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Homework 0 Report

GitHub Repository Link: https://github.com/NaraPvP/IntroToML

Problem 1:

1.

a. For X1 and Y, the linear model found with a learning rate of 0.01 and 1500 iterations was the following:

$$H(X_1) = -2.03541173 * X_1 + 5.92043383$$

b. For X2 and Y, the linear model found with a learning rate of 0.001 and 1500 iterations was the following:

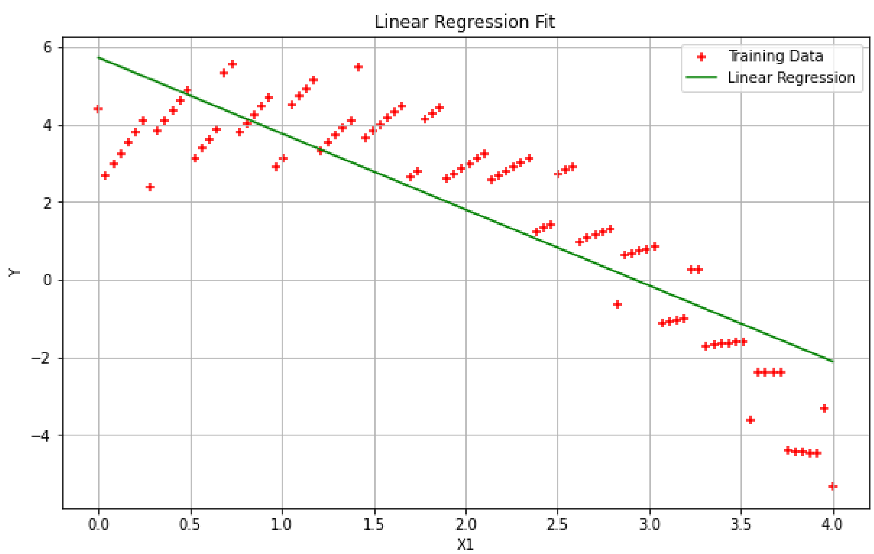
$$H(X_1) = 0.6478467 * X_1 + 0.50420806$$

c. For X3 and Y, the linear model found with a learning rate of 0.02 and 1500 iterations was the following:

$$H(X_1) = -0.51925373 * X_1 + 2.86831421$$

2.

a. Here is the linear regression fit for the X1 variable:



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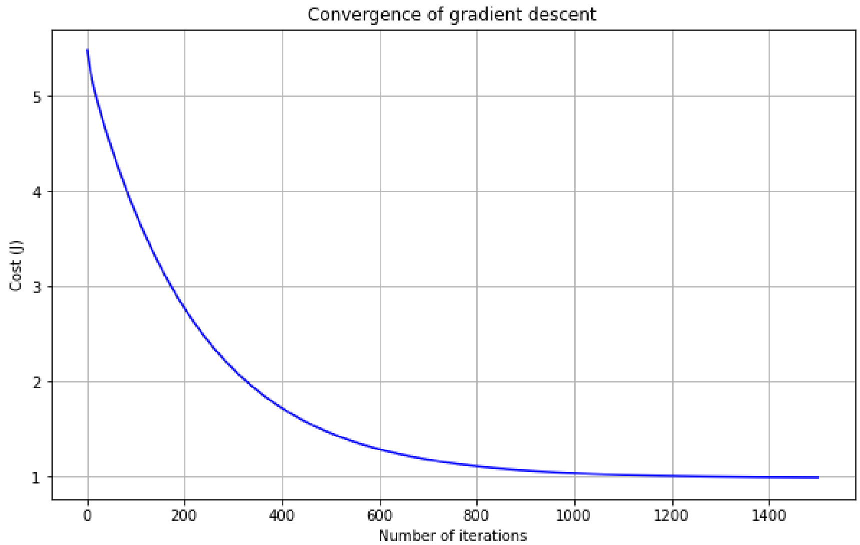
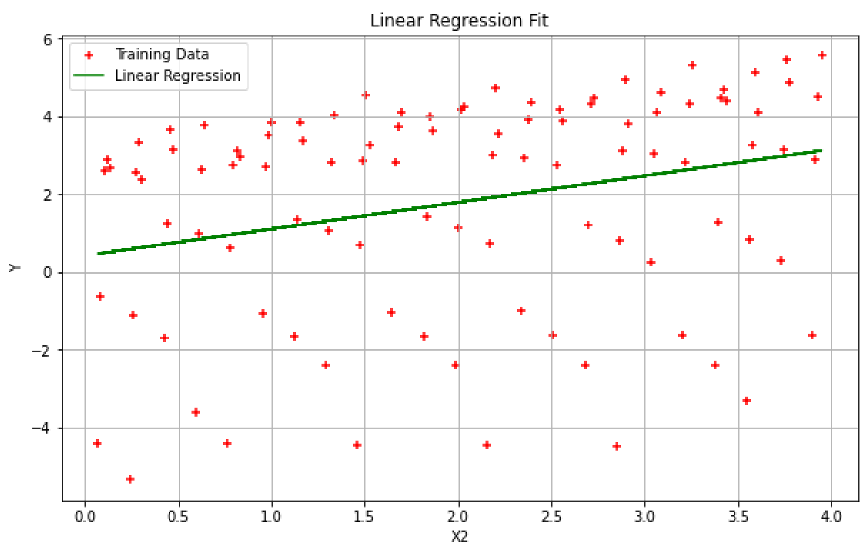
For X1, this is the loss over iterations graph:



b. Here is the linear regression fit for the X2 variable:



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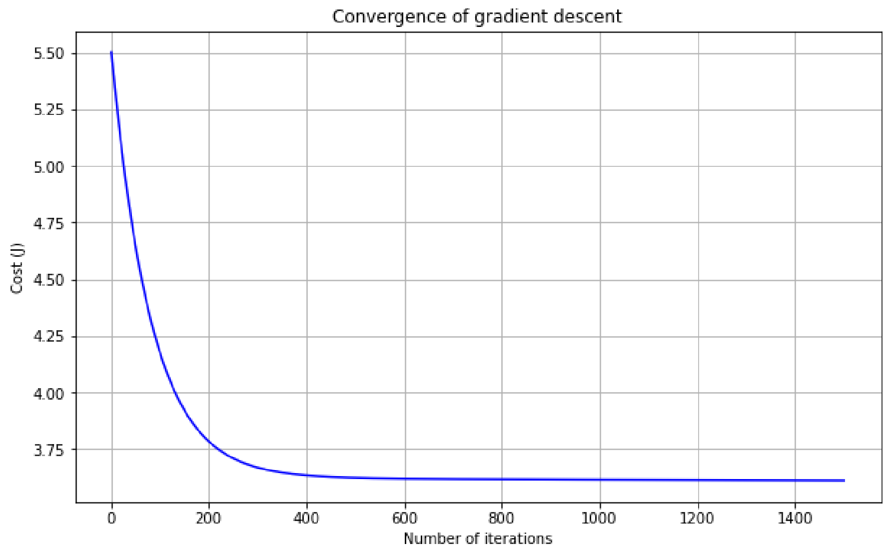
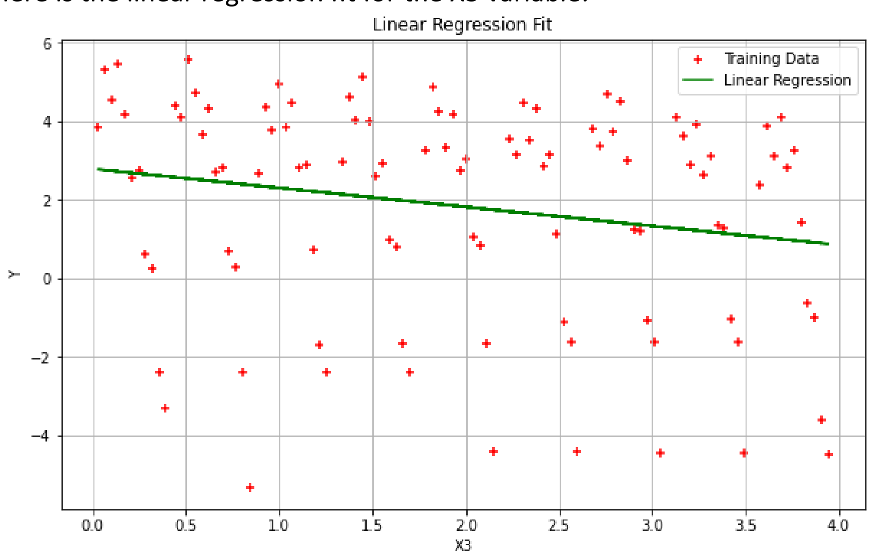
For X2, this is the loss over iterations graph:



c. Here is the linear regression fit for the X3 variable:



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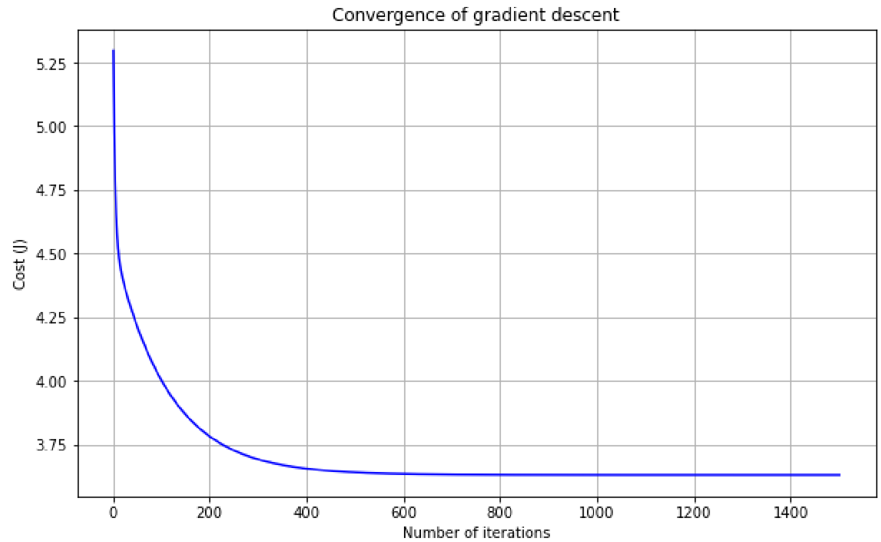
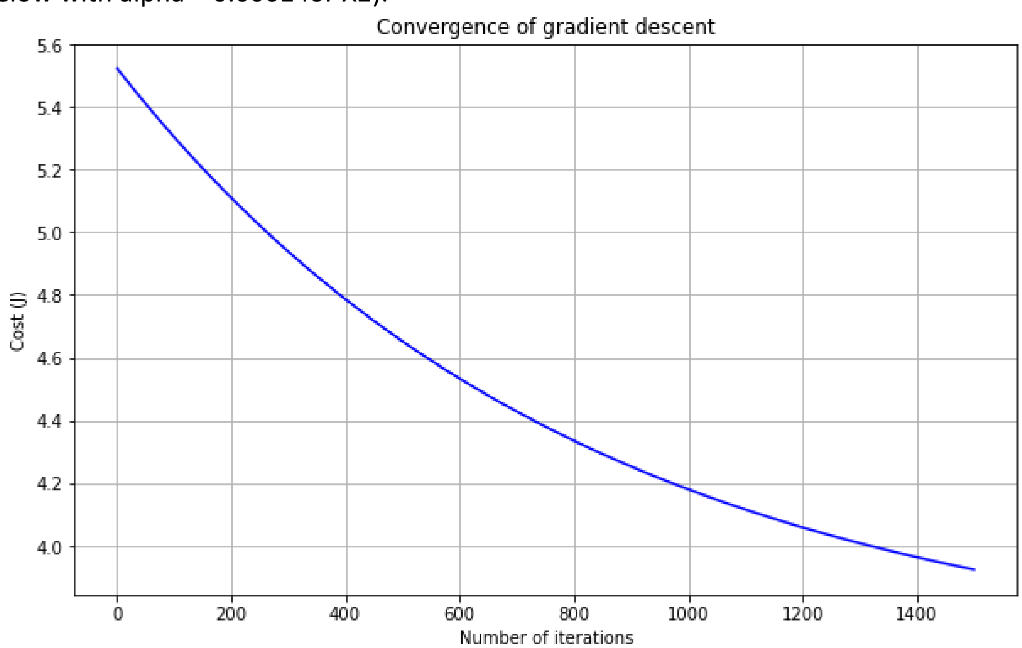
For X3, this is the loss over iterations graph:



3. Based on the cost history from each explanatory variable, X1 has the lowest loss for explaining the output. That is demonstrated in the following image where the cost history of each explanatory variable is shown:

```
Final value of thetas for X1 = [ 5.71850653 -1.9568206 ]
cost_history = [5.48226715 5.44290965 5.40604087 ... 0.99063932 0.99061433 0.99058944]
Final value of thetas for X2 = [0.41275557 0.68335862]
cost_history = [5.50118218 5.47821041 5.45551967 ... 3.61271034 3.61270443 3.61269852]
Final value of thetas for X3 = [ 2.86833779 -0.51926306]
cost_history = [5.29785963 5.12026797 4.98070413 ... 3.62945238 3.62945237 3.62945236]
```

4. The impact of the learning rate is very evident in the loss plot. When the learning rate is too low, the gradient descent may never reach a minimum loss due to too few iterations (shown below with alpha = 0.0001 for X2).



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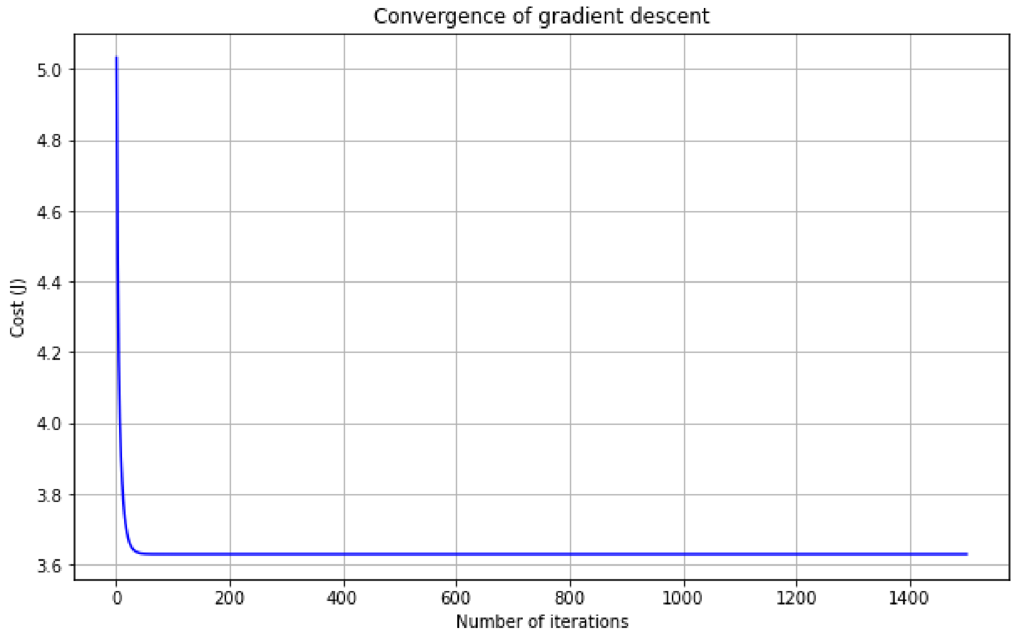
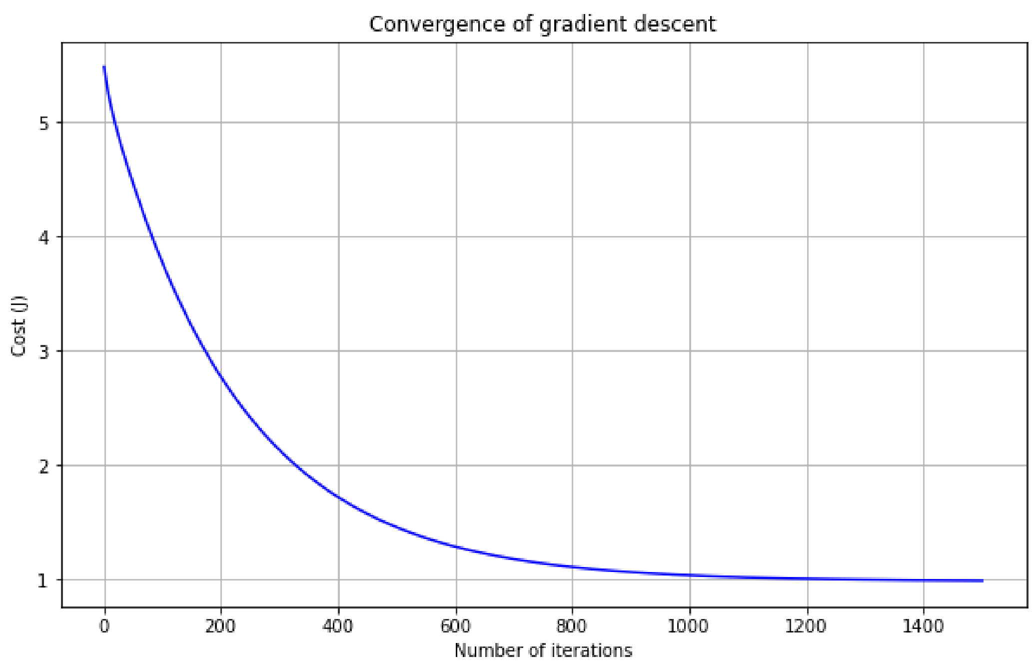
When the learning rate is too high, the plot may diverge due to overestimating the correction needed for a new theta. For this dataset, it would converge very quickly. This is not good either as the slope will change too quickly for a good model to be trained from (shown below with alpha = 0.3 for X3).



