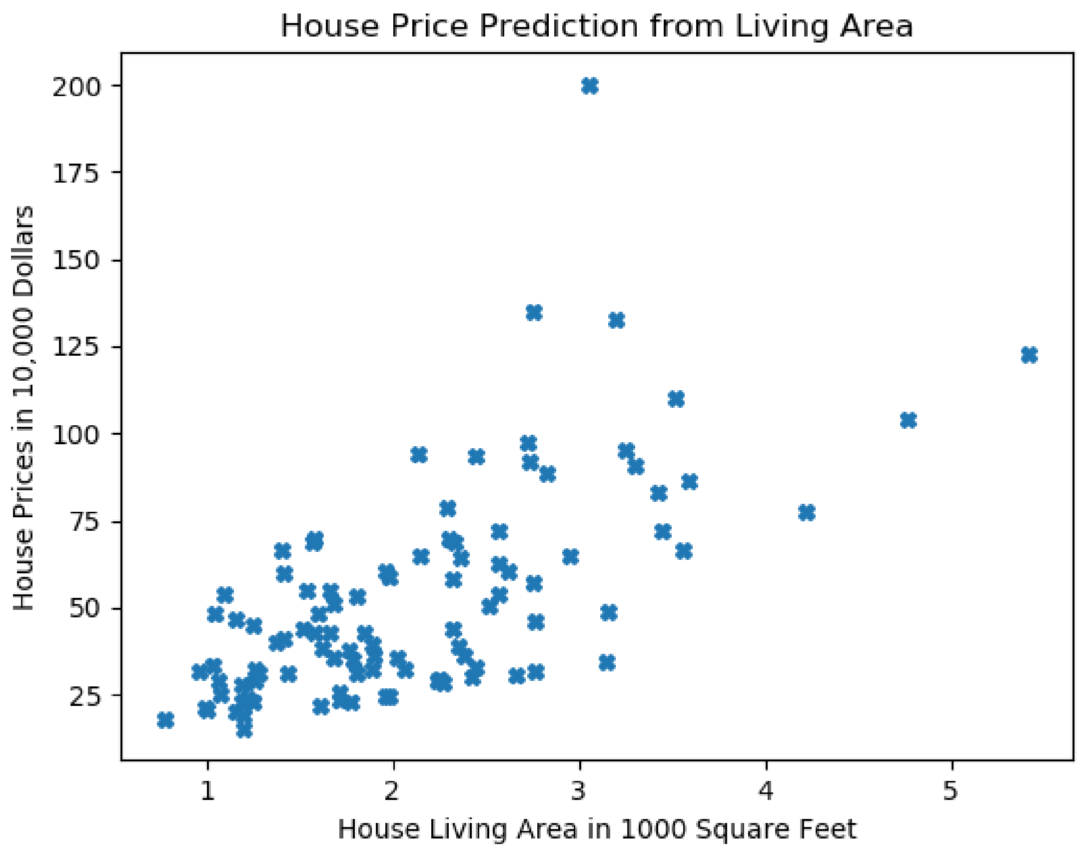
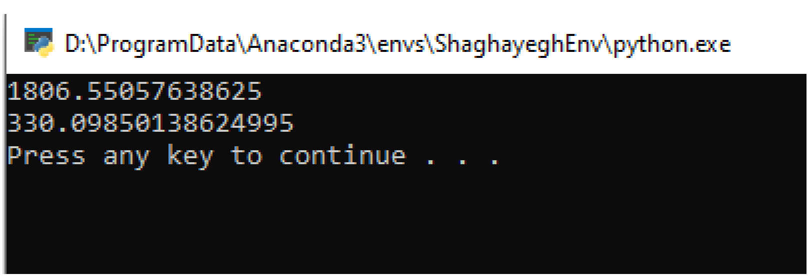

```
a 22.91023628891083,b 4.1518290089287887, loss 266.96938950893605, iteration 971
a 22.910236447544193,b 4.151828710342463, loss 266.96938950893446, iteration 972
a 22.910236604245693,b 4.1518283360119055, loss 266.96938950893275, iteration 973
a 22.910236759038852,b 4.1518279662400115, loss 266.969389508931, iteration 974
a 22.910236911946914,b 4.151827600971266, loss 266.9693895089294, iteration 975
a 22.910237062992834,b 4.151827240150827, loss 266.96938950892803, iteration 976
a 22.9102372121219929,b 4.1518268837245245, loss 266.9693895089263, iteration 977
a 22.910237359588685,b 4.151826531638845, loss 266.9693895089249, iteration 978
a 22.910237505183144,b 4.151826183840926, loss 266.9693895089234, iteration 979
a 22.910237649004525,b 4.151825840278553, loss 266.969389508922, iteration 980
a 22.910237791074426,b 4.151825500900144, loss 266.9693895089207, iteration 981
a 22.910237931414176,b 4.1518251656547465, loss 266.9693895089193, iteration 982
a 22.910238070044844,b 4.151824834492026, loss 266.9693895089179, iteration 983
a 22.91023820698724,b 4.151824507362264, loss 266.9693895089167, iteration 984
a 22.91023834226193,b 4.151824184216347, loss 266.9693895089155, iteration 985
a 22.91023847588922,b 4.151823865005757, loss 266.9693895089143, iteration 986
a 22.91023860788917,b 4.151823549682572, loss 266.969389508913, iteration 987
a 22.910238738281603,b 4.151823238199448, loss 266.969389508912, iteration 988
a 22.910238867086093,b 4.1518229305096215, loss 266.96938950891064, iteration 989
a 22.91023899432198,b 4.151822626566896, loss 266.9693895089097, iteration 990
a 22.910239120008367,b 4.15182232632564, loss 266.96938950890853, iteration 991
a 22.91023924416412,b 4.151822029740775, loss 266.9693895089075, iteration 992
a 22.910239366807883,b 4.151821736767774, loss 266.96938950890654, iteration 993
a 22.91023948795807,b 4.1518214473626 5, loss 266.96938950890546, iteration 994
a 22.910239607632867,b 4.151821161481953, loss 266.96938950890456, iteration 995
a 22.910239725850243,b 4.151820879082762, loss 266.9693895089036, iteration 996
a 22.91023984262795,b 4.151820600122679, loss 266.96938950890274, iteration 997
a 22.910239957983514,b 4.1518203245598215, loss 266.9693895089017, iteration 998
a 22.910240071934258,b 4.151820052352817, loss 266.969389508901, iteration 999
Press any key to continue . . .
```

```
# Desired output of the program
# (1) Plot the data

plt.plot(x,y,'X')
plt.title('House Price Prediction from Living Area')
plt.xlabel('House Living Area in 1000 Square Feet')
plt.ylabel('House Prices in 10,000 Dollars')
plt.show()
```




```python
# (2) Print the loss function for (0,0) and (-1,20)

m = len(x)
y_predicted2 = (0) * x + 0
loss2 = (1/(2*m)) * sum([val**2 for val in (y-y_predicted2)])
print(loss2)

y_predicted3 = (20) * x -1
loss3 = (1/(2*m)) * sum([val**2 for val in (y-y_predicted3)])
print(loss3)
```

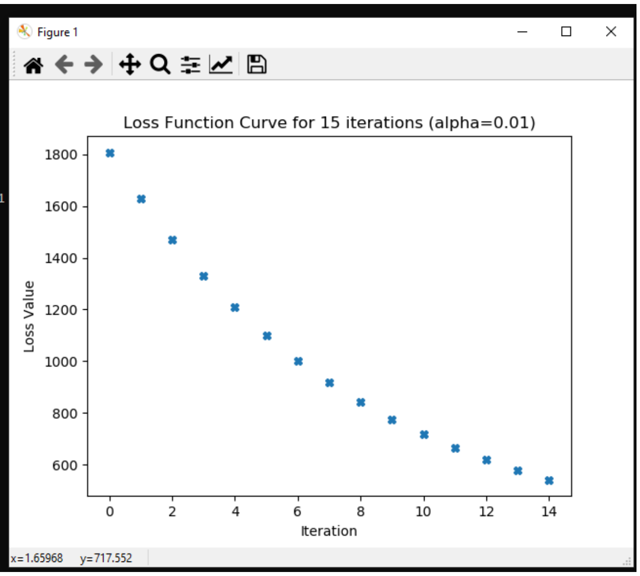

D:\ProgramData\Anaconda3\envs\ShaghayeghEnv\python.exe

```
1806.55057638625
330.09850138624995
Press any key to continue . . .
```

