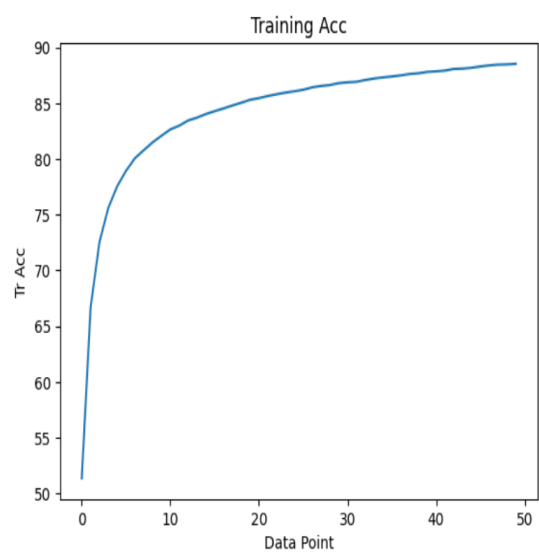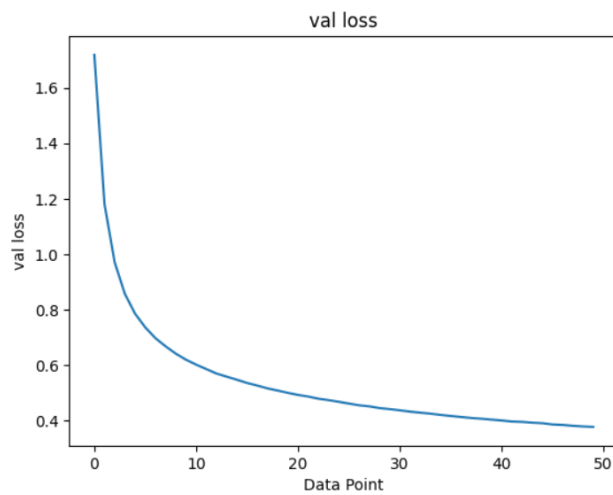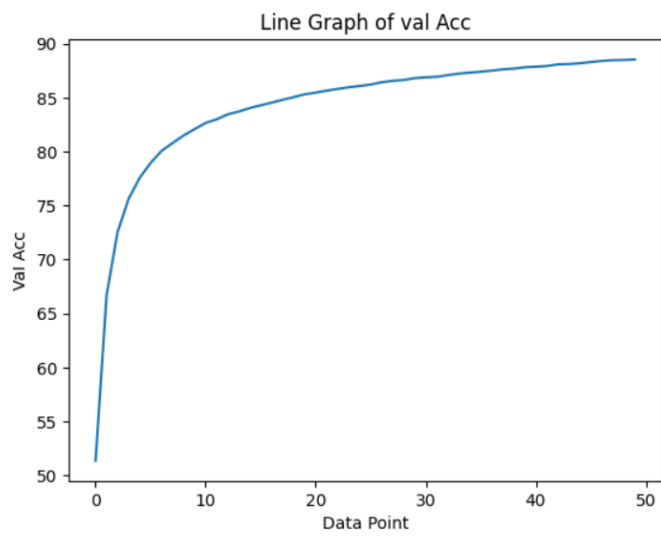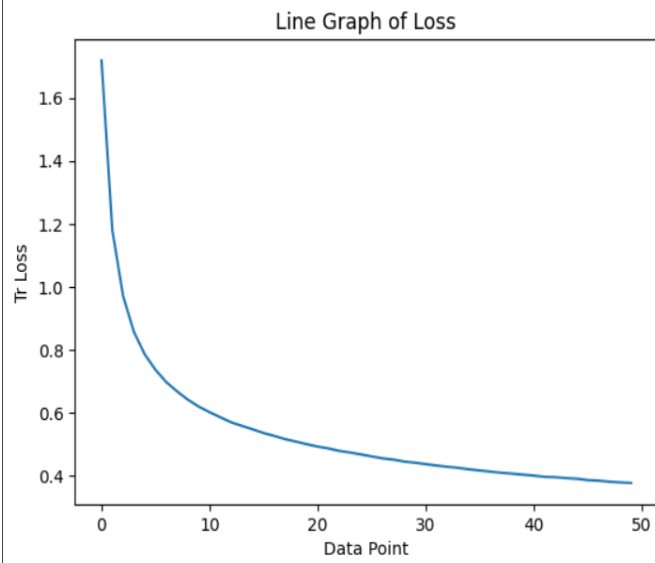# NN Model Performance:

Model 1:

```python
tr_network = [
    Dense(784, 512,'h'),
    DropoutLayer(512,512,'h',0.3),
    Dense(512, 26,'o')
]
```

