

I followed the instructions in the Problem Statement as well as the comments in the code files to implement the functions in the files *layers.py* and *neural_network.py*.

I used numpy operations, specifically **np.dot()** and **np.transpose()** to do the calculations required in the functions.

I first implemented functions in *layers.py* and then used those functions, namely, **compute_activation()**, **compute_gradient()** and **update_weights()** to implement the functions in *neural_network.py* for the various layers by iterating through each one of the layers.

Then, I trained the model by running *toy_example_regressor.py* and generated *simple_net_weights.pkl* and *data_function.png*. I also got the model's loss by running the file, which is included in this pdf.

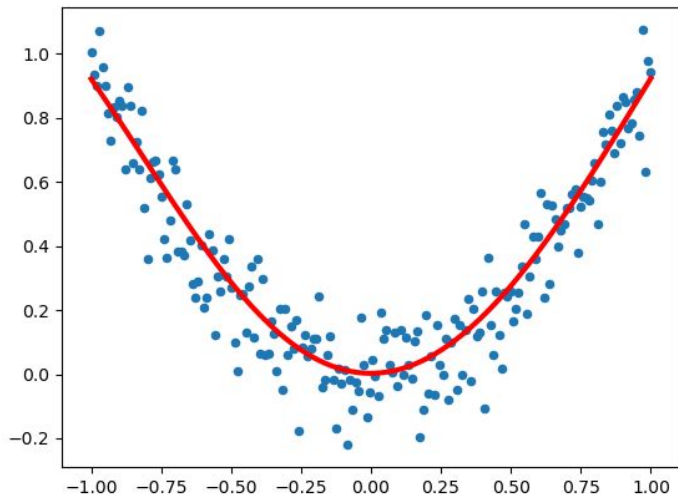
Lastly, I read and understood the file *prime_classifier.py* and ran the code, producing *prime_net_weights.pkl* along with loss values and accuracies, which is also included in this pdf.

Loss Values for *toy_example_regressor.py* :

```
C:\Users\Naqsh Thind\Desktop\Assignment4>python toy_example_regressor.py
[Epoch 0]: loss: 11.849840680207043
[Epoch 0]: loss: 6.415041388570392
[Epoch 0]: loss: 3.204549396441555
[Epoch 50]: loss: 0.08639302372940086
[Epoch 50]: loss: 0.06355492087682418
[Epoch 50]: loss: 0.10430830250754458
[Epoch 100]: loss: 0.06678649862749471
[Epoch 100]: loss: 0.04307034240268327
[Epoch 100]: loss: 0.07336165251287297
[Epoch 150]: loss: 0.05802467774894964
[Epoch 150]: loss: 0.03501619889368944
[Epoch 150]: loss: 0.05945252714791633
[Epoch 200]: loss: 0.050157117098682584
[Epoch 200]: loss: 0.02915545457569461
[Epoch 200]: loss: 0.050070750934957275
[Epoch 250]: loss: 0.04261774683028216
[Epoch 250]: loss: 0.024155259897240898
[Epoch 250]: loss: 0.04253706011446125
[Epoch 300]: loss: 0.035850741472788696
[Epoch 300]: loss: 0.019992677375035933
[Epoch 300]: loss: 0.036268707179545126
[Epoch 350]: loss: 0.03012653671158838
[Epoch 350]: loss: 0.01671199207865618
[Epoch 350]: loss: 0.031134067712501476
[Epoch 400]: loss: 0.025495456189017635
[Epoch 400]: loss: 0.014268265884217948
[Epoch 400]: loss: 0.02704965591799114
[Epoch 450]: loss: 0.021873288891892766
```

```
[Epoch 450]: loss: 0.021873288891892766
[Epoch 450]: loss: 0.012547788294916587
[Epoch 450]: loss: 0.02389634611342622
[Epoch 500]: loss: 0.01911211153806265
[Epoch 500]: loss: 0.011406532030974512
[Epoch 500]: loss: 0.02152438015193027
[Epoch 550]: loss: 0.01704672402648498
[Epoch 550]: loss: 0.010700098009110315
[Epoch 550]: loss: 0.019776768535185885
[Epoch 600]: loss: 0.01552160259368659
[Epoch 600]: loss: 0.010301524807819254
[Epoch 600]: loss: 0.018508520399747173
[Epoch 650]: loss: 0.01440376231539286
[Epoch 650]: loss: 0.010108810777512602
[Epoch 650]: loss: 0.017596907727007758
[Epoch 700]: loss: 0.013586451521400488
[Epoch 700]: loss: 0.010045447433002258
[Epoch 700]: loss: 0.016944306786540193
[Epoch 750]: loss: 0.012987649335143781
[Epoch 750]: loss: 0.010057251985814728
[Epoch 750]: loss: 0.01647648951766266
[Epoch 800]: loss: 0.01254627797243308
[Epoch 800]: loss: 0.010107806902074086
[Epoch 800]: loss: 0.01613886164719725
[Epoch 850]: loss: 0.012217840730803543
[Epoch 850]: loss: 0.010173865590083486
[Epoch 850]: loss: 0.015892268008349742
[Epoch 900]: loss: 0.011970390642428717
[Epoch 900]: loss: 0.01024147445393217
[Epoch 900]: loss: 0.015709099604033622
[Epoch 950]: loss: 0.011781199604152755
[Epoch 950]: loss: 0.01030292965820711
[Epoch 950]: loss: 0.0155701402266945
Validation Loss 0.011285307840366021
```

data_function.png :