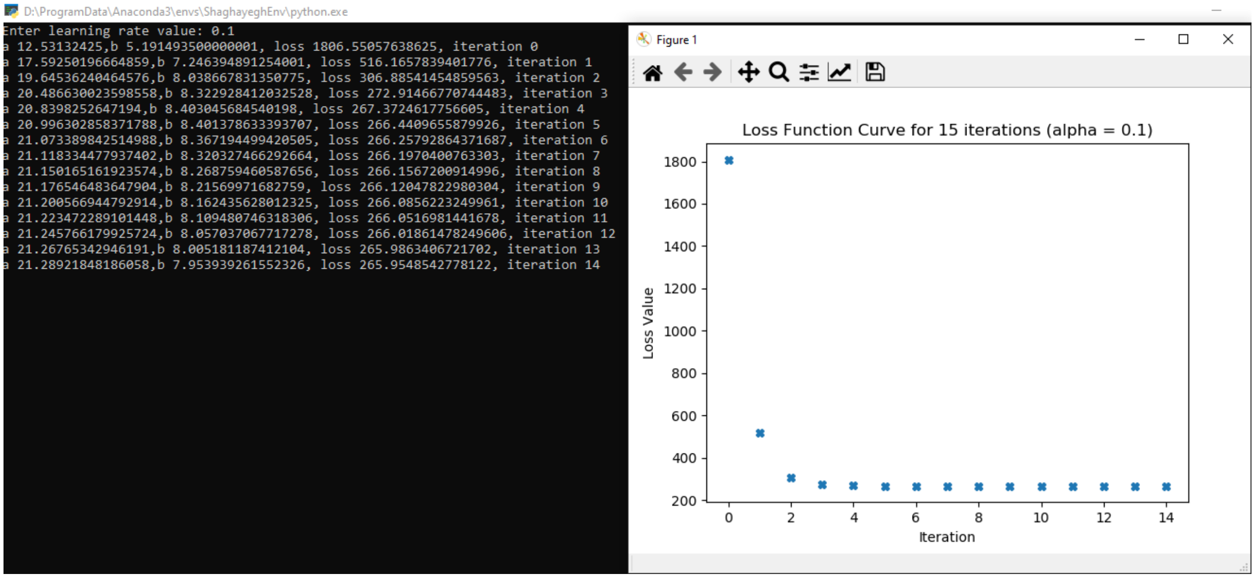
```
# (3) Plot the loss function for n=15 iterations (alpha= 0.01,0.1,0.2,0.4) and print out
parameters (I will get learning rate by using input)

def gradient_descent(x,y):
    b_curr = a_curr = 0
    iterations = 15
    m = len(x)
    learning_rate = float(input('Enter learning rate value: '))
    loss_list = []


    for i in range(iterations):
        y_predicted = a_curr * x + b_curr
        loss = (1/(2*m)) * sum([val**2 for val in (y-y_predicted)])
        loss_list.append(loss)
        ad = -(1/m)*sum(x*(y-y_predicted))
        bd = -(1/m)*sum(y-y_predicted)
        a_curr = a_curr - learning_rate * ad
        b_curr = b_curr - learning_rate * bd
        print ("a {},b {}, loss {}, iteration {}".format(a_curr,b_curr,loss,i))


    plt.plot(list(range(iterations)),loss_list,'X')
    plt.title('Loss Function Curve for 15 iterations (alpha = '+ str(learning_rate) +
')')
    plt.xlabel('Iteration')
    plt.ylabel('Loss Value')
    plt.show()

gradient_descent(x,y)
```

Learning rate = 0.01

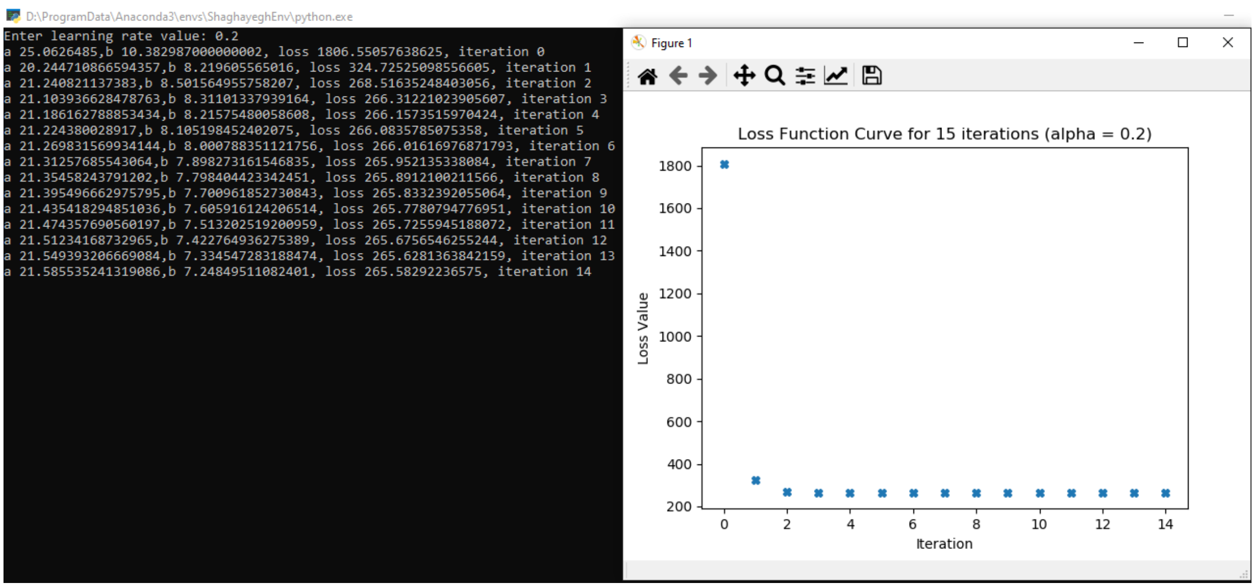
```
Enter learning rate value: 0.01
a 1.253132425,b 0.5191493500000001, loss 1806.55057638625, iteration 0
a 2.431563384666486,b 1.0069327789125402, loss 1628.0596054645266, iteration 1
a 3.539754708254158,b 1.465224250395209, loss 1470.254297935885, iteration 2
a 4.581901714538207,b 1.8957857933490108, loss 1330.737296142899, iteration 3
a 5.56194913082208,b 2.3002741879236184, loss 1207.3890834854396, iteration 4
a 6.483606061082782,b 2.680247252159075, loss 1098.3357841131117, iteration 5
a 7.35036006004992,b 3.037169753118436, loss 1001.9206944628415, iteration 6
a 8.165490366622205,b 3.372418964940977, loss 916.6791141405511, iteration 7
a 8.932080346835251,b 3.687289894905856, loss 841.316093770395, iteration 8
a 9.65302919359517,b 3.98300019733638, loss 774.6867617504561, iteration 9
a 10.331062927572276,b 4.260694793990555, loss 715.7789310333031, iteration 10
a 10.968744740997497,b 4.5214502184698615, loss 663.6977216886017, iteration 11
a 11.56848472361074,b 4.766278701131, loss 617.6519656293012, iteration 12
a 12.13254900766607,b 4.996132010000688, loss 576.9421869580813, iteration 13
a 12.663068366694143,b 5.211905062267758, loss 540.9499753280136, iteration 14
```



