Q1

The experiments was conducted as follows:

For each batch size (8, 16, 32, 64, 128, 256), the neural network was trained using MSE loss. The learning rate was tested on the following values: [0.000001, 0.00001, 0.0001, 0.001, 0.01, 0.1, 1]. For each batch size, the optimal learning rate was selected based on the best accuracy achieved.

The results of **the experiments** :

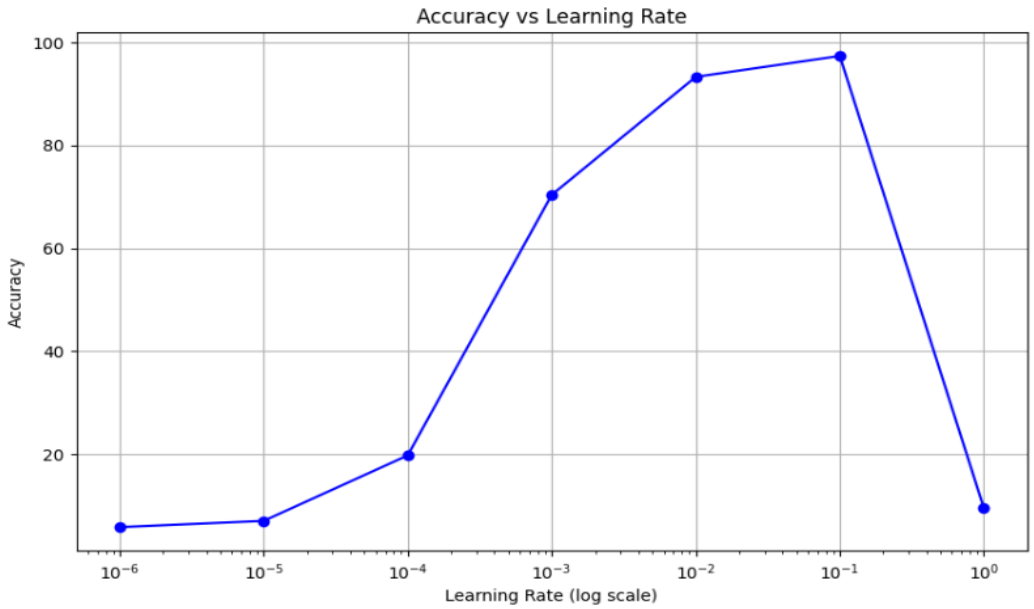
The maximum accuracy achieved is quite similar across all tests. However, the optimal parameters are a **batch size of 64** and a **learning rate of 0.2**, yielding the highest test accuracy of **98.01%**. These settings demonstrate the best balance for model training.

The optimal results:

Loss Function	Batch Size	Learning Rate	Test Accuracy (%)
MSE	8	0.1	97.35
MSE	16	0.1	97.03
MSE	32	1	97.40
MSE	64	0.2	98.01
MSE	128	1	97.27
MSE	256	1	96.37

The process

Test Batch Size = 8, MSE Loss



```
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Training with learning rate: 0.1
Epoch 1, Loss: 0.0003
Epoch 2, Loss: 0.0001
Epoch 3, Loss: 0.0001
Epoch 4, Loss: 0.0002
Epoch 5, Loss: 0.0059
Epoch 6, Loss: 0.0000
Epoch 7, Loss: 0.0000
Epoch 8, Loss: 0.0128
Epoch 9, Loss: 0.0002
Epoch 10, Loss: 0.0003
Epoch 11, Loss: 0.0144
Epoch 12, Loss: 0.0000
Epoch 13, Loss: 0.0000
Epoch 14, Loss: 0.0187
Epoch 15, Loss: 0.0017
Accuracy: 97.35
```

Test result:

Using **MSE** and a batch size of **8**, with a learning rate of **0.1** and the test accuracy achieved was **97.35%**.