Lr:.005
Epochs:50
Batch size:6240

Line Graph of Loss

Line Graph of val Acc

val loss

Line Graph of val f1

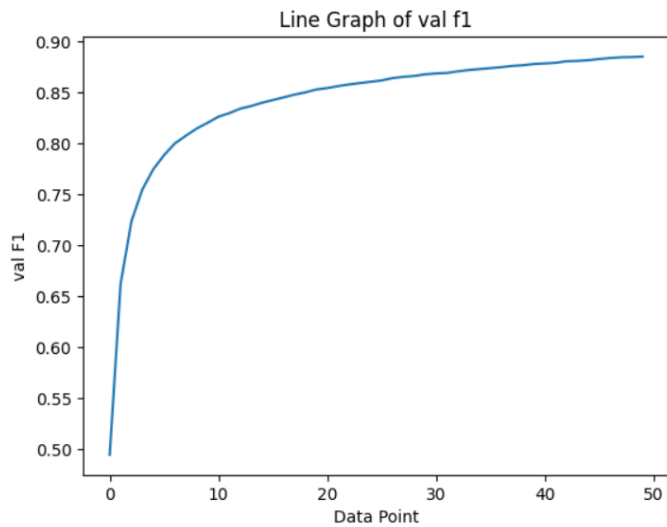## Validation dataset:

```
85.82264957264957
0.8582317007290295
[[573    5    4   15    3    4   10   14    0    0    4    0    4   16   10    7   22    6
    2    2   13    0    1    0    0    9]
 [   6  613    3    8    5    0   12   16    2    2    2    2    1    1    8    1    2    1
    2    2    2    0    1    0    2    8]
 [   4    2  613    0   22    0    3    0    1    1    2    4    0    0   12    7    2    3
    0    2    4    0    0    0    1    0]
 [  11   19    0  647    1    1    3    3    5   10    6    4    0    4   23    7    2    0
    0    0    2    2    2    2    1    4]
 [   6    5   19    0  619   13    9    1    3    0    2    0    0    2    3    2    1    8
    0    2    0    0    1    1    2    2]
 [   0    0    3    0    2  662    3    5    4    3    3    2    0    1    0   24    5   12
    1   26    0    0    0    2    4    0]
 [  16   13    7    0    2    8  507    2    2    9    0    0    2    2    2    2  118    2
    6    2    3    0    1    2    9    7]
 [  11   10    0   14    0    3    0  641    1    0   12    7    2   25    0    2    0    4
    0    4    2    1    5    8    1    0]
 [   0    2    1    4    0    3    2    2  499   14    1  154    0    0    0    1    0    1
    0    2    0    1    0    1    2    9]
 [   0    1    1   14    1    5    3    0   25  637    0    4    1    1    1    0    1    2
    8    9    4    3    0    0    5    1]
 [   0    3    6    5    2    1    0   17    1    1  631    3    1    3    0    0    0   13
    0    2    6    3    1   12    0    1]
 [   1    2    4    1    1    1    0    3  148    1    4  533    0    0    0    1    1    0
    0    0    2    1    0    2    1    4]
 [  12    0    0    0    0    0    2   10    0    0    3    0  682   23    0    0    0    0
    0    2    2    0    1    0    3    1]
```

```
[ 15    3    0    1    0    0    1   16    0    0    5    0   10  607    2    2    0    3
    0    1    5    2   19    4    1    0]
[  1    7    5    6    0    0    3    0    1    0    0    0    4  676    0    4    1
    0    0    2    1    0    0    0    0]
[  4    0    0    2    0    9    2    0    3    0    0    0    0    3    3  701    7    7
    0    3    0    0    2    1    5    0]
[ 34    3    2    5    7    8   97    1    2    1    2    0    1    1    8    5  516    1
    3    6    3    1    0    2    8    3]
[ 15    1    3    0   10    9    2    3    1    0   22    2    1   11    0   16    4  596
    1   10    0    4    1    5    3    2]
[  3    4    2    0    1    1   17    1    3   15    1    1    0    0    5    0    1    2
  681    1    0    0    1    1    0    0]
[  2    5    0    2    7   12    0    5    8    4    5    1    1    0    0    0    4   19
    1  649    0    0    0    2   18    4]
[  7    0    0    6    0    0    0    2    0    2    2    1    1    3    2    2    0    0
    0    1  634   20    3    0    0    0]
[  1    0    0    3    0    0    0    0    1    1    4    1    1    2    1    0    3    8
    0    0   32  625    4    3   15    1]
[  4    3    0    3    0    1    0    6    0    1    2    0    5   10    0    1    2    0
    0    2    3    5  625    0    2    0]
[  6    2    0    1    0    0    1    1    3    1   26    1    3    3    0    0    0    2
    0    3    0   10    1  608   20    7]
[  2    2    0    1    0    1   13    1    2    8    2    4    1    1    0    4    5    6
    2   10   13   25    1    9  625    0]
[  5    6    0    3    3    4    6    0    6    2    1    3    1    1    0    1    2    0
    0    8    0    0    0    7    1  666]]
```

Test Data:

```
85.5048076923077
0.854787240223638
[[650    5    6   11    7    1    8   14    0    2    4    0    3   16    9    8   26    8
    0    2    7    1    1    5    0    6]
 [ 13  690    1   11    5    1   16   17    2    2    3    4    1    5    5    4    4    1
    1    2    3    0    0    0    0    9]
 [  5    3  719    1   30    1    0    0    1    0    4    6    0    1   10    3    2    6
    1    1    3    0    1    0    0    2]
 [ 16   26    1  652    0    3    3    4    4    9    4    0    0    8   40    7    3    1
    5    1    8    1    0    1    2    1]
 [  9    6   29    2  708    7    2    0    2    1    0    1    1    1    4    3    3    5
    5    5    1    0    0    1    0    4]
 [  5    1    1    2    2  686    6    1    4    2    1    3    2    0    0   43    5    8
```

```
    2  23   0   0   0   1   1   1]
[ 21  16  12   2   8   7 547   1   3  11   1   0   0   1   3   4 122   2
  15   0   2   1   5   2  13   1]
[ 14  13   0   7   0   1   1 658   1   0  22  14  10  32   0   2   0   2
   0   5   7   1   5   3   2   0]
[  0   1   1   1   1   1   2   0 577  18   2 171   0   0   0   0   1   4
   2   3   0   1   0   3   0  11]
[  2   1   0  14   1   0   6   1  22 703   0   3   0   0   0   0   3   0
  10  17   1   2   0   1   4   9]
[  2   6   5   1   3   2   0  24   2   1 689   7   3   5   0   1   2   7
   1   3   3   5   3  20   3   2]
[  1   3   3   1   0   2   0   4 173   2   0 591   0   0   0   0   1   3
   0   2   2   2   0   2   4   4]
[  5   0   0   0   0   0   0   6   0   0   1   0 758  17   0   0   1   1
   0   2   2   0   4   1   2   0]
[ 27   1   0   3   1   0   0  28   0   0   7   0  24 671   0   0   2   4
   0   3   5   4  14   3   3   0]
[  3   6   4  10   1   0   4   0   0   0   0   0   2   4 757   2   2   2
   0   0   1   1   1   0   0   0]
[  1   0   0   6   1  15   1   1   1   0   0   0   0   5   1 746   6   5
   0   3   0   0   0   0   8   0]
[ 43   2   2   4   8  12 101   1   4   5   1   2   0   2  13   3 554   5
   4  11   5   0   2   1  11   4]
[ 24   5   3   0   9   9   0   0   4   0  15   1   4   8   0  11   3 660
   1  14   0   5   0   6  11   7]
[  3   5   0   0   2   2  22   1   4  13   1   0   0   1   2   0   2   3
 737   0   0   1   0   1   0   0]
[  4   6   2   3  13   6   3   3   9   6   4   1   0   1   1   3   4  12
   0 697   0   0   0   2  20   0]
[  6   3   1   3   0   0   0   5   0   2   3   1   1   4   2   2   1   1
   1   0 723  31   9   0   1   0]
[  0   0   0   4   0   0   0   0   2   1   3   0   1   8   1   0   0  10
   0   1  34 710   4   3  18   0]
[  2   3   1   3   0   0   0   4   0   1   4   1   4  11   0   0   0   2
   0   1  10   1 751   1   0   0]
[  6   0   0   2   0   2   1   5   1   2  30   4   0   2   0   0   1   4
   1   1   0   9   1 705  19   4]
[  0   1   0   2   0   1  14   1   4   8   0   3   1   4   0   4   4   6
   2   9   5  21   0   8 702   0]
[  3   0   1   2  10   1   6   4   6   1   2   2   1   2   0   1   3   1
   0   2   0   1   0   6   1 744]]
```
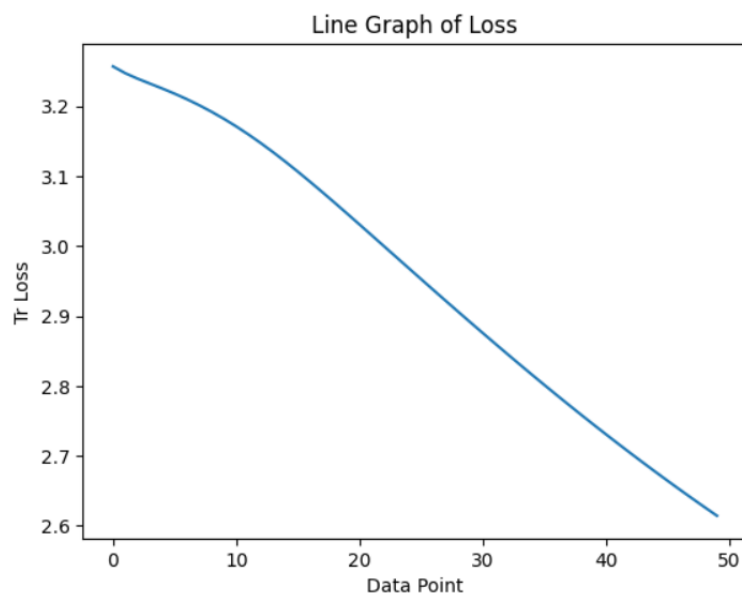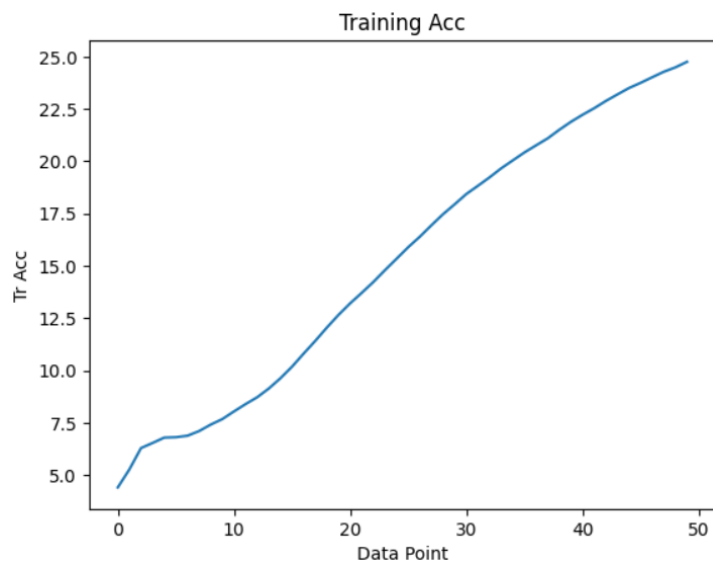
Model 2:

```
tr_network = [
    Dense(784, 5,'h'),
    Dense(5, 26,'o')
]
```