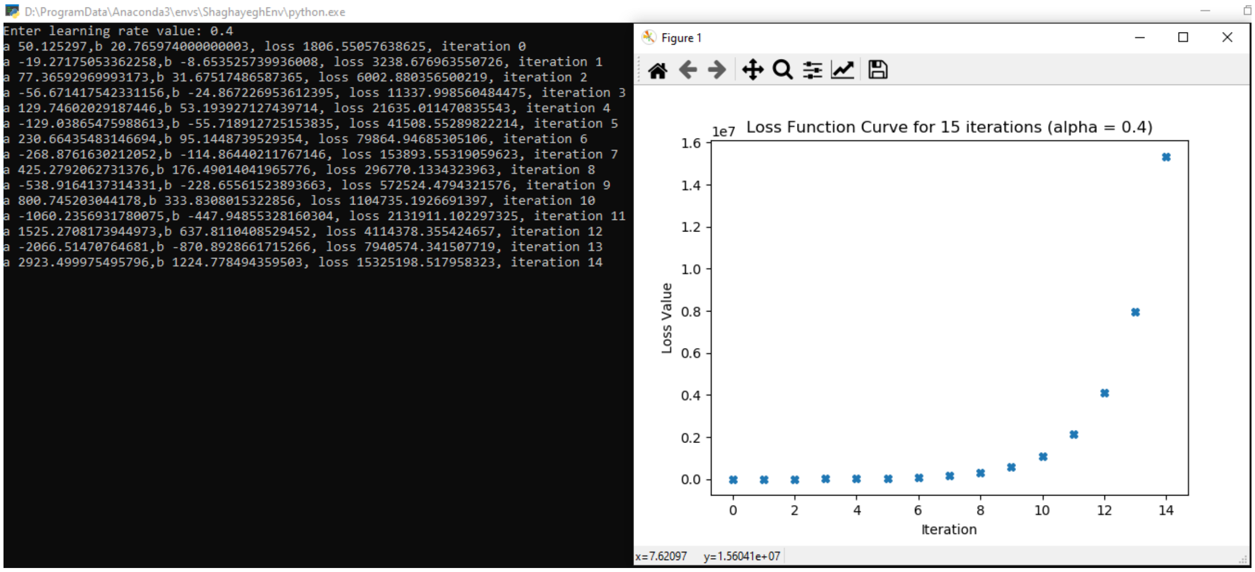
Learning rate = 0.1



Learning rate = 0.2



Learning rate = 0.4



Loss function with learning_rate=0.2 reaches its least value after 15 iterations which is 265.5829.

Final parameters value:

$a = 21.586$

$b = 7.248$

$y = 7.248 + 21.586\,x$

```
# (4) Predict y_predicted for x=3.5 and x=7
print('(4) Predict y_predicted for x=3.5 and x=7')
New_x=[3.5,7]
for l in New_x:
    price=a_curr*l+b_curr
    print("Living area: {}, Price: {}".format(l,price))
```

```
(4) Predict y_predicted for x=3.5 and x=7
Living area: 3.5, Price: 82.7978684554408
Living area: 7, Price: 158.3472418000576
```

Part b:

```
# Dr Jianhua Chen
# Programming assignment part b
# Student name: Seyedeh Shaghayegh Rabbanian 899645944 (srabba2@lsu.edu)
# CSC 7333

# Importing packages
import numpy as np
import pandas as pd
from sklearn import preprocessing
import matplotlib.pyplot as plt



# Loading dataset
mydataset= pd.read_csv('KCSmall_NS2.csv',header=None)
# (1) Print out the first 5 rows of the raw input data
print(mydataset[0:5])
```

```
D:\ProgramData\Anaconda3\envs\ShaghayeghEnv\python.exe
   0     1      2         3
0  3  1180   5650  221900.0
1  3  2570   7242  538000.0
2  2   770  10000  180000.0
3  4  1960   5000  604000.0
4  3  1680   8080  510000.0
Press any key to continue . . .
```

```
x = mydataset.iloc[:,0:3]
y = mydataset.iloc[:,3]

# (2) Standardizing input data
x_scaled = preprocessing.scale(x)
print(x_scaled)
```

```
D:\ProgramData\Anaconda3\envs\ShaghayeghEnv\python.exe
[[-0.50800051 -1.06131799 -0.41304797]
 [-0.50800051  0.56209957 -0.30493907]
 [-1.77800178 -1.54016778 -0.11764991]
 [ 0.76200076 -0.15033547 -0.45718791]
 [-0.50800051 -0.47735484 -0.2480325 ]]
Press any key to continue . . .
```

```
# Defining a dummy column ( Column of all 1)
dummy_column = np.ones((100,1),dtype='int32')


# Adding the dummy column to the scaled matrix
```

```
Final_x = np.append(dummy_column,x_scaled,axis = 1)
print(Final_x[0:5])
```

```
D:\ProgramData\Anaconda3\envs\ShaghayeghEnv\python.exe
[[ 1.         -0.50800051 -1.06131799 -0.41304797]
 [ 1.         -0.50800051  0.56209957 -0.30493907]
 [ 1.         -1.77800178 -1.54016778 -0.11764991]
 [ 1.          0.76200076 -0.15033547 -0.45718791]
 [ 1.         -0.50800051 -0.47735484 -0.2480325 ]]
Press any key to continue . . .
```

```
# (3) Print out the cost J value for theta = (0,0,0,0)
n= Final_x.shape[1]
theta = np.zeros(n)
print(theta)

def cost_function(Final_x,y):
    m=len(y)
    loss=np.sum((Final_x.dot(theta)-y)**2)/(2*m)
    print(loss)

cost_function(Final_x,y)
```

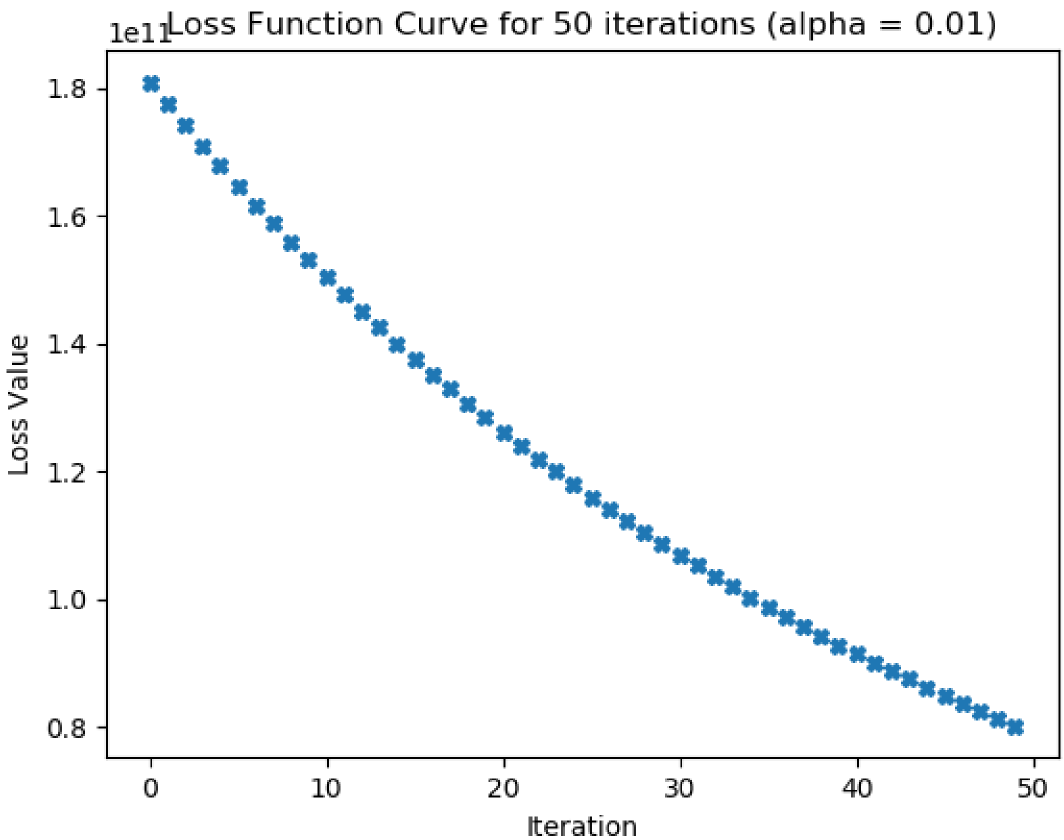
```
D:\ProgramData\Anaconda3\envs\ShaghayeghEnv\python.exe
[0. 0. 0. 0.]
180784127566.625
Press any key to continue . . .
```

```
# (4) Run gradient descent for n=50 iterations with alpha=(0.01,0.1,0.5,1,1.5)
def gradient_descent(x,y):
    theta = np.zeros(n)
    iterations = 50
    m = len(y)
    learning_rate = float(input('Enter learning rate value: '))
    loss_list = []

    for i in range(iterations):
        y_predicted = Final_x.dot(theta)
        loss=np.sum((Final_x.dot(theta)-y)**2)/(2*m)
        loss_list.append(loss)
        thetad = (1/m)*((Final_x.T).dot(y_predicted-y))
        theta = theta - learning_rate * thetad
        print ("Theta{}, loss {}, iteration {}".format(theta,loss,i))

    plt.plot(list(range(iterations)),loss_list,'X')
    plt.title('Loss Function Curve for 50 iterations (alpha = '+ str(learning_rate) +
')')
    plt.xlabel('Iteration')
    plt.ylabel('Loss Value')
    plt.show()


gradient_descent(x,y)
```