Test Batch Size = 16, MSE Loss

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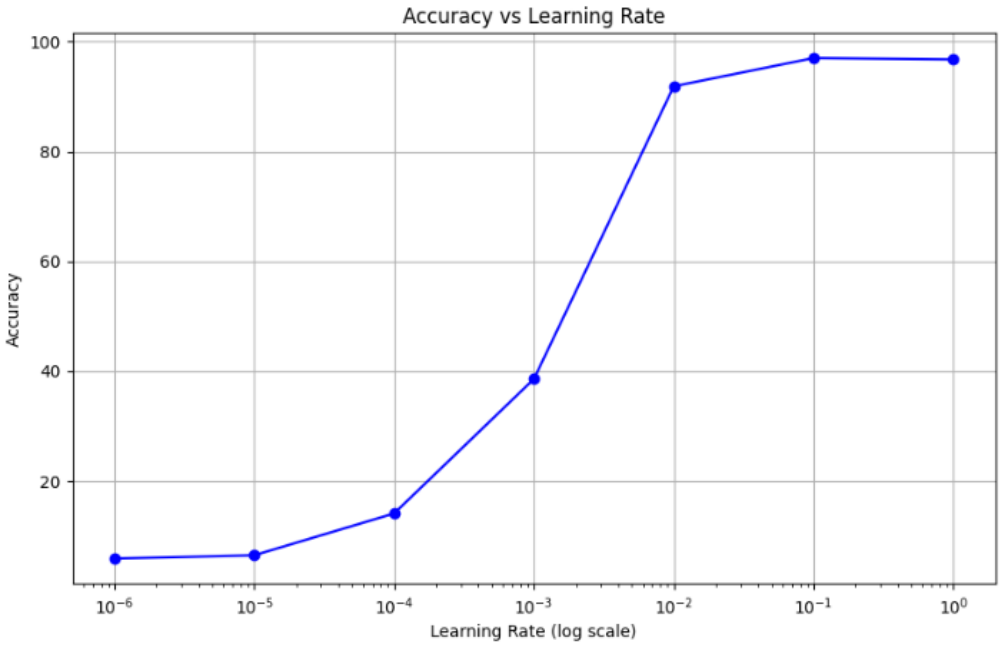
```




```
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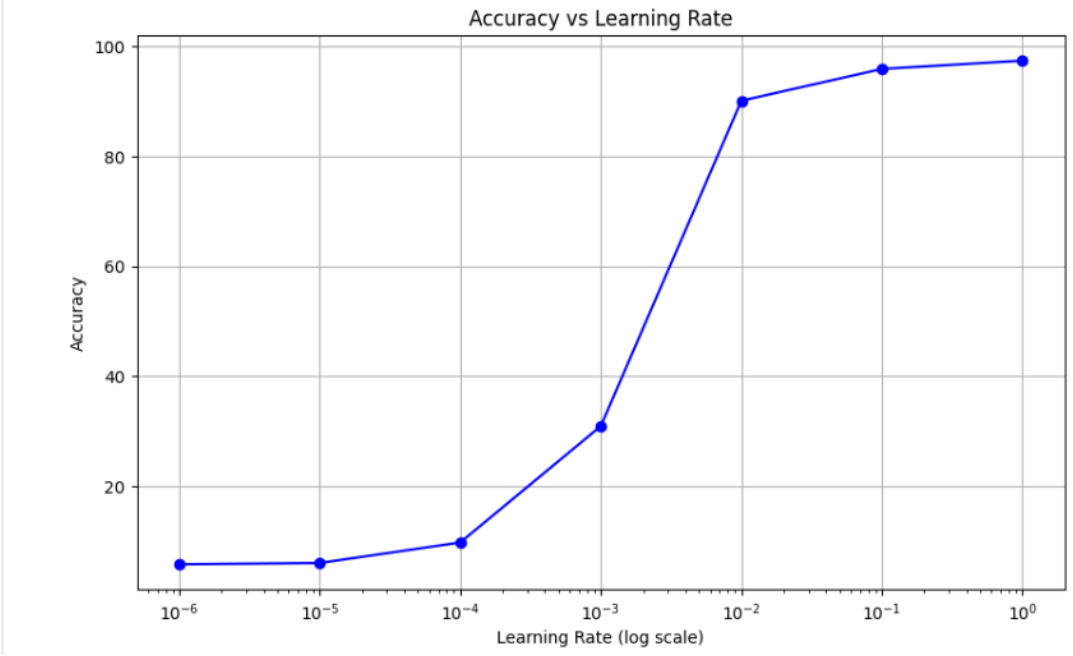
Training with learning rate: 0.1
Epoch 1, Loss: 0.0096
Epoch 2, Loss: 0.0111
Epoch 3, Loss: 0.0052
Epoch 4, Loss: 0.0052
Epoch 5, Loss: 0.0002
Epoch 6, Loss: 0.0014
Epoch 7, Loss: 0.0004
Epoch 8, Loss: 0.0006
Epoch 9, Loss: 0.0185
Epoch 10, Loss: 0.0154
Epoch 11, Loss: 0.0004
Epoch 12, Loss: 0.0110
Epoch 13, Loss: 0.0024
Epoch 14, Loss: 0.0047
Epoch 15, Loss: 0.0005
Accuracy: 97.03
```

Test result:

Using **MSE** and a batch size of **16**, with a learning rate of **0.1** and the test accuracy achieved was **97.03%**.

Test Batch Size = 32, MSE Loss