Loss and Accuracy values for *prime_classifier.py* :

```
C:\Users\Naqsh Thind\Desktop\Assignment4>python prime_classifier.py
[Epoch 0]:      validation loss: 0.20135027,      validation accuracy: 69.36%
[Epoch 1]:      validation loss: 0.11589750,      validation accuracy: 85.96%
[Epoch 2]:      validation loss: 0.09951013,      validation accuracy: 87.46%
[Epoch 3]:      validation loss: 0.09272672,      validation accuracy: 88.22%
[Epoch 4]:      validation loss: 0.08894021,      validation accuracy: 88.76%
[Epoch 5]:      validation loss: 0.08646042,      validation accuracy: 89.03%
[Epoch 6]:      validation loss: 0.08460486,      validation accuracy: 89.33%
[Epoch 7]:      validation loss: 0.08283331,      validation accuracy: 89.45%
[Epoch 8]:      validation loss: 0.08034576,      validation accuracy: 89.83%
[Epoch 9]:      validation loss: 0.07701915,      validation accuracy: 90.26%
[Epoch 10]:     validation loss: 0.07336158,      validation accuracy: 90.82%
[Epoch 11]:     validation loss: 0.06953909,      validation accuracy: 91.49%
[Epoch 12]:     validation loss: 0.06556480,      validation accuracy: 92.03%
[Epoch 13]:     validation loss: 0.06145956,      validation accuracy: 92.71%
[Epoch 14]:     validation loss: 0.05736161,      validation accuracy: 93.29%
[Epoch 15]:     validation loss: 0.05348172,      validation accuracy: 93.83%
[Epoch 16]:     validation loss: 0.05002990,      validation accuracy: 94.34%
[Epoch 17]:     validation loss: 0.04706440,      validation accuracy: 94.62%
[Epoch 18]:     validation loss: 0.04454474,      validation accuracy: 94.83%
[Epoch 19]:     validation loss: 0.04240104,      validation accuracy: 95.09%
[Epoch 20]:     validation loss: 0.04056526,      validation accuracy: 95.27%
[Epoch 21]:     validation loss: 0.03898068,      validation accuracy: 95.49%
[Epoch 22]:     validation loss: 0.03760219,      validation accuracy: 95.70%
[Epoch 23]:     validation loss: 0.03639403,      validation accuracy: 95.88%
[Epoch 24]:     validation loss: 0.03532722,      validation accuracy: 95.97%
[Epoch 25]:     validation loss: 0.03437793,      validation accuracy: 96.06%
[Epoch 26]:     validation loss: 0.03352654,      validation accuracy: 96.10%
[Epoch 27]:     validation loss: 0.03275712,      validation accuracy: 96.23%
[Epoch 28]:     validation loss: 0.03205689,      validation accuracy: 96.30%
[Epoch 29]:     validation loss: 0.03141567,      validation accuracy: 96.38%
[Epoch 30]:     validation loss: 0.03082534,      validation accuracy: 96.43%
[Epoch 31]:     validation loss: 0.03027935,      validation accuracy: 96.48%
[Epoch 32]:     validation loss: 0.02977239,      validation accuracy: 96.54%
[Epoch 33]:     validation loss: 0.02930009,      validation accuracy: 96.61%
[Epoch 34]:     validation loss: 0.02885878,      validation accuracy: 96.62%
[Epoch 35]:     validation loss: 0.02844536,      validation accuracy: 96.64%
[Epoch 36]:     validation loss: 0.02805717,      validation accuracy: 96.65%
[Epoch 37]:     validation loss: 0.02769191,      validation accuracy: 96.73%
[Epoch 38]:     validation loss: 0.02734757,      validation accuracy: 96.76%
[Epoch 39]:     validation loss: 0.02702238,      validation accuracy: 96.81%
[Epoch 40]:     validation loss: 0.02671475,      validation accuracy: 96.81%
[Epoch 41]:     validation loss: 0.02642328,      validation accuracy: 96.86%
[Epoch 42]:     validation loss: 0.02614671,      validation accuracy: 96.89%
[Epoch 43]:     validation loss: 0.02588390,      validation accuracy: 96.97%
[Epoch 44]:     validation loss: 0.02563382,      validation accuracy: 96.99%
[Epoch 45]:     validation loss: 0.02539553,      validation accuracy: 97.04%
[Epoch 46]:     validation loss: 0.02516819,      validation accuracy: 97.05%
[Epoch 47]:     validation loss: 0.02495103,      validation accuracy: 97.08%
[Epoch 48]:     validation loss: 0.02474334,      validation accuracy: 97.11%
[Epoch 49]:     validation loss: 0.02454448,      validation accuracy: 97.12%
```