`Learning rate=0.01`

D:\ProgramData\Anaconda3\envs\ShaghayeghEnv\python.exe

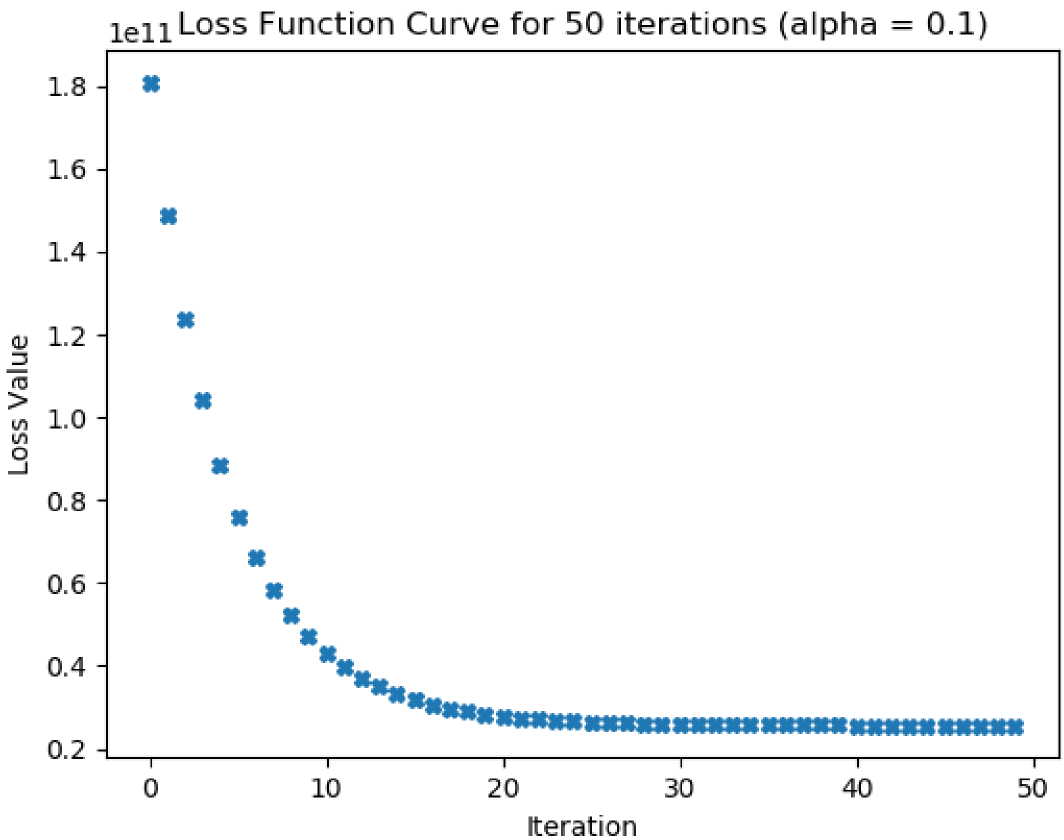
```
Enter learning rate value: 0.01
Theta[5192.5055     1073.12033912 1973.77957182 1373.80535386], loss 180784127566.625, iteration 0
Theta[10333.085945    2122.81643664  3914.97203449  2722.77696037], loss 177414102542.26462, iteration 1
Theta[15422.26058555  3149.53465386  5824.15809193  4047.35312675], loss 174121735104.8238, iteration 2
Theta[20460.54347969  4153.71311354  7701.90795878  5347.96435751], loss 170905095874.82803, iteration 3
Theta[25448.4435449   5135.78185033  9548.78155026  6625.03349446], loss 167762307675.50458, iteration 4
Theta[30386.46460945  6096.16295843 11365.32866863  7878.97585413], loss 164691543998.1634, iteration 5
Theta[35275.10546335  7035.27073667 13152.08918624  9110.19936286], loss 161691027515.91367, iteration 6
Theta[40114.85990872  7953.51183085 14909.59322531 10319.1046893 ], loss 158759028644.11346, iteration 7
Theta[44906.21680963  8851.28537354 16638.36133442 11506.08537465], loss 155893864146.00772, iteration 8
Theta[49649.66014154  9728.98312133 18338.9046618  12671.52796043], loss 153093895782.0622, iteration 9
Theta[54345.66904012 10586.98958959 20011.72512553 13815.81211408], loss 150357529001.5497, iteration 10
Theta[58994.71784972 11425.68218475 21657.31558058 14939.31075219], loss 147683211674.99808, iteration 11
Theta[63597.27617122 12245.43133426 23276.15998291 16042.39016155], loss 145069432866.15295, iteration 12
Theta[68153.80890951 13046.60061404 24868.73355053 17125.41011802], loss 142514721642.15747, iteration 13
Theta[72664.77632042 13829.54687376 26435.5029217  18188.72400327], loss 140017645920.6925, iteration 14
Theta[77130.63405721 14594.62035976 27976.92631019 19232.67891938], loss 137576811352.86667, iteration 15
Theta[81551.83321664 15342.16483576 29493.45365783 20257.61580143], loss 135190860240.6834, iteration 16
Theta[85928.82038447 16072.51770135 30985.5267842  21263.86952799], loss 132858470487.95529, iteration 17
Theta[90262.03768063 16786.01010836 32453.57953367 22251.76902968], loss 130578354583.57204, iteration 18
Theta[94551.92280382 17482.9670751  33898.03791976 23221.63739577], loss 128349258616.0661, iteration 19
Theta[98798.90907578 18163.70759849 35319.32026689 24173.7919788 ], loss 126169961318.45682, iteration 20
Theta[103003.42548503  18828.54476421  36717.83734953  25108.5444974 ], loss 124039273142.38727, iteration 21
Theta[107165.89673018  19477.78585481  38093.99252889  26026.2011372 ], loss 121956035360.60092, iteration 22
Theta[111286.74326287  20111.73245584  39448.1818871   26927.06264995], loss 119919119196.83984, iteration 23
Theta[115366.38133025  20730.68056009  40780.79435896  27811.42445081], loss 117927424982.27454, iteration 24
Theta[119405.22301694  21334.9206699   42092.21186128  28679.57671398], loss 115979881337.60646, iteration 25
Theta[123403.67628677  21924.73789759  43382.80941994  29531.80446651], loss 114075444380.01465, iteration 26
Theta[127362.14502391  22500.41206415  44652.95529462  30368.38768046], loss 112213096954.14278, iteration 27
Theta[131281.02907367  23062.21779605  45903.01110124  31189.60136343], loss 110391847886.35374, iteration 28
Theta[135160.72428293  23610.42462028  47133.33193221  31995.71564741], loss 108610731261.50104, iteration 29
Theta[139001.6225401   24145.29705774  48344.26647454  32786.99587607], loss 106868805721.49493, iteration 30
Theta[142804.1118147   24667.09471489  49536.15712571  33563.70269043], loss 105165153784.96283, iteration 31
Theta[146568.57619655  25176.07237368  50709.34010756  34326.09211305], loss 103498881187.32861, iteration 32
Theta[150295.39593459  25672.48007991  51864.14557804  35074.41563069], loss 101869116240.65767, iteration 33
Theta[153984.94747524  26156.56323     53000.89774096  35808.9202754 ], loss 100275009212.63545, iteration 34
Theta[157637.60350049  26628.56265609  54119.91495375  36529.84870428], loss 98715731724.07047, iteration 35
Theta[161253.73296548  27088.71470966  55221.50983327  37237.43927771], loss 97190476164.33084, iteration 36
Theta[164833.70113583  27537.25134364  56305.98935972  37931.92613623], loss 95698455124.14438, iteration 37
Theta[168377.86962447  27974.40019293  57373.65497862  38613.53927597], loss 94238900845.2113, iteration 38
Theta[171886.59642823  28400.38465361  58424.80270101  39282.50462279], loss 92811064686.0965, iteration 39
Theta[175360.23596394  28815.42396053  59459.72320177  39939.04410505], loss 91414216603.88582, iteration 40
Theta[178799.1391043   29219.73326364  60478.70191623  40583.3757251 ], loss 90047644651.10925, iteration 41
Theta[182203.65321326  29613.52370281  61482.01913495  41215.71362941], loss 88710654487.44836, iteration 42
Theta[185574.12218113  29997.00248141  62469.95009685  41836.26817757], loss 87402568905.76341, iteration 43
Theta[188910.88645932  30370.37293841  63442.76508062  42445.24600988], loss 86122727371.98935, iteration 44
Theta[192214.28309472  30733.83461931  64400.7294945   43042.8501139 ], loss 84870485578.4657, iteration 45
Theta[195484.64576378  31087.58334563  65344.10396439  43629.27988966], loss 83645215010.27959, iteration 46
Theta[198722.30480614  31431.8112833   66273.14442042  44204.73121377], loss 82446302524.21465, iteration 47
Theta[201927.58725808  31766.70700962  67188.1021819   44769.39650238], loss 81273149939.91217, iteration 48
Theta[205100.8168855   32092.4555792   68089.22404079  45323.46477295], loss 80125173642.86455, iteration 49
```


