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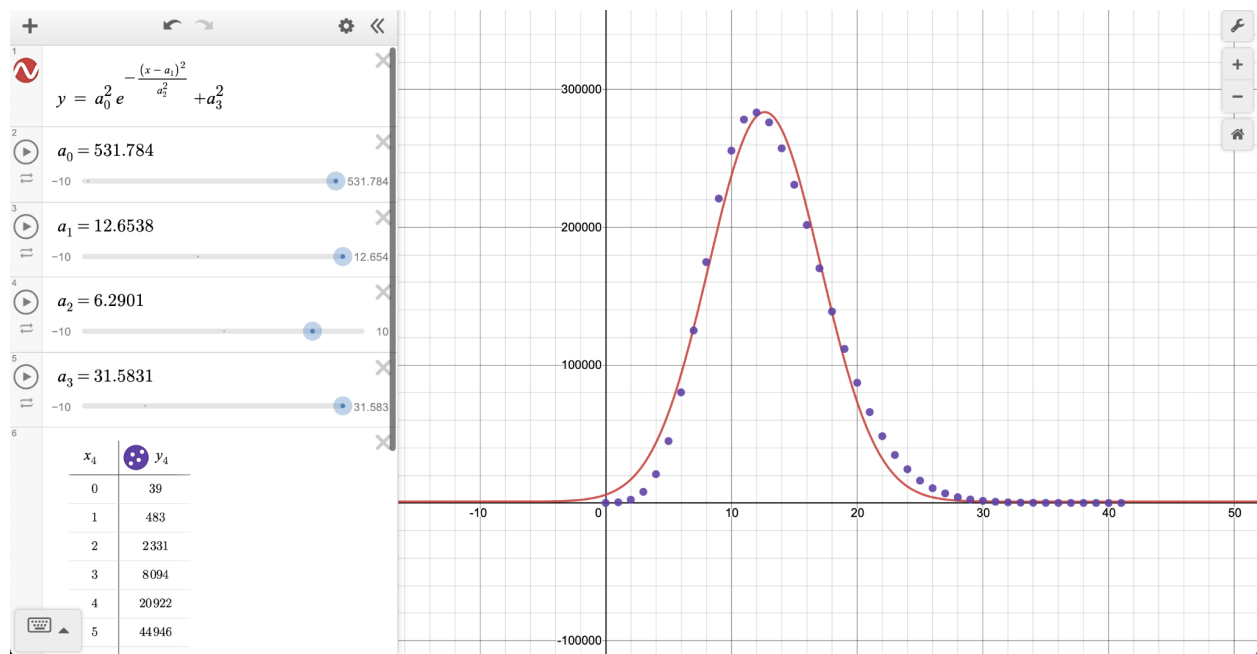
ATCS Numerical Method, p3

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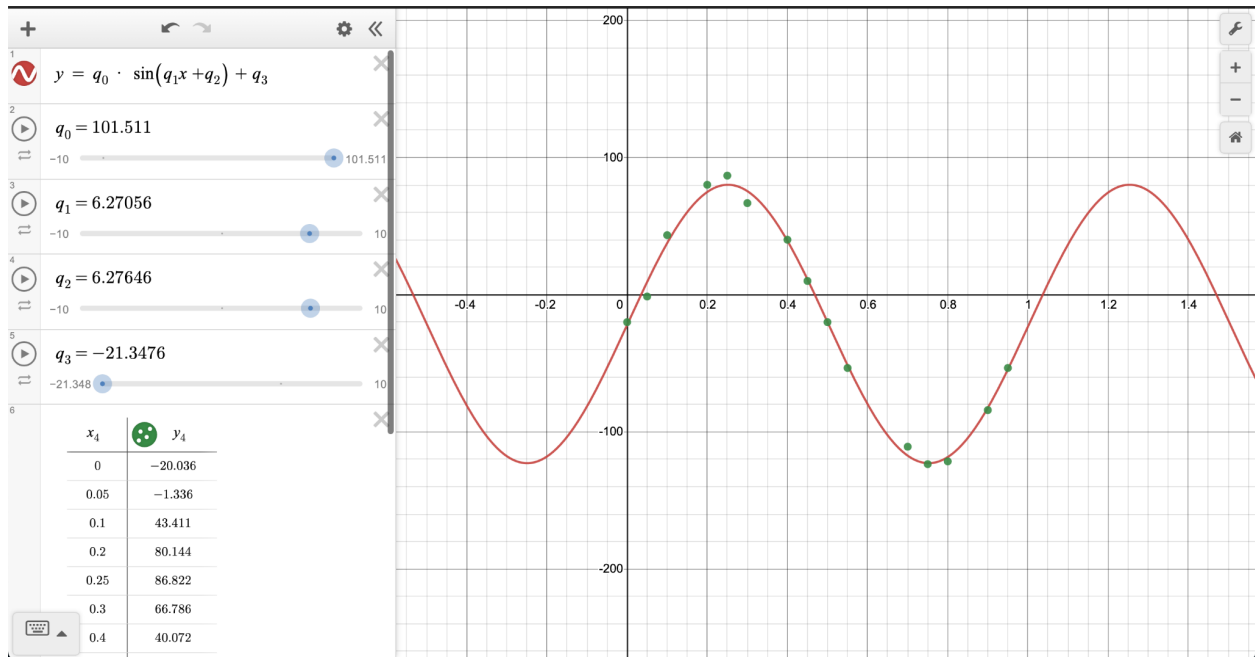
### Least Squares Lab Report