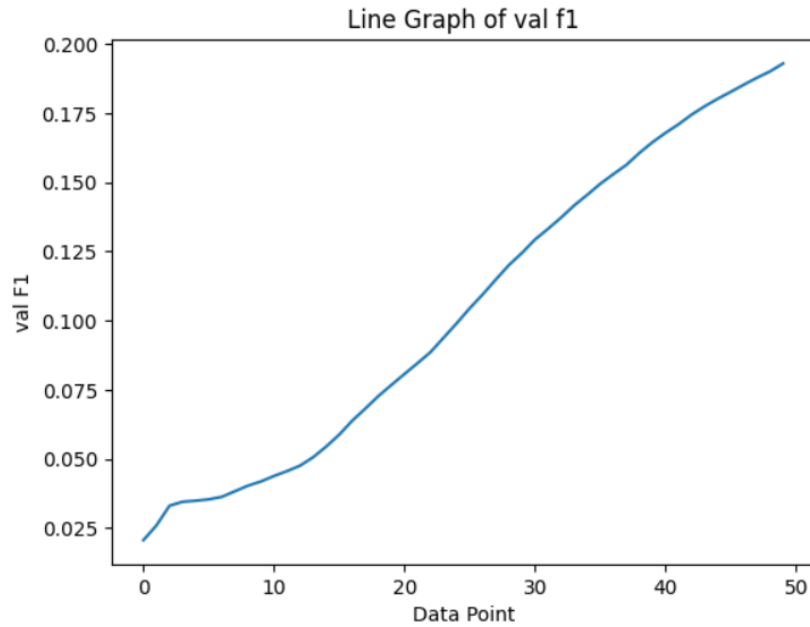Lr: .005
Epochs: 50
Batch size: 6240

Training Acc

Line Graph of Loss

Line Graph of val Acc

val loss

Line Graph of val f1
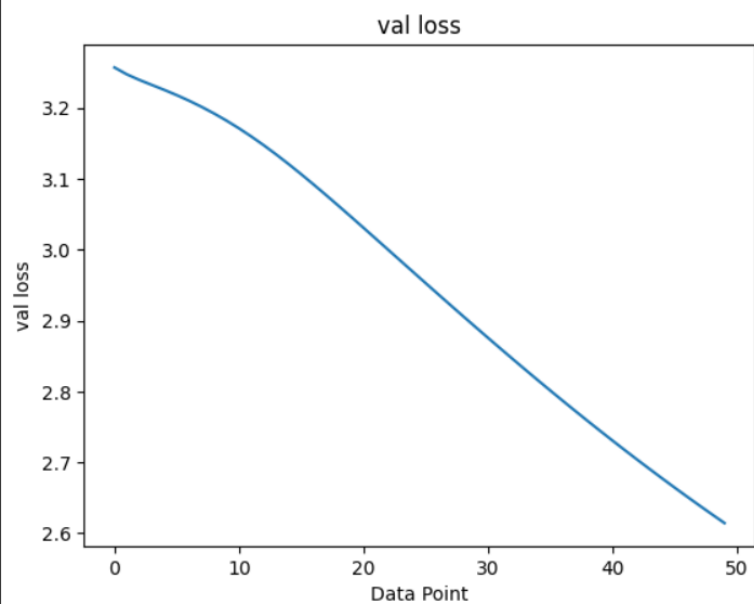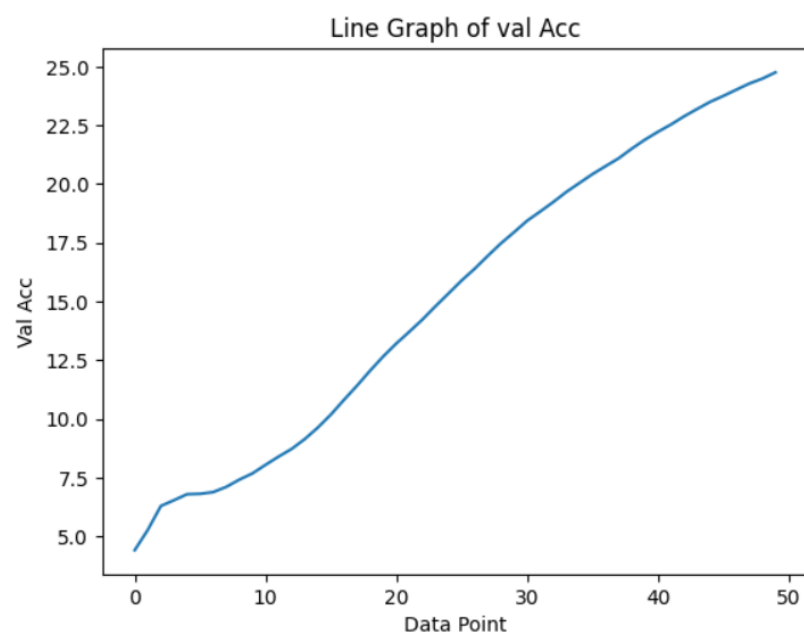
Validation Set:

```
Acc:24.326923076923077
F1:0.18927132010926193
[[ 80    1   69    0   37    0    2    0    6   12   53    0   50   69  122    2   64   73
   13    0   19   20    6   20    1    5]
 [  5    1   18    0   58    0    7    1   81   70    6    0    8   13   46   15   50   16
   56    0   11   64    1  110   22   43]
 [ 14    0  137    0   97    1    9    0    5    9    8    0   27   14  108    1  140   12
   32    0   15   25    2   23    0    4]
 [  4    3   15    0   33    0   39    2   21   82   10    0   11    9  122   14   65    5
   11    1   57  179    7   24   23   22]
 [ 14    0   66    0  283    0    4    1    0    1   71    0   15   16   75    1   20   27
   25    0    5   12    0   63    1    1]
 [ 14    8    6    0   15    0   32    1   90   28   56    0    8    1    8   24   13  114
   21    6    1   31    1  217    9   58]
 [  9    2   30    0   25    0   35    0   44   52    7    0   25    9   57    0  252    4
   48    1   19   46    0   28   13   18]
 [  4    7    1    0   25    1    5    2   86   42   17    0   10   94   20   27    4   80
   22    2   18   39    1  182    3   61]
 [  0    1    0    0    0    0    5    0  507   60    5    0    0    0    2    1   11    1
   31    1    0    4    0   16    3   51]
 [  0    7    1    0    5    0   42    0  130  250    1    0    1    1   60    2   54    6
   62    2   19   52    1    9    8   14]
 [ 23    0   10    0   70    0    2    0    7    7  150    0   12   15    6    8    6  229
    7    0    5   32    1  110    1   11]
 [  0    6    7    0   29    0    3    0  435   37   15    0    1    2    8    7   14   10
   35    0    6   17    1   35    5   38]
```

```
[ 46    0    6    0    2    0    1    0    0    0    1    0 397 173   42    4   14   20
    0    0   19    4   10    2    0    0]
[ 15    0    8    0   21    0    0    0    0    3   11    0   89 344   89    0    2   70
    1    0   14    8   10   11    0    1]
[  0    0   13    0   10    0    0    0    2    1    0    0   19   37 545    0   43    2
   20    1   16    2    0    0    0    0]
[  5    3    2    0   17    0   15    0   16   13   15    0   13   29   22   21    8 148
   20    2   23   66    3 270   14   27]
[  1    2   35    0   11    0   19    0   82   24   19    0   31    4   85    0 215    7
   27    2   64   41    0   35    3   13]
[ 34    1    8    0   42    1    5    0    3    2   70    0   32   63   17    2    9 268
   29    1    2    5    0 126    0    2]
[  0    0   15    0   15    0   34    0   37   91    5    0    0    1   63    1   55    0
  343    0    0   16    1   22   15   27]
[  3    7   25    0   30    0   18    0 192   33   32    0    3    3   23    6   24   68
   81    8    3    4    2 122    3   59]
[ 13    0   16    0   14    0    9    0    2    7    5    0   33   35 117    4   83    6
    1    0 249   85    1    3    0    3]
[  1    1    3    0   23    0   18    2    0    5    0    0    3   10    8    9   30   47
   10    0   82 327    6   88   16   17]
[ 13    0    0    0    4    0    6    0    0   10    2    0   51 182 168    1   16   20
    1    0   88   47   64    1    0    1]
[  2    2    3    0   33    0    4    0   27   17   50    0    0    2    1    9   23   55
  112    1    3   37    0 290    4   24]
[  0    4    6    0   16    0   26    0 133   27    6    0    3    3   16    9   63   17
   77    1   29   77    2 154   13   56]
[  5    2    7    0   67    0   15    0   20   98   14    0    2   17   36    4   23   39
  262    3    3   16    2   42   24   25]]
```