Loss Function Curve for 50 iterations (alpha = 0.01)
1e11
1.8
1.6
1.4
1.2
1.0
0.8
Loss Value
0
10
20
30
40
50
Iteration

`Learning rate=0.1`

D:\ProgramData\Anaconda3\envs\ShaghayeghEnv\python.exe

```
Theta[318082.24800548  41050.17788472  98014.32293426  62795.14423434], loss 52136953325.12955, iteration 8
Theta[338199.07820493  41437.68451895 102525.77751449  64889.15939837], loss 47071024033.8043, iteration 9
Theta[356304.22538444  41508.74378886 106460.17987093  66544.69500738], loss 42995836822.36497, iteration 10
Theta[372598.857846    41332.54726405 109914.78606567  67838.0704822 ], loss 39712042010.71461, iteration 11
Theta[387264.0270614   40965.01050561 112969.4516905   68832.31219299], loss 37061941450.52271, iteration 12
Theta[400462.67935526  40451.23370141 115689.77731347  69579.50626804], loss 34920323211.05105, iteration 13
Theta[412341.46641973  39827.51201736 118129.68441985  70122.7303833 ], loss 33187450566.104324, iteration 14
Theta[423032.37477776  39122.97760944 120333.52498052  70497.6403204 ], loss 31783659897.845177, iteration 15
Theta[432654.19229998  38360.94036725 122337.80910394  70733.77339726], loss 30645170582.65658, iteration 16
Theta[441313.82806998  37559.98228167 124172.61993397  70855.61966588], loss 29720815402.177597, iteration 17
Theta[449107.50026299  36734.8503599  125862.77243076  70883.50258902], loss 28969475557.47072, iteration 18
Theta[456121.80523669  35897.18484899 127428.76241546  70834.30338467], loss 28358058906.94744, iteration 19
Theta[462434.67971302  35056.11284794 128887.54386015  70722.05706362], loss 27859899775.081253, iteration 20
Theta[468116.26674172  34218.73191873 130253.16552623  70558.44313616], loss 27453487871.053757, iteration 21
Theta[473229.69506754  33390.50382977 131537.29242164  70353.18982585], loss 27121455499.539062, iteration 22
Theta[477831.78056079  32575.57490076 132749.63293486  70114.40723846], loss 26849768433.838394, iteration 23
Theta[481973.65750471  31777.0364187  133898.28872612  69848.8621557 ], loss 26627078033.376846, iteration 24
Theta[485701.34675424  30997.13613997 134990.04136311  69562.20484642], loss 26444201475.310997, iteration 25
Theta[489056.26707882  30237.44988484 136030.58715521  69259.15642215], loss 26293704088.178375, iteration 26
Theta[492075.69537093  29499.02058672 137024.72956612  68943.66373404], loss 26169563269.769306, iteration 27
Theta[494793.18083384  28782.47081365 137976.53688574  68619.02755438], loss 26066897739.721684, iteration 28
Theta[497238.91775046  28088.09367897 138889.47145134  68288.00875809], loss 25981749212.642754, iteration 29
Theta[499440.08097541  27415.92615797 139766.49556881  67952.91637639], loss 25910906197.344727, iteration 30
Theta[501421.12787787  26765.80809115 140610.15835186  67615.68070395], loss 25851761694.962658, iteration 31
Theta[503204.07009008  26137.42955207 141422.66693327  67277.91407341], loss 25802198206.380238, iteration 32
Theta[504808.71808107  25530.36876589 142205.94487654  66940.96144666], loss 25760494761.25628, iteration 33
Theta[506252.90127297  24944.12236159 142961.68010421  66605.94259002], loss 25725251718.949635, iteration 34
Theta[507552.66614567  24378.12941215 143691.36423958  66273.78728786], loss 25695329921.36599, iteration 35
Theta[508722.4545311   23831.79044758 144396.32491487  65945.26479171], loss 25669801442.42134, iteration 36
Theta[509775.26407799  23304.48240633 145077.75231783  65621.00849108], loss 25647909712.24241, iteration 37
Theta[510722.79267019  22795.57031081 145736.72101828  65301.5366187 ], loss 25629037222.98178, iteration 38
Theta[511575.56840317  22304.41630618 146374.2079275   64987.26966045], loss 25612679368.19885, iteration 39
Theta[512343.06656286  21830.38658206 146991.10708886  64678.54502346], loss 25598423245.784977, iteration 40
Theta[513033.81490657  21372.85659893 147588.24187165  64375.62941911], loss 25585930478.623833, iteration 41
Theta[513655.48841591  20931.21496141 148166.37503658  64078.72933898], loss 25574923288.129135, iteration 42
Theta[514214.99457432  20504.86621579 148726.21705635  63787.99993636], loss 25565173201.933975, iteration 43
Theta[514718.55011689  20093.23279587 149268.43300549  63503.55257239], loss 25556491895.08118, iteration 44
Theta[515171.7501052   19695.75629861 149793.64827673  63225.46124159], loss 25548723759.51161, iteration 45
Theta[515579.63009468  19311.89823546 150302.45333454  62953.76805532], loss 25541739873.83294, iteration 46
Theta[515946.72208521  18941.14037701 150795.40767831  62688.48793144], loss 25535433107.788162, iteration 47
Theta[516277.10487669  18582.98478545 151273.04315663  62429.61261369], loss 25529714146.362675, iteration 48
Theta[516574.44938902  18236.95361022 151735.86674829  62177.11412385], loss 25524508259.354664, iteration 49
```


Loss Function Curve for 50 iterations (alpha = 0.1)
1e11
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Loss Value
0
10
20
30
40
50
Iteration