```
Training with learning rate: 1
Epoch 1, Loss: 0.0098
Epoch 2, Loss: 0.0001
Epoch 3, Loss: 0.0025
Epoch 4, Loss: 0.0073
Epoch 5, Loss: 0.0018
Epoch 6, Loss: 0.0121
Epoch 7, Loss: 0.0028
Epoch 8, Loss: 0.0033
Epoch 9, Loss: 0.0002
Epoch 10, Loss: 0.0033
Epoch 11, Loss: 0.0001
Epoch 12, Loss: 0.0001
Epoch 13, Loss: 0.0021
Epoch 14, Loss: 0.0000
Epoch 15, Loss: 0.0000
Accuracy: 97.4
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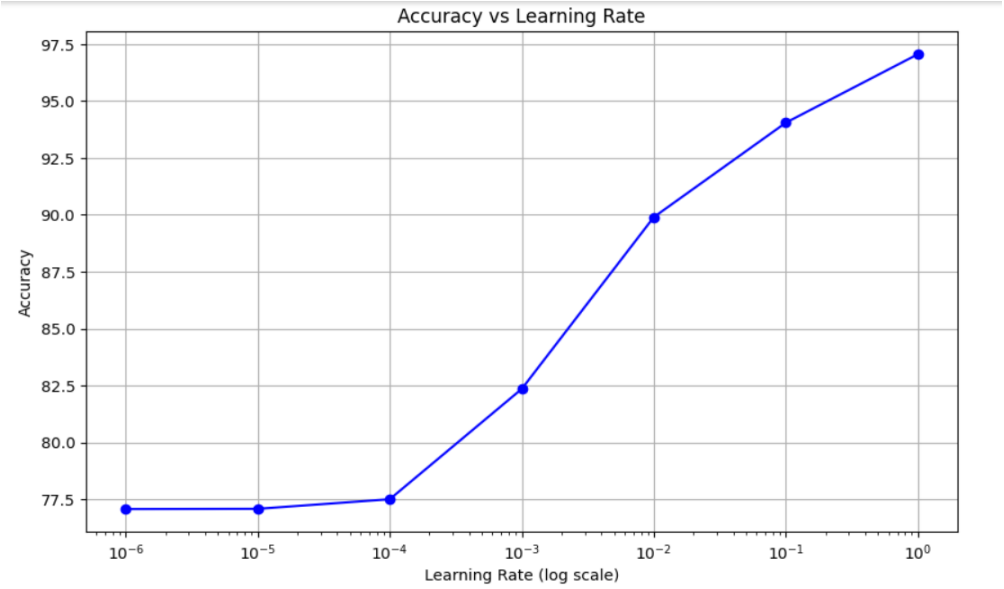
```

Test result:

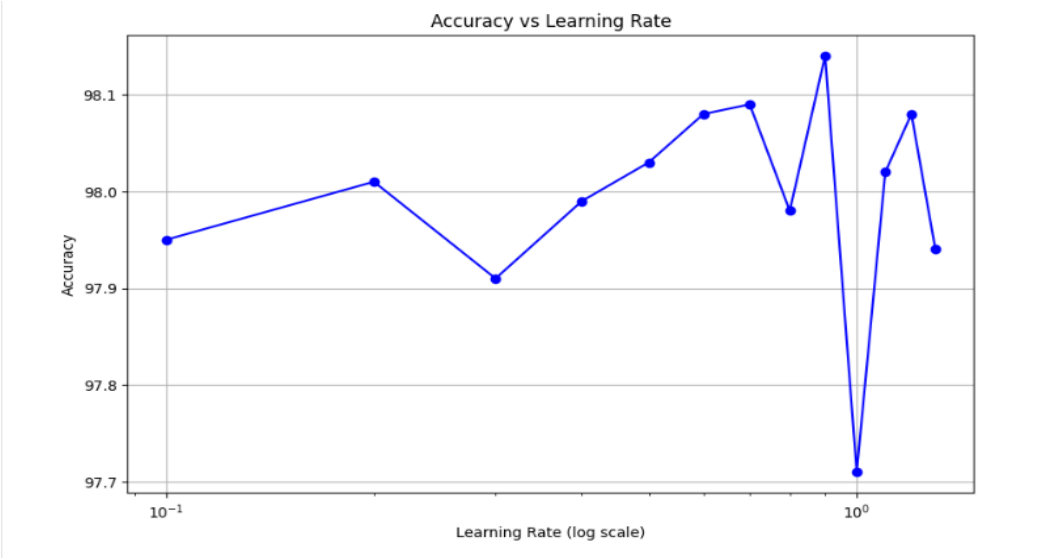
Using **MSE** and a batch size of **32**, with a learning rate of **1** and the test accuracy achieved was **97.4%**.

- Test Batch Size = 64, MSE Loss

- Testing the learning rate on the following values:
  [0.000001, 0.00001, 0.0001, 0.001, 0.01, 0.1, 1]



- in Test 2, I conducted a more informed examination based on the results of Test 1 to further improve accuracy. This involved testing the learning rate on the following values:
  [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3]



When testing different learning rates, I observed that a few learning rates produced the same accuracy, approximately 0.15% difference. Despite this, I preferred to select the smaller learning rate that gave the same accuracy.

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------------------------------
Training with learning rate: 0.2
Epoch 1, Loss: 0.0001
Epoch 2, Loss: 0.0000
Epoch 3, Loss: 0.0002
Epoch 4, Loss: 0.0014
Epoch 5, Loss: 0.0002
Epoch 6, Loss: 0.0002
Epoch 7, Loss: 0.0000
Epoch 8, Loss: 0.0006
Epoch 9, Loss: 0.0003
Epoch 10, Loss: 0.0007
Epoch 11, Loss: 0.0002
Epoch 12, Loss: 0.0004
Epoch 13, Loss: 0.0063
Epoch 14, Loss: 0.0003
Epoch 15, Loss: 0.0001
Accuracy: 98.01
------------------------------
```