A good learning rate will produce a loss graph that is gradually decreases in slope until it flattens out, signifying it has reached minimal loss (shown below with alpha = 0.01 for X1).



The number of iterations will impact how long the plot is along with how long it will take to train the model. Iterations and learning rate must be balanced to reach an efficient training for a good-fitting model.

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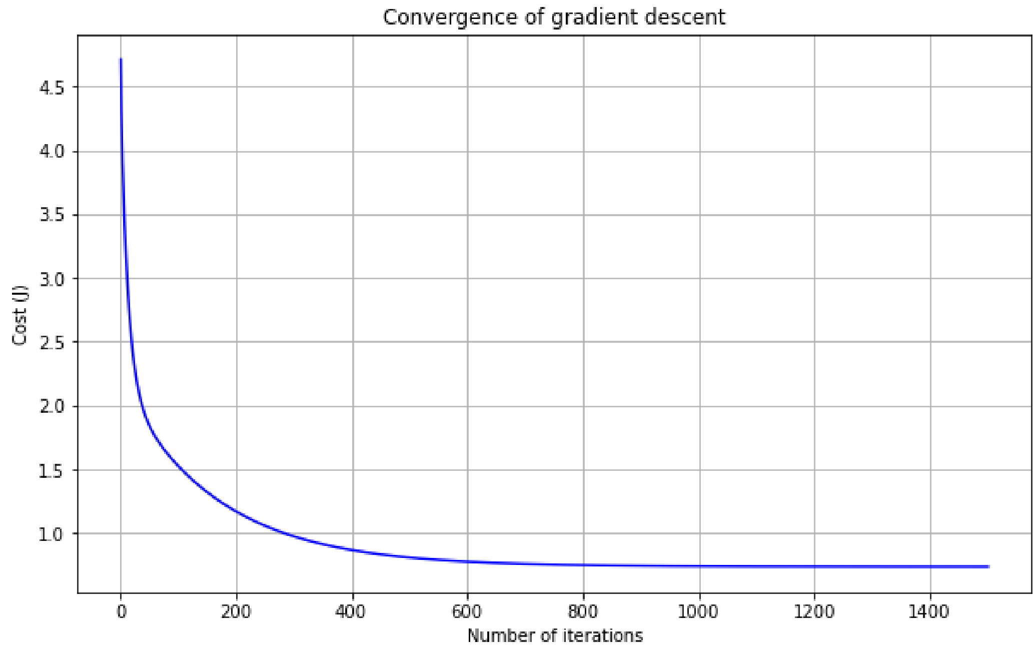
Problem 2:

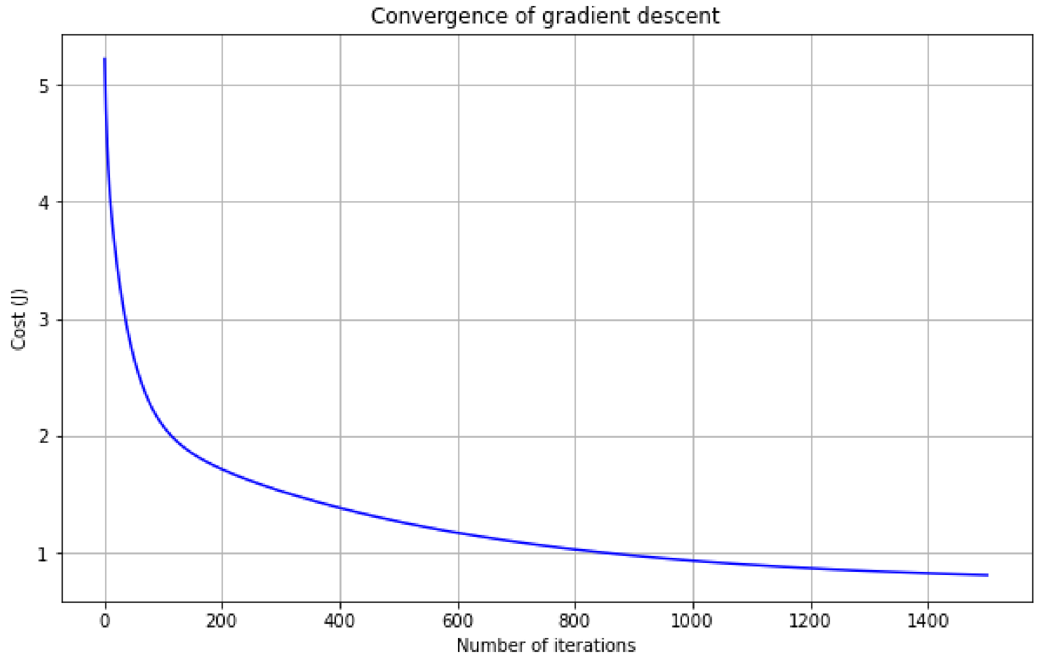
1. The final linear model that was found is the following:

$$H(X_1, X_2, X_3) = -0.25708468 * X_3 + 0.54216503 * X_2 + -1.99551081 * X_1 + 5.25606097$$



2.
3. As the same reasons mentioned in Problem 1, the learning rate is very impactful to the training of our model. For the loss shown above, the learning rate was 0.03. When the learning rate is set to 0.01, the resulting plot doesn't reach a minimal loss within the

iterations:



The number of iterations will impact how long the plot is along with how long it will take to train the model. Iterations and learning rate must be balanced to reach an efficient training for a good-fitting model.

4. By using our trained linear model, we can simply plug the new datapoint into it to get a predicted output. That is demonstrated and shown below:

```
[410]: #Predict y for (1, 1, 1)
       y1 = thetaX[0] + thetaX[1]*1 + thetaX[2]*1 + thetaX[3]*1
       y1

[410]: 3.5456305154702545

[393]: #Predict y for (2,0,4)
       y2 = thetaX[0] + thetaX[1]*2 + thetaX[2]*0 + thetaX[3]*4
       y2

[393]: 0.23670064969674898

[394]: #Predict y for (3,2,1)
       y3 = thetaX[0] + thetaX[1]*3 + thetaX[2]*2 + thetaX[3]*1
       y3

[394]: 0.096773927699143
```