Learning rate=0.5

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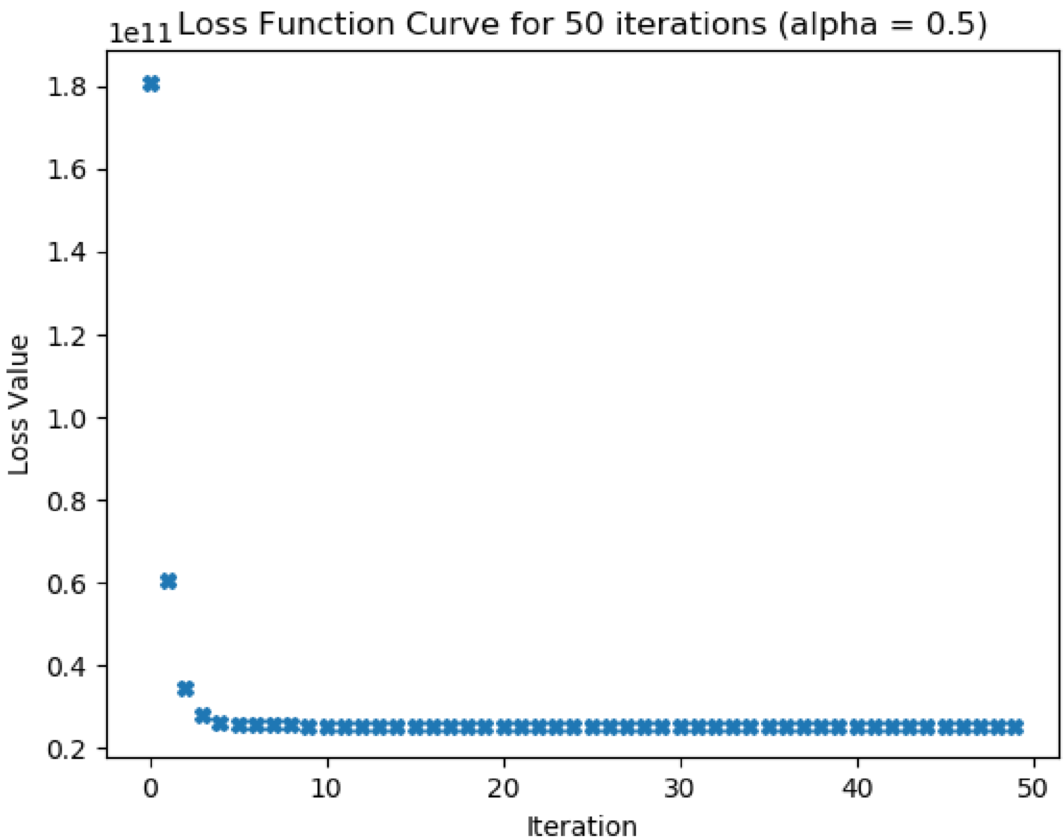
```
Theta[518743.46938477  17044.39536892 153223.22450054  61457.50238435], loss 25524288750.540314, iteration 9
Theta[518997.00969238  15594.83909398 155235.20618015  60287.283678  ], loss 25504522323.110878, iteration 10
Theta[519123.77984619  14375.8169166  156938.4904884   59287.72962247], loss 25490543488.66178, iteration 11
Theta[519187.1649231   13348.42095774 158380.37242408  58436.61306588], loss 25480573991.50028, iteration 12
Theta[519218.85746155  12481.2655708  159600.93113973  57713.3653275 ], loss 25473442618.00424, iteration 13
Theta[519234.70373077  11748.64958134 160634.11754947  57099.59532957], loss 25468336037.702213, iteration 14
Theta[519242.62686539  11129.30182535 161508.68391894  56579.18774585], loss 25464678002.372204, iteration 15
Theta[519246.58843269  10605.48761903 162248.97574051  56138.19532324], loss 25462057272.892406, iteration 16
Theta[519248.56921635  10162.34650765 162875.60482499  55764.64111234], loss 25460179615.158394, iteration 17
Theta[519249.55960817   9787.38428818 163406.02061072  55448.29146587], loss 25458834319.595116, iteration 18
Theta[519250.05480409   9470.07242439 163854.99462657  55180.43057925], loss 25457870442.89031, iteration 19
Theta[519250.30240204   9201.52540087 164235.03105705  54953.65102906], loss 25457179843.57179, iteration 20
Theta[519250.42620102   8974.23680207 164556.71454018  54761.66606543], loss 25456685041.940052, iteration 21
Theta[519250.48810051   8781.86104922 164829.00471495  54599.14490875], loss 25456330525.634842, iteration 22
Theta[519250.51905026   8619.03152018 165059.48562749  54461.57008412], loss 25456076521.17234, iteration 23
Theta[519250.53452513   8481.2082005  165254.57688921  54345.11484414], loss 25455894531.60449, iteration 24
Theta[519250.54226256   8364.54962364 165419.71243906  54246.53839708], loss 25455764139.394447, iteration 25
Theta[519250.54613128   8265.8049756  165559.49187209  54163.09665456], loss 25455670715.750908, iteration 26
Theta[519250.54806564   8182.22304674 165677.80854034  54092.46636633], loss 25455603779.411797, iteration 27
Theta[519250.54903282   8111.47532031 165777.95798877  54032.68072646], loss 25455555820.743885, iteration 28
Theta[519250.54951641   8051.59095813 165862.72974374  53982.07476789], loss 25455521459.23174, iteration 29
Theta[519250.54975821   8000.90181789 165934.4850091   53939.23908612], loss 25455496839.834072, iteration 30
Theta[519250.5498791    7957.99594035 165995.22243297  53902.98063742], loss 25455479200.484024, iteration 31
Theta[519250.54993955   7921.67819365 166046.63377676  53872.2895392 ], loss 25455466562.210957, iteration 32
Theta[519250.54996978   7890.9369692  166090.15103648  53846.31095824], loss 25455457507.118458, iteration 33
Theta[519250.54998489   7864.91599608 166126.98632894  53824.32131019], loss 25455451019.30961, iteration 34
Theta[519250.54999244   7842.89048593 166158.16565351  53805.70811044], loss 25455446370.91271, iteration 35
Theta[519250.54999622   7824.24694225 166184.55747     53789.95291712], loss 25455443040.42099, iteration 36
Theta[519250.54999811   7808.46607076 166206.89688839  53776.61689234], loss 25455440654.18433, iteration 37
Theta[519250.54999906   7795.10831428 166225.80614435  53765.32857983], loss 25455438944.489223, iteration 38
Theta[519250.54999953   7783.80160895 166241.81193084  53755.77355904], loss 25455437719.523815, iteration 39
Theta[519250.54999976   7774.23102064 166255.36006839  53747.68568764], loss 25455436841.8584, iteration 40
Theta[519250.54999988   7766.12997271 166266.82792292  53740.83968865], loss 25455436213.027122, iteration 41
Theta[519250.54999994   7759.27282078 166276.53491675  53735.04487576], loss 25455435762.48097, iteration 42
Theta[519250.54999997   7753.46856764 166284.75142568  53730.13984198], loss 25455435439.67284, iteration 43
Theta[519250.54999999   7748.55554326 166291.70630998  53725.98796396], loss 25455435208.386715, iteration 44
Theta[519250.54999999   7744.39690164 166297.59328899  53722.47359653], loss 25455435042.6744, iteration 45
Theta[519250.55         7740.87680918 166302.57633693  53719.49885152], loss 25455434923.94455, iteration 46
Theta[519250.55         7737.89721821 166306.79425018  53716.98087124], loss 25455434838.87678, iteration 47
Theta[519250.55         7735.37513607 166310.36451328  53714.8495206 ], loss 25455434777.927265, iteration 48
Theta[519250.55         7733.24031342 166313.3865713   53713.04543358], loss 25455434734.258053, iteration 49
```


Loss Function Curve for 50 iterations (alpha = 0.5)
1e11
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Loss Value
0
10
20
30
40
50
Iteration