Test Set:

```
Acc: 24.985576923076923
F1: 0.19574400973461115
[[ 91    0   88    0   49    0    3    0    6   15   47    0   53   74 124    4   77   82
   14    1   16   20    8   25    1    2]
 [  8    5   23    0   52    0   12    0   80   85   13    0    2   13   43   15   48   15
   72    1   14   80    1 149   19   50]
 [ 17    1 151    0 116    0   10    0    8    6   20    0   30   24 127    0 157   12
   47    0   21   17    0   31    0    5]
 [  1    3   10    0   28    0   45    2   33   75    5    0    8   15 149   13   59    6
   18    1   66 186    6   30   27   14]
 [ 29    0   81    0 275    0    4    0    2    3   88    0   16   21   86    0   23   43
```

```
   34    1    3    7    1   81    0    2]
[ 16   13    4    0   18    1   39    0  101   34   55    0    6    1   11   20   28  125
  15    7    2   32    1  211    6   54]
[  6    3   41    0   32    0   28    0   57   61   15    0   31    4   64    1  293    4
  49    1   23   37    0   31    9   10]
[  9    9    4    0   32    0    2    0   87   46   17    0   13   87   26   33    5   85
  16    0   20   59    2  209    3   36]
[  0    4    0    0    0    0    1    0  615   49    8    0    0    1    5    0    6    2
  37    1    3    3    1   18    3   43]