Test result:

Using **MSE** and a batch size of **64**, with a learning rate of **0.2** and the test accuracy achieved was **98.01%**

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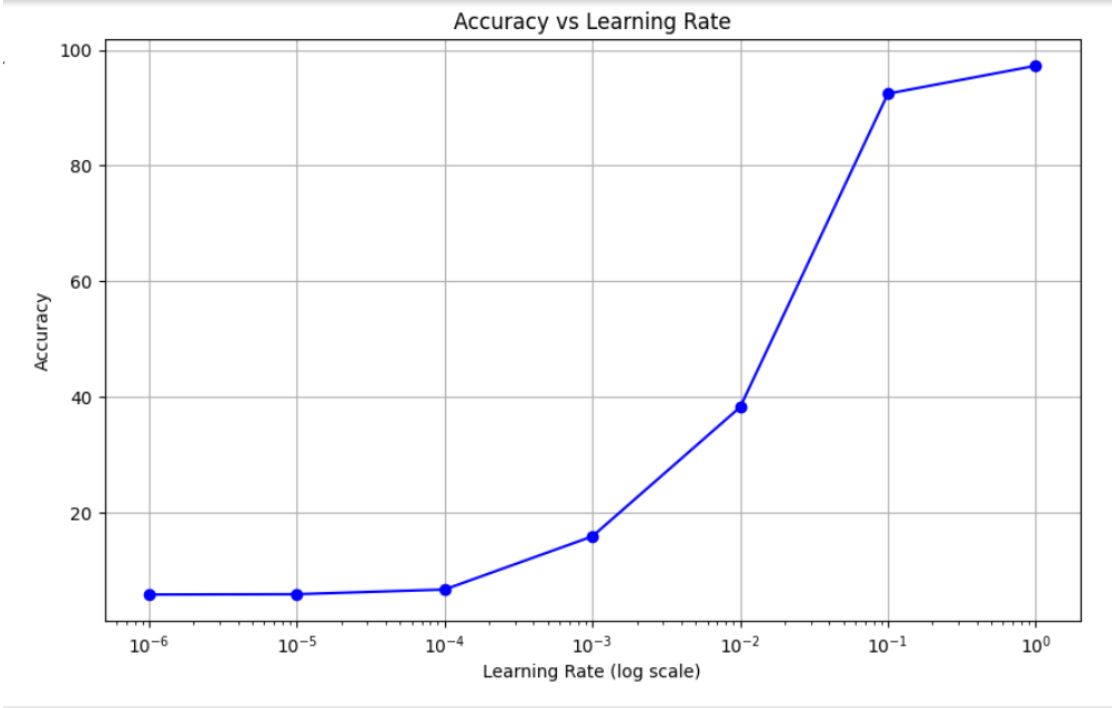
Test Batch Size =128, MSE Loss




```
------------------------------
Training with learning rate: 1
Epoch 1, Loss: 0.0064
Epoch 2, Loss: 0.0053
Epoch 3, Loss: 0.0059
Epoch 4, Loss: 0.0084
Epoch 5, Loss: 0.0040
Epoch 6, Loss: 0.0087
Epoch 7, Loss: 0.0078
Epoch 8, Loss: 0.0014
Epoch 9, Loss: 0.0042
Epoch 10, Loss: 0.0021
Epoch 11, Loss: 0.0044
Epoch 12, Loss: 0.0012
Epoch 13, Loss: 0.0058
Epoch 14, Loss: 0.0009
Epoch 15, Loss: 0.0051
Accuracy: 97.27
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```
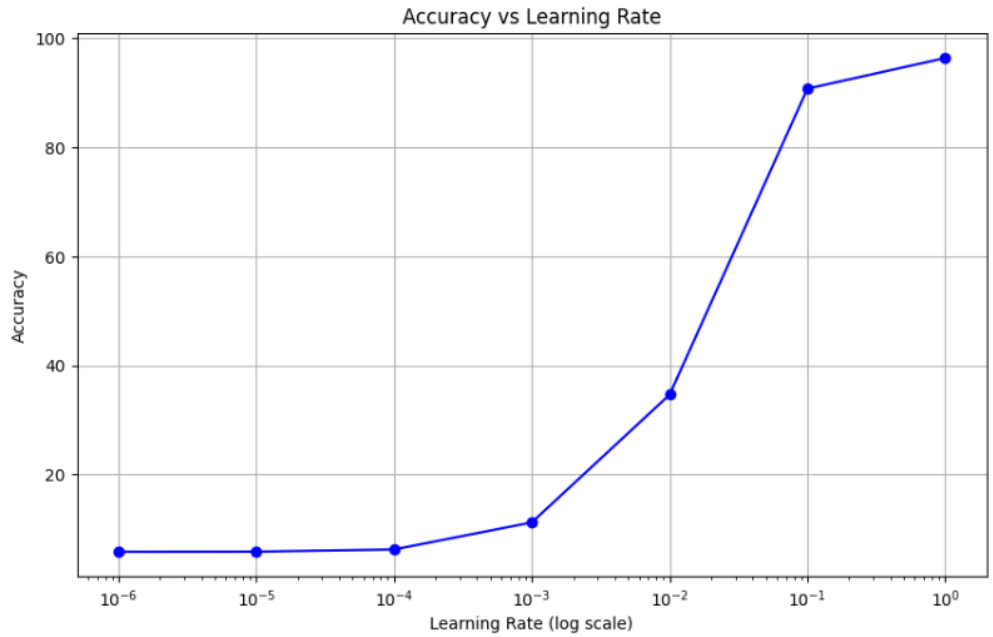

Test result:

Using **MSE** and a batch size of **128**, with a learning rate of **1** and the test accuracy achieved was **97.27%**

Test Batch Size =256, MSE Loss




```
------------------------------
Training with learning rate: 1
Epoch 1, Loss: 0.0091
Epoch 2, Loss: 0.0079
Epoch 3, Loss: 0.0093
Epoch 4, Loss: 0.0130
Epoch 5, Loss: 0.0050
Epoch 6, Loss: 0.0118
Epoch 7, Loss: 0.0083
Epoch 8, Loss: 0.0055
Epoch 9, Loss: 0.0092
Epoch 10, Loss: 0.0053
Epoch 11, Loss: 0.0054
Epoch 12, Loss: 0.0037
Epoch 13, Loss: 0.0076
Epoch 14, Loss: 0.0023
Epoch 15, Loss: 0.0069
Accuracy: 96.37
------------------------------
```

Test result:

Using **MSE** and a batch size of **256**, with a learning rate of **1**, , the test accuracy achieved was **96.37%**.