Learning rate=1.0

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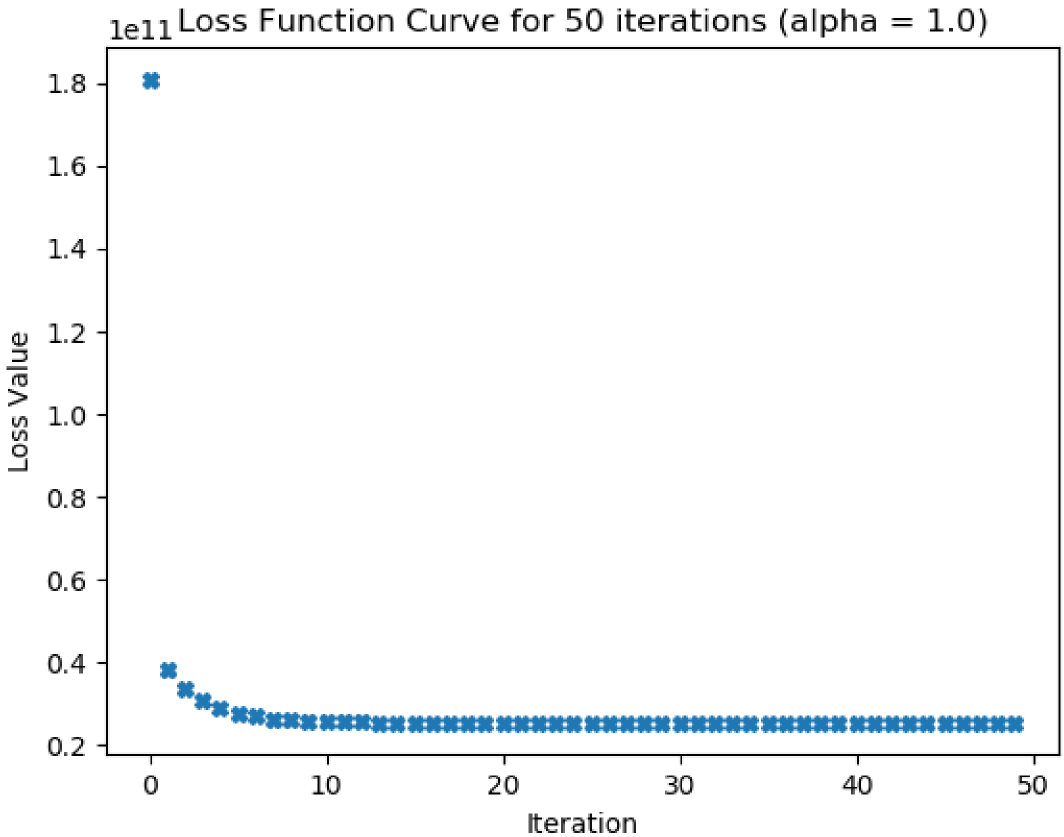
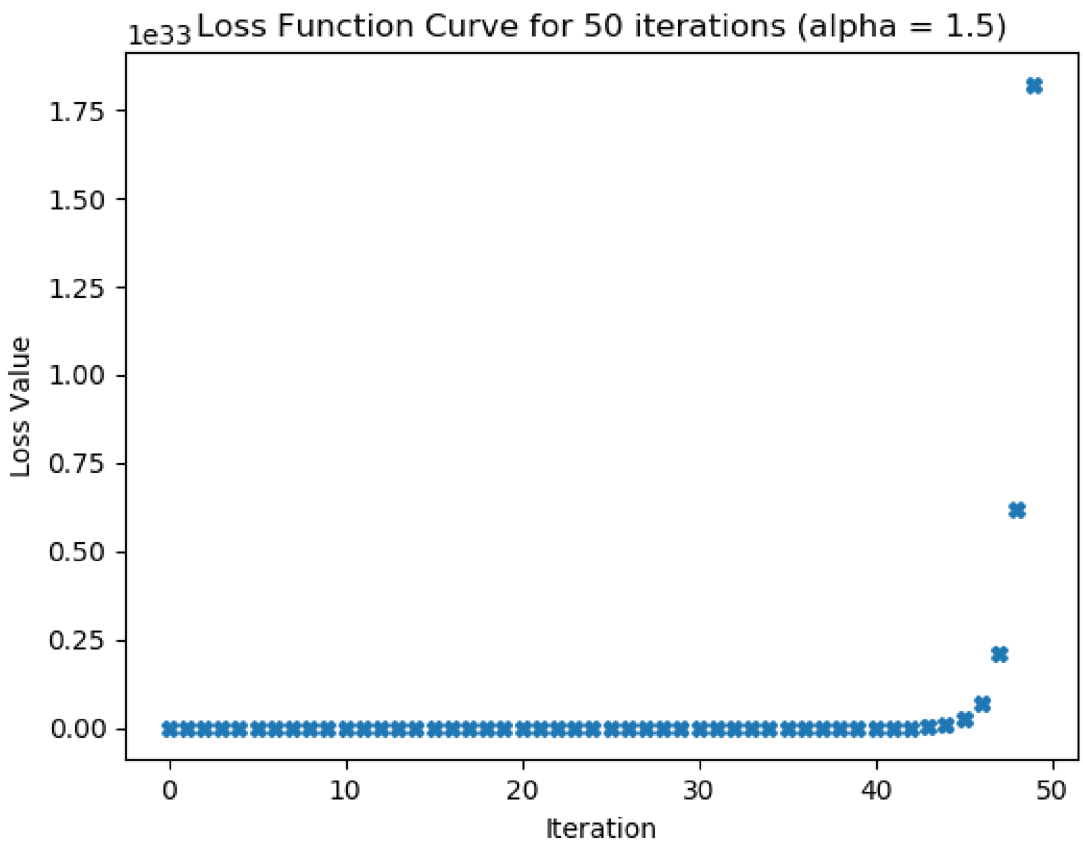
```
Theta[519250.55          -588.56014657 152580.1581327   46008.83235438], loss 25886286140.912487, iteration 9
Theta[519250.55         16340.92050977 174815.36266137  61531.78638253], loss 25738361554.615536, iteration 10
Theta[519250.55          2036.30139596 157604.45146669  48457.12661352], loss 25641282308.698055, iteration 11
Theta[519250.55         13234.47298363 172126.21218877  58720.04247845], loss 25577541371.9306, iteration 12
Theta[519250.55          3877.32021286 160744.32110811  50164.19457028], loss 25535675384.40303, iteration 13
Theta[519250.55         11272.105664   170245.13322247  56939.04202731], loss 25508170196.555485, iteration 14
Theta[519250.55          5143.04876633 162730.18962019  51333.27974743], loss 25490096432.33107, iteration 15
Theta[519250.55         10020.34751862 168954.12668569  55800.57620031], loss 25478218478.831512, iteration 16
Theta[519250.55          6001.77125026 163998.13204897  52124.34636769], loss 25470411594.28872, iteration 17
Theta[519250.55          9215.82028537 168079.29399415  55067.67720214], loss 25465280081.620987, iteration 18
Theta[519250.55          6579.09102246 164813.65169726  52655.20913655], loss 25461906928.33732, iteration 19
Theta[519250.55          8695.74075767 167491.62690906  54593.31828631], loss 25459689530.769634, iteration 20
Theta[519250.55          6964.77026763 165341.12717009  53009.3964031 ], loss 25458231846.921993, iteration 21
Theta[519250.55          8358.06878463 167099.26217464  54285.04674447], loss 25457273567.66166, iteration 22
Theta[519250.55          7221.27198829 165683.74270731  53244.73831134], loss 25456643586.750824, iteration 23
Theta[519250.55          8138.11020404 166838.4214468   54084.10117015], loss 25456229427.394108, iteration 24
Theta[519250.55          7391.31805602 165906.99035131  53400.6542982 ], loss 25455957150.329117, iteration 25
Theta[519250.55          7994.48057436 166665.54977845  53952.81970511], loss 25455778148.61225, iteration 26
Theta[519250.55          7503.79064675 166052.8010471   53503.73218996], loss 25455660467.924767, iteration 27
Theta[519250.55          7900.52337352 166551.2325089   53866.90781067], loss 25455583101.138187, iteration 28
Theta[519250.55          7578.05976463 166148.20114548  53571.77444786], loss 25455532237.79349, iteration 29
Theta[519250.55          7838.97824114 166475.7568615   53810.61698807], loss 25455498798.584316, iteration 30
Theta[519250.55          7627.04326342 166210.69920479  53616.63996555], loss 25455476814.53899, iteration 31
Theta[519250.55          7798.6246354  166425.98313751  53773.70096687], loss 25455462361.48546, iteration 32
Theta[519250.55          7659.3218159  166251.68137013  53646.19958168], loss 25455452859.553978, iteration 33
Theta[519250.55          7772.1467644  166393.18649858  53749.47502695], loss 25455446612.65643, iteration 34
Theta[519250.55          7680.57891913 166278.57347312  53665.6635763 ], loss 25455442505.72904, iteration 35
Theta[519250.55          7754.76424978 166371.58947622  53733.56914241], loss 25455439805.69167, iteration 36
Theta[519250.55          7694.57139449 166296.22879605  53678.47451781], loss 25455438030.592564, iteration 37
Theta[519250.55          7743.34836056 166357.37385693  53723.1221844 ], loss 25455436863.580093, iteration 38
Theta[519250.55          7703.77885048 166307.82426838  53686.90390456], loss 25455436096.345055, iteration 39
Theta[519250.55          7735.84890823 166348.0198571   53716.25884985], loss 25455435591.937714, iteration 40
Theta[519250.55          7709.83614636 166315.44189508  53692.44905224], loss 25455435260.322567, iteration 41
Theta[519250.55          7730.92126711 166341.8662944   53711.74898683], loss 25455435042.307056, iteration 42
Theta[519250.55          7713.82034189 166320.44728107  53696.09624675], loss 25455434898.975964, iteration 43
Theta[519250.55          7727.68298867 166337.81884628  53708.78516491], loss 25455434804.74505, iteration 44
Theta[519250.55          7716.44061234 166323.7366971   53698.49481837], loss 25455434742.79431, iteration 45
Theta[519250.55          7725.55466708 166335.15700892  53706.83718202], loss 25455434702.06571, iteration 46
Theta[519250.55          7718.16371221 166325.89865054  53700.07209719], loss 25455434675.289288, iteration 47
Theta[519250.55          7724.15573913 166333.40658995  53705.55676773], loss 25455434657.685524, iteration 48
Theta[519250.55          7719.29675092 166327.3196951   53701.10923516], loss 25455434646.112183, iteration 49
```