[  0    2    5    0    7    0   50    0  153  280    0    0    0    0   38    1   70    4
  63    4   12   70    4   13    8   16]
[ 25    0    6    0   68    0    1    0   11   14  172    0   18   16    5    2    8  264
  10    0    9   38    3  110    0   20]
[  1    4   10    0   30    0    6    0  468   46   12    0    1    1    8    7   11    9
  40    1   15   28    0   47   10   45]
[ 66    0    5    0    2    0    3    0    1    0    1    0  425  184   45    1    9   32
   0    0   17    4    4    1    0    0]
[ 17    0    9    0   19    0    0    0    1    4   17    0  124  376  112    5    4   66
   4    0   24    8    4    6    0    0]
[  2    0   16    0    6    0    1    0    0    3    0    0   33   32  614    0   47    2
  24    0   12    0    1    2    0    5]
[  1    6    5    0   23    0    8    1   30   21   18    0   12   25   13   22   14  162
  22    2   16   69    0  297   10   23]
[  1    1   28    0   18    0   27    0   87   17   20    0   36    5   98    1  253    6
  43    1   55   47    1   40    4   11]
[ 27    1   15    0   59    0    1    0    5    1   81    0   44   51   27    3    6  311
  26    0    4   15    1  116    1    5]
[  1    0   13    0   17    0   17    0   53  102    4    0    2    2   76    0   55    1