The Least Squares algorithm is achieved through the use of gradient descent to minimize the error in the lab. In addition, momentum is used in this project to facilitate the training process. The training is considered finished when the change in error between interactions is below the given threshold.

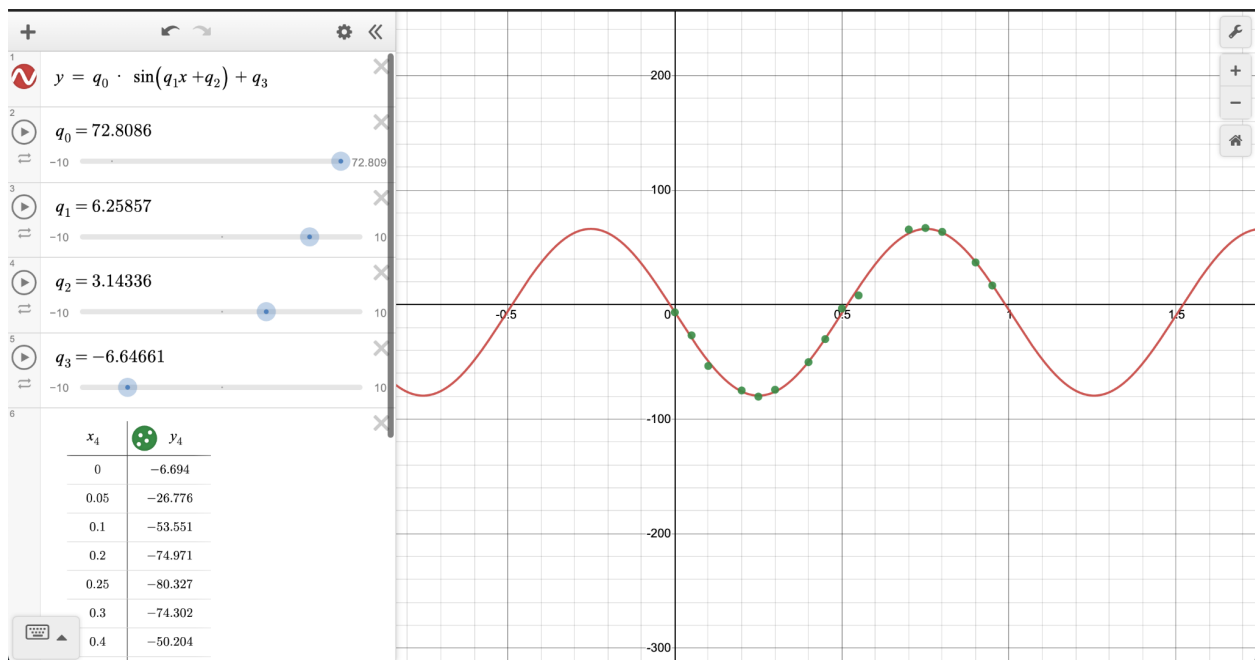
The training process for the function  $F(x) = q_0^2 e^{-(x-q_1)^2/q_2^2} + q_3^2$  took 2,218,536 iterations to minimize the error to  $2.40973e+09$ . It had a  $1e-11$  learning rate and a threshold of  $1e-1$ . The final parameters are listed following:  $q_0 = 531.784$ ,  $q_1 = 12.6538$ ,  $q_2 = 6.2901$ , and  $q_3 = 31.5831$ .



The following function is for  $F(x) = q_0 * \sin(q_1 * x + q_2) + q_3$ . The first dataset trained is the UCrBMg2 data set. It took 457,659 iterations to minimize the error to 180.838, with a learning rate of  $1e-6$  and a threshold of  $1e-5$ . The final parameters are listed following:  $q_0 = 101.511$ ,  $q_1 = 6.27056$ ,  $q_2 = 6.27646$ , and  $q_3 = -21.3476$ .



The final dataset trained on the function above is UCrBHe1. It took 425,359 iterations to minimize the error to 53.0586, with a learning rate of 1e-6 and a threshold of 1e-5. The final parameters are listed following:  $q_0 = 72.8086$ ,  $q_1 = 6.25857$ ,  $q_2 = 3.14336$ , and  $q_3 = -6.64661$ .



These three training of data sets within the least squares algorithms well demonstrates the effectiveness of the code.