Loss Function Curve for 50 iterations (alpha = 1.0)
1e11
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Loss Value
0
10
20
30
40
50
Iteration

Learning rate=1.5

D:\ProgramData\Anaconda3\envs\ShaghayeghEnv\python.exe

```
Theta[  519504.09030763 29628487.10499476 37276182.99903473 27166300.38432316], loss 919011365157617.8, iteration 10
Theta[   519123.77984617 -50828372.80576955 -63523104.17782316
 -46477801.86601216], loss 2706866589654029.5, iteration 11
Theta[5.19313935e+05 8.72545136e+07 1.09472322e+08 7.99127945e+07], loss 7972932166276093.0, iteration 12
Theta[ 5.19218857e+05 -1.49728311e+08 -1.87428579e+08 -1.37003298e+08], loss 2.3483945740537584e+16, iteration 13
Theta[5.19266396e+05 2.56990080e+08 3.22123401e+08 2.35275852e+08], loss 6.9171098435336376e+16, iteration 14
Theta[ 5.19242627e+05 -4.41034593e+08 -5.52387937e+08 -4.03642961e+08], loss 2.0374102266135686e+17, iteration 15
Theta[5.19254512e+05 7.56940337e+08 9.48479737e+08 6.92892376e+08], loss 6.001120687444709e+17, iteration 16
Theta[ 5.19248569e+05 -1.29906713e+09 -1.62736310e+09 -1.18902083e+09], loss 1.7676092422521518e+18, iteration 17
Theta[5.19251540e+05 2.22952649e+09 2.79339060e+09 2.04078599e+09], loss 5.206431688083899e+18, iteration 18
Theta[ 5.19250055e+05 -3.82637221e+09 -4.79366516e+09 -3.50232411e+09], loss 1.5335363973570458e+19, iteration 19
Theta[5.19250798e+05 6.56697796e+09 8.22751156e+09 6.01095990e+09], loss 4.516978283643712e+19, iteration 20
Theta[ 5.19250426e+05 -1.12704617e+10 -1.41198981e+10 -1.03160787e+10], loss 1.330460291966148e+20, iteration 21
Theta[5.19250612e+05 1.93427909e+10 2.42335265e+10 1.77049695e+10], loss 3.918824660600154e+20, iteration 22
Theta[ 5.19250519e+05 -3.31967692e+10 -4.15899939e+10 -3.03857567e+10], loss 1.1542762166253735e+21, iteration 23
Theta[5.19250566e+05 5.69735048e+10 7.13786884e+10 5.21492693e+10], loss 3.399880575674176 5e+21, iteration 24
Theta[ 5.19250542e+05 -9.77799478e+10 -1.22502209e+11 -8.95002972e+10], loss 1.0014230357056183e+22, iteration 25
Theta[5.19250554e+05 1.67813468e+11 2.10243128e+11 1.53603760e+11], loss 2.949656830949933e+22, iteration 26
Theta[ 5.19250548e+05 -2.88007461e+11 -3.60826332e+11 -2.63620127e+11], loss 8.688111926892874e+22, iteration 27
Theta[5.19250551e+05 4.94288737e+11 6.19263521e+11 4.52434446e+11], loss 2.559053245185045e+23, iteration 28
Theta[ 5.19250549e+05 -8.48316006e+11 -1.06280177e+12 -7.76484048e+11], loss 7.537602607791182e+23, iteration 29
Theta[5.19250551e+05 1.45591032e+12 1.82401891e+12 1.33262987e+12], loss 2.2201747142183667e+24, iteration 30
Theta[ 5.19250548e+05 -2.49868540e+12 -3.13044610e+12 -2.28710695e+12], loss 6.539447644214727e+24, iteration 31
Theta[5.19250552e+05 4.28833336e+12 5.37258413e+12 3.92521497e+12], loss 1.9261716304377127e+25, iteration 32
Theta[ 5.19250546e+05 -7.35979123e+12 -9.22062078e+12 -6.73659432e+12], loss 5.673471754430731e+25, iteration 33
Theta[5.19250557e+05 1.26311372e+13 1.58247599e+13 1.15615845e+13], loss 1.671101434559530 2e+26, iteration 34
Theta[ 5.19250537e+05 -2.16780099e+13 -2.71590191e+13 -1.98424051e+13], loss 4.9221713361065714e+26, iteration 35
Theta[5.19250572e+05 3.72045767e+13 4.66112814e+13 3.40542462e+13], loss 1.4498085012041858e+27, iteration 36
Theta[ 5.19250513e+05 -6.38518266e+13 -7.99959495e+13 -5.84451164e+13], loss 4.270360673439216e+27, iteration 37
Theta[5.19250606e+05 1.09584791e+14 1.37291913e+14 1.00305601e+14], loss 1.2578199304328642e+28, iteration 38
Theta[ 5.19250441e+05 -1.88073341e+14 -2.35625296e+14 -1.72148064e+14], loss 3.7048649947404798e+28, iteration 39
Theta[5.19250745e+05 3.22778202e+14 4.04388570e+14 2.95446671e+14], loss 1.0912551389235612e+29, iteration 40
Theta[ 5.19250213e+05 -5.53963506e+14 -6.94026141e+14 -5.07056154e+14], loss 3.21425417638058e+29, iteration 41
Theta[5.19251023e+05 9.50732002e+14 1.19111251e+15 8.70227925e+14], loss 9.467474233909367e+29, iteration 42
Theta[ 5.19249703e+05 -1.63168030e+15 -2.04422993e+15 -1.49351632e+15], loss 2.788611710560778e+30, iteration 43
Theta[5.19252223e+05 2.80034815e+15 3.50838060e+15 2.56322618e+15], loss 8.21375910844772e+30, iteration 44
Theta[ 5.19247663e+05 -4.80605775e+15 -6.02120840e+15 -4.39910054e+15], loss 2.419334267159078e+31, iteration 45
Theta[5.19255223e+05 8.24832838e+15 1.03338134e+16 7.54989385e+15], loss 7.126065202265616e+31, iteration 46
Theta[ 5.19241543e+05 -1.41560765e+16 -1.77352606e+16 -1.29573981e+16], loss 2.0989577982777327e+32, iteration 47
Theta[5.19266983e+05 2.42951653e+16 3.04378891e+16 2.22379506e+16], loss 6.1824074210690795e+32, iteration 48
Theta[ 5.19225703e+05 -4.16962325e+16 -5.22385951e+16 -3.81655669e+16], loss 1.8210066706177996e+33, iteration 49
```



Loss function with learning_rate=1 reaches its least value after 50 iterations which is 25455434646.112.

Final parameters value:

$$Theta = [519250.55\ , 7719.29675092, 166327.3196951, 53701.10923516]$$

$$y = 519250.55 + 7719.29675092 * (n_{bed}) + 166327.3196951 * (live\ area) + 53701.10923516 * (lot\ area)$$

```
# (5) Print out the predicted y value for the input n_bed=3, liv_area=2000,
lot_area=8550.
# First we should standardize data point.
x_test = np.array([3, 2000, 8550])
colaverage = x.mean(axis = 0)
colstd = x.std(axis = 0)
standard = (x_test-colaverage)/colstd
#print(standard)
#Adding dummy column to standardized matix
dummy_column2 = np.array([1])
Final_xtest = np.append(dummy_column2,standard,axis = 0)
print(Final_xtest)

New_theta = np.array([519250.55 ,7719.29675092,166327.3196951,53701.10923516])
print(New_theta)
Predictedvalue = Final_xtest.dot(New_theta.T)
print(Predictedvalue)
```

D:\ProgramData\Anaconda3\envs\ShaghayeghEnv\python.exe

```
[ 1.         -0.50545412 -0.10309903 -0.21503264]
[519250.55          7719.29675092 166327.3196951    53701.10923516]
486653.1235186905
Press any key to continue . . .
```