 376    0    2   13    0   15   10   41]
[ 14    2   27    0   21    0   24    1  218   32   43    0    1    4   32    4   21   57
  86   13    3    8    2  124    4   59]
[  9    0   12    0   20    0   10    0    2    3    6    0   28   46  121    2   80   10
   2    1  326  113    6    1    1    1]
[  1    2    0    0   32    0   25    0    2    3    1    0    3   10   16    8   30   56
   9    0   83  383    3   92   22   19]
[ 13    0    2    0    8    0    6    0    0   13    2    0   58  228  177    2   23   16
   0    0  122   38   90    1    0    1]
[  3    0    0    0   30    0    9    1   32   17   61    0    0    2    2    4   21   60
 143    0    4   45    2  329   10   25]
[  1    2    0    0    5    0   37    2  136   30    3    0    0    5   17   16   74   19
  95    1   14   83    2  170   20   68]
[  2    1    9    0   68    0   12    0   21  108   17    0    5   20   37    5   27   30
 287    1    4   21    4   58   22   41]]
```
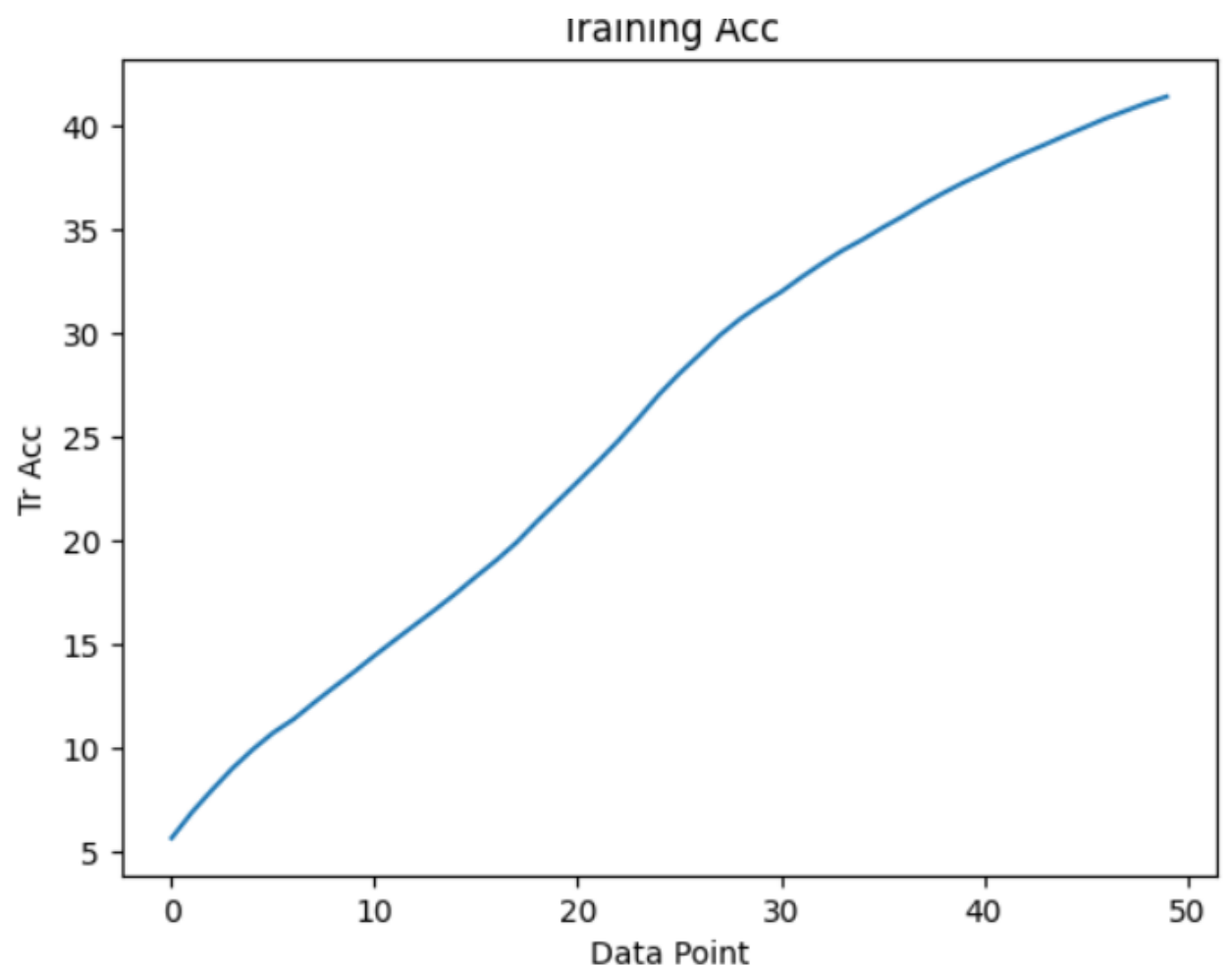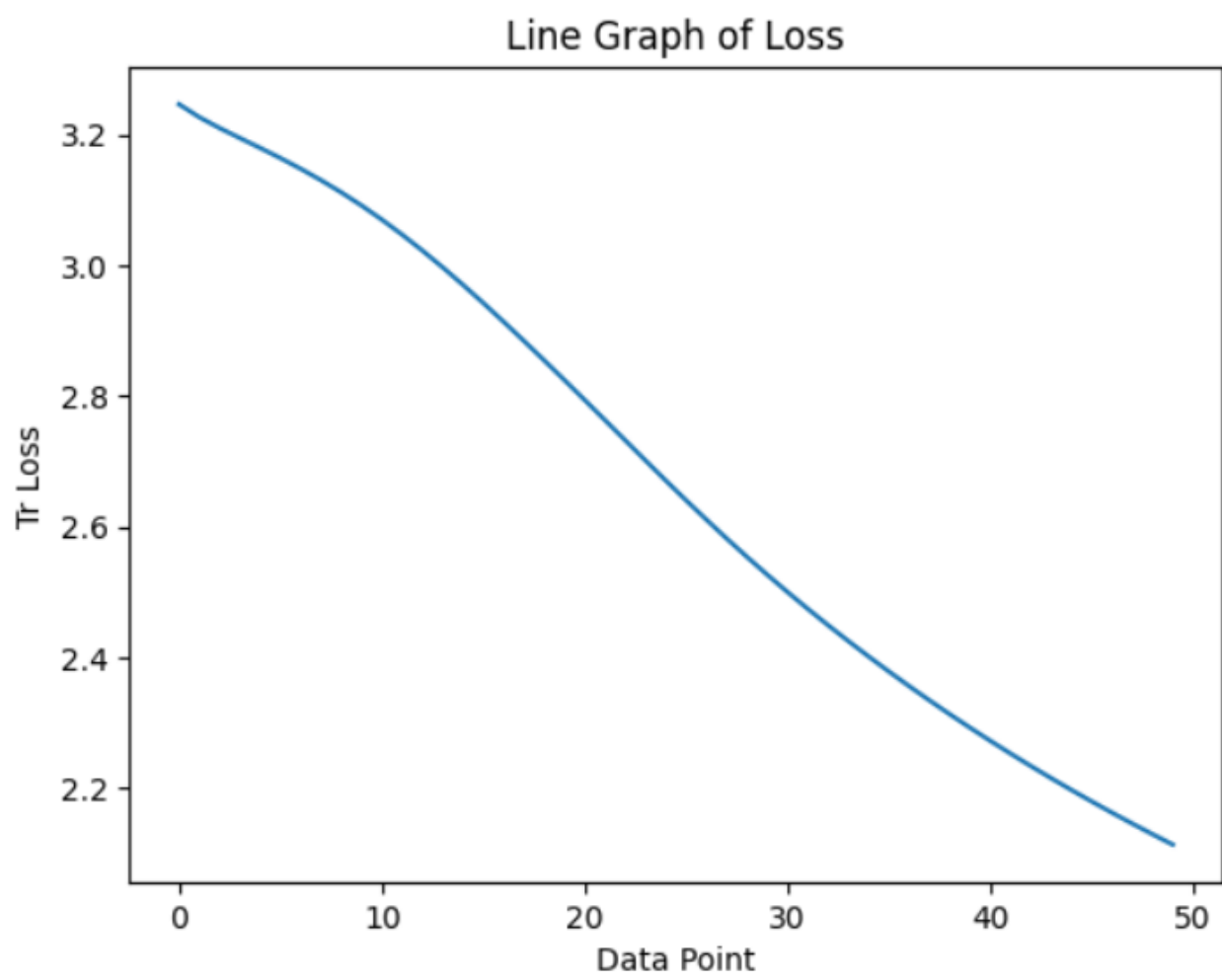
Model 3:

```
tr_network = [
    Dense(784, 10,'h'),
    Dense(10, 26,'o')
]
```
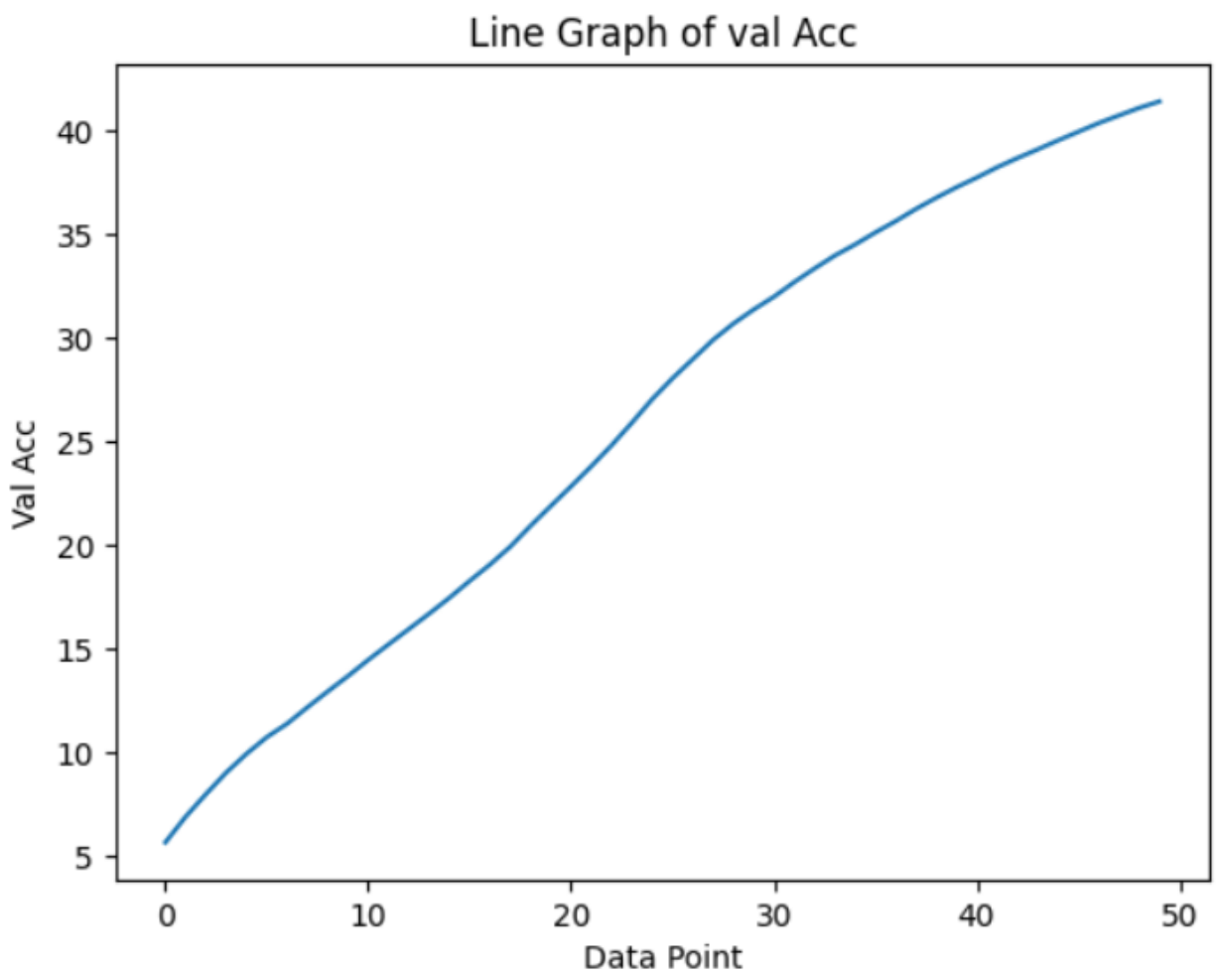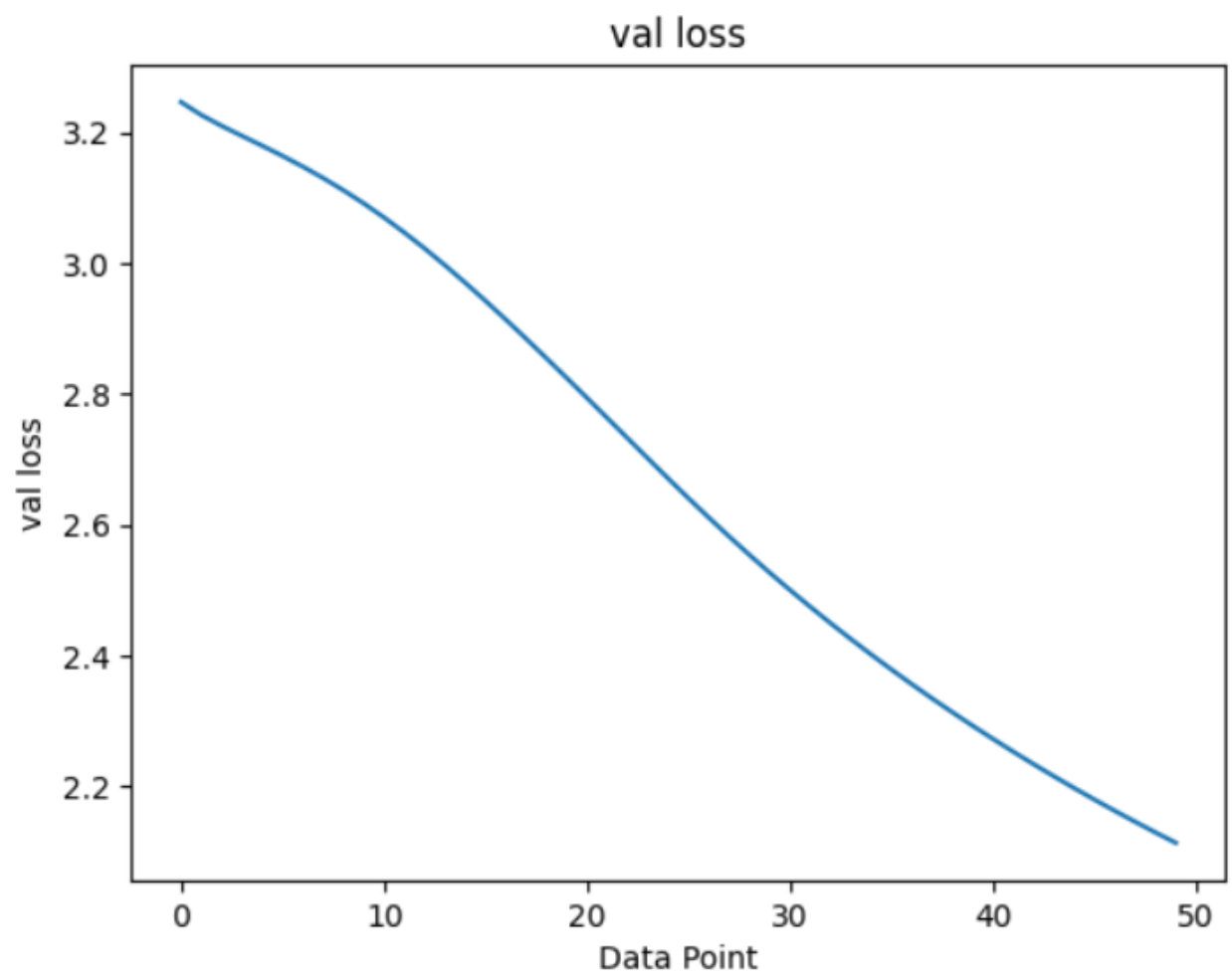
Lr: .005
Epochs:50
Batch size:6420

Line Graph of Loss

Line Graph of val Acc

val loss

Line Graph of val f1
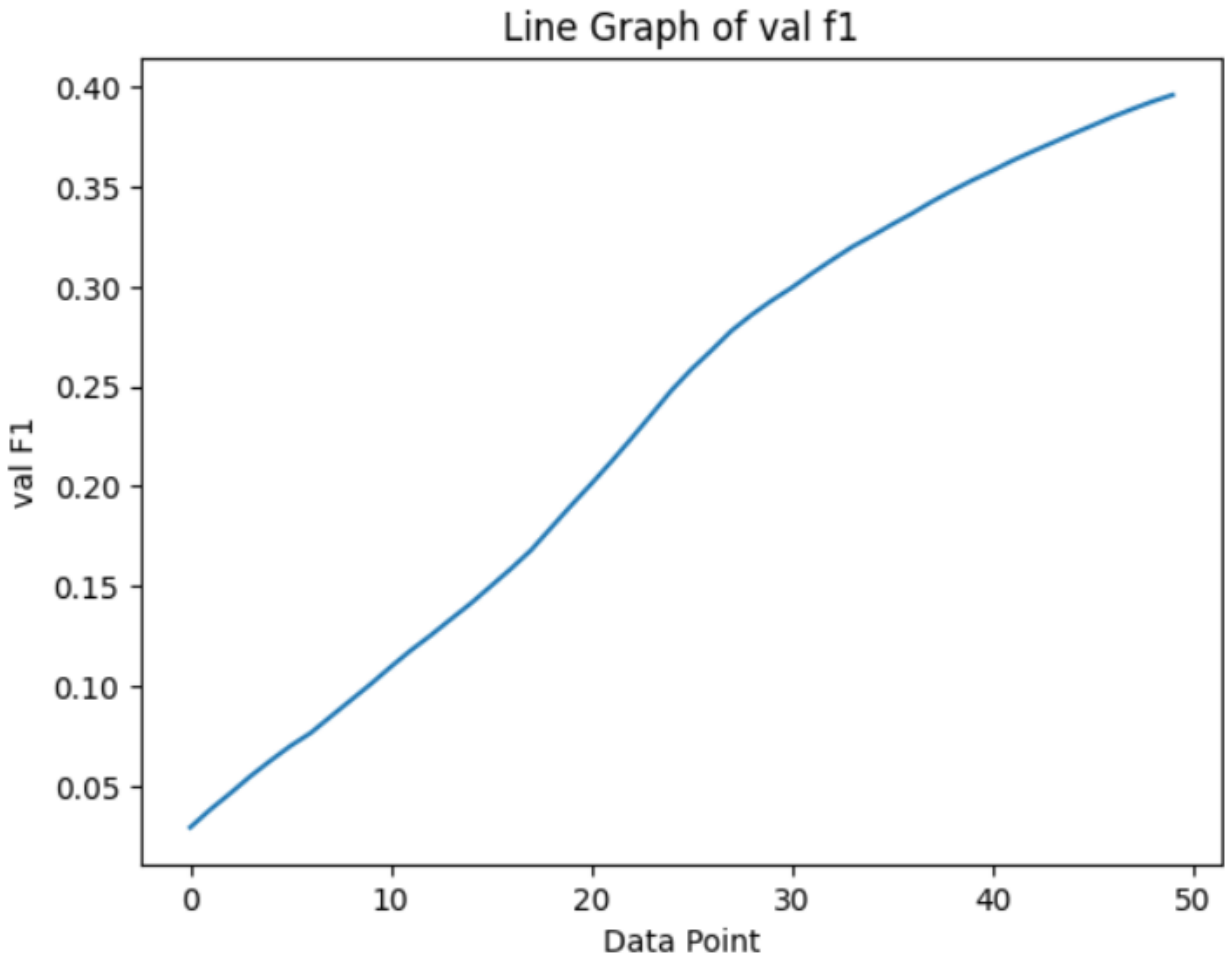

Validation:

40.81730769230769

0.3904790257080195

```
[[141   22   29   23   32   24   13   86    2    2   31    1   19   46   56    5   44   28
    17    0   32    8   56    6    0    1]
 [   9  243   23   60   39    4   16   52   11   73    1    6    1    7   11   14    6    0
    69    2    6   15    3    3    2   26]
 [   3   34  341   14   92    1   51    0    1    4    3    0   10   13   52    4    2    6
     6    4    5    2    5    1    0   29]
 [   7   63   52  244    8    6   23   33    1   61    7    6    2    8   76   11    4    1
    34    2   34   44   10    5    9    8]
 [  12   53   65   11  321    2   11    4    0    0   24    0    5   12   25   35    7   56
     2    2    3    4    4    6    0   37]
 [  13    4    1    0    2  248    2   22   49    4   45   13   10    0    1  146   11   45
     5   47    1   18    5   37   29    4]
 [  48   29   17   28    3    8  177   12   12   71    3    6   11    6   35    6   60    5
    64   21   37   10    5    5   28   17]
 [  33   14    0    6    7    9    0  306   57   14   32    2    5   52    2   13    5    0
```

```
   57    1    5   33   30   61    3    6]
 [  0    3    0    1    0    6    9    1  484   18    2   36    0    0    1    4    1    3
   20   25    3   14    1   12   31   24]
 [  1    3    6   71    1    2   49    2   66  259    0   20    1    5   21    4    3   19
   78   35   32    7    1    5    9   27]
 [ 11    4    3    0   27    7    1   18    5    1  297    2    6   12    0   51    1  112
    5    4    8   56    1   73    3    4]
 [  0   23   12   15   52    8    3    1  393    3    4   34    0    3    0   10    2    1
   14   32    8   21    1   17   23   31]
 [  9    0    1    0    3    7    0    5    0    0    7    0  541   98    7    3    4   22
    0    0    2    4   27    1    0    0]
 [ 51    1    7    2   16   10    0   21    1    1   26    0  128  264   12    5    2   21
    4    1    6    7  105    6    0    0]
 [  6    6   61    6    1    3   18    4    0   12    1    0    4   27  495    0    2    3
   25    0    9    4   11    1    0   12]
 [  5    7    1    1    3   61    3    3    5    0   17    1   16    7    7  408    5   42
    2   53    2   20   46   15   18    4]
 [ 35    9   17   13    7   15   90   16   43    6    5   12    3    3   90    9  100    5
   49   28   90    9   13   12   39    2]
 [ 12    3   16    1   36    9    2   16    3    0   68    1   43   13    0   61    8  328
    0   39    1    8    6   34    1   13]
 [  9   65   10   14    8    1   49    6    7   58    1    0    1    0   47    0    7    2
  400    8    5    3    3    7    3   27]
 [ 15   10    3    2   26   33    5   21  119    4   11   56    4    0    2   73   18  116
   15  128    0   10    3   19   38   18]
 [ 19    8    8   43    6    2   10   11    2    3   15    0    6   45   75    1   24    3
    7    0  308   53   32    4    0    1]
 [  1    6    0   10    1    2    5    2    2    6   31    1    4   12    4   27    8    8
    2    2   44  413   30   53   31    1]
 [ 11    0    0   10    1    4    0   13    0    1    3    0   44   66   28    7    0    8
    0    0   34   41  398    3    1    2]
 [  3    2    0    2    5   19    3   31   34    2   51    1    2    0    0   18   10   19
   22   11    1   60    5  382   10    6]
 [  7    7    7    8    0   11   19   15   73   21    7    8    4    5    2   41   36    8
   21   88    9   89   25  127   98    2]
 [  3   86    9   14   73    5    3    3    5   18    2    9   13    3   10   17    2   32
   22    4    1   15   37   46   11  283]]
```

Test set:

```
42.09615384615385
0.4036416577724952
[[184   20   33   18   32   32   22  104    2    5   36    1   25   54   57    1   40   13
   11    1   34    4   63    5    0    3]
 [ 13  249   17   78   47    2   18   66    9   75    2    6    1    8   13   31    4    1
   96    1    7   10    5    6    5   30]
```

```
[   2   38  370   13  120    0   55    1    0    5    3    1    5   16   70    8    5   13
    4    3    8    4    9    3    1   43]
[   9   60   46  297   11    0   26   37    7   75    7    4    1   10   78    9    2    0
   32    3   33   26    8    5    7    7]
[  12   59   92   15  379    2    5    2    1    0   24    0    9   24   22   24    5   51
    7    2    4    6    5    8    2   40]
[   9    2    1    0    7  269    4   20   40    2   53   14    4    1    0  146   20   55
    6   54    3   17    5   31   32    5]
[  45   44   36   29   10   10  220   16   14   60    8    3    5   12   37    8   67    4
   78   18   36    7    6    4   12   11]
[  33   17    0    8   11   12    2  333   39    9   36    1   11   40    1   20    7    7
   65    1   16   46   21   56    2    6]
[   0    3    1    1    0   13    9    1  527   29    1   41    0    1    2    2    3    4
   25   38    4   14    1   17   36   27]
[   1    5   10  103    1    4   67    3   69  299    0   14    0    1   18    2    4   14
   81   34   23    6    1   11   11   18]
[  11    4    3    1   39    9    0   23   10    1  330    1   10   19    2   46    2  125
    3    5    3   59    2   73    7   12]
[   3   31   22   14   54    3    4    0  432    5    2   30    0    1    3   15    1    1
   12   35   13   30    1   21   35   32]
[   7    0    0    0    3    9    0    6    1    0   14    0  599   93    4    2    6   20
    0    1    2    7   25    1    0    0]
[  53    3    9    8   12    8    0   27    1    1   32    0  132  319   12   12    8   26
    6    2   14   11   99    3    0    2]
[   6    1   76    6    3    1   14    3    0   17    0    0   17   25  549    0    2    4
   26    3   10    3   15    1    1   17]
[   3    7    1    1    5   62    0    3    9    0   14    0   14   10    1  477    4   39
    0   61    6   19   21   17   22    4]
[  40   12   22   10   11   26   88   15   50    5   15    9    6    6   80    8  133    7
   47   32  101    7   22   14   29    5]
[  14    0   17    2   33   15    1   18    5    0   83    1   45   14    1   79    7  346
    0   38    1   21   11   34    4   10]
[   7   60   12   18    5    2   36    1    5   71    2    1    2    3   52    0    9    7
  451   14    4    1    2    7    2   26]
[   9   16    6    0   17   48    4   14  152    2   13   50    8    1    6   65   18  109
   14  158    0   12    6   25   29   18]
[  34    5    8   46    5    4   13   19    1    4   14    0    2   44   78    1   23    3
    4    0  394   58   33    5    0    2]
[   2    2    1   14    2    3    2    3    7    0   32    0    4   12    2   30    7   12
    1    0   40  492   42   49   40    1]
[  19    1    1   11    4    7    1   16    1    3    9    0   39   80   30    3    4    4
    0    0   46   26  489    1    0    5]
[   3    2    0    5    8   34    5   25   39    4   47    2    1    1    0   21    7   19
   26    3    2   74    8  440   17    7]
[   6    5    9    7    0   12   22   15   84   24    4    5    1    3    6   52   38    8
   24  103   13  101   13  133  107    5]
[   1   95    9   12   80    4    5    3    6   23    3    6   14    1   12   16    5   29
```

```
 21   3   1  26  30  64  16 315]]
```